



INSTRON 5582 UNIVERSAL TESTER

‘Fat Tony’

Operating Instructions

Table of Contents

Introduction	1
1 SAFETY	
Safety Hazards	1
Safety Precautions	1
2 BACKGROUND	
Background Information	2
The Tension Test	2
Metals	2
Polymers	4
The Flexure (Bend) Test	5
Ceramics	5
The Compression Test	6
References	6
3 OPERATION	
Grips Setup	7
Software Setup	7
Running the Test	8
Helpful Hints	11



Introduction

The Instron 5582 Universal Tester is a state-of-the-art testing machine that features a 100 kN load frame, a variety of specimen fixtures, several strain gauge extensometers, and Merlin software that is loaded with data collection and analysis features.

Specimen Geometry. The Instron universal tester can handle a variety of specimen geometries. If you can find appropriate test fixtures in our supply cabinets, or design and fabricate your own test fixtures, you can probably test your sample.

Test Fixtures. Our current stock of test fixtures includes the following:

- 3-Point Bend Setup for flexure testing.
- Platens for compression testing.
- Wedge Grips with various faces (for different specimen geometries) for tension testing.

Safety

Safety Hazards

- Fracture of brittle materials may result in projectiles.
- The Instron Universal Tester is capable of applying forces that can easily crush hands or other body parts, and the machine does not know or care if it's testing a steel rod or your fingers.

Safety Precautions

- Always wear eye protection when working with or around the universal tester.
- Move the yellow and black limit switches on the left column to positions close to the crosshead when changing fixtures to prevent accidental crushing of you or your specimen.
- Keep all limbs clear of the machine when running tests.
- Stand away from the instrument while a test is running.
- Be careful when removing or adjusting the specimen grips. Some grips are quite heavy, and they parts of the grips may become loose and fall if improper adjustments are made.

2

Background Information

A vast number of standardized tests are available for the measurement of mechanical properties. Three of the more common tests that may be easily performed with the Instron Universal Tester are tension testing, compression testing, and flexure testing. Each of these tests is used to determine how a material will respond to a particular type of loading. Depending on the type of test, the relevant output from the Instron may include load, displacement, stress, and strain data.

The Tension Test

NOTE: The following background text is taken directly or adapted from the *Uniaxial Tension Testing* section of *ASM Handbook, Volume 8 Mechanical Testing and Evaluation*.

The tension test is one of the most commonly used tests for evaluating materials. In its simplest form, the tension test is accomplished by gripping opposite ends of a test item within the load frame of a test machine. A tensile force is applied by the machine, resulting in the gradual elongation and eventual fracture of the test item. During this process, force-extension data, a quantitative measure of how the test item deforms under the applied tensile force, usually are monitored and recorded. When properly conducted, the tension test provides force-extension data that can quantify several important mechanical properties of a material. These mechanical properties determined from tension tests include, but are not limited to, the following:

- Elastic deformation properties, such as the modulus of elasticity (Young's modulus) and Poisson's ratio,
- Yield strength and ultimate tensile strength,
- Ductility properties, such as elongation and reduction in area, and
- Strain-hardening characteristics.

See Chapter 6 of your textbook for equations and information on analysis of stress/strain curves.

The material characteristics determined from tension tests are used for quality control in production, for ranking performance of structural materials, for evaluation of newly developed alloys, and for dealing with the static-strength requirements of design. Tension tests are generally performed on metals and polymers. Ceramic materials, which are generally brittle, are difficult to grip in tension without causing damage or fracture, so flexure tests are more commonly used for ceramic materials.

Metals

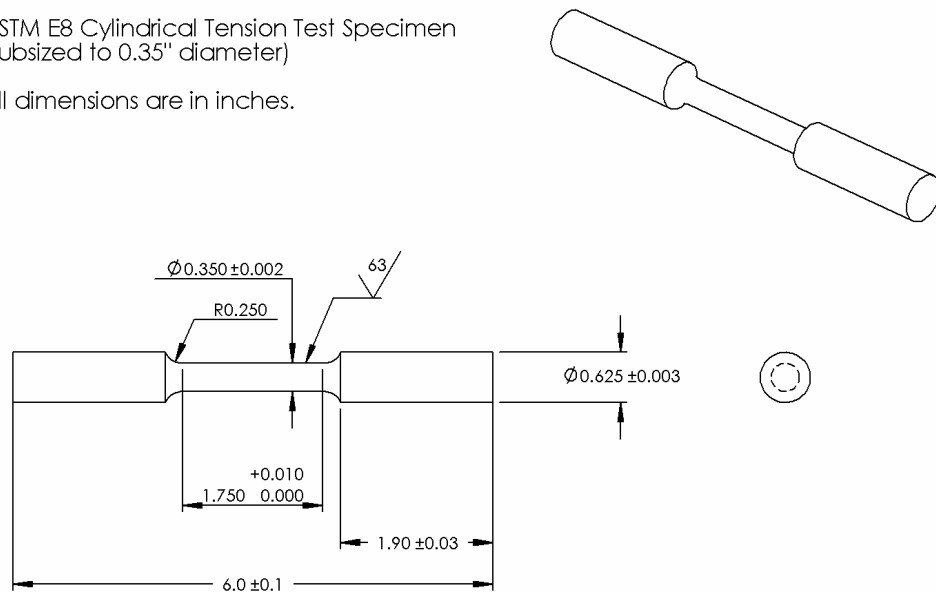
Plastic deformation in metals is the result of the motion of large numbers of linear defects, or dislocations, in the material. The mechanical properties and stress-strain response of metals

and alloys are largely a result of the ease at which dislocations can move in the material. If dislocation motion in a particular metal or alloy is difficult, the metal will experience very little strain before brittle fracture occurs. If dislocation motion is easy, the material will behave in a ductile manner and exhibit a large amount of plastic deformation prior to failure. The chemical composition, mechanical processing, thermal processing (heat treatments), and the presence of defects will all affect the microstructure and mechanical properties of metals and alloys.

Your instructor will provide a number of different metals and alloys ready for tensile testing. The cylindrical metal alloys are machined in accordance with ASTM E8 (“Standard Test Methods for Tension Testing of Metallic Materials”), a commonly-used standard that outlines specimen geometries and specific procedures for tensile testing. This standard by no means dictates the only sample shape that can be tested in the Instron, it is simply the industry standard for formal materials testing.

ASTM E8 Cylindrical Tension Test Specimen
(subsize to 0.35" diameter)

All dimensions are in inches.



Alloy numbers and fabrication/processing information for the alloys are shown in the following table:

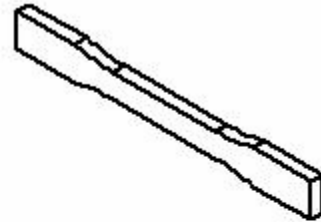
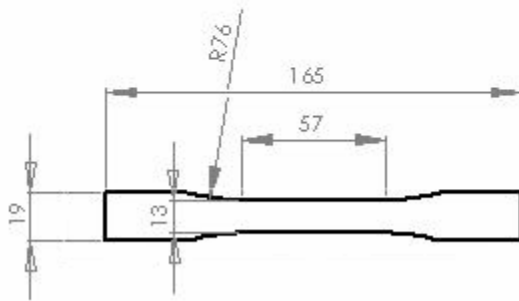
Metal	Finish/Temper
Alloy 110 copper	Cold rolled
Alloy 360 brass	Cold rolled
Grade 2 titanium	
6061 aluminum	T6
2024 aluminum	T6
Gray cast iron	Cast
304 stainless steel	Cold Rolled
1045 steel	Hot Rolled
1018 or 1020 steel	Cold Drawn
1018 or 1020 steel	Hot Rolled

Polymers

The mechanical properties and stress-strain response of polymers are largely a result of the chemical structure of the polymer. Polymers exhibit three basic types of stress-strain behavior: (i) “brittle” stress-strain behavior, described by high strength but very low strain to failure (generally observed in glassy or amorphous polymers), (ii) “plastic” stress-strain behavior, described by moderate strengths and relatively high elongations to failure (generally observed in semicrystalline polymers), and (iii) “elastomeric” stress-strain behavior, described by extremely high strains and very low stresses at failure (generally observed in rubbers).

Your instructor will provide a number of different polymers ready for tensile testing. The rectangular dog-bone samples are machined in accordance with ASTM D638-02a (“Standard Test Methods for Tensile Properties of Plastics”), a commonly-used standard that outlines specimen geometries and specific procedures for tensile testing. This standard by no means dictates the only sample shape that can be tested in the Instron; it is simply a common, accepted standard for formal polymer tension testing.

ASTM D638-02a Tension Test Specimen
All dimensions are millimeters.



Available polymers and recommended processing information are shown in the following table:

Polymer	Abbr.	Recommended Crosshead Speed (mm/min)
High Density Polyethylene	HDPE	20-100
Nylon		20-100
Polypropylene	PP	20-100
Polytetrafluoroethylene (Teflon)	PTFE	20-100
Polyester	PETG	5-20
Polystyrene	PS	5-20
Polymethyl methacrylate	PMMA	5-20
Polycarbonate	PC	5-20
Polyvinyl chloride	PVC	5-20
Acetal (Delrin)		5-20
Acrylonitrile butadiene styrene	ABS	5-20

The Flexure (Bend) Test

A typical application of the flexure test is to gain strength and ductility information on a brittle material, such as a ceramic. Flexural testing is preferred for brittle materials because surface flaws on the material or the grip of the testing machine can accidentally create unwanted cracks that may affect test results. The flexure test creates an environment in which strength can be measured without having to worry as much about surface flaws.

Ceramics

Probably one of the most distinguishing mechanical features of ceramics is their high compressive but low tensile strength. Since most ceramics are formed from ionic and covalent bonds, dislocation motion does not play a significant role in their room temperature strength as it does with metals. Instead, the mechanical properties of ceramics have much more to do with the number of flaws within the material, as well as the types of forces exerted on the material. Of note are the incredibly high compressive strengths of most ceramics – usually an order of magnitude higher than their tensile strengths. Further, most ceramics are very brittle under tensile stresses. In general, temperature has much less of an effect on ceramics as it does on metals and polymers.

Many types of flexural testing are possible, but the most common is the 3-point flexure test, in which a sample is set upon two supports, and a force is applied directly between the two supports. Since the forces exerted on a material are different from a tensile test, the calculations necessary to find strength and ductility are also different. More information about calculating flexural strength and the 3-point flexure test can be found in Chapter 6 of your textbook.



An illustration of a 3-point flexure test of a ladder. Note that the many surface inconsistencies would make it very difficult to perform an accurate tension test of this specimen.

The ASTM D5023-01 standard sample for a flexure test is a 2.5 x 0.5 x 0.125 in. rectangular bar. While these exact dimensions are not required, the length of the sample needs to be long enough to prevent the interference of any external forces during the test. Thus, at least 10% of the specimen should hang over each of the two end supports. It is a good idea to consult the ASTM standard for specific guidelines for nonstandard test samples.

The Compression Test

Compression testing is generally used to evaluate materials at high strain and temperatures levels, as well as highly brittle materials for which creation of a standard tensile specimen is very difficult. Further, it can also be used to simulate more realistic stresses on materials that will be used for specific purposes, such as concrete. Unlike a tension test, a compression test is performed by exerting an inward force on the material, resulting in a plastic deformation of the material into something shorter and wider than its original form. One major benefit to a compression test is that the sample material ideally will not experience any sort of mechanical failure – there will be no weakening such as necking experienced during the test. Unfortunately, compression tests are not always successful in this regard. Sometimes, failure such as buckling and barreling will weaken the specimen and create a non-uniform distribution of stress on the sample. More information on both of these phenomena can be found in Volume 8 of the ASM Handbook.

The standard test specimen for a compression test is a simple cylinder. The cylindrical sample shape provides an advantage over tension testing, since the specimen is generally easier to make and requires less material. The following table, taken from ASTM E9 (“Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature”), shows standard diameter to length ratios for compression test samples. Note that these recommendations are for metallic materials. Appropriate sample sizes for compression testing of polymers, ceramics, and composites may be found in other standards.

TABLE 2 Suggested Solid Cylindrical Specimens^A

NOTE 1—Metric units represent converted specimen dimensions close to, but not the exact conversion from inch-pound units.

Specimens	Diameter		Length		Approx L/D Ratio
	in.	mm	in.	mm	
Short	1.12 ± 0.01	30.0 ± 0.2	1.00 ± 0.05	25. ± 1.	0.8
	0.50 ± 0.01	13.0 ± 0.2	1.00 ± 0.05	25. ± 1.	2.0
Medium	0.50 ± 0.01	13.0 ± 0.2	1.50 ± 0.05	38. ± 1.	3.0
	0.80 ± 0.01	20.0 ± 0.2	2.38 ± 0.12	60. ± 3.	3.0
	1.00 ± 0.01	25.0 ± 0.2	3.00 ± 0.12	75. ± 3.	3.0
	1.12 ± 0.01	30.0 ± 0.2	3.38 ± 0.12	85. ± 3.	3.0
Long	0.80 ± 0.01	20.0 ± 0.2	6.38 ± 0.12	160. ± 3.	8.0
	1.25 ± 0.01	32.0 ± 0.2	12.50 min	320 min	10.0

^A Other length-to-diameter ratios may be used when the test is for compressive yield strength.

References

- Callister: Sections 6.2, 6.3, and 6.6 for metals; sections 15.2 - 15.4, 15.7 - 15.9 for polymers
- Askeland: Sections 6.2-6.6 for mechanical testing and stress/strain behavior; 15.1-15.2 for ceramics
- ASM Handbook Volumes 1 and 2 for Metals
- ASM Handbook Volume 8 for Mechanical Testing Methods
- ASTM D5023-01, D638-02, E8, E9
- <http://www.wfrfire.com/website/articles/ladtest5.gif> for the elephant picture

3

Operation

Startup

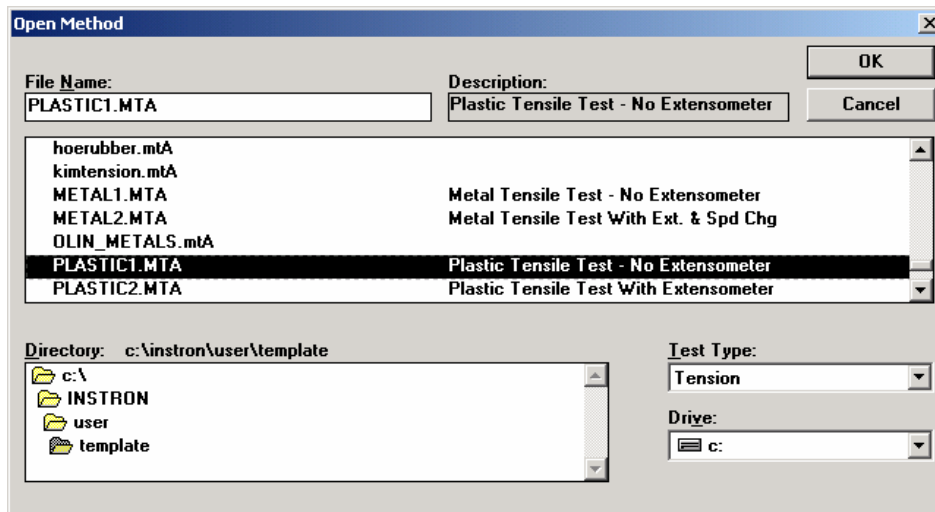
1. If the appropriate sample grips are already installed, skip to Step 6.

Grips Setup

1. If the appropriate sample grips are already installed, skip to Step 6.
2. If necessary, raise or lower the crosshead to an appropriate position by pressing the up and down arrows on the load frame control panel.
3. Change fixtures according to the test you wish to run – wedge clamps with various faces for tension tests, three point bend fixtures for flexural tests, compression platens for compression tests. Use appropriate adapters and pins for your fixturing.
4. After you have attached the fixtures with pins, tighten the knurled collars at the attachment point of the grips. The pins should now be tight, and they should no longer slide in and out with finger pressure.
5. Attach wire clips around the pins to keep them from sliding out during the test.
6. Raise or lower the crosshead to an appropriate position for sample loading. Use the up and down arrows on the load frame control panel for large displacements. Use the scroll-wheel for fine motion.
7. **SAFETY:** Set the crosshead limit switches (the yellow and black sliders on the left column) to appropriate positions to prevent the crosshead from moving too far up or down. If you accidentally cause the crosshead to hit one of the limit switches, the machine will automatically stop.

Software Setup

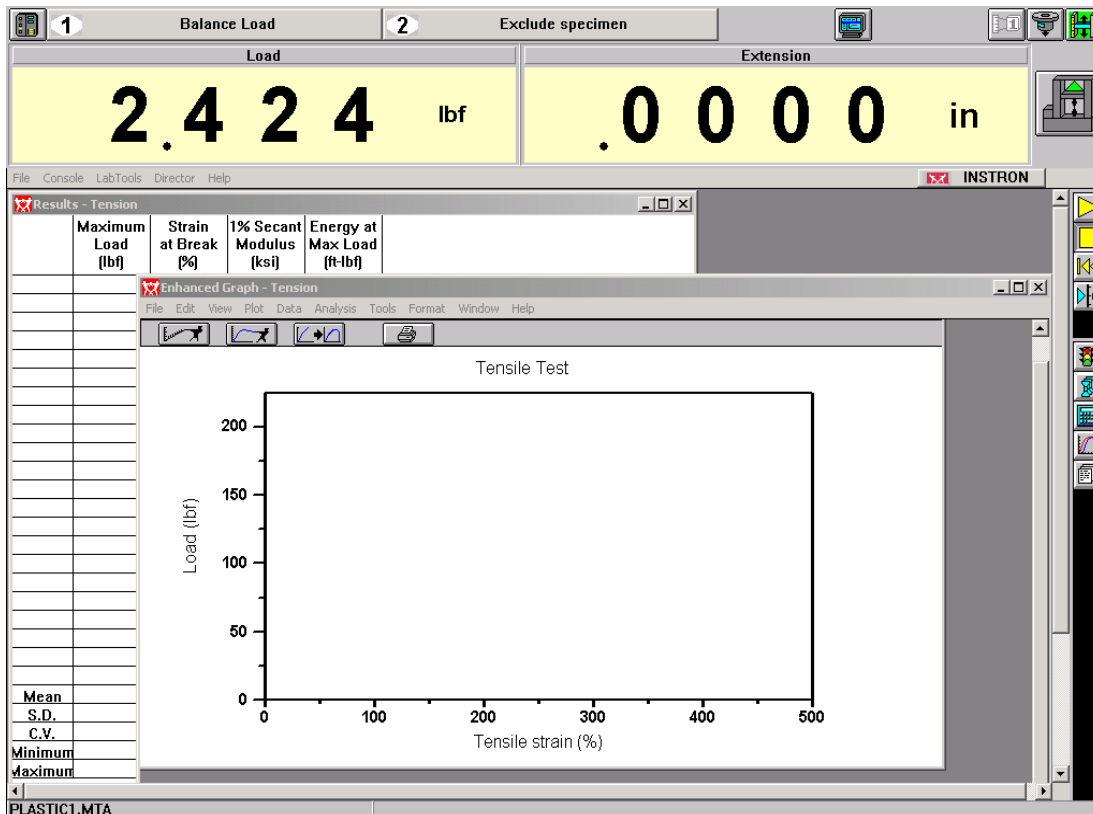
1. Open the software by double-clicking the Merlin icon on the desktop.
2. If you see the desired test method in the list, click on it. Otherwise, click the Merlin button at the bottom right to open other test methods. You should see a screen that looks like this:



3. Select the **Test Type** (tension, flexure, etc.) at the lower right.
4. Select the procedure **File Name** (example: selection of test type **Tension**, file name: **PLASTIC1.MTA** will open a test method designed for tension testing of polymers without the use of an extensometer).

Running the Test

1. If you have successfully opened a test method, you will see a screen that looks something like this:



OVERVIEW OF THE SCREEN:

- The two top left buttons numbered “1” and “2” correspond to the “1” and “2” buttons on the load frame control panel. These buttons are programmable via the software.
- The monitor-looking button at the top controls the view on the screen.
- The three top right buttons are used to calibrate and balance (zero) the extensometer, load cell, and crosshead position.
- The buttons along the right edge are used to (i) control the crosshead and (ii) set the test and data analysis parameters.
- The large digital readouts show live signals of load, crosshead position, and (sometimes) extensometer strain. The default display for many test methods is just the load and crosshead position. To add a third or fourth live signal display, click on the monitor-looking button at the top and adjust the display parameters.

Set Test Parameters

2. Click on the traffic light icon on the right side of the window. The following settings are adjusted under the traffic light menu:

Pretest – unless you want to apply a pre-load, all boxes should be unchecked

Test – set crosshead rate (Ramp 1). 0.25 in/min is a good speed for metals.

Data – set the data capture to “Manual” and an appropriate time interval (decent values are 500 ms for slow tests, 50 ms for longer tests)

Strain – if you’re using the extensometer, set Source to “Strain 1” and use your good judgment in setting a strain value for extensometer removal (you don’t want the sample breaking with the extensometer attached...damage to the device could result)

Close the window after making your changes.

Set Sample Parameters

3. Click on the tensile specimen icon (blue dogbone specimen) on the right side of the window. The following settings are adjusted under the tensile specimen menu:

Define – use this menu to specify the specimen name and specimen geometry (circular)

Specimen – use this menu to indicate the specimen name and initial dimensions.

Notes – write some humorous notes to yourself or your teammates, if you like.

Bend Fixture (flexure testing only) – enter the fixture type and support span.

Close the window after making your changes.

Load the Sample

4. Be sure you have measured and recorded the specimen dimensions before placing the specimen in the grips (see previous step).
5. Load your test specimen in the grips.
 - **Tension:** If you are running a tension test with the wedge grips, insert your specimen into the top grip first and tighten the grip. Then use the crosshead controls to lower the specimen into the bottom grip. Tighten the lower grip.
 - **Flexure:** Adjust the lower flexure fixture to an appropriate span. Place the specimen on the lower fixture and align. Lower the crosshead until the top fixture is just above your specimen.

- **Compression:** Center and align your specimen. Lower the crosshead until the top fixture is just above your specimen.

Attach the Extensometer

6. Attach the extensometer to the specimen, if necessary – ask your course instructor or TA for specific instructions on attaching the extensometer.

Start the Test

7. Zero the Load, Extension, and Strain 1 readouts by clicking on the icons at the upper right of the window.
 - Load: click on the Balance button then click Done at the right of the dialog box.
 - Extension: click on the Reset Gauge Length button then click Done at the right of the dialog box.
 - Strain 1: if you're using the extensometer, click on the Balance button then click Done at the right of the dialog box.
8. Start the test by pressing the “Start Test” button on the load frame control panel or the yellow play button on the screen.
9. **Four ways to stop a test:** If something does not go as desired or planned, the run can be stopped by pressing the red Stop Test button on the control panel, the big emergency stop button on the frame, jostling one of the yellow switches on the left column, or pressing the stop button on the computer.
10. The graph can be monitored by pressing the button that looks like a graph on the right sidebar. The top left button under graph lets you specify what each axis is well as units and scale. Pressing the third button on the graph display will autoscale the plot.

After the Test

11. On the main window (not the graph window), go to **File...Setup...** and make sure the **ASCII Raw Data to:** option is checked. Click OK.
12. On the main window (not the graph window), to go **File...Data...End&Save.** Name your file and save it to the hard drive. The default save directory is c:\instron\user\data.
13. Carefully remove the specimen from the grips and measure the final dimensions.
14. Use Olin's web mail service, to email the appropriate data files from the hard drive to yourself. Unless you are planning to do your data analysis on the Instron machine's control computer, the most useful file is the one with the “raw” extension. The “raw” data file is a well-labeled, comma-delimited ASCII data file that works very well with Excel (be sure to tell Excel that the data are comma delimited).

Helpful Hints

1. Be gentle whenever possible. Some pins or samples may need to be tapped with a soft mallet to get them in or out, but you should not have to muscle any part of the machine into place.
2. If the load frame is not responding, press the button on the right side of the screen that looks like a load frame, then press the Enable Frame button.
3. If you wish to see the raw data, pull up a graph, then go to the graph pull-down menu, and select data.
4. An extensometer should be used with tension tests if accurate displacement data is desired. If you don't use an extensometer, your elastic modulus values will be off.
5. Reasonable crosshead displacement rates for metal tests are along the lines of 2 to 3 mm/min. Polymers may be tested between 2 and 500 mm/min; in general, the greater the expected elongation, the higher the crosshead speed. Ceramics and inorganic glasses should be tested at very low crosshead speeds, e.g., 1-2 mm/min.