MATRIX | MATERIALS

UNIVERSAL TESTING MACHINE

CP4868

Inspiring The Next Generation Of Engineers

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Laboratory Technique

Safety in the Laboratory

The principle hazards that arise from the use of mechanical experimental apparatus are where rotary or linear motion occurs and where the handling of loose heavy items, for example weights, is part of the procedure.

Should one of the heavier weights fall onto the feet of those around the apparatus there is a risk of injury. Hence it is recommended that weights be handled carefully and when moving and placing the heavier ones on load hangers should be regarded as a two handed operation. It is surprisingly easy to spill a complete stack of weights off a hanger when adding a further one.

In addition to weights there are some heavy parts that have to be interchanged during some experiments and a similar approach using two hands where required is suggested. It may also be both sensible and necessary for two people to take part in changes to the apparatus.

Success in the Laboratory

Work in the laboratory depends on understanding, observation and skill. In the first place a good understanding of the performance, and limitations, of experimental models is needed. To know about the theory involved is useful but not essential. In the second place keen observation leads to better results and avoidance of mechanical mistakes. Lastly, the way in which students handle the apparatus can influence the accuracy and speed of the work.

To help students gain experience and improve their experimental technique a range of information is offered in the following notes. Bear in mind that in the world of real engineering it is often necessary to check the performance of new designs using the methods and instruments of laboratory experiments.

Design of Experimental Models

The purpose of each experiment is to illustrate an item of structural theory, or to show how well simplifying assumptions in the applied mathematics correspond to actual behaviour. This often requires the model to exaggerate the behaviour of a real structure.

In order to achieve specific objectives each experiment has a particular arrangement best suited to the theoretical requirement. These arrangements of the apparatus are described in the Construction Appendix, where included, of each experimental Instruction Manual. Before starting an experiment students should read through the Instruction Manual and be prepared to follow the recommended procedure.

Laboratory Technique

Increased deflections are usually achieved by using very flexible models. The stiffness depends on EI or EA so a change of material from steel (E = 205 kN/mm2) to aluminium (E about 1/3 E for steel) or a plastic (E about 1/80 E for steel) is a solution. The alternative is to use thin steel beams with a low I.

One disadvantage experimentally is that friction in bearings may affect displacements and force measurements. The other is that large changes in dimension (geometry) of models must be accommodated if possible.

Results can be improved by using stiffer models and larger loads, but this reduces visual effects such as curvature of beams.

Sources of Resistance

A knife-edge can simulate a frictionless pin or bearing, but horizontal and rotational movements demand ball bearings. These are packed with grease and fitted with shields to keep out dust and grit. Hence ball bearings have some torsional restraint, which affects forces in the order of magnitude 1 N. This shows up as a difference in readings for loading and unloading.

Pin joints in trusses are also subject to friction, which increases in proportion to the loading.

Repeatability of Readings

The ability to obtain accurate and repeatable experimental results is generally a matter of care and technique. Of course it helps to know the sources of error and to recognise when the apparatus contributes to the variability of readings.

Frictional variation can be minimised by using vibration. The extent of the friction can be observed by first increasing and then decreasing an applied load by hand to get the difference in readings. Tapping the frame on which the experiment is mounted will reduce the variation.

Cast iron weights for loading must always be applied gently. A load suddenly added will instantaneously apply twice its static value. Although weights are hand finished there is a manufacturing tolerance of ± ½%. This may affect linearity in experimental readings.

Safety

Safety

The clear guard of the MH9198 is made from 10mm Polycarbonate for the user's protection. The hinged door is fitted with a slam latch and must be closed when testing specimens.

A pair of safety glasses and ear defenders has also been supplied.

This ensures that the eyes and ears are protected at all times from possible flying debris and the noise of specimen fracture, which can be sudden.

The image above shows the safety glasses symbol attached to the door of the apparatus.

DANGER! Risk of injuries
Base frame may make sudden motions when the sample fractures!
Parts of the sample could fly away!
Keep clear of the tension/compression area during the test!

CAUTION!
With the help of the universal tester you can generate very large forces.
Therefore it is essential to check all fittings prior to running tests.

Important safety warnings are HIGHLIGHTED.

Introduction

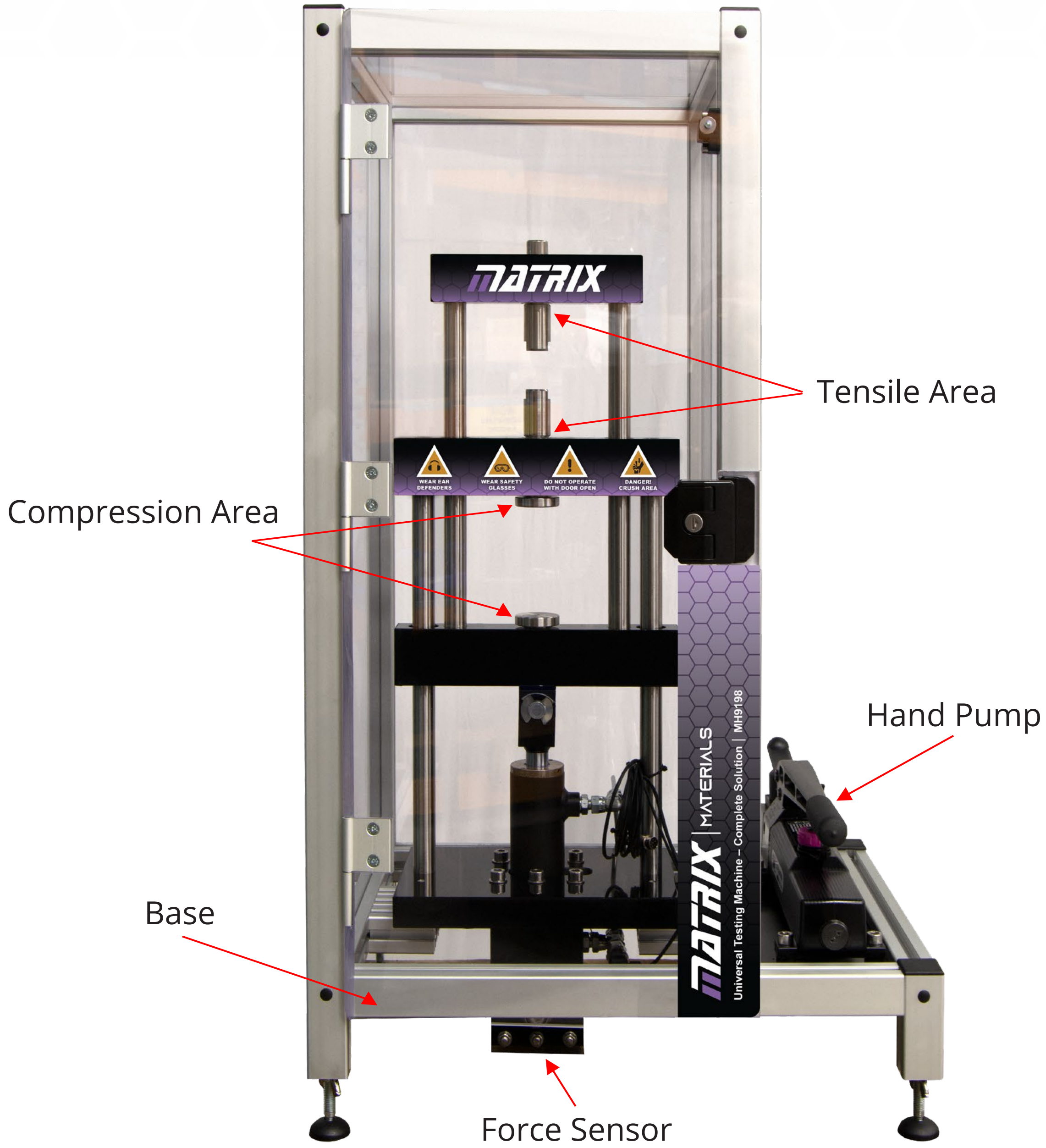
Tensile, compressive, shear and bending testing are fundamental experiments in materials testing. They illustrate important regularities for the evaluation of materials.

With the Universal Tester students are able to observe all details and phases of the experimental procedure.

Simple operation and a robust configuration are also positive aspects for use in student experiments. In this way, material data and regularities can be verified using measurement data obtained by the student themselves.

APPARATUS DESCRIPTION

Apparatus Description



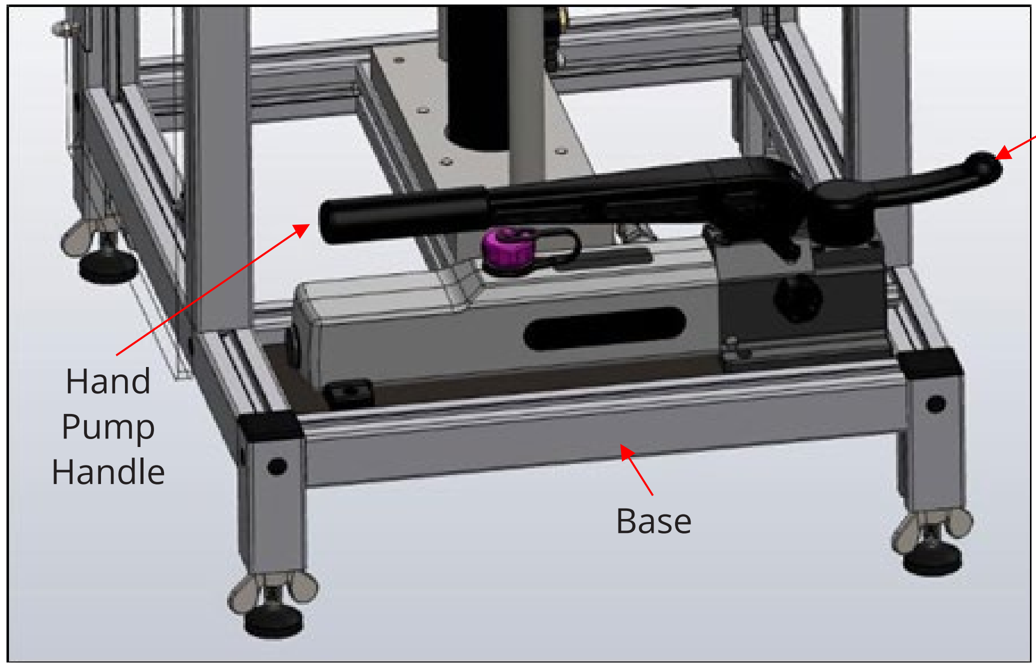
A robust base holds the key elements of the Universal Tester Apparatus.

All key items are mounted to this base and they are described in more detail below.

The base has two large diameter ground steel rods protruding from its upper surface. Onto these rods run the main compressive and tensile components used for testing.

The base has four levelling feet at either corner to allow levelling of the unit when sited. The levelling feet also give enough height to the base to allow it to be picked up by two people.

Hand Pump

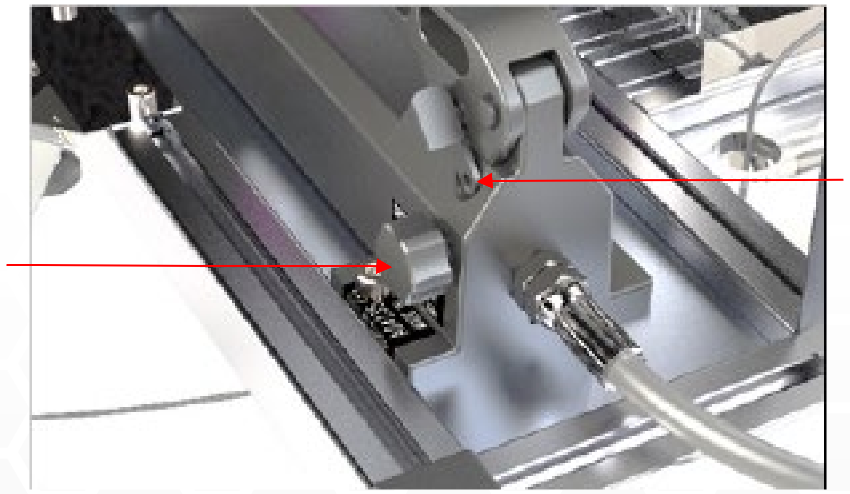


The hand pump is mounted to a plate on the base. The hand pump has all the hydraulic hosing and connectors attached to load the system.

The over pressure range has been factory set. This ensures that the system is not overloaded and damage occurs.

The hand pump has a long handle which is used to gradually increase the pressure and hence force within the system.

The hand pump has a "direction" lever at its front. This aids the raising and lowering of the cross members of the apparatus. When turned in one direction it will raise the cross members, and when turned in the other direction it will lower the cross members.



APPARATUS DESCRIPTION
Apparatus Description

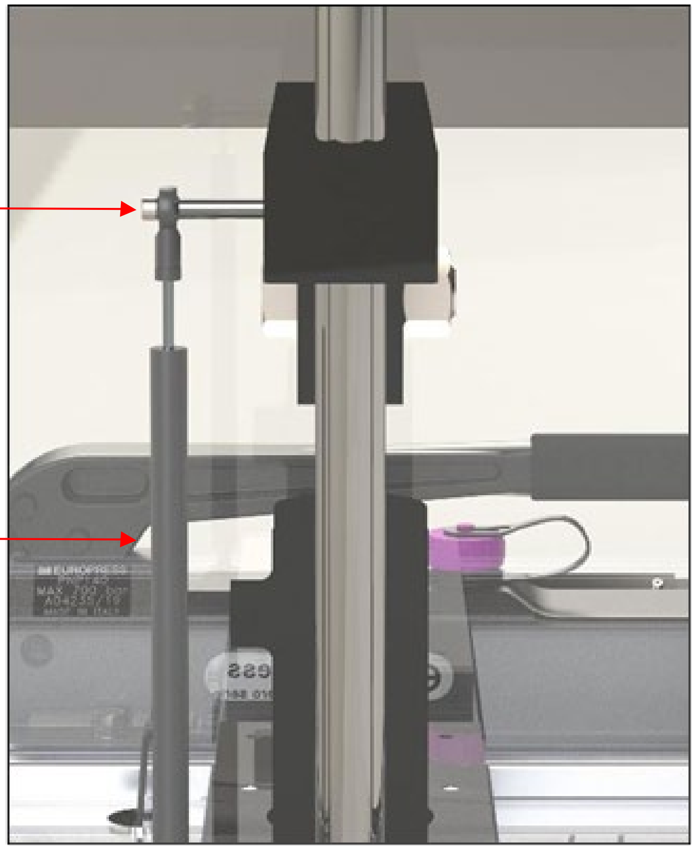
On the side of the pump is a small knob. This knob is the pressure release knob. When this knob is rotated clockwise the hand pump is primed to increase pressure. When the pressure release knob is rotated anti-clockwise the pump is primed to reduce the pressure.

WARNING: DO NOT OVERTIGHTEN THIS KNOB. HAND TIGHT IS SUFFICIENT

Also near to the pressure release knob is the handle lock. This can be hooked into place when the unit is not being used or when it is in transit.

Underneath the base is the electronic Force sensor. This sensor allows the applied force to be monitored in the Data Acquisition system supplied. The connections for this device are shown later in this manual.

Elongation Sensor (Linear Displacement Transducer)



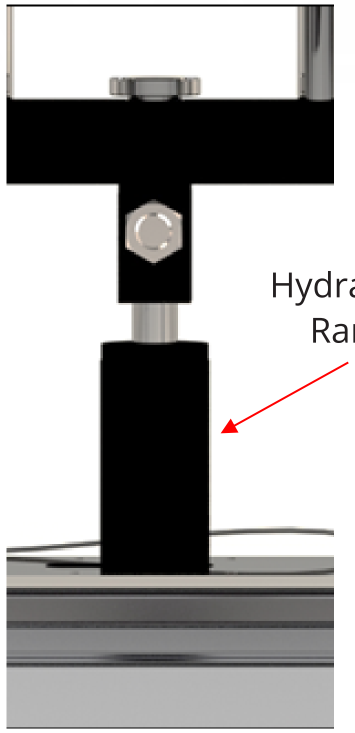
Attached to the side of the unit is an elongation sensor with rotary end bearings. The signal from this sensor is fed into the interface to capture the elongation during testing. This unit has been factory set.

When receiving the unit for the first time, this sensor will have one end detached. This is for protection during transit. Re-attached the linear sensor as shown above.

WARNING: DO NOT ADJUST THIS TRANSDUCER. IT HAS BEEN FACTORY SET

APPARATUS DESCRIPTION
Apparatus Description

Hydraulic Ram

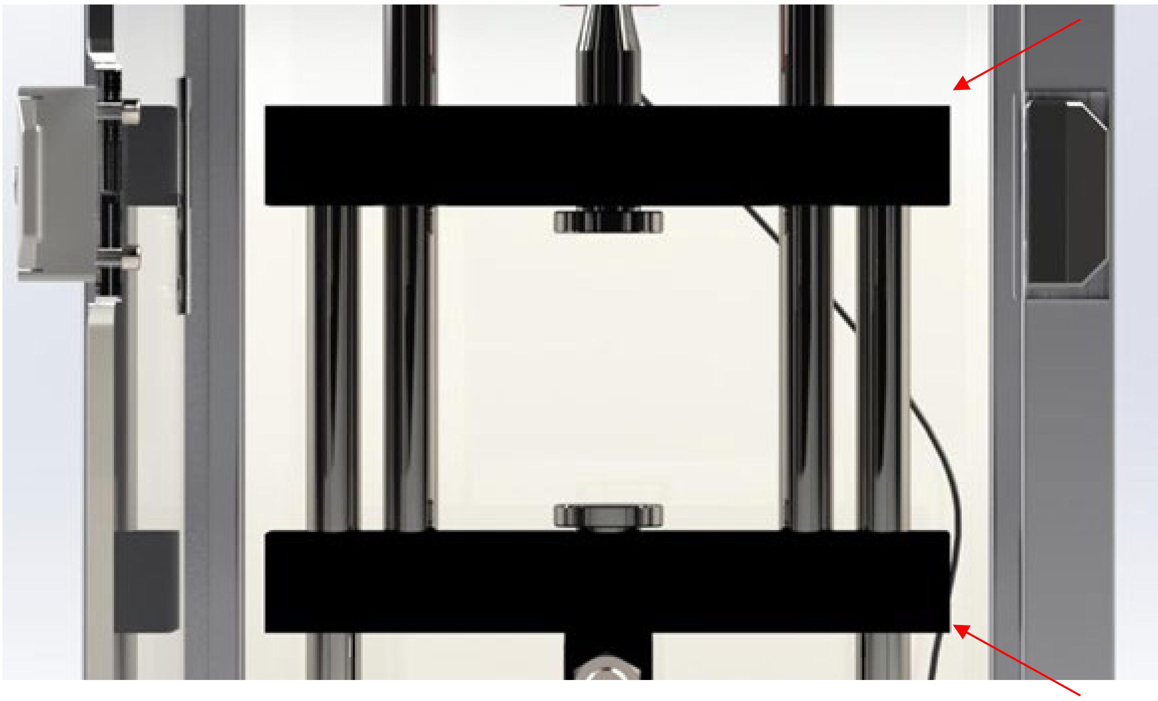


The hydraulic ram sits vertically on the base in a central position. It has a piston stroke of up to 100mm. The piston diameter is Ø50mm. When pressurised the ram extends and forces up the cross member directly above it. This then allows compression and tensile testing to be undertaken.

When the pressure is released from the hand pump the hydraulic ram piston and cross member will not automatically retract. You will have to move the pump "direction" lever to the alternative position and operate the pump handle to bring the piston downwards.

APPARATUS DESCRIPTION
Apparatus Description

Compression Area



Between the 1st and 2nd cross member is the compression area. The extension and retraction of the hydraulic ram forces the 1st cross member upwards towards the fixed 2nd cross member, thus creating a compression area.

All compression testing is undertaken within this area.

WARNING: CARE MUST BE TAKEN AT ALL TIME IN THIS AREA. DO NOT LEAVE HANDS, FINGERS, TOOLS OR ANYTHING ELSE WITHIN THIS AREA WHEN THE HYDRAULIC RAM IS BEING OPERATED.

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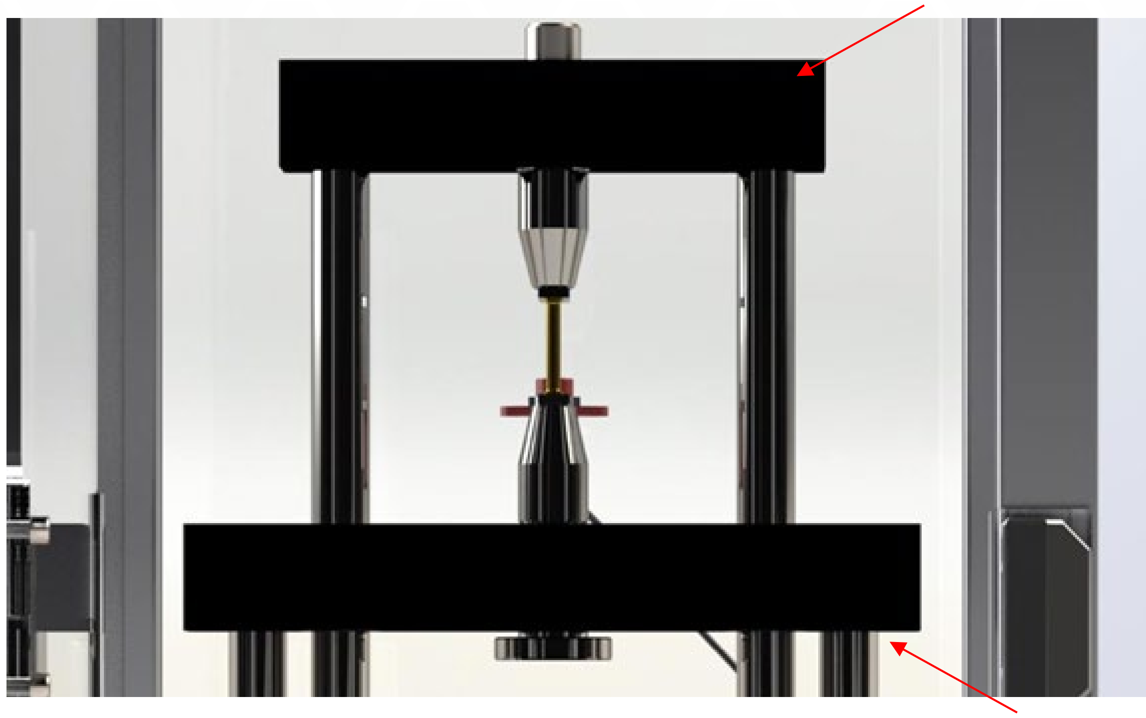
Tension Area

3rd Cross Member



2nd Cross Member

Between the 2nd and 3rd cross member is the tension area. The extension of the hydraulic ram forces the 3rd cross member upwards away from the fixed 2nd cross member, thus creating a tension area.

All tension testing is undertaken within this area.

WARNING: CARE MUST BE TAKEN AT ALL TIME IN THIS AREA. DO NOT LEAVE HANDS, FINGERS, TOOLS OR ANYTHING ELSE WITHIN THIS AREA WHEN THE HYDRAULIC RAM IS BEING OPERATED.

Within the 1st, 2nd and 3rd cross members are M16 threads that run right through these members. This thread accepts the accessories described later in this manual.

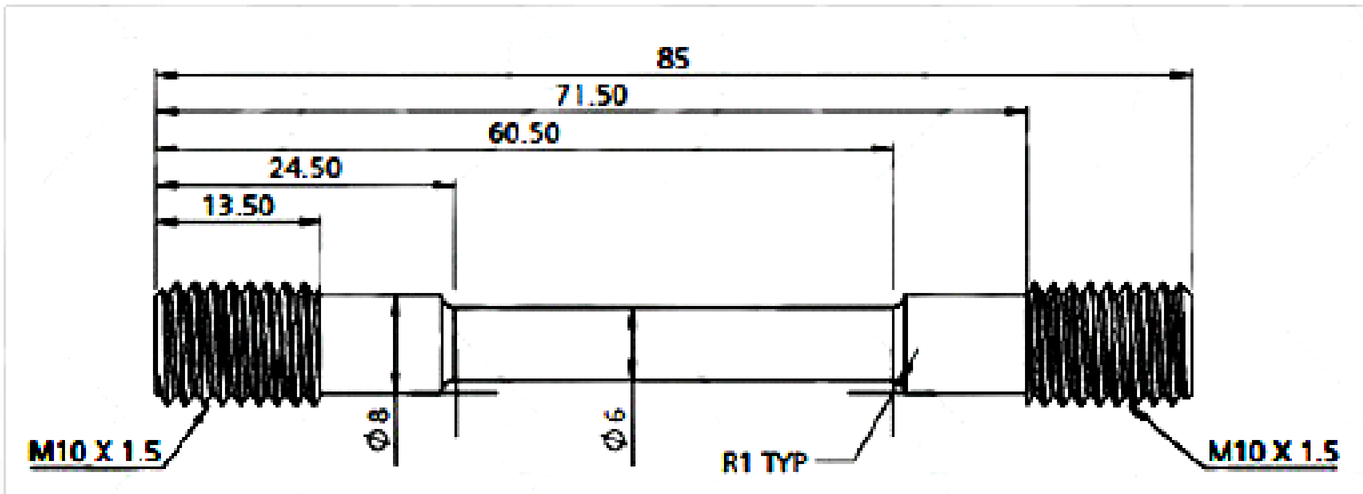
Tensile Test Specimens

The specimen set supplied with the apparatus as standard is aluminium, brass, steel and titanium:

NB: The above diagram shows 5 aluminium tensile specimens with threaded ends for visual reference only. The quantity actually supplied with the apparatus will vary and will be detailed on the packing list for the apparatus when shipped.

Material	Grade	Typical Tensile Strength Rm, N/mm2	Typical Elongation at Fracture, A (%) (min)	Typical Modulus of Elasticity, E, N/mm2
Steel	EN1A (BS970 230M07)	350...500	7...18	190,000 - 210,000
Aluminium	6082-T6	130...300	5...27	60,000 - 75,000
Brass	CZ121 (BS 2874)	360...580	5...25	96,000...110,000
Titanium	TI-6AL-4V	900...950	14	104,000...113,000

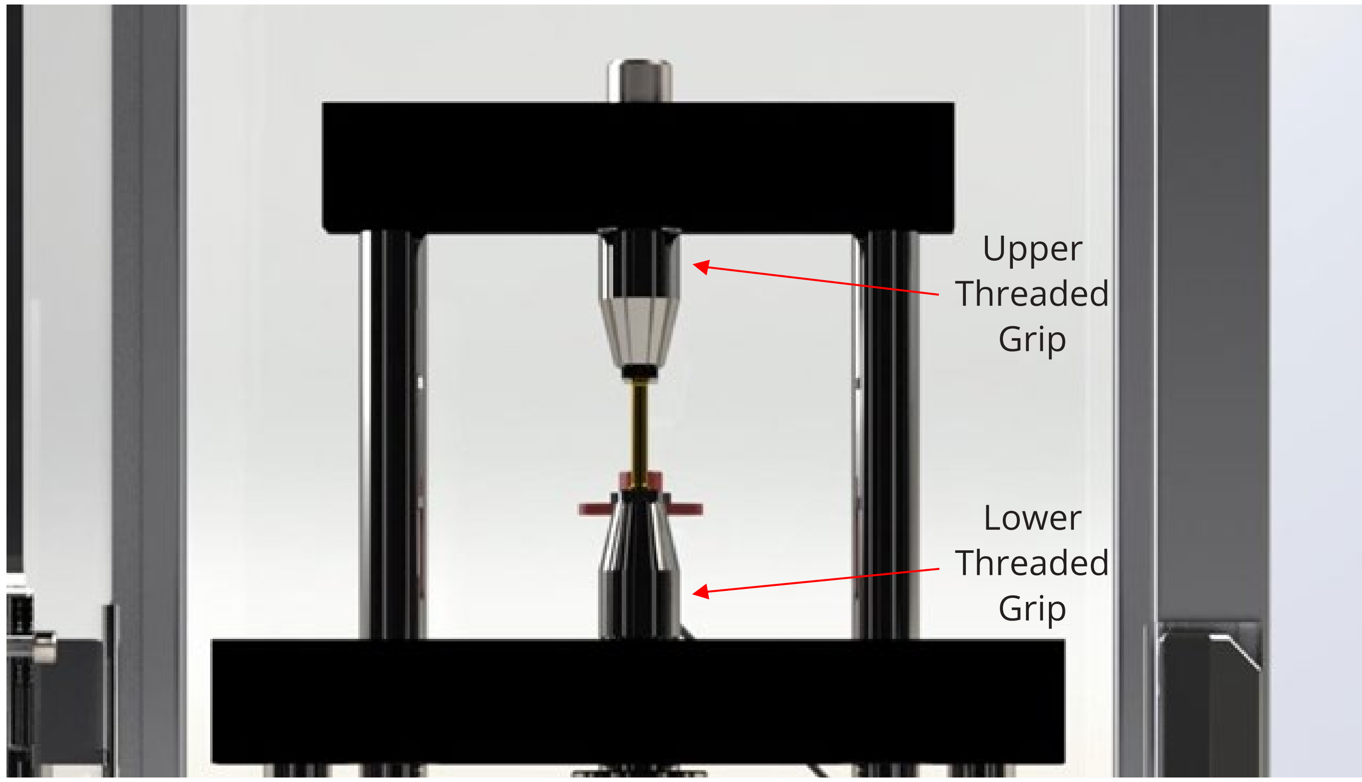
The technical details of the specimens are shown in the drawing below:



The dimensions stated above are nominal dimensions and will change very slightly due to machining tolerances. The gauge length is the 36mm, but this will have to be measured on each specimen used using the digital vernier supplied.
The standard specimens supplied have an M10 x 1.5 thread at each end. This allows the specimens to be attached to the threaded grips supplied.

The specimens also have an Ø8mm neck onto which the extensometer is attached.

Threaded Tensile Test Grips



In the tension area of the apparatus, the two threaded tensile test grips are secured for tensile testing the standard specimens.

The lower threaded grip is screwed into the mating thread in the 2nd cross member. The upper threaded grip has a female M16 thread. An M16 fastener is used through the 3rd cross member to secure the upper threaded grip in position.

The reason the upper threaded grip is mounted this way is that it enables the threaded specimens to be easily threaded and secured into position because the M16 fastener can be loosened and the specimen or grip rotated.

Securing a Threaded Specimen into the Threaded Tensile Test Grips

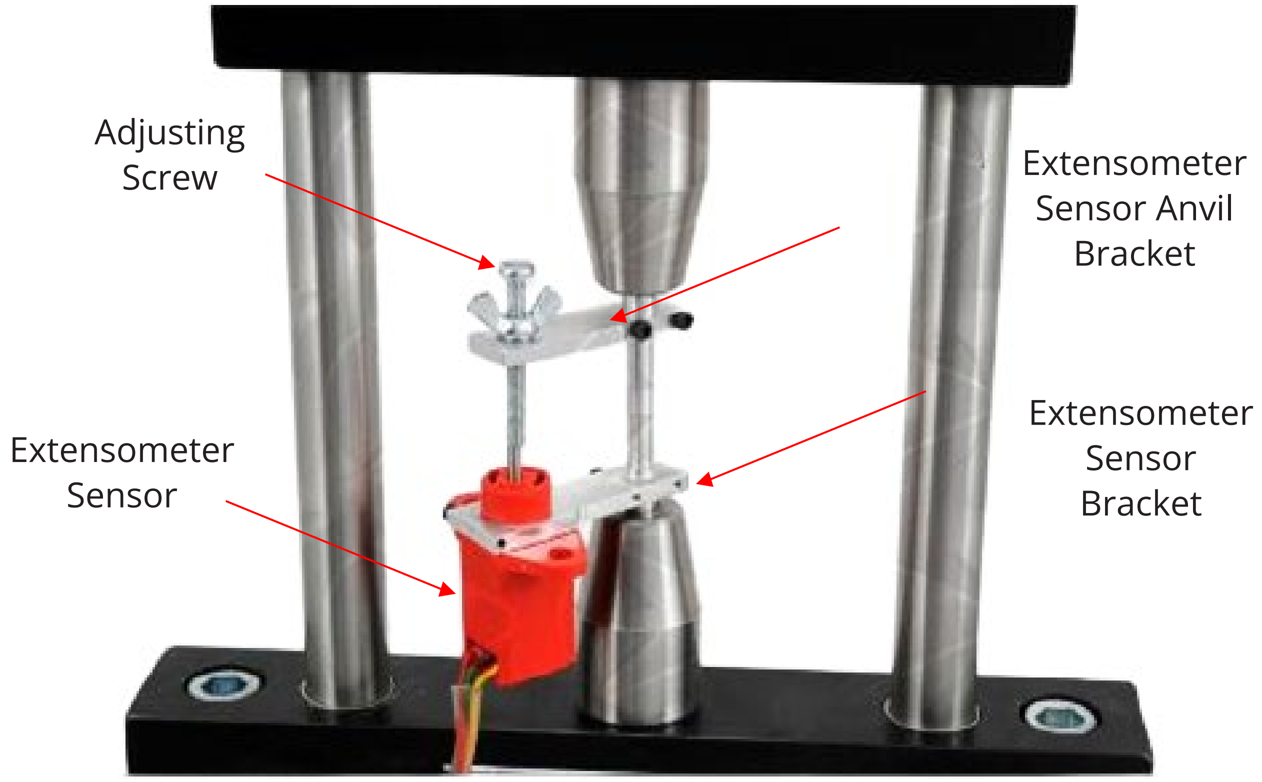
Raise the 3rd cross member to allow the length of the threaded specimen to enter the tensile area. Mount one end of the threaded specimen into the lower threaded grip and screw down until the thread is no longer showing.

Lower the 3rd cross member down until the upper threaded grip is touching the other end of the threaded specimen as shown in the image below.

Loosen the M16 fastener that secures the upper grip. Rotate the upper threaded grip so that the specimen threads itself into the grip. Again thread the specimen into the grip until the thread is no longer showing. The specimen fully mounted is shown in the image below.

Extensometer

To calculate the Modulus of Elasticity of the tensile test specimens it is important to measure the extension of the specimen directly from the specimen. To do this we use an extensometer.

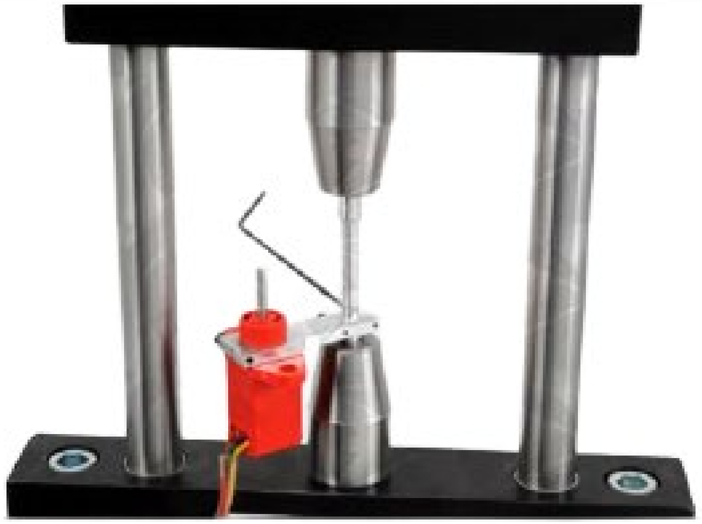


The image above shows the extensometer attached to the threaded specimen. The extensometer consists of a sensor mounted into an extensometer sensor bracket. This bracket attaches to the lower Ø8mm neck of the tensile test specimen.

On the other Ø8mm neck of the tensile test specimen is attached the extensometer sensor anvil bracket. Within this bracket there is an adjusting screw with a wing nut and vibration washer. This allows the starting position of the sensor to be adjusted as required.

Both brackets have a split at the area it attaches to the Ø8mm neck. The sensor bracket mounts to the lower Ø8mm neck of the specimen by using the split and the two small socket head cap screws supplied. The 2mm hexagon wrench is used as shown below.

APPARATUS DESCRIPTION
Apparatus Description



The above image shows the position of the brackets on the Ø8mm necks of the tensile test specimen.

The sensor for the extensometer has an integral cable with a connector fitted at its end. This can then be fitted into the data acquisition unit.

The image below shows the extensometer kit supplied, but also shows the split nature of the brackets and the fixing screws used.

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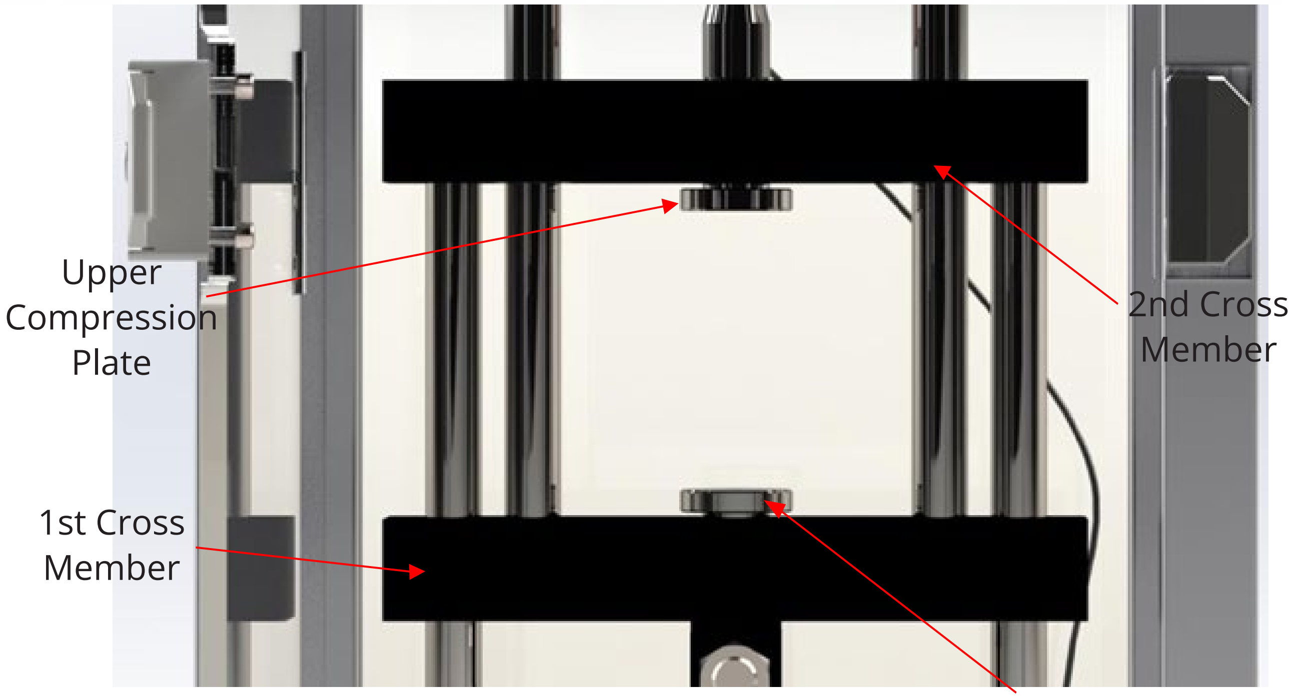
APPARATUS DESCRIPTION

Apparatus Description

Compression Plates



Within the compression area of the apparatus are mounted two compression plates.

The lower compression plate is mounted into the threaded hole within the 1st cross member as shown above. The upper compression plate is mounted on the underside of the 2nd cross member as shown in the image above. Both compression plates are mounted using their threads and the threads within the cross members. They can be removed by unscrewing each one.

DATA ACQUISITION BOX

Data Acquisition Box

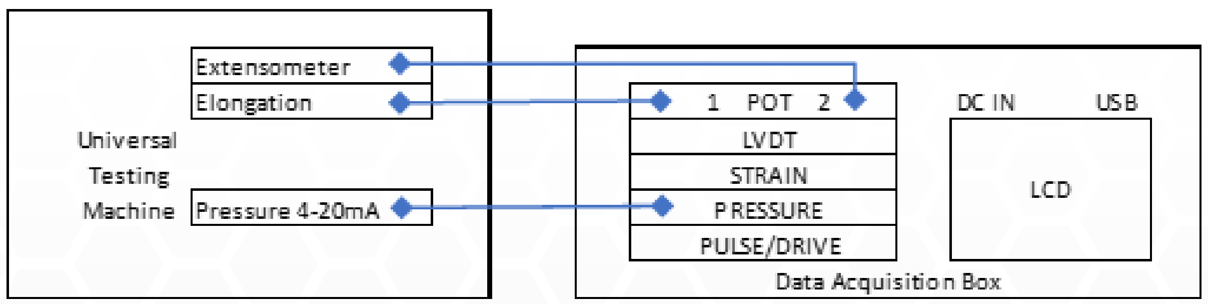
The Data Acquisition Box allows the applied force and linear displacements to be captured, and displayed on the LCD screen in terms of Force (kN), elongation (millimetres - mm) and extension (millimetres – mm) respectively.

When the interface is connected to the hardware it will capture and display the sensor measurements for the test.

When the device is connected to a PC, the data can be plotted and logged to a file giving a record of the whole test.

The electronic pressure/force sensor, elongation sensor and extensometer connect directly into the interface using the factory fitted connectors. Specific connectors and sockets are used for each sensor.

The elongation sensor is fitted with a three-pin plug and connects to the Pot 1 socket. The extensometer is fitted with a three-pin plug and connects to the Pot 2 socket and the pressure sensor is fitted with a two-pin plug and connects to the Pressure socket.



DATA ACQUISITION BOX
Data Acquisition Box

Power Supply

The power supply for this unit is a 24VDC. It is plugged into the socket labelled DC IN. The unit is supplied with interchangeable primary plugs. The supplied plug heads are for use with sockets styled for UK, Europe or America. Below is an image of the supplied parts

The Unit is supplied with the correct Jack Plug fitted. It is recommended that only the supplied power supply be used with the product. If any replacement is needed, please contact matrix.

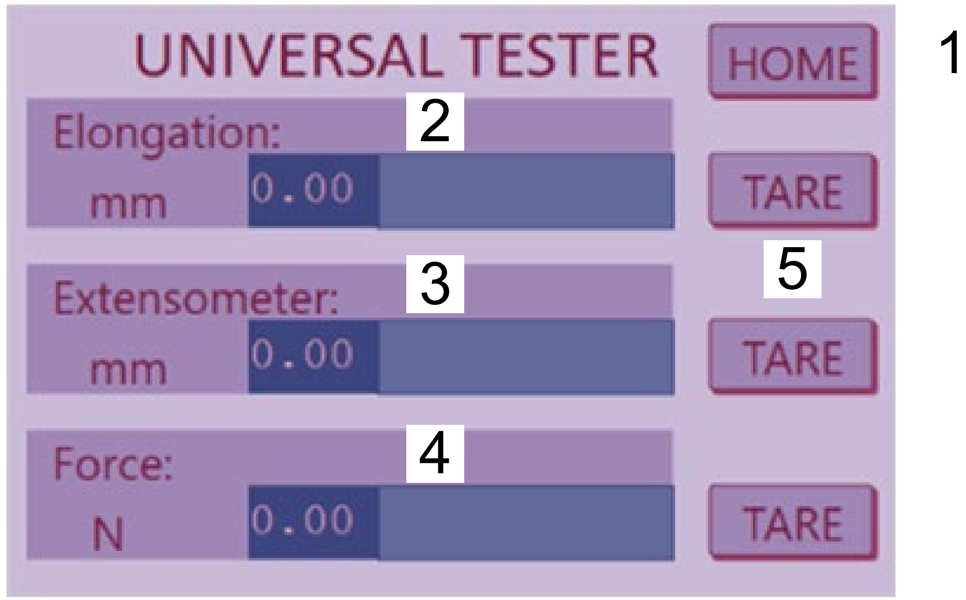
The electrical details of the power supply are as follows:

Input: Between 80 and 264VAC at a frequency between 47 and 63 Hz.
Output 24VDC 60W

DATA ACQUISITION BOX
Data Acquisition Software

Touch Screen Interface Control Layout

Below is an image of the touch screen for the universal testing machine. This screen is reached by touching the Uni Tester button on the main menu. The elements of the screen are described below.



1: Home Button

Touching this button will cause the touch screen to return to the main menu.

2: Elongation Display
This block shows the elongation measurement as a digital display, an analogue bar and also displays the units of measurement.

3: Extensometer Display
This block shows the extensometer measurement as a digital display, an analogue bar and also displays the units of measurement.

4: Force Input Display
This block shows the force measurement as a digital display, an analogue bar and also displays the units of measurement.

5: Tare Buttons
These buttons will cause the sensor inputs to be tared. They will read zero and subsequent measurements will be relative to the current position.

Further information on the touch screen interface can be found in the manual for the Data Acquisition box.

Interface Software Installation to Host Computer

A PC application is available that takes measurements from the Data Acquisition box, displays them on a chart and logs to a file. The software is designed to be as flexible and possible, with many parameters that are editable to increase the amount of experimental options as much as possible.

Installation

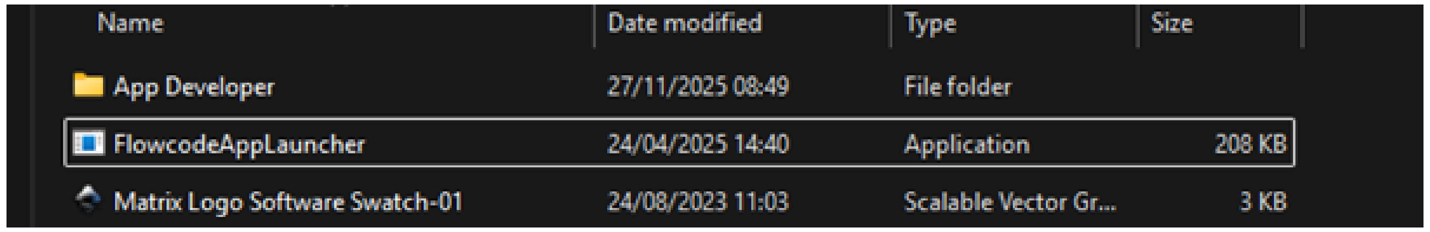
The software can be downloaded from the Matrix website. Choose Materials from the Products menu. On the Materials page, select the Resources tab. The Data Acquisition software is available to download in a zip file.

www.matrixtsl.com/materials

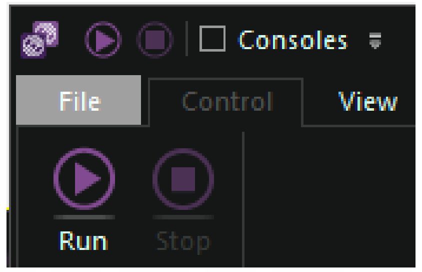
Save the zip file on a Windows PC and extract the whole folder in a convenient location.

Running the Software

To start the software, open the folder and run the file FlowcodeAppLauncher.exe.



Connect a USB cable between the Data Acquisition Box and the PC. Plug the 24VDC power supply into the socket labelled 'DC IN'. Wait for the device to power up and show the main menu, then click the Run button in the top left corner of the software screen. Alternatively, a larger Run button can be found by clicking on the Control menu.



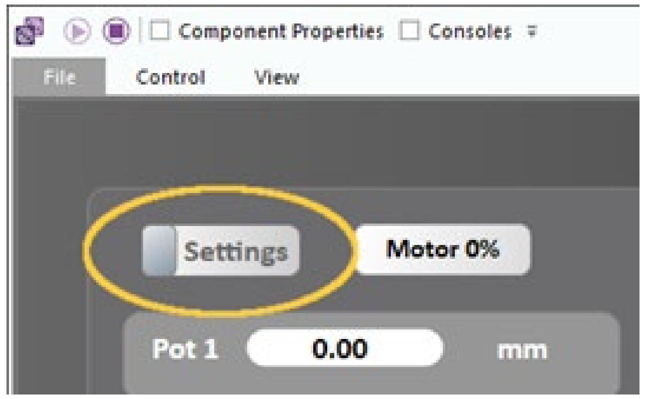
When the run button is clicked, the software should immediately begin displaying and plotting sensor values.

Run/Stop Buttons

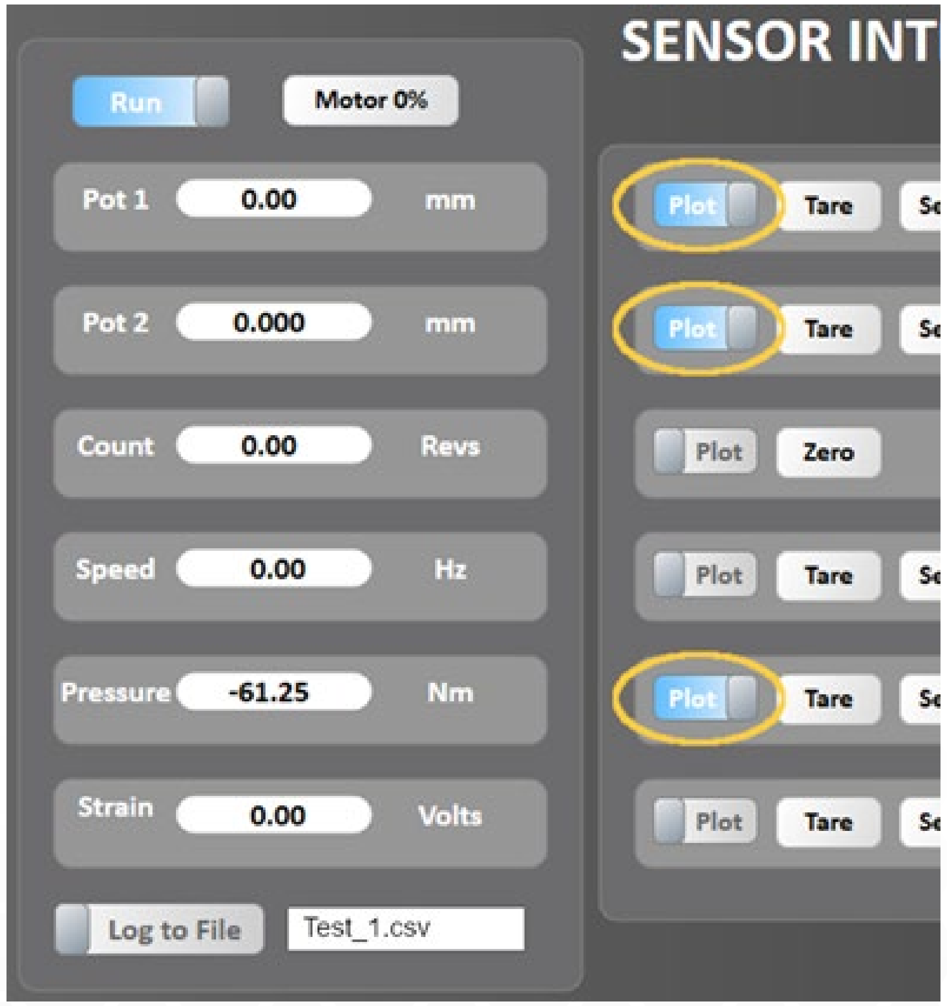
When the run button is clicked, the software should immediately begin displaying and plotting sensor values.

Capture and Plot Data

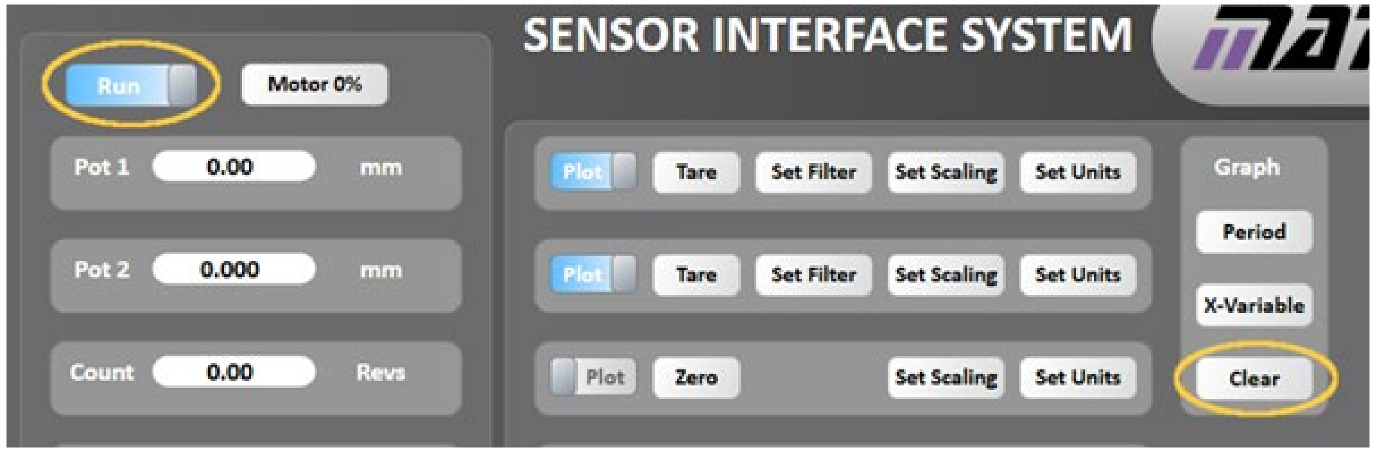
With the software running, click on the Settings mode switch to hide the graph display and enter settings mode.



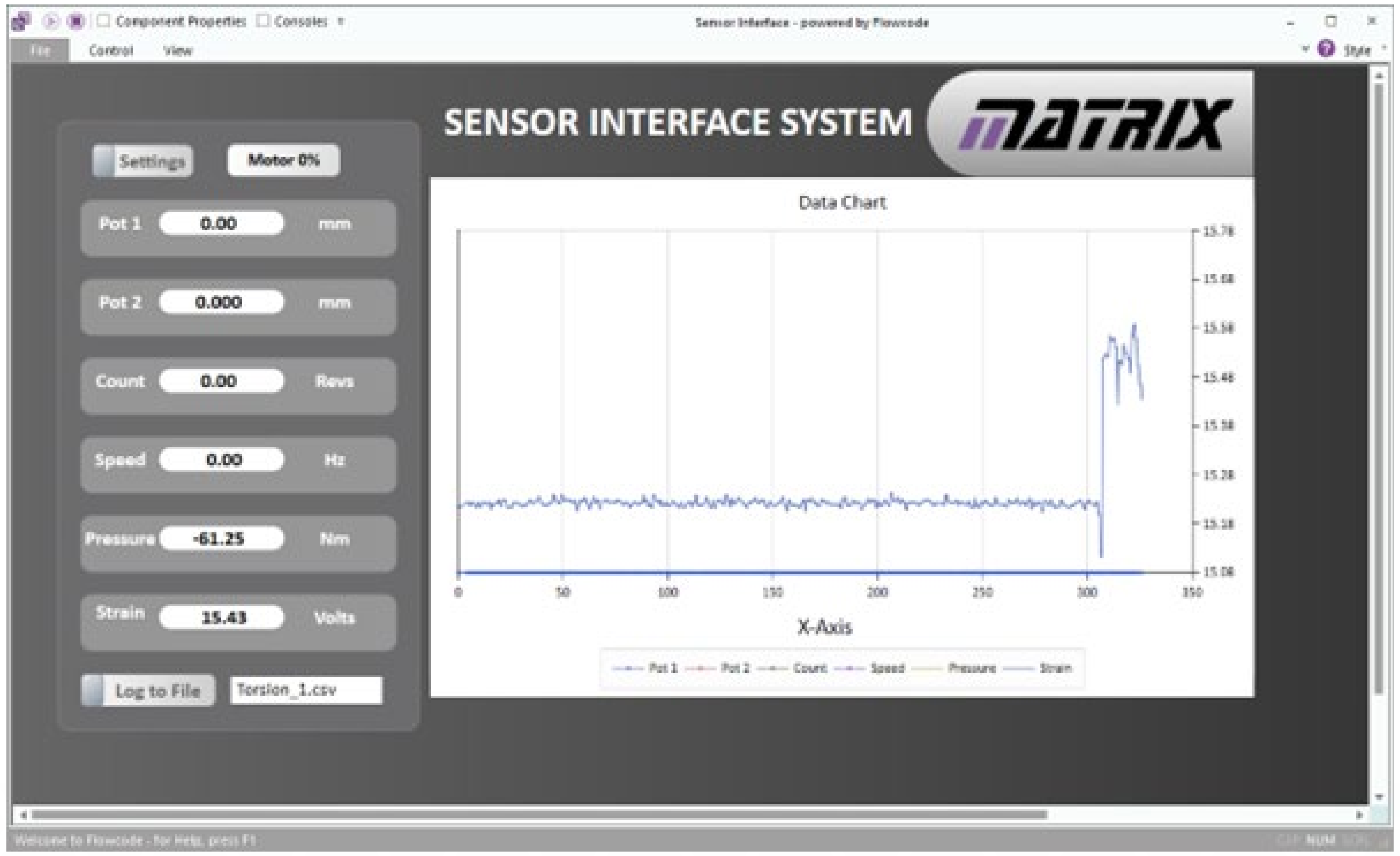
In settings mode, switch on plotting for the Counter and Strain channels. Switch off plotting for the remaining channels.



Click on the Clear button to refresh the graph display and then click on the Run mode switch to return to live data.

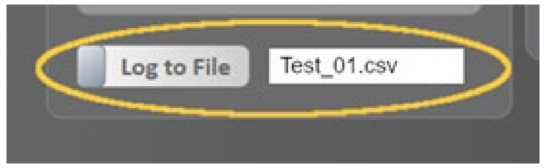


In live data mode, the measurement values will be plotted on the graph.



Log Data to File

To log the recorded data to a file, type a file name into the box at the bottom left of the window. Then, click on the Log to File switch. All received data will now be written into the specified file. The file will be stored in the same directory as the application.



Once a test is complete, click the log switch again to suspend writing to the file. The file is now available for importing into an analysis program.

Import Data into Spreadsheet

The logged file is saved as a comma-separated-value file. It can be opened in a text editor, a spreadsheet or many data analysis programs. The software will store all sensor channels regardless of whether they are plotting or contain valid data. The file begins with the column headings; Time, Pot 1, Pot 2, Counter, Speed, Pressure, Strain and LVDT.

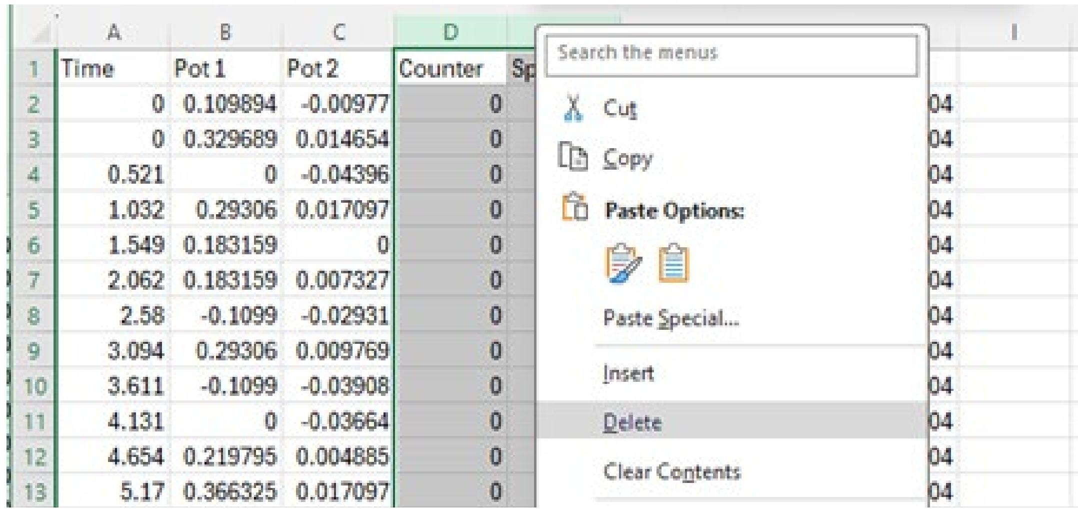
	A	B	C	D	E	F	G	H
1	Time	Pot 1	Pot 2	Counter	Speed	Pressure	Strain	LVDT
2	0	0.109894	-0.00977	0	0	-8.86597	0.001419	0.000004
3	0	0.329689	0.014654	0	0	4.83606	0.001544	0.000004
4	0.521	0	-0.04396	0	0	-6.44794	0.001774	0.000004
5	1.032	0.29306	0.017097	0	0	17.73206	0.00144	0.000004
6	1.549	0.183159	0	0	0	4.030029	0.001566	0.000004
7	2.062	0.183159	0.007327	0	0	-0.80597	0.00155	0.000004
8	2.58	-0.1099	-0.02931	0	0	-22.568	0.001746	0.000004
9	3.094	0.29306	0.009769	0	0	-11.284	0.001698	0.000004
10	3.611	-0.1099	-0.03908	0	0	-9.67194	0.001436	0.000004

The useful columns in these tests are: -
Time – the time in seconds of the reading.
Pot 1 – The reading from the elongation sensor.
Pot 2 – The reading from the extensometer.
Pressure – The force reading derived from the pressure sensor.

DATA ACQUISITION BOX

Data Acquisition Software

In a spreadsheet application, the remaining columns can be selected and then deleted.



	A	B	C	D
1	Time	Pot 1	Pot 2	Counter
2	0	0.109894	-0.00977	0
3	0	0.329689	0.014654	0
4	0.521	0	-0.04396	0
5	1.032	0.29306	0.017097	0
6	1.549	0.183159	0	0
7	2.062	0.183159	0.007327	0
8	2.58	-0.1099	-0.02931	0
9	3.094	0.29306	0.009769	0
10	3.611	-0.1099	-0.03908	0
11	4.131	0	-0.03664	0
12	4.654	0.219795	0.004885	0
13	5.17	0.366325	0.017097	0

The relevant columns can then be used to analyse or plot the experimental data.

	A	B	C	D
1	Time	Pot 2	Pressure	
2	0	-0.00977	-8.86597	
3	0	0.014654	4.83606	
4	0.521	-0.04396	-6.44794	
5	1.032	0.017097	17.73206	
6	1.549	0	4.030029	
7	2.062	0.007327	-0.80597	
8	2.58	-0.02931	-22.568	
9	3.094	0.009769	-11.284	
10	3.611	-0.03908	-9.67194	
11	4.131	-0.03664	-20.9559	
12	4.654	0.004885	10.47803	
13	5.17	0.017097	-8.86597	

EXPERIMENT

Preparation

Preparing the Unit

When the apparatus is shipped it comes fully assembled except for the accessories and interface. These are supplied in suitable boxes.

The Main unit will have the 1st and 3rd cross member secured to the 2nd cross member so that it does not move during transit. Remove any securing materials.

The upper and lower threaded grips have transport screws fitted. These can be removed. These stop any damage to the threads inside the grips occurring during transit.

The handle on the hand pump has also been secured down. Remove the securing material around the handle of the hand pump also.

THE UNIT IS VERY HEAVY. ENSURE ANY LIFTING IS DONE CORRECTLY AND WITH TWO PEOPLE AT EACH SIDE OF THE UNIT. DO NOT ALLOW THE UNIT TO DROP OR TIP THROUGH 90° DEGREES.

Locate the apparatus onto a sturdy, level bench top and level the feet.

EXPERIMENT
Tensile Test

The tensile test is the best-known test in materials testing. It determines tensile strength, one of the most important properties of a material. Furthermore, it is also possible to determine elongation at fraction as a measurement of the toughness of the material

In the tensile test, a mono-axial stress is generated in a material sample. This stress is induced via external loading of the sample in a longitudinal direction via a tensile force. There is then an even distribution of direct stress in the test cross-section of the sample.

In order to determine the strength of the material, loading of the sample is slowly and continuously increased until it fails. The maximum test force occurring is a measurement of the strength of the material. The so-called tensile strength Rm is calculated from the maximum test force, FB and the initial cross-section, A0 of the sample.

$$R_m = \frac{F_B}{A_0} \quad [1]$$

The simplest way of determining the maximum test force is via the software and the graph it creates during a test.

In the tensile test itself, the cross-section of the sample is reduced - it is constricted, and the actual stresses are considerably higher.

The elongation at fracture, A refers to the change in length of the sample compared with its original length L0 and is calculated using the length LU of the sample after fracture.

$$A = \frac{L_U - L_0}{L_0} x \left(100\%\right) \quad [2]$$

In order to measure the lengths, two measuring marks are applied to the test bar. After fracture, the two ends of the sample are placed together neatly at the fracture point and the distance between the two measuring marks is measured.

The modulus of Elasticity of the material can be calculated using the following equation:

$$E = \frac{\sigma}{\varepsilon} \quad [3]$$

EXPERIMENT
Tensile Test

Where:
E= Modulus of Elasticity, N/mm2
σ= Stress, N/mm2
ε= Strain, (no units)

The value σ/ε is the gradient of the linear portion of the stress/strain graph created in tensile testing.

Now

$$\sigma = \frac{F}{A_0} \quad [4]$$

And

$$\varepsilon = \frac{\Delta L}{L} \quad [5]$$

Combining equations 4 and 5 into 3 gives us the following:

$$E = \frac{F}{\Delta L} \times \frac{L_e}{A_O} \quad [6]$$

The term F/ΔL is actually the gradient of the linear portion of the extension against force graph produced by the software and imported into spreadsheet software.

Preparing the Unit

1. Choose a tensile specimen.

2. Measure the diameter of the necked area in a number of places using the digital vernier supplied. Calculate the average diameter of the specimen in the necked area and record into table 1.

Table 1 - Tensile Test

Specimen Details	Results	
	Actual	Typical
Material		
Average Diameter, mm		
Initial Cross Sectional Area, A0 (mm2)		
Elongation Gauge Length, L0, mm		
Extensometer Gauge Length, Le, mm		
Measured Elongation after testing, mm, Lu		
Percentage Elongation, A (%)		
Tensile Strength, Rm (N/mm2)		
Modulus of Elasticity, E (N/mm2)		
Specimen Details	Results	
	Actual	Typical
Material	Steel	
Average Diameter, mm	6.00	
Initial Cross Sectional Area, A0 (mm2)	28.25	
Elongation Gauge Length, L0, mm	85.05	
Extensometer Gauge Length, Le, mm	37.77	
Measured Elongation after testing, mm, Lu	88.51	
Percentage Elongation, A (%)	4.07	
Tensile Strength, Rm (N/mm2)	643	
Modulus of Elasticity, E (N/mm2)	190761	190000 - 210000

3. Calculate the initial cross sectional area, A0 and add to table 1.

4. Ensure the upper and lower threaded grips are inserted into the respective cross members. Secure the lower threaded grip fully into position.

5. Loosely secure the upper threaded grip.

6. Measure the total length of the specimen (end to end length) and add this into table 1 as parameter L0. This should be around 85mm as a guide.

EXPERIMENT
Tensile Test

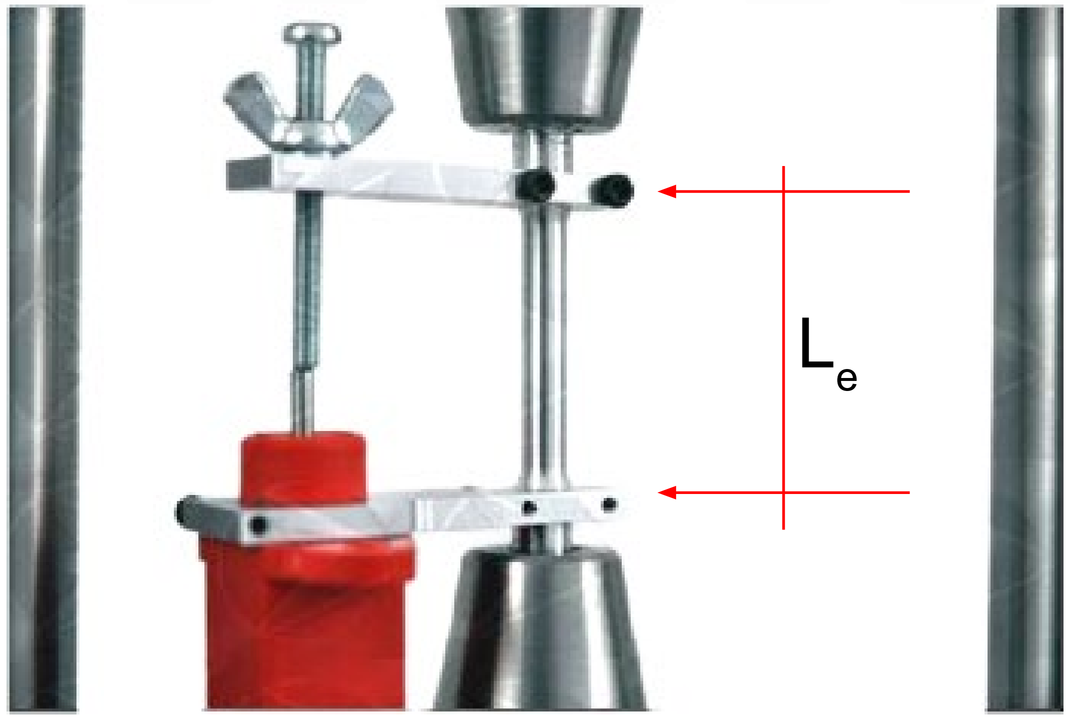
7. Fit one end of the threaded specimen into the lower threaded grip.

8. Bring the upper threaded grip down onto the top thread of the specimen and screw the grip onto the specimen. Screw the specimen into both grips till the thread can no longer be seen.

9. Make sure the 3rd cross member is fully down onto the upper threaded grip and then tighten the knurled knob.

10. The specimen installed should look like the image below.

11. Attach the extensometer to the specimen as shown in the image below:



12. Record the distance between the inside faces of the extensometer brackets into table 1. This will be the extensometer gauge length, Le.

13. Plug the connector of the extensometer into the Pot 2 socket of the interface.

14. Plug the force sensor into the Pressure socket of the interface.

15. Plug the USB cable from the data acquisition box to the PC if required

16. Plug the power supply unit into the interface then turn on the interface at the power switch.

17. Select 'Uni Tester' from menu screen.

18. Screw the adjusting screw on the extensometer down until the extensometer sensor shaft cannot retract any further. Turn the adjusting screw back 3 whole turns.

19. Release the pressure release knob and lower the handle.

20. Tare the readings on the interface by pressing the Tare buttons.

21. WEAR THE SAFETY GLASSES. AND ENSURE THE SAFETY DOOR IS SHUT

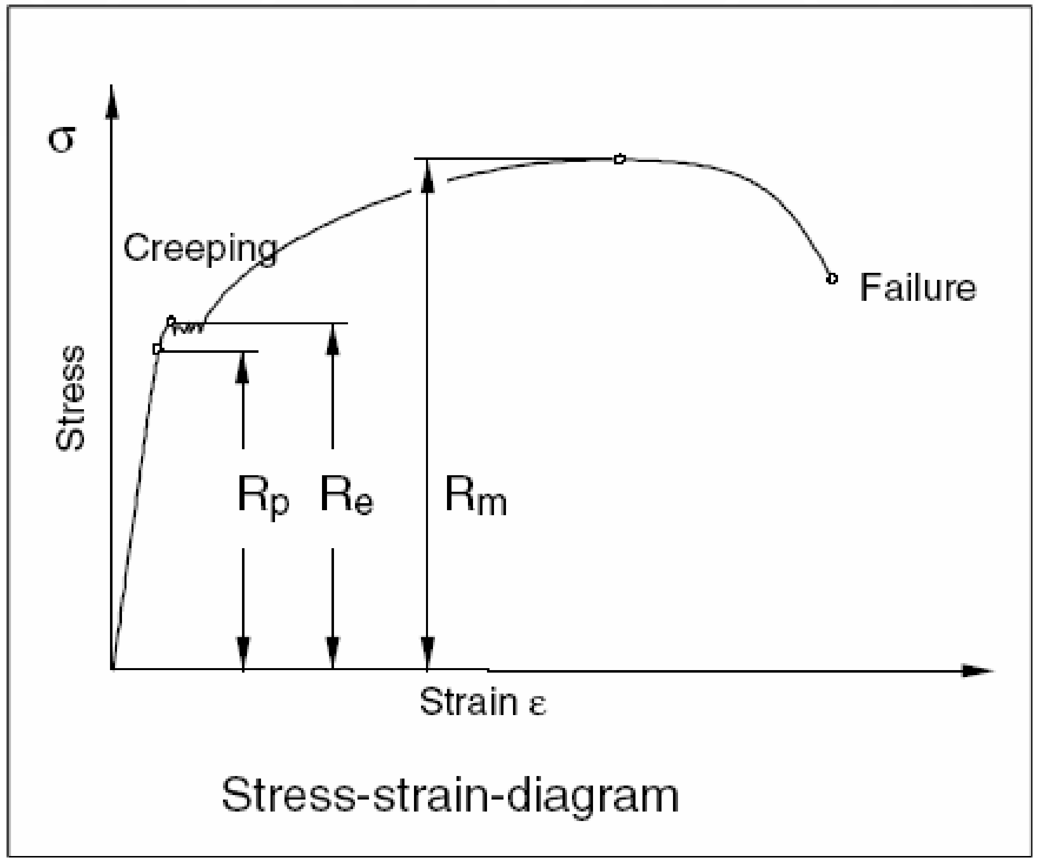
22. Start to slowly pump the handle of the hand pump in an even speed. The force and extension will start to increase.

23. Record the extensometer and force readings at regular intervals. Recording can be done manually by taking readings from the screen or by using the software to log readings to a file.

24. Continue until the specimen fractures. A sudden fracture will occur so be prepared.

25. Release the pressure relief knob on the hand pump and lower the ram by hand using the 3rd cross member.

26. Record the final specimen length and place the value in the Final Specimen Length, Lu field in the test results. Note the Maximum Test Force (N) that occurred just before the fracture. Please see the following sections to calculate the Modulus of Elasticity of the material.



The stress-strain diagram shows the different behaviour of the individual materials. Each material has a characteristic pattern of stress and strain.

Important material data can be read from the stress-strain diagram. In addition to tensile strength Rm, the limit of proportionality Rp is particularly interesting.

Beneath this limit, the material conforms to Hooke's law with the modulus of elasticity E, i.e. Strain (ε) is proportional to Stress (σ).

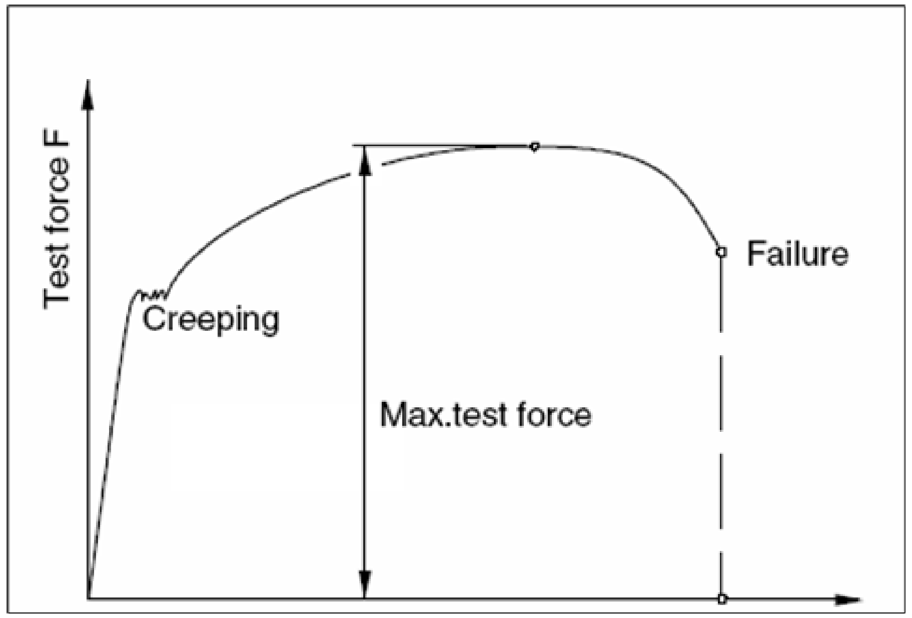
When this stress is exceeded, elongation is no longer proportional to the load.
One particularly important parameter from a technical point of view is the yield point Re. From this point onwards, the material becomes continuously plastically deformed.

Elongation remains when the load is relieved. To safeguard the function of the component, it should not be loaded any further. With some materials, such as annealed soft steel, pronounced creeping occurs from the yield point onwards. The sample is elongated without the load being increased further.

In materials without pronounced creeping, the proof stress Rp0.2 is specified. In such a case, the material has a permanent elongation of 0.2% which remains after relief of the load.

Procedure to Conduct a Stress/ Strain Diagram

The stress-strain diagram is produced from the values for applied force and elongation recorded during the tensile test above.



Convert the applied force into stress using the following:

$$\sigma = \frac{F}{A_0}$$

Where:
σ = Stress (N/mm2)
F = Applied Force (N)
A0 = Initial Cross sectional Area (mm2)

Convert the elongation into strain using the following:

$$\varepsilon = \frac{L - L_e}{L_e}$$

Where:
L = Extension point + Le, mm
Le = Extensometer gauge length, mm

Plot stress against strain and from this determine the key areas.

RESULTS
Example Results

Steel

Test Type	Tensile
File Name:	S:\RD_FOLDERS\RD
Date/Time:	03/03/2020
Operator:	MJN

Specimen Details	
Material Type:	Steel

Diameter 1:	6	mm
Diameter 2:	5.99	mm
Diameter 3:	6	mm
Diameter 4:	6	mm
Ave. Diameter:	6.00	mm
C.S.A (mm^2)	28.25	mm^2
Extensometer Gauge Length, Le (mm):	37.77	mm
Initial Speciment Length, Lo (mm)	85.05	mm

Results		
Final Length, Lu (mm):	88.51	mm
Change in Length, (mm):	3.46	mm
Percentage Elongation, (%)	4.07	%

Maximum Test Force, (N)	18.18	kN
Maximum Test Force, (N)	18180	N
Modulus of Elasticity, E (N/mm^2)	190761.31279331	N/mm^2

Window 1 - Steel

Specimen Details	Results	
	Actual	Typical
Material	Steel	
Average Diameter, mm	6.00	
Initial Cross Sectional Area, A0 (mm2)	28.25	
Elongation Gauge Length, L0, mm	85.05	
Extensometer Gauge Length, Le, mm	37.77	
Measured Elongation after testing, mm, Lu	88.51	
Percentage Elongation, A (%)	4.07	7 - 18
Tensile Strength, Rm (N/mm2)	643	350 – 500
Modulus of Elasticity, E (N/mm2)	190761	190000 - 210000

Table 1 - Tensile Test

RESULTS
Example Results

Aluminium

Test Type	Tensile
File Name:	S:\RD_FOLDERS\RD
Date/Time:	07/04/2020
Operator:	MJN

Specimen Details	
Material Type:	Aluminium

Diameter 1:	6.02	mm
Diameter 2:	6.02	mm
Diameter 3:	6.03	mm
Diameter 4:	6.03	mm
Ave. Diameter:	6.03	mm
C.S.A (mm^2)	28.51	mm^2
Extensometer Gauge Length, Le (mm):	38.02	mm
Initial Speciment Length, Lo (mm)	85.03	mm

Results		
Final Length, Lu (mm):	90.19	mm
Change in Length, (mm):	5.16	mm
Percentage Elongation, (%)	6.07	%

Maximum Test Force, (N)	10.94	kN
Maximum Test Force, (N)	10940	N
Modulus of Elasticity, E (N/mm^2)	73369.62628656	N/mm^2

Window 2 - Aluminium

Specimen Details	Results	
	Actual	Typical
Material	Aluminium	
Average Diameter, mm	6.03	
Initial Cross Sectional Area, A0 (mm2)	28.51	
Elongation Gauge Length, L0, mm	85.03	
Extensometer Gauge Length, Le, mm	38.02	
Measured Elongation after testing, mm, Lu	90.19	
Percentage Elongation, A (%)	6.07	5 – 27
Tensile Strength, Rm (N/mm2)	383	130 – 300
Modulus of Elasticity, E (N/mm2)	73369	60000 - 75000

Table 1 - Tensile Test

RESULTS
Example Results

Brass

Test Type	Tensile
File Name:	S:\RD_FOLDERS\RD
Date/Time:	09/04/2020
Operator:	MJN

Specimen Details	
Material Type:	Brass

Diameter 1:	6	mm
Diameter 2:	6.01	mm
Diameter 3:	6.01	mm
Diameter 4:	6.01	mm
Ave. Diameter:	6.01	mm
C.S.A (mm^2)	28.35	mm^2
Extensometer Gauge Length, Le (mm):	37.75	mm
Initial Speciment Length, Lo (mm)	85.09	mm

Results		
Final Length, Lu (mm):	89.59	mm
Change in Length, (mm):	4.50	mm
Percentage Elongation, (%)	5.29	%

Maximum Test Force, (N)	17.06	kN
Maximum Test Force, (N)	17060	N
Modulus of Elasticity, E (N/mm^2)	104229.091326076	N/mm^2

Window 3 - Brass

Specimen Details	Results	
	Actual	Typical
Material	Brass	
Average Diameter, mm	6.01	
Initial Cross Sectional Area, A0 (mm2)	28.35	
Elongation Gauge Length, L0, mm	85.09	
Extensometer Gauge Length, Le, mm	37.75	
Measured Elongation after testing, mm, Lu	89.59	
Percentage Elongation, A (%)	5.29	5 – 25
Tensile Strength, Rm (N/mm2)	601	360- 580
Modulus of Elasticity, E (N/mm2)	104229	96,000 – 110,000

Table 1 - Tensile Test

EXPERIMENT
Compression Testing

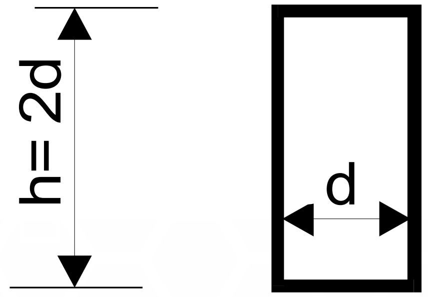
Compression test is used to determine strength of materials primarily intended for compression loads and for brittle materials that do not withstand tensile deformations.

Compression strength can be determined only with brittle materials that break up when compressed. With plastics only the plasticity limit can be determined. This is the limit where the material becomes plastically deformed.

Observe the behaviour of the test sample. With increasing load the test piece becomes shorter and finally breaks.

Procedure to Conduct a Compression Test

1. Choose a Compression specimen (specimens not supplied). Prepare a cylindric test piece with height equal to diameter or double diameter.



2. Test samples are cylindrical. Place the test sample onto the centre of the lower compression plate. When using the test samples increase the force at a slow constant rate. The test is carried out by compressing the test piece to a certain height or to the height where cracks form in the material.

EXPERIMENT
Compression Testing

3. Plug the connector of the elongation sensor into the Pot 1 socket of the data acquisition box.

4. Plug the force sensor into the Pressure socket of the box.

5. Plug the power supply unit into the interface.

6. Plug the USB cable from the data acquisition box to the PC if required

7. Plug the power supply unit into the interface then turn on the interface at the power switch.

8. Select 'Uni Tester' from menu screen.

9. Release the pressure release knob and lower the handle.

10. Tare the readings on the interface by pressing the Tare buttons.

WARNING: WEAR SAFTEY GLASSES AND ENSURE THE DOOR IS CLOSED AT ALL TIMES

11. Start to slowly pump the handle of the hand pump in an even speed. The force and elongation will start to increase.

12. Record the elongation and force readings at regular intervals. Recording can be done manually by taking readings from the screen or by using the software to log readings to a file.

13. Continue until the specimen fractures. A sudden fracture will occur so be prepared.

MAINTENANCE
Maintenance

The following is a list of key maintenance checks to perform at periodic intervals throughout the life of the unit.

The equipment needs little maintenance since so far as possible materials and finishes are corrosion proof and long lasting.

1. Check screws, fasteners are tight and in good condition.
2. Check the oil reservoir level within the hand pump.
3. Check for any leaks of oil during, after and before testing.
4. If leaks occur, it may be a simple task of tightening the joint(s), as the fittings are tapered pipe fittings. However if this does not work and the joint(s) have to be disconnected completely, a roll of PTFE tape has been provided to assist with improving the sealing of the joint(s). Simply wrap one or two times around the pipe thread and reconnect the joint(s).
5. Never place the unit on its side.
6. Check sensor wires are in good condition.
7. Turn the interface OFF after lab sessions.
8. Check the threads of the threaded grips. Oil if necessary.
9. Check the cross members have grease within their threads. Grease is applied before dispatching the equipment. This helps the components to be installed and removed.
10. Check the main base unit is level on the work surface.
11. Check the extensometer screws are in good condition.
12. Regularly check the extensometer continues to grip the specimens.

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Safety Data Sheet: Hydraulic Oil 32

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SAFETY DATA SHEET

HYDRAULIC OIL 32

1 SUBSTANCE/ PRODUCT IDENTIFICATION

Product Trade Name Hydraulic Oil 32

Company As above

Preparation / Revision Date July 2011

Appication Hydraulic fluid - For specific application advice see appropriate Technical Data Sheet or consult your Specialised Products representative

Emergency Phone Number 01202 891393

2 HAZARDS IDENTIFICATION

This material is not considered to be hazardous, but should be handled in accordance with good industrial hygiene and safety practices.
Note: High Pressure Applications - Injections through the skin resulting from contact with the product at high pressure constitute a major medical emergency.
See 'Medical Advice' under First-Aid Measures, Section 4 of this Safety Data Sheet.

3 COMPOSITION/ INFORMATION ON INGREDIENTS

Component	CAS No.	EC No.	Reg No.	Content	Classification EC1272/2008	Classification 1999/45/EC
Mineral Oil	74869-22-0	278-012-2	01-2119495601-36	75-80%		
Distillates hydrotreated light naphthenic	64742-53-6	265-156-6	01-2119480375-34	>20%		
Zinc Dialkyldithiophosphate	68649-42-3	272-028-3	Not Available	<0.05%	Aquatic Chronic 2; H411 Eye Dam. 1; H318	Xi, N R41, R51/53

Hazardous Components No component is present at sufficient concentration to require a hazardous classification
Not considered to be carcinogenic under IARC. All of the oils in this product have been demonstrated to contain less than 3% extractables by the IP 346 DMSO test.

4 FIRST AID MEASURES

Eyes Wash eye thoroughly with copious quantities of water, ensuring eyelids are held open. Obtain medical advice if any pain or redness develops or persists.

Skin Wash skin thoroughly with soap and water as soon as reasonably practicable. Remove heavily contaminated clothing and wash underlying skin.

Ingestion If contamination of the mouth occurs, wash out thoroughly with water.
Except as a deliberate act, the ingestion of large amounts of product is unlikely. If it should occur, do not induce vomiting; obtain medical advice.

Inhalation If inhalation of mists, fumes or vapour causes irritation to the nose or throat, or coughing, remove to fresh air. If symptoms persist obtain medical advice.

Medical Advice Treatment should in general be symptomatic and directed to relieving any effects.
Note: High Pressure Applications

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Hydraulic Oil 32

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Injections through the skin resulting from contact with the product at high pressure constitute a major medical emergency. Injuries may not appear serious at first but within a few hours tissue becomes swollen, discoloured and extremely painful with extensive subcutaneous necrosis. Surgical exploration should be undertaken without delay. Thorough and extensive debridement of the wound and underlying tissue is necessary to minimise tissue loss and prevent or limit permanent damage. Note that high pressure may force the product considerable distances along tissue planes.

5 FIRE-FIGHTING MEASURES

Use foam, dry powder or water fog. DO NOT USE water jets.
Fires in confined spaces should be dealt with by trained personnel wearing approved breathing apparatus.
Water may be used to cool nearby heat exposed areas/objects/packages. Avoid spraying directly into storage containers because of the danger of boil-over.

Combustion Products Toxic fumes may be evolved on burning or exposure to heat.
See Stability and Reactivity, Section 10 of this Safety Data Sheet.

6 ACCIDENTAL RELEASE MEASURES

Contain and recover spilled material using sand or other suitable inert absorbent material.
It is advised that stocks of suitable absorbent material should be held in quantities sufficient to deal with any spillage which may be reasonably anticipated. Spilled material may make surfaces slippery.
Protect drains from potential spills to minimise contamination. Do not wash product into drainage system.
In the case of large spills contact the appropriate authorities, or call 01202 891393
In the case of spillage on water, prevent the spread of product by the use of suitable barrier equipment.
Recover product from the surface. Protect environmentally sensitive areas and water supplies.

7 HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes. If splashing is likely to occur wear a full face visor or chemical goggles as appropriate. Avoid frequent or prolonged skin contact with fresh or used product.
Good working practices, high standards of personal hygiene and plant cleanliness must be maintained at all times. Wash hands thoroughly after contact.
Use disposable cloths and discard when soiled. Do not put soiled cloths into pockets.

Fire Prevention Product contaminated rags, paper or material used to absorb spillages, represent a fire hazard, and should not be allowed to accumulate. Dispose of safely immediately after use.

Storage Conditions Store under cover away from heat and sources of ignition.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Limits There is no appropriate occupational exposure limit for this material. Ensure good ventilation. Avoid, as far as reasonably practicable, inhalation of vapour, mists or fumes generated during use. If vapour, mists or fumes are generated, their concentration in the workplace air should be controlled to the lowest reasonably practicable level.

Protective Clothing Wear face visor or goggles in circumstances where eye contact can accidentally occur.
If skin contact is likely, wear impervious protective clothing and/or gloves. Protective clothing should be regularly dry cleaned. Change heavily contaminated clothing as soon as reasonably practicable; dry clean, launder and preferably starch before re-use.
Wash any contaminated underlying skin with soap and water.

Respiratory Protection Respiratory protection is unnecessary, provided the concentration of vapour, mists or fumes is adequately controlled. The use of respiratory equipment must be strictly in accordance with the manufacturers' instructions and any statutory requirements

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Safety Data Sheet: Hydraulic Oil 32

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SAFETY DATA SHEET

governing its selection and use.

9 PHYSICAL AND CHEMICAL PROPERTIES

Typical Values

	Test Methods	Units	
Grades:			32
Physical state			liquid
Colour			amber
Odour			oily
Density @ 20°C	ASTM D 1298	kg/m³	0.876
Kinematic viscosity @ 40°C	ASTM D 445	mm²/s	32.02
Kinematic viscosity @ 100°C	ASTM D 445	mm²/s	5.4
Flash point (COC)	ASTM D 92	°C	215
Pour point	ASTM D 97	°C	-30

10 STABILITY AND REACTIVITY

Stability — Products of this type are stable and unlikely to react in a hazardous manner under normal conditions of use. Hazardous polymerisation reactions will not occur. This material is combustible.

Materials To Avoid — Avoid contact with strong oxidizing agents.

Hazardous Decomposition Products — Thermal decomposition products will vary with conditions. Incomplete combustion will generate smoke, carbon dioxide and hazardous gases, including carbon monoxide.

11 TOXICOLOGICAL INFORMATION

Eyes — Unlikely to cause more than transient stinging or redness if accidental eye contact occurs.

Skin — Unlikely to cause harm to the skin on brief or occasional contact but prolonged or repeated exposure may lead to dermatitis.

Ingestion — Unlikely to cause harm if accidentally swallowed in small doses, though larger quantities may cause nausea and diarrhoea.

Inhalation — At normal ambient temperatures this product will be unlikely to present an inhalation hazard because of its low volatility.
May cause irritation to eyes, nose and throat due to exposure to vapour, mists or fumes.
May be harmful by inhalation if exposure to vapour, mists or fumes resulting from thermal decomposition products occurs.

12 ECOLOGICAL INFORMATION

Mobility — Spillages may penetrate the soil causing ground water contamination.

Persistence/Degradability — This product is inherently biodegradable.

Bio-Accumulation — There is no evidence to suggest bioaccumulation will occur.

Aquatic Toxicity — Spills may form a film on water surfaces causing physical damage to organisms. Oxygen transfer could also be impaired.

Results of PBT and vPvB Assessment — Not classified as PBT/vPvB by current EU criteria.

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Hydraulic Oil 32

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13 DISPOSAL CONSIDERATIONS

Where possible, arrange for product to be recycled.
Dispose of via an authorised person/ licensed waste disposal contractor in accordance with local regulations.
Incineration may be carried out under controlled conditions provided that local regulations for emissions are met.

14 TRANSPORT INFORMATION

Not classified as hazardous for transport (ADR, RID, UN , IMO, IATA/ICAO).

15 REGULATORY INFORMATION

Labelling Information — Not classified as hazardous for supply

16 OTHER INFORMATION

Compiled By — QSHE Department
As above

This data sheet and the health, safety and environmental information it contains is considered to be accurate as of the date specified below. We have reviewed any information contained herein which we received from sources outside of the Company. However, no warranty or representation, express or implied is made as to the accuracy or completeness of the data and information contained in this data sheet.

Health and safety precautions and environmental advice noted in this data sheet may not be accurate for all individuals and/or situations. It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. No statement made in this data sheet shall be construed as a permission, recommendation or authorisation given or implied to practise any patented invention without a valid licence. The Company shall not be responsible for any damage or injury resulting from abnormal use of the material, from any failure to adhere to recommendations, or from any hazards inherent in the nature of the material.

RESULTS
Tables

Table 1 - Tensile Test

Specimen Details	Results	
	Actual	Typical
Material		
Average Diameter, mm		
Initial Cross Sectional Area, A0 (mm2)		
Elongation Gauge Length, L0, mm		
Extensometer Gauge Length, Le, mm		
Measured Elongation after testing, mm, Lu		
Percentage Elongation, A (%)		
Tensile Strength, Rm (N/mm2)		
Modulus of Elasticity, E (N/mm2)		

UNIVERSAL TESTING MACHINE

CP4868

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