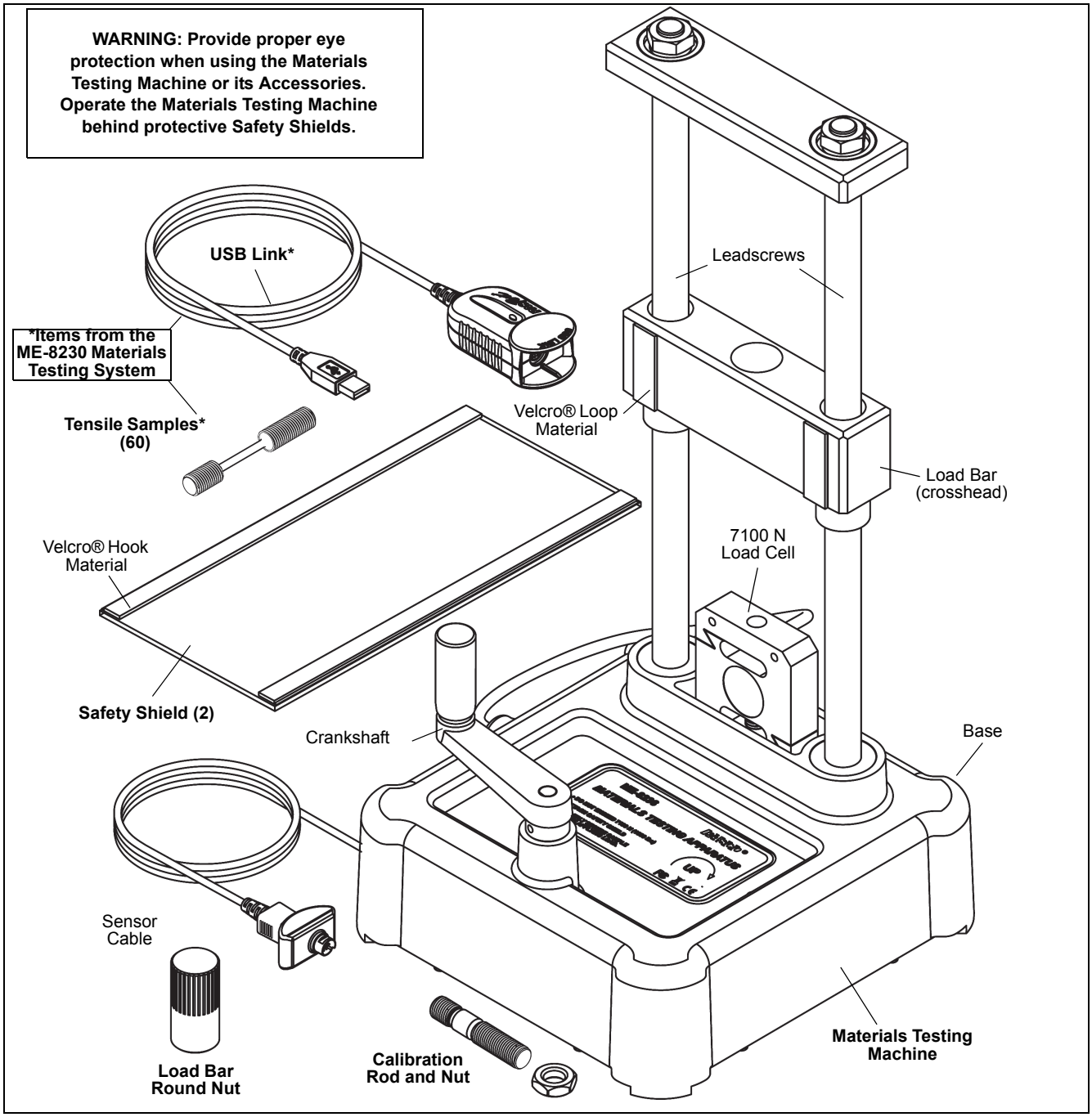
Materials Testing Machine

ME-8236

Part of the

Comprehensive Materials Testing System

ME-8244



Materials Testing Machine (ME-8236)

Included Items	Included Items
Materials Testing Machine	Calibration Rod and Nut
Load Bar Round Nut	Safety Shield (2)

Required Items*
PASCO Interface (PASPORT compatible)
PASCO Capstone Data Collection Software

**See the PASCO catalog or web site at WWW.PASCO.COM*

Materials Testing System (ME-8230)

The Materials Testing System includes the items in the Materials Testing Machine PLUS an interface, software, and sixty tensile samples as shown in Table 1.

Table 1: .Materials Testing System

Model	Materials Testing System Items
ME-8236	Materials Testing Machine
PS-2100A	USB Link
UI-5401	PASCO Capstone Software
ME-8231	Tensile Sample, Aluminum (10)
ME-8232	Tensile Sample, Brass (10)
ME-8233	Tensile Sample, Annealed Steel (10)
ME-8234	Tensile Sample, Acrylic (10)
ME-8235	Tensile Sample, Polyethylene (10)
ME-8243	Tensile Sample, Steel (10)

Comprehensive Materials Testing System (ME-8244)

The *Comprehensive Materials Testing System* includes all the items in the *Materials Testing System* shown in Table 1 PLUS the accessories and other items shown in Table 2.

Table 2: Comprehensive Materials Testing System

Model	Comprehensive Materials Testing System Items
ME-8230	Materials Testing System (MTS)
ME-8229	Materials Testing System Base
ME-8237	Materials Bending Accessory
ME-8238	Materials Coupon Adapter
ME-8239	Materials Shear Accessory
ME-8240	Materials Shear Samples (3 ea. of 3)
ME-8241	Materials Photoelasticity Accessory
ME-8242	Materials Structures Beam Adapter
ME-8245	Material Testing System Clevis Clip
ME-8246	MTS 10-32 Adapter
ME-8247	MTS Compression Accessory
ME-8248	MTS Compression Samples (20)
ME-8249	MTS Four-point Load Anvil
ME-6983	Cast Beam Spares Kit (10 molds)
ME-7011	Photoelastic I-Beams (24 each size)
ME-7012	Thin I-Beams (24 each size)
AP-8222*	Coupons, Plastic (10 each of 4 types)
AP-8223*	Coupons, Metal (10 each of 5 types)

**AP-8217A Replacement Test Coupons (Full Set) consists of the AP-8222 Plastic Coupons and the AP-8223 Metal Coupons.*

Introduction

The PASCO Materials Testing Machine is a device for measuring force and displacement for various materials as the materials are stretched, compressed, sheared, or bent. The Materials Testing Machine has a built-in load cell (strain gauge transducer) capable of measuring up to 7100 newtons (N) of force (1600 pounds), and an optical encoder module that measures displacement of the load bar. A crank-and-gear system raises or lowers the load bar on two leadscrews (also known as *power* screws or *translation* screws). Force data from the load cell and displacement data from the encoder module can be recorded, displayed, and analyzed by a PASCO Interface with PASCO Data Collection Software. The sensor cable from the Materials Testing Machine connects to a PASPORT input port. (See the PASCO catalog or web site at www.pasco.com for more information about PASCO interfaces and data collection software.)

Included Equipment

The *Materials Testing Machine* (ME-8236) includes a calibration rod and nut, a load bar round nut, and a pair of safety shields with Velcro® hook material.

Calibration Rod and Nut, Load Bar Round Nut, Safety Shields

- The calibration rod and nut can be used to determine how much the Machine itself flexes as force is applied, either in tension or in compression.
- The load bar round nut is used to connect one end of a tensile sample to the load bar, for example, or can be used to attach an accessory or adapter to the bottom side of the load bar.
- The safety shields attach to the Velcro® loop material on the front and back of the load bar.

Materials Testing System

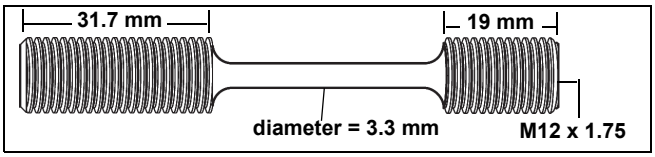
The *Materials Testing System* (ME-8230) consists of the Materials Testing Machine, plus a PASPORT interface called the USB Link, PASCO Capstone Software, and sixty tensile samples.

The USB Link connects the sensor cable of the Materials Testing Machine to a USB port on a computer. The PASCO Capstone software records, displays, and analyzes the data from the Materials Testing Machine. (The software is available as an automatic digital download from PASCO.)

The tensile samples include four metals: aluminum, brass, annealed steel, and steel and two plastics: acrylic and polyethylene, for tensile strength testing. There are ten samples for each material.

Tensile Sample Information

All the tensile samples (ME-8231 through ME-8235 and ME-8243) have an overall length of 90 millimeters (mm) or 3.5 inches. The center section of each sample has an approximate diameter of 3.3 mm or 0.131 inches. The threaded ends are metric M12 x 1.75.



The tensile samples can be ordered separately.

The table shows typical values.

Table 3: Typical Values

Material	Tensile Strength	Young's Modulus
Aluminum (2024-T3)	400 MPa	70 GPa
Brass (360)	500 MPa	80 GPa
Steel (1018)	700 MPa	200 GPa
Annealed Steel (1018)	400 MPa	200 GPa
Polyethylene	30 MPa	1 GPa
Acrylic	80 MPa	3 GPa

Accessories

Table 2 lists accessories and adapters that are included in the Comprehensive Materials Testing System and are available separately for the Material Testing Machine.

Other accessories and adapters are being developed.

Replacement Items

Also available separately are replacement items such as the previously mentioned Tensile Samples, the Materials Shear Samples (ME-8240) with nine metal rods (three each of aluminum, brass, and steel), the Plastic Coupons (AP-8222) with ten samples each of four different plastics, the Metal Coupons (AP-8223) with ten samples each of five different metals, and the MTS Compression Samples (ME-8248).

About This Manual

The manual describes the basic setup of the Materials Testing Machine and the accessories and replacement items included in the Comprehensive Materials Testing System. It also describes the procedure for calibrating the Materials Testing Machine using the included calibration rod and nut.

Experiment Guide

NOTE: An Experiment Guide in electronic format is available to download from www.pasco.com.

Enter "Materials Testing System" in the Search window and look for the downloadable file(s) under "Resources".

Operation

Caution: Be sure to wear adequate eye protection when using the Materials Testing Machine or its accessories. Operate the Machine from behind a protective shield.

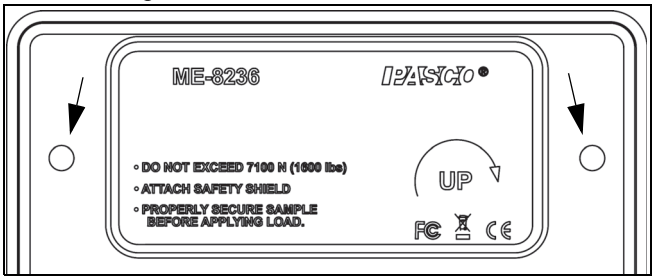
Basic operation involves mounting the Materials Testing Machine firmly to a sturdy support, calibrating the Machine, mounting the item to be tested onto the Materials Testing Machine, connecting the Materials Testing Machine to an

interface for data recording, and then turning the crank to apply tension (stretching), compression (squeezing), bending, or shearing (cutting) forces to the test item.

ME-8229 MTS Storage Base

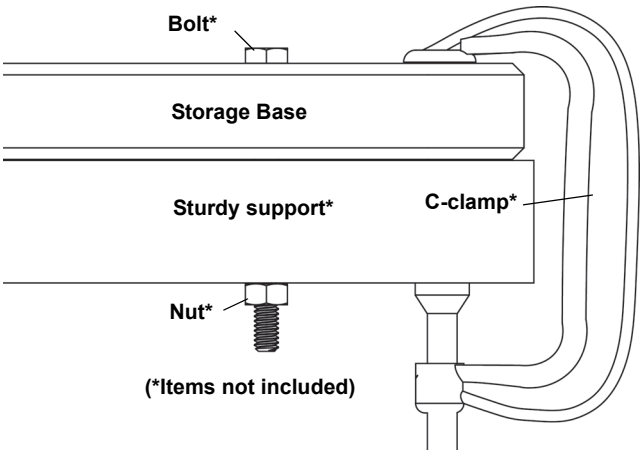
Secure the Materials Testing Machine

There are two holes through the base of the Materials Testing Machine that can be used for bolting the Machine to a sturdy support. The two 6 millimeter (mm) diameter holes are 15 centimeters apart; one on either side of the label.



Bolting the Machine will avoid the problem of the Machine moving during a sample test. The Materials Testing System Storage Base (ME-8229) is designed for two purposes: provide a sturdy base to which the Materials Testing Machine can be bolted, and serve as a storage place for accessories, tools, and other items in the Comprehensive Materials Testing System.

The Storage Base includes two screws and two washers and has two threaded holes that match the spacing of the holes in the Materials Testing Machine base. Place the Materials Testing Machine on the Storage Base. Put the washers on the screws, and put one screw through a hole in the base of the Materials Testing Machine. Align the screw with the threaded hole in the Storage Base, and tighten the screw using your fingers. Put the other screw through the base and align it with the other threaded hole. Use a 7/16 inch (11 mm) wrench to tighten the screws in place. Use C-clamps to fasten the Storage Base to a sturdy table or bench. An option is to bolt the Machine directly to a table or bench as shown. The Storage Base has through holes at each of its corners.



Calibration Setup

The calibration rod and nut can be used for calibrating the Materials Testing Machine for compression or tension. The PASCO Capstone data collection software includes a "calibration wizard" that allows the calibration information - called a "compliance calibration" - for the Materials Testing Machine to be stored for later use. (PASCO Capstone is provided in the ME-8230 Materials Testing System.)

Lab 02: Compliance Calibration Tutorial

NOTE: A PASCO Capstone workbook file about compliance calibration is available to download from the PASCO web site. Go to www.pasco.com and enter "Materials Testing System" in the Search window. In the web page that opens, select *Materials Testing System*. Click "Sample Labs" and then download the ZIP file for Lab 02.

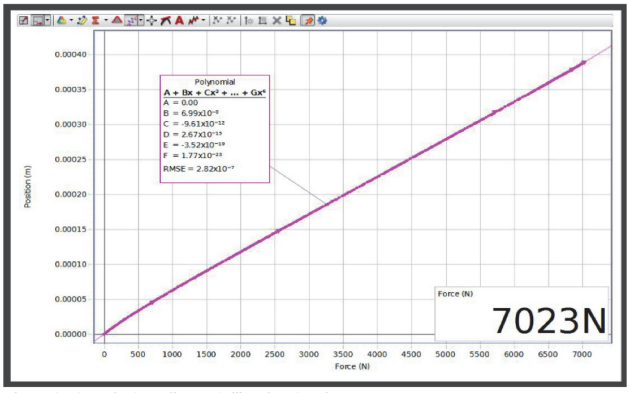
Information covered in the Compliance Calibration Tutorial includes:

- How a compliance calibration works.
- How to create, save, and delete calibrations.
- Hints and practice in making an accurate calibration.

Reason for Calibration

The reason for the compliance calibration procedure is this: if the Materials Testing Machine were perfectly rigid it would give completely accurate measurements of force and displacement. However, the Machine is not perfectly rigid. To correct for the fact that the Machine "flexes" slightly, the stiffness of the Machine is characterized and a calculation is performed in the software to adjust the raw position data and compute the displacement that is due only to the distortion of the sample being tested. The compliance calibration information for the Machine can then be stored within the Machine or stored in a Capstone file.

The calibration rod will not change shape significantly under tension or compression. This means that any displacement measured when the calibration rod is used is due to the flexing of the Materials Testing Machine itself.



For example, the sample graph shows that the Machine flexes 0.2 mm per 3,500 newtons of force when the calibration rod is stretched. If you use the Machine to stretch a material sample, then the "flex" amount of 0.2 mm per 3,500 N would need to be subtracted.

Creating the Compliance Calibration Information

In the software, a polynomial curve fit is applied to the plot of position versus force data. The coefficients of the polynomial curve fit are saved as the calibration information.

Once the compliance calibration is created for the Machine, the software automatically subtracts the amount of "flex" from the raw data. After the calibration information is stored in the Machine, it cannot be edited. However, it you make a new calibration, it will replace the stored calibration data.

Saving the Calibration Information

The calibration information can be saved in two ways: in the Capstone file or in the Materials Testing Machine itself. If the calibration information is saved in the Capstone file, it can be used with any Materials Testing Machine. If the calibration information is stored in the Materials Testing Machine, the information stays with that unit (even when it is unplugged) and can be used with any Capstone file in the future.

Mount the Calibration Rod for Tension

To mount the calibration rod for tension, screw the short-threaded end of the rod into the top of the load cell.

Lower the load bar until the threaded part at the top of the calibration rod goes through the hole in the load bar. Screw the load bar round nut onto the top of the calibration rod.

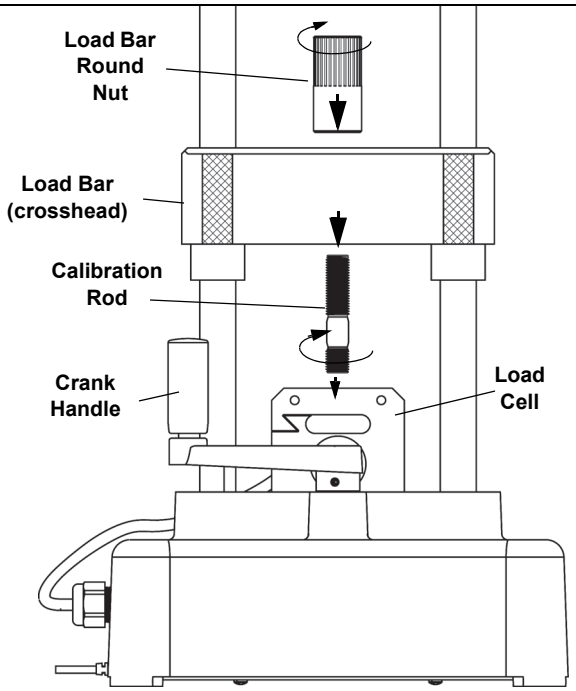


Figure: Mount Calibration Rod for Tension

Mount the Calibration Rod for Compression

To mount the calibration rod for compression, screw the short-threaded end of the rod into the top of the load cell. Screw the calibration nut onto the top threaded part of the calibration rod until the nut is at the bottom of the threaded section. Lower the load bar until the bottom of the load bar rests on the top of the calibration nut.

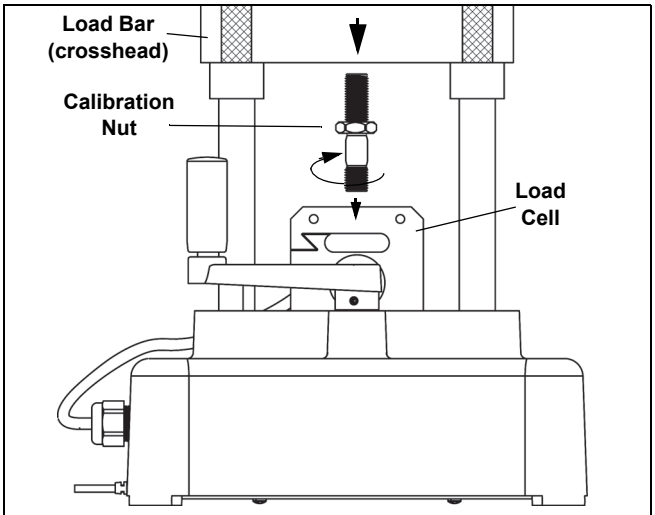


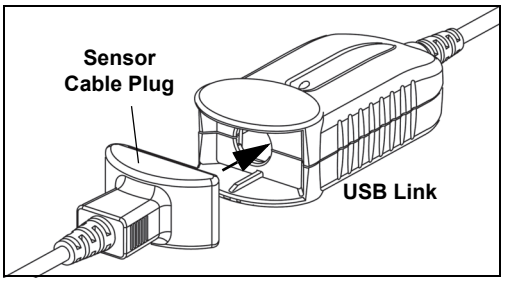
Figure: Mount Calibration Rod and Nut for Compression

Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar. Adjust the position of the shields so that they will block any fragments that may come from the calibration rod in case it accidentally breaks.

Prepare to Record Calibration Data

Connect the plug on the sensor cable into a PASPORT interface, such as the USB Link (included in the Materials Testing System). Connect the interface to a USB port on a computer.



See Appendix A for details of the Calibration Procedure.

After the Calibration Procedure is complete, return to this point.

Mount a Tensile Sample

Select a tensile sample to mount onto the Materials Testing Machine. Put the end of the sample with the short threaded section into the threaded hole in the top of the load cell. Screw in the sample until the top edge of the short threaded section is flush with the top of the load cell.

Lower the load bar so that the longer threaded section of the sample goes up through the hole in the center of the load bar. Adjust the load bar until the bottom edge of the longer threaded section is flush with the bottom of the load bar. While holding the tensile sample so it does not turn, screw the sample nut onto the longer threaded section until the sample is held tightly in place.

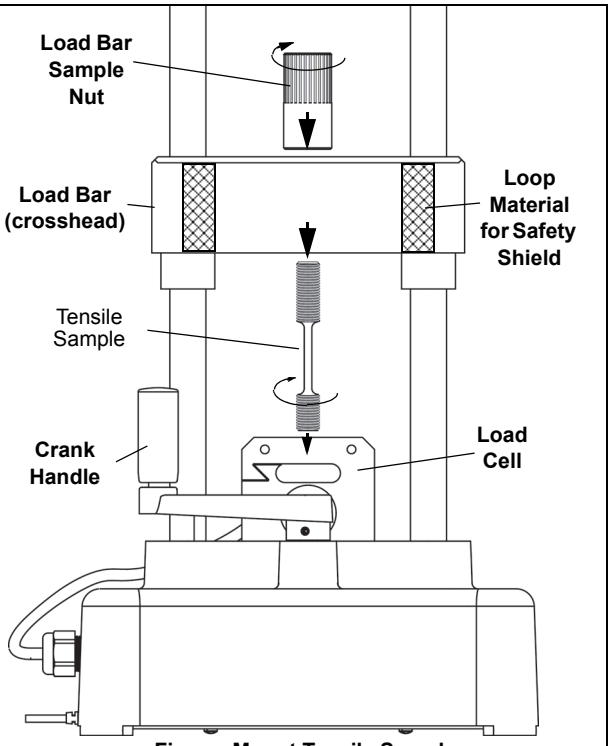


Figure: Mount Tensile Sample

Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar. Adjust the position of the shields so that they will block any fragments that may come from the sample.

Record Data

Prepare PASCO Capstone software to record data. (If there is a stored calibration file that is to be used, select it in the "Calibration" window.)

Start data recording. Turn the crank in a clockwise direction to apply a tension force to the tensile sample. Observe the graph display of force and position. (Note that the default for the Materials Testing Machine in the software shows force and position as 'negative' when a tension force is applied. See Appendix A for information about changing signs.))

When the sample breaks, or is stretched the maximum amount, stop data recording.

Materials Bending Accessory (ME-8237)

The Materials Bending Accessory includes a plunger, a adjustable support anvils, and a small hex key (allen wrench). The plunger is mounted on the bottom of the load bar using the sample nut. The base for the adjustable anvils is screwed onto the top of the load cell.

The spacing between the two triangular support anvils can be adjusted. Use the hex key to loosen the screws holding the anvils and slide them closer together or farther apart. Tighten the screws securely.

Use the sample nut to secure the plunger in place on the load bar. Remove the screws from the base for the anvils and align the base on top of the load cell. Use the screws and the hex key to fasten the base in place.

Place a sample for testing on the two support anvils.

Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar and adjust the position of the shields if needed.

Apply a Force

Turn the crank counterclockwise to apply a compression force through the plunger onto the sample.

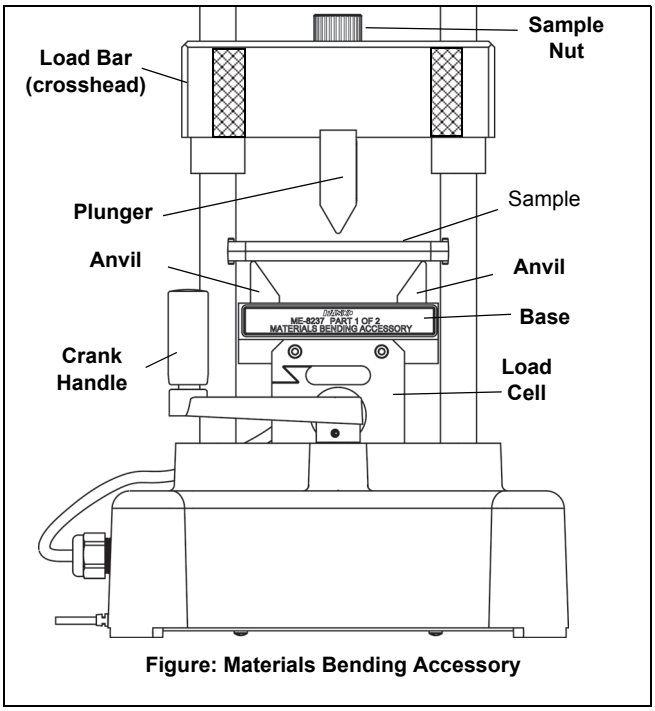
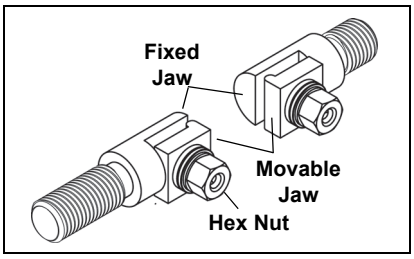


Figure: Materials Bending Accessory

Materials Coupon Adapter (ME-8238)

The Materials Coupon Adapter includes two coupon clamps, a "tee-handle", and a 3/8" socket (12 point). One clamp fits in the load cell and the other fits in the load bar. They can be used to mount a plastic coupon (AP-8222) or metal coupon (AP-8223) onto the Materials Testing Machine for testing of tensile strength.



Loosen but do not remove the hex nut on each clamp. The jaws of the clamp are spring loaded, so the moveable jaw will separate from the fixed jaw. Screw the clamp with the shorter threaded section into the load cell. Put the threaded section of the other clamp up through the hole in the load bar, and use the sample nut to hold the upper clamp. NOTE: Do not completely tighten the sample nut yet.

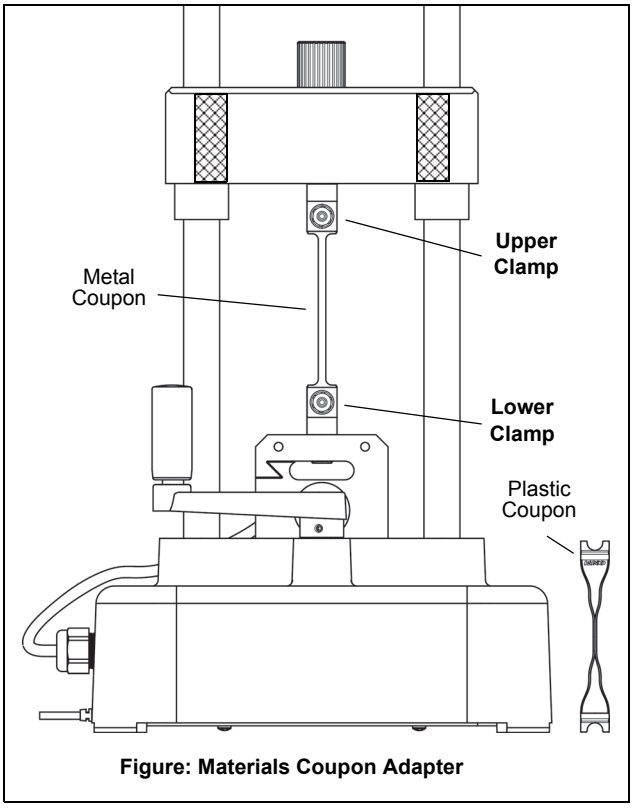


Figure: Materials Coupon Adapter

Carefully place one end of a coupon between the jaws of the bottom clamp. While holding the moveable jaw to keep it aligned with the fixed jaw, use the tee-handle and socket to tighten the hex nut. CAUTION: Each coupon is fragile. Do not let the moveable jaw twist out of alignment with the fixed jaw as this might bend the coupon.

Turn the upper clamp so that it is aligned with the lower clamp. Adjust the position of the load bar so that you have room to carefully put the other end of the coupon between the jaws of the upper clamp. Keep the movable jaw aligned with the fixed jaw so that the coupon does not twist or bend. Once again, tighten the hex nut.

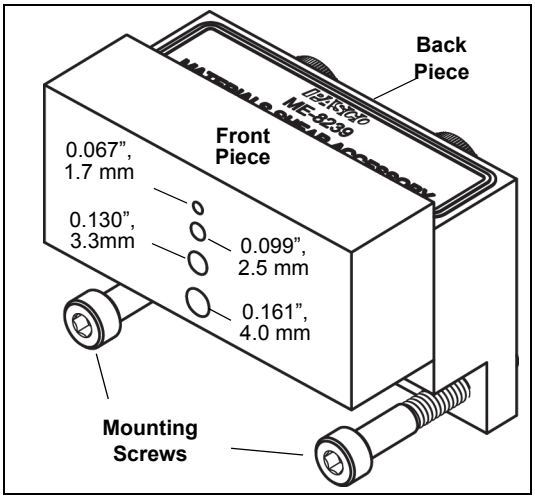
Hold the upper clamp so it remains parallel to the lower clamp and tighten the sample nut slightly to remove any slack in the coupon.

Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar and adjust the position of the shields if needed.

Materials Shear Accessory (ME-8239)

The Materials Shear Accessory consists of two pieces of hardened steel - a front piece and a back piece - held together by a pair of permanent screws, and a package of Materials Shear Samples. The front piece can slide vertically relative to the back piece, which is designed to be mounted on the load cell using an included hex key (allen wrench). The two pieces have pairs of matching holes with four different diameters to fit a variety of samples for testing. The hole diameters are approximately 1/16”, 3/32”, 1/8”, and 5/32”. The Materials Shear Samples includes three 1/8” diameter rods each of three metals: aluminum, brass, and mild steel.
NOTE: **Do not use a sample with a hardness greater than mild steel.**



Use the two mounting screws and the included hex key (allen wrench) to attach the back piece of the Materials Shear Accessory to the top of the load cell. Note that when the front piece is raised by hand as far as it will go, the holes in the front piece align with the matching holes in the back piece.

Insert the test sample through the pair of holes that best match the diameter of the sample. Use a sample that is long enough so that it extends about 1/4” (6 mm) beyond the front and back pieces. Doing this makes it easier to remove the sample remnants from the accessory after the test.

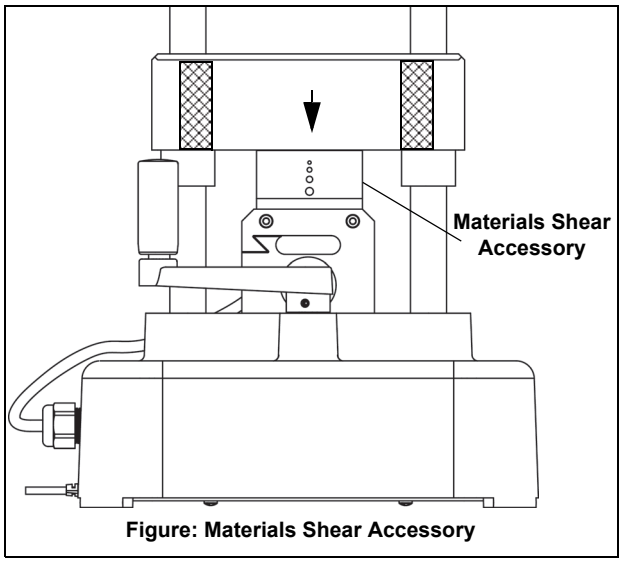


Figure: Materials Shear Accessory

Adjust the position of the load bar so that it rests on the top surface of the front piece.

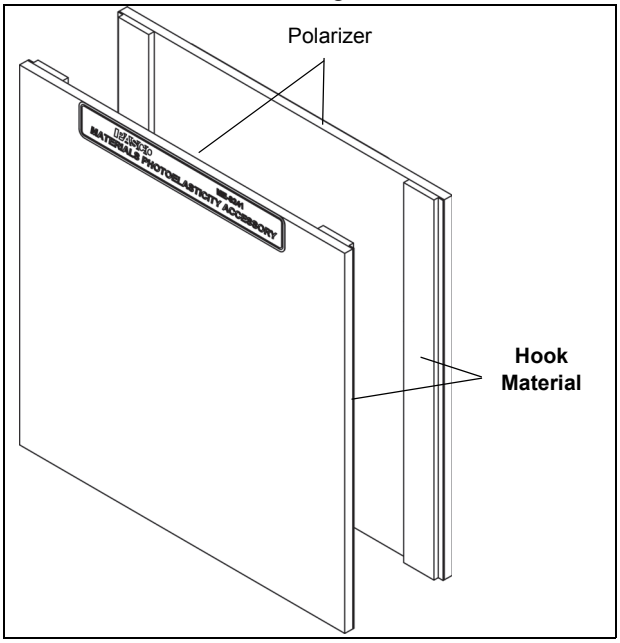
Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar. Adjust the position if needed.

Materials Photoelasticity Accessory (ME-8241)

Clear plastic samples that are viewed through crossed polarizers reveal patterns of different colors that show stress distribution. The Materials Photoelasticity Accessory is designed to demonstrate the photoelastic phenomenon in clear plastic samples.

The Accessory consists of two rectangles of polarizer material that can be attached to the Velcro® loop material on the Load Bar of the Materials Testing Machine.



To place the polarizers on the Load Bar, align a polarizer with the strips of loop material on the front of the Load Bar and press the edges of the polarizer so that the hook material adheres to the loop material. Repeat the process with the second polarizer on the other side of the load bar.

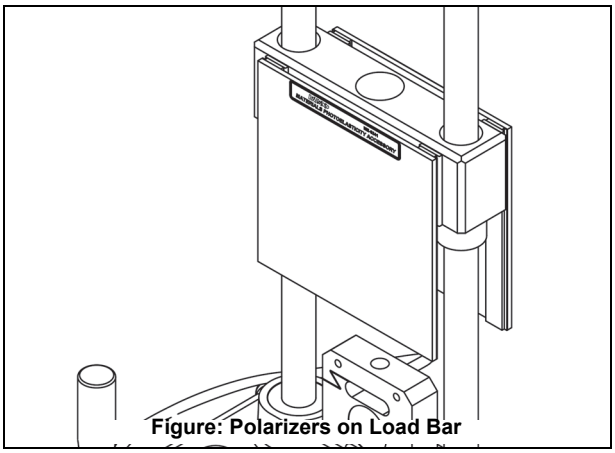


Figure: Polarizers on Load Bar

Place a light source so that it shines through the polarizers from behind.

Materials Structure Beam Adapter (ME-8242)

The PASCO Structures System includes a variety of beams that can be used with the Materials Testing Machine. The beams are models of I-beams and other structure elements. The Materials Structure Beam Adapter is designed to hold a structures beam so that it can be tested under tension and compression.

The Materials Structures Beam Adapter consists of two clamps and an included hex key. Each clamp has two jaws, one of which can be removed so that an end of a structures beam can be put in the clamp. The threaded ends of the two clamps fit in the load bar and load cell of the Materials Testing Machine.

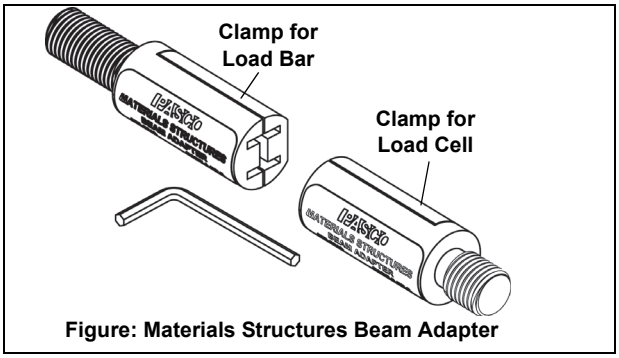
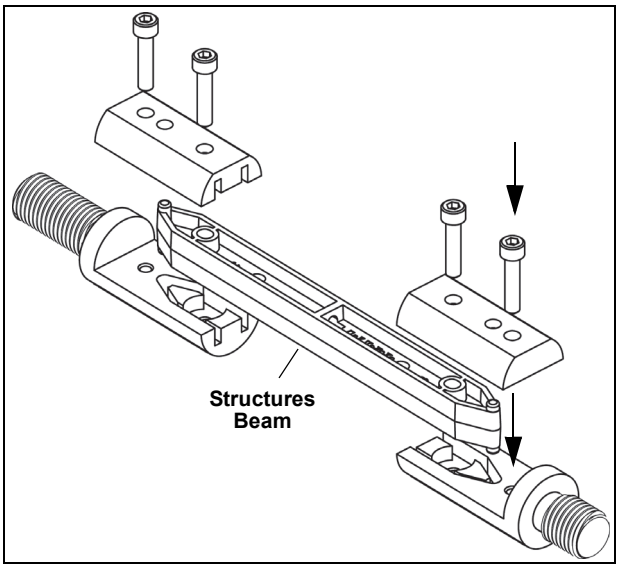


Figure: Materials Structures Beam Adapter

Use the included hex key to remove the screws that hold the two parts of the clamp together. Put the ends of a structures beam, such as a #3 I-Beam, into one part of each clamp, and then use the screws to reattach the other part of each clamp.



Screw the clamp with the short threaded end into the top of the load cell, and put the other clamp through the hole in the load bar. Use the sample nut to secure the clamp to the load bar.

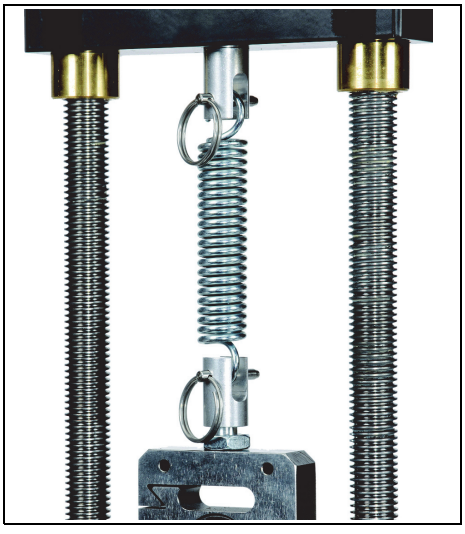
Attach the Safety Shields

Attach the Velcro® hook material on the two safety shields to the Velcro® loop material on the front and back of the Load Bar. Adjust the position if needed.

MTS Clevis Clip (ME-8245)

The Materials Testing System Clevis Clip is designed to tensile test a wide variety of samples that have hooked ends or through holes. The diameter of each clevis pin is 0.187 in (0.47 cm). Each pin contains a pair of small, spring-loaded spheres near its end to keep the pin from slipping out of the clip.

The Clevis Clip with the longer threaded section is mounted in the Load Bar of the Materials Testing Machine, and the Clevis Clip with the shorter threaded section and the hex nut is mounted in the top of the Load Cell.

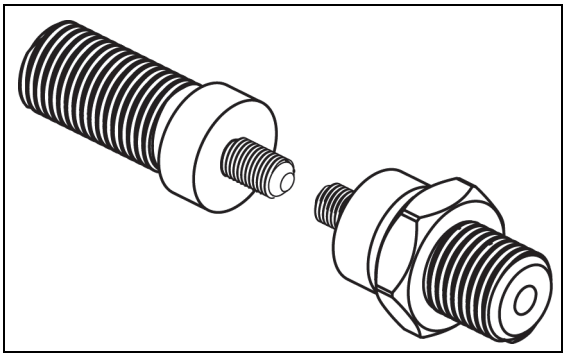


Remember to attach the two safety shields to the Load Bar.

MTS 10 – 32 Adapter (ME-8246)

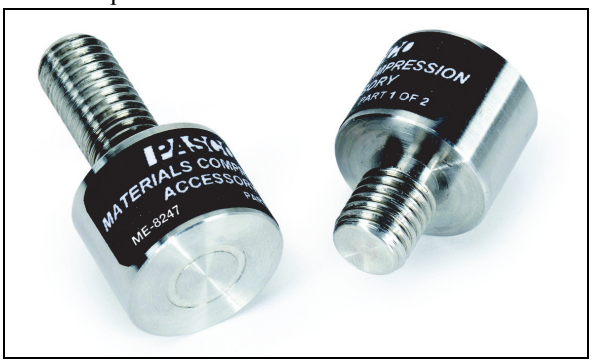
There are several devices used in material testing that hold materials in place and have a threaded 10 - 32 hole designed for mounting the device on a materials tester, such as the Materials Testing System. The Materials 10 - 32 Adapter is designed to connect devices with a threaded 10 - 32 hole to the Load Bar and Load Cell of the Materials Testing Machine.

The 10 - 32 Adapter with the longer larger diameter threaded section is mounted in the Load Bar of the Materials Testing Machine, and the 10 - 32 Adapter with the shorter threaded section and the hex nut is mounted in the top of the Load Cell.



MTS Compression Accessory (ME-8247)

The Materials Compression Accessory is designed to work with the Materials Testing Machine to compress samples. The Compression Accessory consists of two one inch (2.54 cm) diameter platforms that provide a sturdy base for compression samples.

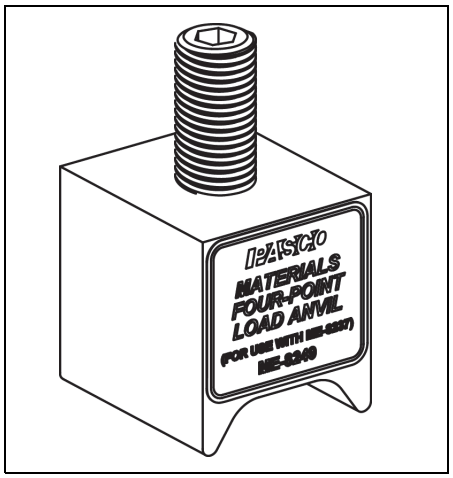


The Materials Compression Accessory includes twenty Materials Compression Samples (ME-8248). The polyethylene cylinders are approximately 0.5 in (1.3 cm) in diameter and 0.75 in (2 cm) long.

MTS Four-point Load Anvil (ME-8249)

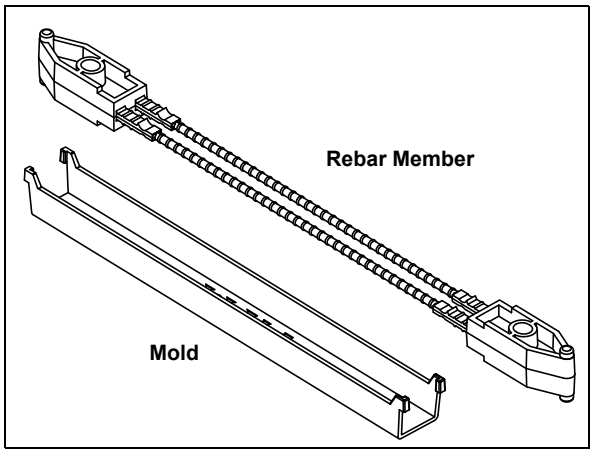
The Materials Four-point Load Anvil extends the capabilities of the Materials Bending Accessory. When used with the Bending Accessory and the Materials Testing Machine, data to find the flexural plastic modulus and the modulus of rup-

ture of tested samples can be measured, recorded, and analyzed.

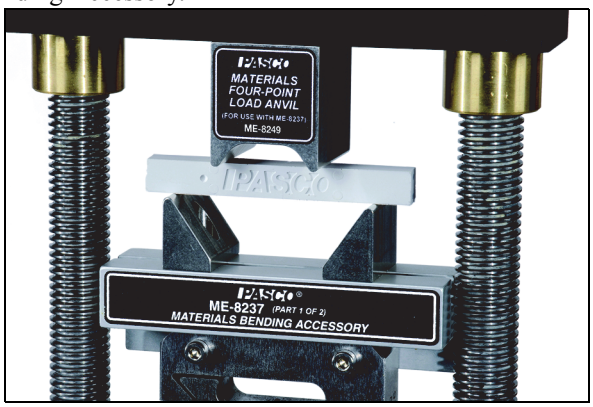


Cast Beam Spares Kit (ME-6983)

The Cast Beam Spares Kit includes 30 “Rebar” members and 10 “molds”. A Cast Beam consists of a beam that is a model of the reinforcement bars (“rebar”) used in construction, and a mold that is used to produce a model of a beam of reinforced “concrete” or prestressed “concrete”. A mixture of fine sand, plaster, and water is poured into the assembled rebar beam and mold. After the mixture hardens and the mold is removed, the beam can be used as a #4 beam in any PASCO Structure Set, or tested on the Materials Testing Machine.



The illustration shows a Cast Beam with the Materials Testing Machine and the Four-point Load Anvil attached to the Bending Accessory.



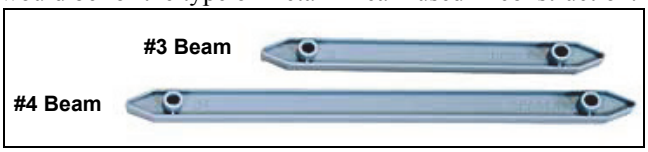
Photoelastic I-Beams (ME-7011)

The Photoelastic I-Beams are similar to the #3 I-Beams and #4 I-Beams that are part of the PASCO Structures Systems (such as the Truss Set, ME-6990). However, the Photoelastic I-Beams differ in that they are clear polycarbonate plastic and do not have any holes in the web area of the beam. They can be mounted on the Materials Testing Machine using the Materials Structures Beam Adapter. When viewed with the Materials Photoelasticity Accessory, the distribution of stress in the beams can be studied.

The set includes twenty-four each of the two sizes of I-beams. The #3 I-Beam is 11.5 cm long, and the #4 I-Beam is 17 cm long.

Thin I-Beams (ME-7012)

The Thin I-Beams set consists of 48 thin I-Beams of two sizes: #3 Beam (24) and #4 Beam (24). The beams are like those in the PASCO Structures Systems, but there are no holes in the web area. Therefore, when used with the Materials Testing Machine, the test results are more like the results would be for the type of metal I-Beam used in construction.



Maintenance

Regular maintenance for this equipment is minimal. The leadscrews need to be kept clean, and they may need to be re-lubricated at some point. Use a food grade anti-seize grease containing PTFE (polytetrafluoroethylene, commonly known as Teflon®).

If problems arise with the Materials Testing Machine, notify PASCO scientific. It is not recommended that you attempt to fix this equipment yourself. (See the Technical Support information at the end of this manual.)

Specifications

Item	Description
Load Cell capacity	7100 N (1600 lbs)
Load Cell maximum	100% of capacity

Experiment Guide

NOTE: An Experiment Guide in electronic format is available to download from www.pasco.com. The Experiment Guide includes information about the calibration procedure and also describes the available Capstone Workbook files for the Materials Testing Machine.

Enter “Materials Testing System” in the Search window and look for the downloadable file(s) under “User Resources”.

The list of Capstone Workbook files for the Materials Testing Machine includes the following. Each lab is available as

a downloadable ZIP folder containing a PDF setup file and a Capstone data file:

Sample Labs

- Lab 01: Intro to Materials Tester
- Lab 02: Compliance Calibration Tutorial
- Lab 03: Tensile Testing - Brass
- Lab 04: Young's Modulus
- Lab 05: Tensile Testing - Annealed Steel
- Lab 06: Tensile Testing - Metal Coupons
- Lab 07: Tensile Testing - Plastic Coupons
- Lab 08: Tensile Testing - Plastic Samples
- Lab 09: Three Point Bending
- Lab 10: Round Rod Bending
- Lab 11: Bend Testing Beams
- Lab 12: Tensile Testing Beams
- Lab 13: Column Buckling and Slenderness Ratio
- Lab 14: Euler Column Buckling

Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific
10101 Foothills Blvd.
Roseville, CA 95747-7100

Phone: +1 916-462-8384 (worldwide)
877-373-0300 (U.S.)

E-mail: support@pasco.com

Web www.pasco.com

For the latest information about the Materials Testing Machine or the replacement items and accessories, so to the PASCO web site at www.pasco.com and enter the model number in the search window.

Product End of Life Disposal Instructions:

This electronic product is subject to disposal and recycling regulations that vary by country and region. It is your responsibility to recycle your electronic equipment per your local environmental laws and regulations to ensure that it will be recycled in a manner that protects human health and the environment. To find out where you can drop off your waste equipment for recycling, please contact your local waste recycle/disposal service, or the place where you purchased the product.

The European Union WEEE (Waste Electronic and Electrical Equipment) symbol (to the right) and on the product or its packaging indicates that this product must not be disposed of in a standard waste container.

Appendix A: Calibration

General Information: Pre-Calibration

Lab 02: Compliance Calibration Tutorial

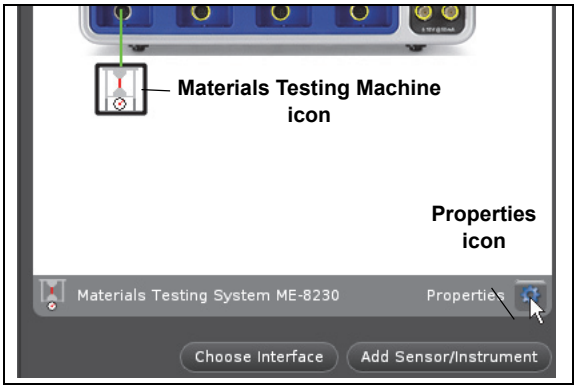
REMINDER: A PASCO Capstone workbook file about compliance calibration is available to download from the PASCO web site. Go to www.pasco.com and enter "Materials Testing System" in the Search window. In the web page that opens, select *Materials Testing System*. Click "**Sample Labs**" and then download the ZIP file for Lab 02.

Information covered in the "Lab 02 Compliance Calibration Tutorial" includes:

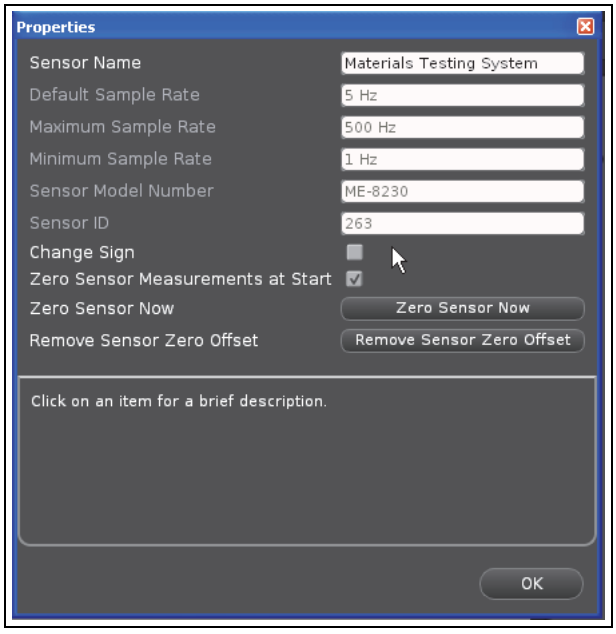
- How a compliance calibration works.
- How to create, save, and delete calibrations.
- Hints and practice in making an accurate calibration.

Optional: Change Sign

NOTE: The default for the Materials Testing Machine in the software is a negative value for force and position as 'negative' when a tension force is applied. Although it is possible to use the Materials Testing Machine with negative values for force and position, it is easier to change the sign convention to be positive while you use the "Calibration Wizard" for the calibration procedure.



- To change the sign for the force and position data, click the "Hardware Setup" icon in the Tools palette.
- In the Hardware Setup window, click the "Properties" icon (shaped like a gear wheel) to open the "Properties" window for the Materials Testing Machine.
- In the "Properties" window, note that the default for the "Change Sign" is an un-checked box. This means there is a positive value for both position and force when the Load Bar is moving down, as in a *compression*.
- If you want positive values for both position and force when the Load Bar is moving up, as in *tension*, click the check box for "Change Sign".
- Click **OK** to close the "Properties" window.
- Click the "Hardware Setup" icon to close the "Hardware Setup" window.



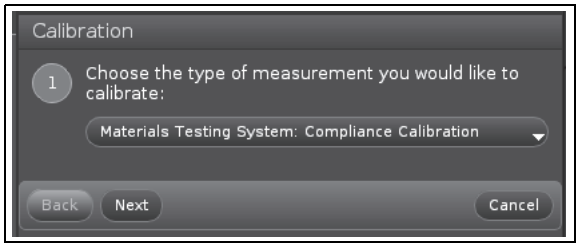
Prepare to use the software to calibrate the Material Testing Machine.

Calibration Procedure

The following steps describe how to use the "calibration wizard" in PASCO Capstone to create a compliance calibration for the Materials Testing Machine. Please preview the steps to become familiar with the procedure *before* doing the calibration.

Step One: Choose the Type of Measurement to Calibrate

In the Capstone software, select the "Calibration" icon ( ) in the Tools palette to open the "Calibration" window.



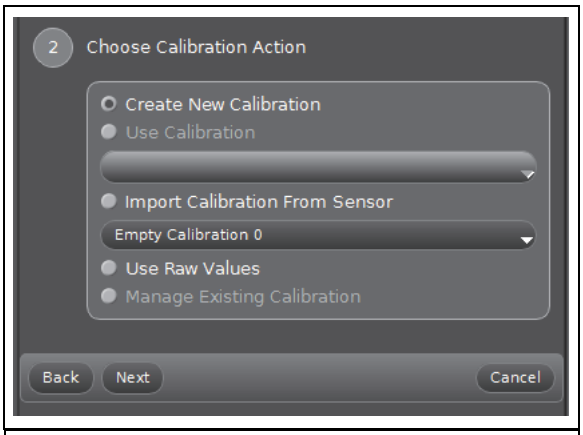
There are two types of calibration for the Materials Testing Machine. One is a simple calibration of the force measured by the Load Cell. The other, the default choice, is "Materials Testing System: Compliance Calibration". Use this choice to setup the program to automatically make corrections on position data.

- Click **Next** to show Step Two, the "Choose Calibration Action" menu.

Step Two: Choose Calibration Action

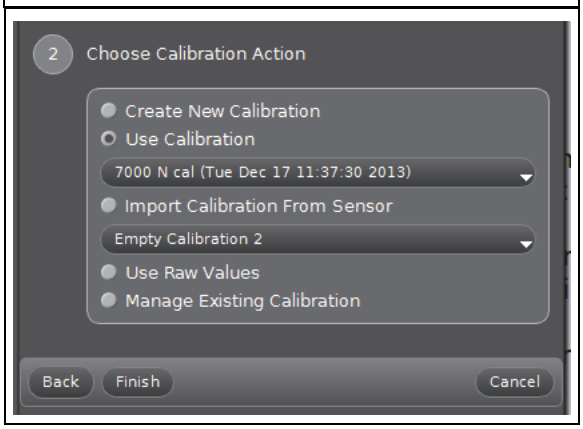
There are several choices in "Create New Calibration" that allow you to create, select, save, modify, and delete calibrations.

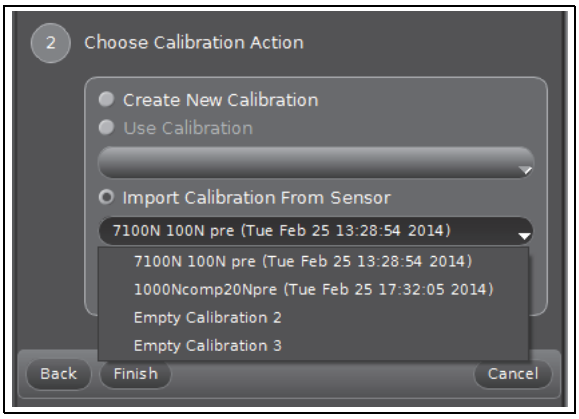
- **Create New Calibration:** This is the default choice. In this selection, the "calibration wizard" will take you through the steps needed to create and save a new compliance calibration. This includes prompting you to install the calibration rod (Step Three), record a data run on the graph provided (Step Four), and create a polynomial curve fit (Step Five) that will be stored as your compliance calibration.



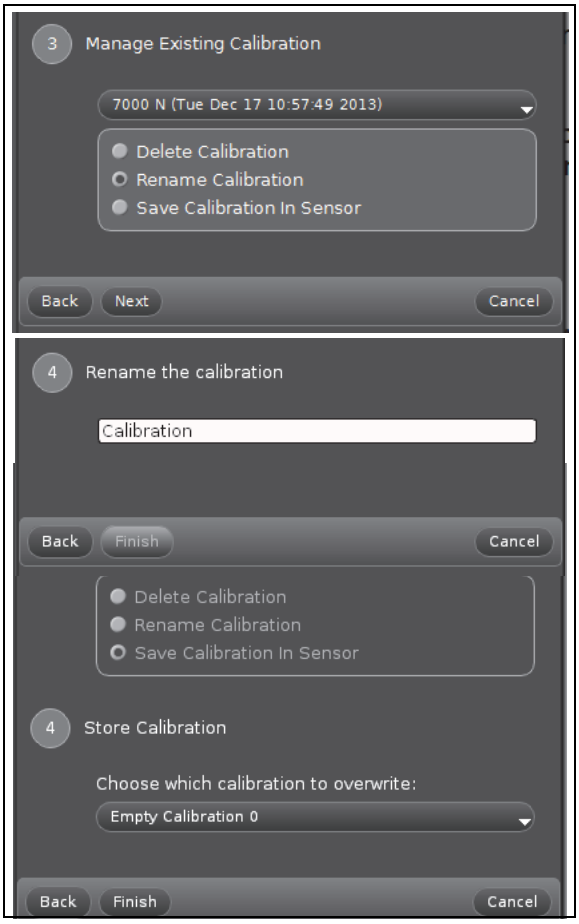
The following is a description of the other Calibration Action choices.

- **Use Calibration**: If the text window below "Use Calibration" is blank, it means that there is no "active" calibration being used. However, if any compliance calibrations have been saved previously in this Capstone file, they will be displayed in the pull down menu (click the down arrow). (The previously saved compliance calibration "7000 N cal (Tue Dec 17 11:37:30 2013)" is shown as an example.) If you select a previously saved compliance calibration from the pull down menu, it becomes the "active" calibration. When you click **Finish**, the selected calibration will be used to make the compliance correction to any *future* data you collect.





- **Import Calibration From Sensor:** If any compliance calibrations have been stored in the Materials Testing Machine (the "Sensor"), they will be displayed in the pull down menu. (The stored calibration "7100N 100N pre (Tue Feb 25)" is shown as an example.) If you click **Finish**, the selected stored calibration will be imported and added to the list for use. It will also become the "active" calibration. NOTE: Calibrations stored in the Material Testing Machine (the Sensor) can not be used or renamed until they are imported.
- **Use Raw Values:** If this choice is selected and you click **Finish**, the selected compliance calibration (if any) is temporarily disabled. Any future data collected will not be adjusted. NOTE: The calibration is still saved.



- **Manage Existing Calibration:** If this choice is selected and you click **Next**, Step 3 is revealed as shown in the illustration. Your choices are: Delete Calibration, Rename Calibration, or Save Calibration in Sensor (the Materials Testing Machine).
- If you wish to delete a calibration, select the calibration you want to delete from the pull down menu and then select "Delete Calibration". Click **Finish** to delete the calibration.
- If you select "Rename Calibration" (the default choice) and click **Next**, a text window opens and you can enter a new name for a calibration. ADVICE: Create a name that includes the maximum force used. It is also helpful to record any pre load that is used. Click **Finish** after entering a name.
- If you select "Save Calibration in Sensor" and click **Next**, the window shows "Store Calibration" and "Choose which calibration to overwrite". The default view of the pull down menu shows "Empty Calibration 0". If you click **Finish**, the calibration you wish to store will take the place of "Empty Calibration".

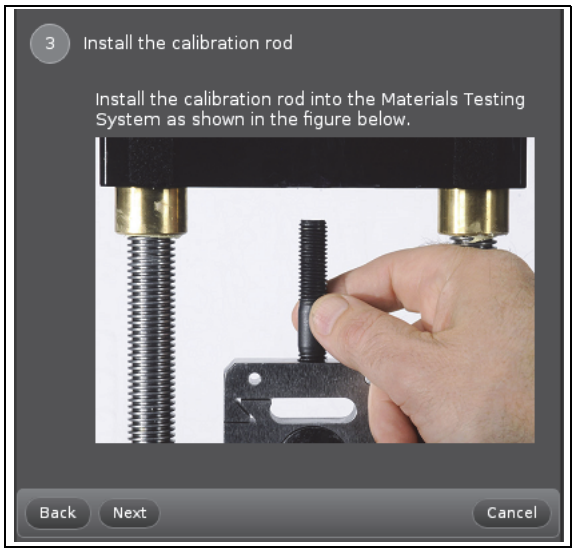
CAUTION: Only four calibrations can be stored in the Materials Testing Machine. If you already have four calibrations stored, and you wish to store another calibration, you will be prompted to select which calibration you want to replace.

NOTE: You can have any number of calibrations saved as part of the *Capstone file.* When you name your calibration as in Step Six "Name the calibration" (see below), create a name that includes the maximum force used. It is also helpful to record any pre load that is used. When the saved Capstone file is re-opened, the calibrations will still be available.

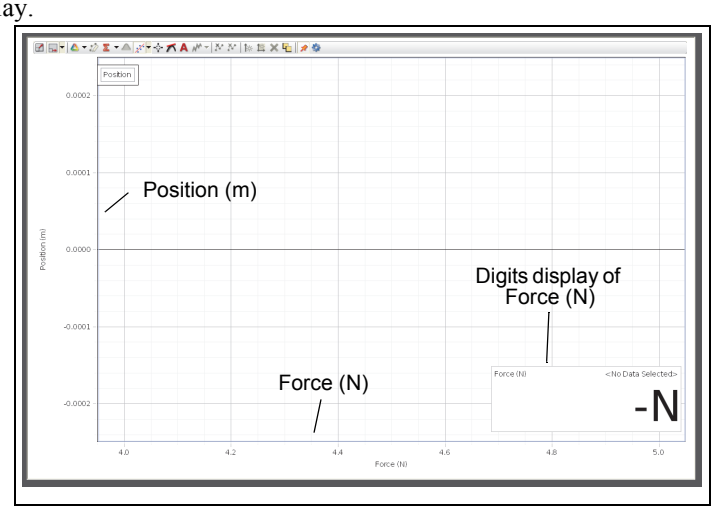
- After you have made your Calibration Action choice (REMINDER: "Create New Calibration" is the default), click **Next** to show the illustration in Step Three, "Install the calibration rod".

Step Three: Install the Calibration Rod

The ‘calibration wizard” changes to show an illustration about how to install the calibration rod.



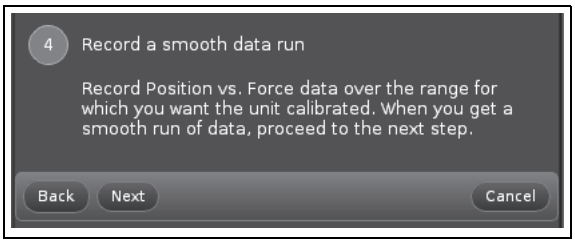
In addition to the illustration, a Graph display of Position (m) versus Force (N) opens. A Digits display of Force (N) is part of the Graph display.



- Click **Next** to show Step Four: “Record a smooth data run”.

Step Four: Record a Smooth Data Run

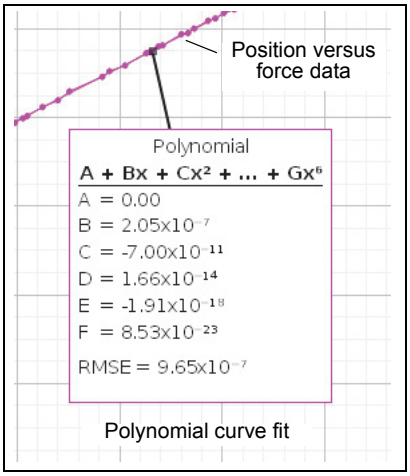
NOTE: To make a calibration that will accurately correct for compliance, it is necessary to calibrate the Materials Testing Machine over the same range of force and the same conditions you expect to use when you are testing your samples.



- Click **Record** and collect a smooth run of position versus force data.
- When the data collection is finished, click **Stop**.

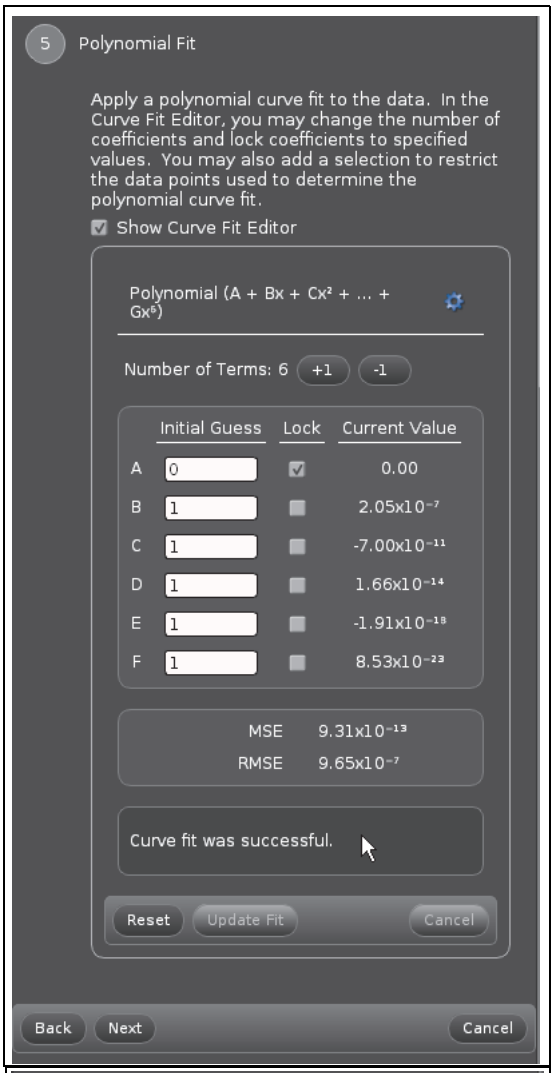
REMINDER: If the run of data is not smooth, delete the run and try again.

NOTE: A Polynomial curve fit is automatically applied to the run of position versus force data.



- Click **Next** to open Step Five, “Polynomial Fit”.

Step Five: Polynomial Fit



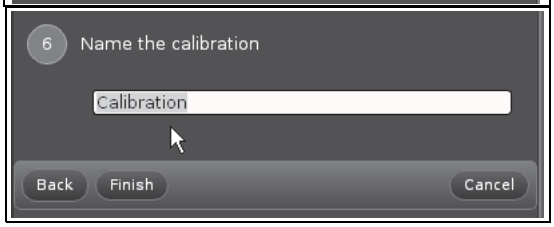
NOTE: By default, the "Show Curve Fit Editor" window is open in the "Polynomial Fit" window. The Curve Fit Editor window shows the default values for the coefficients of the polynomial.

In the Curve Fit Editor window you can change the "Number of Terms", enter an "Initial Guess" for each coefficient and lock or unlock a coefficient value.

- If the message "Curve fit was successful" is shown, click **Next** to open Step Six, "Name the calibration".

NOTE: If the curve fit was not successful, use "trial-and-change" in the Curve Fit Editor to adjust the coefficients until the curve fit is successful. Click "Update Fit" to determine if the new coefficients made a better curve fit

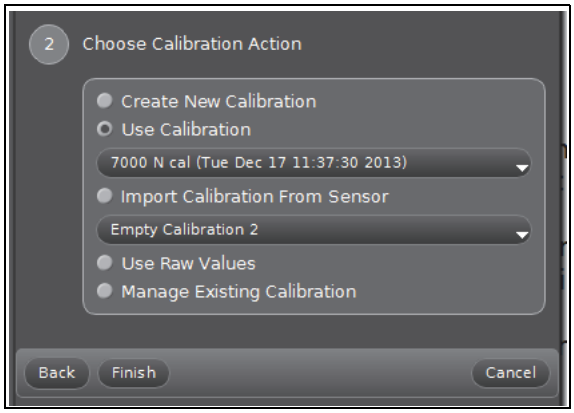
Step Six: Name the Calibration.



- Type a name for the calibration in the text area. (Example names might be "Calibration 7000" or "Tension Calibration".)
- Click **Finish** to store the calibration as part of the Capstone file.

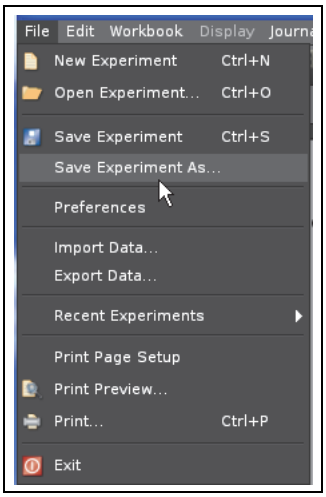
Finishing Step

NOTE: The "Calibration" window goes back to Step One. When you click **Next**, the "Choose Calibration Action" window (Step Two) will show a menu of the saved and/or stored calibration(s).



- Click "Use Calibration" and select a specific saved calibration from the pull down menu below "User Calibration", or click "Import Calibration From Sensor" to load a selected stored calibration from the pull down menu below "Import Calibration From Sensor".
- Click **Finish**. The "Calibration" window goes back to Step One.
- Click the "Calibration" icon in the Tools palette to close the "Calibration" window. Save the Capstone file for future use.

- From the “File” menu, save the Capstone file for future use.



Appendix B: “Seating” a Test Sample and Setting a Pre-Load

In the following procedure, a test sample is stretched and relaxed to properly “seat” the sample (remove any slack) and a pre-load is set.

“Seat” the Sample

1. Mount a test sample onto the Materials Testing Machine. Make sure that the Load Bar Round Nut is slightly loose and not applying a force on the test sample.

2. In the Capstone software, set up a Graph display of Position versus Force, and a Digits display of Force.

3. Click **Record**.

- NOTE: If the position and force data on the graph are not zero, check the “Properties” window in the “Hardware Setup” panel. The check box for “Zero Sensor Measurement at Start” should be checked.

4. Turn the crank clockwise about a quarter of a turn and note that the position and force data are being plotted on the Graph display.

5. With data still being recorded, slowly turn the crank back counter-clockwise. Watch the Digits display, and turn the crank to reduce the force to between 10 and 20 N. Don’t let the force go back to zero.

6. Turn the crank clockwise to increase the force as before. Notice how the second plot of data looks on the graph compared to the first. If the second plot of data “tracks” on top of the first plot, then the sample is properly “seated” and you can click **Stop**. *If not*, repeat the process of applying force and then unloading the force.

- NOTE: Usually it is necessary to load and unload the system several times to remove all the slack and “seat” the test sample.

7. When two consecutive plots of data track on top of each other, the test sample is properly “seated”. Click **Stop**.

Set a Pre-Load

8. Click Record to begin collecting data and increase the force back up to 100 N. Click Stop and DO NOT change the crank position. Since the Materials Testing Machine is set to automatically zero itself the next time you start recording data, this puts a pre-load of 100 N on the sample, which results in better data.