EXHIBIT D

(Part 4 of 5)

c. Press the BREAK key to set the displays to show load, extension and strain values at specimen break. This can be done at any time, either before, during, or at the end of a test when the values are stored. During a test, the displays will remain blank until a break condition occurs. The BREAK lamp is lit when this function is active.

d. Press the PEAK BREAK key to set the LOAD display to show peak load value for a test and the EXTENSION and STRAIN displays to show values at specimen break. This can be done at any time, either before, during, or at the end of a test when values are stored. The PEAK BREAK lamp is lit when this function is active.

e. Press the RESET PEAKS key during a test to reset stored peak values of load, extension and strain to values at the current load. Peak storage is then updated to values at the next peak load. This key does not change which values are selected to be displayed (Break, Peak or Track) and is active only during a test.

8.7 LIMITS PANEL

8.7.1 Description

The optional Limits Panel allows the user to specify a crosshead action to be independently assigned to the maximum and minimum values of load, extension and strain that occur during a test, and to specimen break. Limits for the two strain channels (1 and 2) must be set independently.

The action assigned at a limit can be:

STOP - stop crosshead at current position.

RETURN - return crosshead to gage length.

CYCLE - cycle crosshead between limits.

OFF - no action

Limits are set and crosshead action assigned before starting a test. The limits are entered into the system through the numeric keypad and are viewed on the Basic Panel Display.

An indicator lamp lights at the active limit and at the corresponding crosshead action key. A STATUS indicator lamp is lit whenever a limit is set to control a crosshead action. The lamp flashes after the limit is reached and the action occurs, except at CYCLE and OFF.

Descriptions of the Limits Panel control functions are in Table 6-3.

8.7.2 Operation

IMPORTANT NOTES

1. For either the load or strain (1 or 2) channel limits to be enabled, the respective channel must be calibrated.

2. For the strain limits to be enabled when a Recorder Panel is installed, the recorder X-axis selection control (X-Y RECORDER SELECT) on the panel must be set to STRAIN.

3. When system operating units are changed (Section 6.9.1), any Load, Extension and Strain (1 and 2) limits previously set on the Limits Panel default to "0" and the related crosshead action defaults to "OFF". Any STATUS lamp which is lit to indicate an active load, extension or strain channel limit will go out. Each limit must be reset using values stated in terms of the

new operating units, and the crosshead action selected.

4. When the operating mode for the Strain 1 and 2 channels is changed (Section 8.11.2), any Strain 1 or 2 limits previously set on the Limits Panel default to "0" and the related crosshead action defaults to "OFF". The STATUS lamp, which may be lit to indicate that the limits for a selected strain channel are active, will go out. Each limit must be reset using values stated in terms of the new operating mode, and the crosshead action selected.

5. When Area Compensation is in use, the gain of the load signal actuating the Load Limits is divided by the normalized mantissa (base number) of the area value (see Section 7.8.4). Hence, when Area Compensation is not equal to 1.000, the Load Limits should be set based on the normalized value of stress.

EXAMPLE

Maximum stress limit = 100 psi
Area compensation (normalized) = 2.0
Set LOAD LIMIT MAX to 100 (NOTE: Actual load = 200 lb.)

CAUTION

Before setting stress limits, the user should be familiar with the limitations due to load cell capacity as described in Appendix A, Section A.8.3.

To set a limit and a crosshead action:

a. Press the LOAD, EXTENSION or STRAIN limit key (MIN or MAX) for the required limit. The related lamp will light and the current limit value will appear on the Basic Panel Display. If a STRAIN limit is to be set, select the channel (STRAIN 1 or 2) on the Basic Panel to which the limit will apply.

b. Enter the value, and the sign if negative (see NOTES 1 and 2 below), of the limit on the keypad. The displayed number will flash until it has been entered into the system.

NOTES

1. If the sign (+ or -) of the output signal of the load cell (or strain transducer) in use is negative (-) with increasing load (or strain), then a limit value (maximum or minimum load or strain) must also be negative. Press the ± key on the keypad to obtain the correct sign when setting a limit.

2. If the sign (+ or -) of the output signal of the load cell (or strain transducer) in use is negative (-) with increasing load (or strain), the 4200 system considers the most negative value as the minimum load (or strain). For example: If load limits of -300 lb and -100 lb are specified for a test, set the minimum load (LOAD MIN key) to -300 lb, and the maximum load (LOAD MAX key) to -100 lb.

c. Press ENTER on keypad. The number will stop flashing.

d. Press the CROSSHEAD ACTION key for the limit just entered. Indicator lamps (ACTION and STATUS) for the limit will light.

e. To set a crosshead action to occur at specimen break, press the BREAK key and then a CROSSHEAD ACTION key.

EXAMPLE

Crosshead to stop at a maximum load of 200 lb, and to return to gage length if specimen breaks.

Enter key sequence:

[LOAD MIN] [2] [0] [0] [ENTER] [STOP] [BREAK] [RETURN]

Whenever one of the six limit condition lamps, or the break lamp, is lit, one of the four crosshead lamps will be lit. The crosshead action may be changed by pressing another action key.

NOTE

If the crosshead action is to CYCLE between LOAD limits during a compression test and the load cell in use has a positive (+) output signal for an increase in load (2511-200 series), set TESTING AREA to ABOVE XHEAD (Section 7.8.6).

The limit settings may be checked by pressing each limit key and reading the setting on the Basic Panel Display.

CAUTION

Always verify that the limit settings and crosshead actions are properly set before starting a test. Also, always ensure that limit settings are within the maximum capacity of the load cell in use.

When a limit or specimen break causes a crosshead action, the related STATUS lamp will flash to inform the user why the action occurred (except at the CYCLE and OFF actions). The lamp will stay flashing until the next test is started.

8.8 PRINTER

8.8.1 Description

The printer option for a 4200 series system provides a hard copy record of test parameters and results. This printer features up to 80 characters on a line, which may consist of letters, numbers or special symbols, printed at a rate of about 100 characters per second. The printout includes the name, value and units of several parameters, as described in Section 8.8.4.

The printer is set up for and supplied with $9^1/_2$ x 11 inch fanfold paper. Additional pads of paper are available from Instron.

8.8.2 Installation

To use the printer with the 4200 system, plug the cable (A459-97) provided with the unit into connector, J3 (PRINTER), on the connector panel at the rear of the console.

The printer and the 4200 system are set up at the factory for a baud rate of 1200. A baud rate of 300 can be selected, if required. To change baud rate in the printer, refer to the manufacturer's manual provided with the unit.

To change baud rate in the 4200 system, requires changing a switch position in the control console. An 8-section DIP switch assembly (S5) is located on the lower right-hand corner of the motherboard (reference Figure 6-11). The No. 4 switch of the S5 assembly, marked 1200 BAUD, controls the system baud rate as shown in Figure 8-1. The switch is accessed by removing the left rear corner panel of the console, as described in Section 6.9. Note the

position of the NO. 4 switch for 1200 baud. To change to 300 baud, push down on the OPEN side of the switch with a sharp pointed tool. It is not necessary to shut power off.

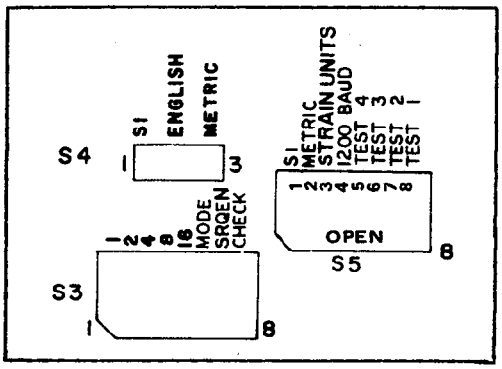

Figure 8-1. Baud Rate and Strain Units Switch, S5

(The S3 and S4 switch assemblies are shown in Figure 8-1 for location purposes only. The S3 assembly sets the addressing of the IEEE-488 option and is described in a separate manual. The S4 switch controls the system operating units, as detailed in Section 6.9.1.)

8.8.3 Operation

An Operating Instructions manual is supplied with the printer. This section provides the additional procedures required to use the unit with a 4200 series system.

a. To obtain a printout at any time, press the PRINT key on the Basic Panel.

b. To obtain a printout automatically at the end of a test, enter the key sequence [S1] [6] [±] on the keypad. The Basic Panel Display must show "SL 6" for this option to be enabled, and "SL-6" to be disabled. Toggle the "±" key to set the condition required. A printout will occur after every test as long as the option is enabled.

NOTE

All crosshead commands are locked out during a printout.

8.8.4 Printout Format

The format of the Printer output consists of up to seven lines and five fields, depending upon parameters and actions that are included or omitted as described below.

The printout format is:

Line 1 - indicates the current active units for Load, Extension, Strain 1 or Strain 2, and Energy. If Strain is not installed, the Strain field (No. 4) is omitted.

Line 2 - lists Peak data.

Line 3 - lists Break data. If specimen break did not occur, line 3 is omitted.

Line 4 - Preset Point 1 data. If Preset Points are suppressed, line 4 is omitted.

Line 5 - Preset Point 2 data. If Preset Points are suppressed, line 5 is omitted.

Line 6 - Crosshead Speed and Area (Area Compensation).

Line 7 - Energy (total). If Energy is suppressed, the Energy field (No. 5) and line 7 are omitted.

8.8.5 Printer Units

The units that appear on a printout depend upon the selection of operating units (English, metric, SI), as described in Section 6.9. In addition, the printed units for Strain depend upon the type of extensometer installed (self identified or non-self identified) and the strain operating mode - percent or displacement - (see Section 8.11.2).

The units that will appear in the printout of the Strain field are shown in Table 8-4.

Table 8-4. Strain Units Printout

Extensometer Type	Strain Mode	Strain Units
Self Identified	Percent	%
	Displacement (Eng)	MILS
	Displacement (Met)	MM
Non-Self Identified	All	SN

Besides the system operating units, the printed units for Energy and Preset Points depend upon the independent variable (extension or strain), and, if strain is the independent variable, the extensometer type (self identified or non-self identified). The units that will appear in the printout of the Energy field and for Total Energy are shown in Table 8-5.

Table 8-5. Energy Units Printout

Independent Variable	Extens. Type	Energy Units
Extension - English	-	LB*EX IN/A (NOTES 1 & 3)
- Metric		KGF*EX MM/A
- S.I.		KN*EX MM/A
Strain - English	Self Ident.	LB*S1 MILS/A (NOTES 2 & 3)
- Metric		KGF*S1 MM/A
- S.I.		KN*S1 MM/A
	Non-Self Ident.	(See NOTE 4)

NOTES
(Reference Table 8-5)

1. When a non-self identified load cell is used, "LD" will be printed instead of "LB", "KGF" or "KN".

2. If Strain 2 is the active channel, "S2" will be printed instead of "S1".

3. The units for Energy and Total Energy will be printed showing division by "A" only when Area Compensation is not equal to 1.000.

4. When a non-self identified extensometer is used, "SN" will be printed instead of "MM" or "MILS".

Figure 8-2 shows a typical printout with Strain as the independent variable and Strain 1 as the active channel. Figure 8-3 shows a typical printout with Extension as the independent variable. (Note that AREA is greater than 1.000 in both printouts, so the Load and Energy fields show division by "A".)

	LB/A	IN	MILS	LB*S1 MILS/A
PEAK=	-1.616E02	5.469	23.54	-7.690E00
BREAK=	-9.745E01	5.482	23.54	-7.690E00
PPT1=	-2.953E-01		10.00	-2.870E00
PPT2=	-2.953E-01		20.00	-5.827E00

SPEED= 5.000 IN/MIN AREA= 2.000E-01

TOTAL ENERGY= -7.737E00 LB*S1 MILS/A

Figure 8-2. Printout with Strain as Independent Variable

	LB/A	IN	MILS	LB*EX IN/A
PEAK=	-2.315E02	3.453	23.97	-4.019E02
BREAK=	-2.303E02	3.466	24.00	-4.057E02
PPT1=	-6.679E01	1.000		-3.874E01
PPT2=	-1.830E02	3.000		-3.095E02

SPEED= 5.000 IN/MIN AREA= 2.000E-01

TOTAL ENERGY= -4.070E02 LB*EX IN/A

Figure 8-3. Printout with Extension as Independent Variable

NOTES

1. The Load, Energy, Total Energy and Area values are always printed with the exponent shown in the floating point format; where, for example, E01 = 10^1 = 10 and E-01 = 10^{-1} = 0.1.

2. If Strain 1 or Strain 2 is installed but not calibrated, an "SN" will be printed instead of units in the Strain field and a "----" instead of strain values.

8.9 PRESET POINTS

8.9.1 Description

The Preset Point option allows the user to specify the values of up to two independent variables at two preset points for recording the values of two dependent variables. Preset Points are accessible if the Printer option or the IEEE-488 option is in use.

The Preset Points are set to trip on a specific value of either extension or strain. When this value is reached, the system automatically records the values of load and energy at those points. Figure 8-4 is a typical test curve showing the data obtainable at preset points.

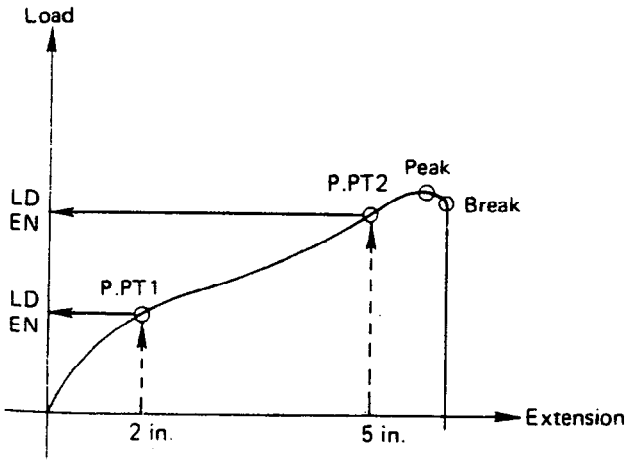

Figure 8-4. Typical Test Curve with Preset Points

8.9.2 Operation

The procedure required to use the preset points option is to set the independent variable, set the preset point values, and then enable the option to get a printout at the end of a test. The default condition of the independent variable is the active strain channel (1 or 2) or extension if the strain option is not installed.

To set the independent variable, enter the sequence on the keypad:
[S1] [5] [±].

The Basic Panel Display will show either,

SL-5 for Strain, or

SL 5 for Extension

Toggle the [±] key until the required display appears.

NOTE

The key sequence [S1] [5] [±] .... [±] also toggles the Energy integration variable between extension and strain.

The default values of the Preset Points (PPT1, PPT2) are:

	PPT1	PPT2
Extension (in)	1	3
Extension (mm)	20	60
Strain (%)	100	300

To set other values within the range of the load or strain transducer in use, enter the key sequences:

[S1] [41] PPT1 [ENTER]

[S1] [42] PPT2 [ENTER]

Where PPT1 and PPT2 are indicated, enter the actual numerical value of the independent variable: Extension in inches or millimeters; or Strain in either percent, mils or millimeters (see Section 8.11.2).

To obtain a printout of load and energy (see Section 8.10) at the preset points, enter key sequence:

[S1] [4] [±]

The Basic Panel Display will show either,

SL-4 to suppress printout, or
SL 4 to enable printout.

Toggle the [±] key until the required display appears.

The printed values are always expressed in the current operating units (see Section 6.9).

NOTE

The key sequence [S1] [4] [±] does not disable the Preset Point function of the IEEE-488 supervisory program.

8.10 ENERGY

8.10.1 Description

The Energy option allows the user to obtain at the end of a test: the total energy under the load curve, the values at Peak and Break, and the values at two preset points (Section 8.9). Energy is defined as the integral of composite load (analog load divided by analog area) and extension or strain. Recorded values may range from 1.000E-04 to 2.147E05.

Energy is accessible if the Printer option or the IEEE-488 option is in use. The units of energy are described in Section 6.9.5, and the printed units are described in Section 8.8.5.

8.10.2 Operation

The procedure required to obtain energy readouts is to set the independent variable, and then enable the energy option so a printout can be obtained at the end of a test. The default condition of the independent variable is the active strain channel (1 or 2) or extension if strain is not installed.

To set the independent variable, enter the following sequence on the keypad:

[S1] [5] [±].

The Basic Panel Display will show either,

SL-5 for Strain, or

SL 5 for Extension

Toggle the [±] key until the required display appears. (This action also toggles the independent variable for Preset Points, as described in Section 8.9.2.)

To obtain a printout of energy values at the end of a test, enter the key sequence:

[S1] [3] [±]

The Basic Panel Display will show either,

SL-3 to suppress printout, or

SL 3 to enable printout.

Toggle the [±] key until the required display appears.

8.11 STRAIN MEASUREMENT

8.11.1 Introduction

Strain measurement on a 4200 system requires an optional Strain Sensor Conditioner Board to be installed in the control console. There are three types of these boards available, as listed in Table 8-1. The conditioner board for strain gage extensometers is normally installed in the Strain 1 channel, and the XL type and LVDT type

extensometer conditioner boards are installed in the Strain 2 channel of the system. Complete installation instructions are included with the strain measuring options.

NOTE: When using an XL extensometer for strain measurement with a Micro-con II, The XL conditioner board, A504-17, must be installed in the Strain 1 channel (see Figure 5-8).

The functions of these boards are similar to the Load Sensor Conditioner Board described in Section 3.5.1. The output is an unranged, or automatically ranged, 0 to 10 vdc full scale strain signal. The calibration procedure for a strain channel completes an operating reliability check of a Strain Sensor conditioner Board (see Self Test Routine, Section 6.5).

The strain signal may be monitored during a test, used for X-Y recording of load-strain data, used with strain limits to control crosshead action, and a printout obtained of peak, break and preset point values. These operations are described in other sections of Chapter 8.

8.11.2 Strain Operating Mode

The operating mode for the Strain 1 and 2 channels can be selected by the user to be either Percent Strain (%) or, depending upon the type of extensometer, displacement in inches or meters x 10^{-3} (mils or mm).

The user should be aware of the strain operating mode when monitoring the signal, and setting up for strain recording and strain limits.

To change the strain operating mode, requires changing the setting of a switch in the control console. This switch is part of an 8-section DIP switch assembly (S5) located on the lower right-hand corner of the motherboard (see Figure 6-11). The No. 3 switch on the S5 assembly is marked STRAIN UNITS (see Figure 8-1). The switch is accessed by removing the left rear corner panel of the console, as described in Section 6.9. To change position of the rocker type switch, push down on either side with a sharp pointed tool. To set the mode for operation in displacement units, push down on the side of the switch marked STRAIN UNITS; and for percent, push down on the OPEN side of the switch.

If the strain operating mode switch setting is changed with the system powered down, the Basic Panel Display will show "LOSS" when power is applied. This indicates that nonvolatile memory is reset to the default state and stored test data is lost. Load and strain channels must be recalibrated and electronic limits reset.

If the strain operating mode switch setting is changed with power applied to a calibrated system, there will not be an indication on the front panel, but one of the following procedures must be performed to make the mode change valid:

1. Cycle main power off then on;

2. Enter the system reset sequence: Press S1, then 0 and ENTER on the keypad; or,

3. Enter the "warm start" sequence: Press switch, S1, then [1] and [ENTER] on the keypad.

After switching units and performing one of the above procedures, the Basic Panel display will show "LOSS", indicating that nonvolatile memory is reset to the default state and stored test data is lost (see IMPORTANT NOTE).

IMPORTANT NOTE

After changing the strain operating mode, load and strain channels must be recalibrated and all limits reset (load, extension, strain 1 and 2).

8.12 STRAIN GAGE EXTENSOMETERS

8.12.1 Overview

The Instron series 2630 strain gage extensometers are lightweight units that are provided with clamps for attaching the devices to round or flat test specimens. These extensometers are available in models covering high and medium magnification ranges, and with initial gage lengths of 10, 25 or 50 mm (1/2, 1 or 2 in.). Operating instructions are included with each extensometer.

NOTE

A 2630 series extensometer may be a self identified, electrically calibrated type, or a non-self identified, mechanically calibrated type.

The calibration procedure for an extensometer calibrates the strain measuring system of a 4200 series instrument against a precisely generated signal, and sets system calibration for the extensometer in use. The system then is able to provide an accurate strain signal which is automatically ranged during a test over 100% (X1), 50% (X2), 20% (X5) and 10% (X10) of the maximum range of the extensometer.

The calibration procedure will vary depending upon the type of extensometer installed and the method used, which can be as follows:

1. Self identifying and electrically calibrated.

2. Self identifying and mechanically calibrated.

3. Non-self identifying and mechanically calibrated.

The 4200 series system responds to an improper strain calibration procedure by flashing the STRAIN BAL or STRAIN CAL lamps. If either of these lamps flash, the user must correct the error before proceeding (reference Section 7-7).

NOTE

For maximum accuracy of strain measurement, extensometers should be mechanically calibrated over the range of interest, as described in Section 8.12.3.

The following procedures, describing the calibration of strain gage extensometers, assume that the devices have been properly installed in a 4200 system with a strain conditioner board and cabling.

NOTE

An extensometer calibrator with a micrometer adjustment, such as the Instron High Magnification type with a 25 mm (or 1 in.) range, is required for the mechanical calibration procedures.

A test cannot be started while the STRAIN CAL or STRAIN BAL lamp is lit, and the calibration and balance functions are locked out while a test is running.

8.12.2 Electrical Calibration of Self Identifying Strain Gage Extensometers

NOTE

When electrically calibrating a 2630 series self identifying strain gage extensometer, the balance operation is performed automatically.

To electrically calibrate a 2630 series self identifying strain gage extensometer:

a. Clamp extensometer onto the

specimen (Figure 8-5) at gage length, as described in the manual supplied with the device. Allow up to 15 minutes for extensometer to stabilize after applying excitation.

b. Press STRAIN CAL key. The Basic Panel Display shows the maximum strain (%) or range (mils or mm) of the extensometer (see Section 8.11.2), and the STRAIN CAL lamp lights.

c. Press ENTER. After about 6 seconds, STRAIN CAL lamp goes out, the display goes blank and calibration is completed.

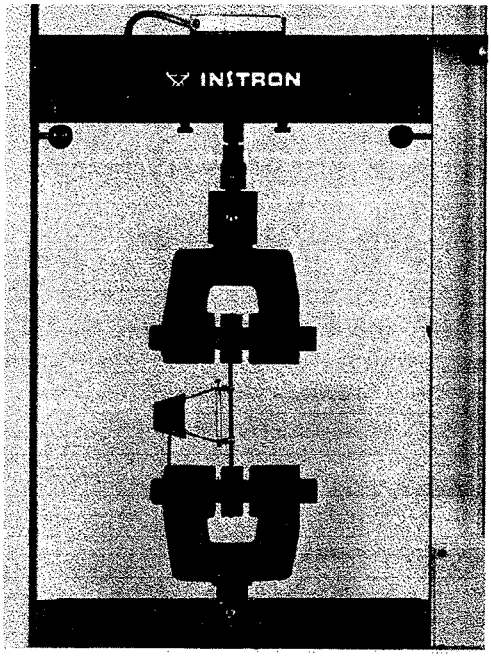

Figure 8-5. Strain Gage Extensometer Mounted on Specimen

8.12.3 Mechanical Calibration of Strain Gage Extensometers

To mechanically calibrate a 2630 series self identifying, or non-self identifying, strain gage extensometer:

a. Mount spindles on calibrator that fit the extensometer clamps, and set calibrator in a vertical position for greatest accuracy.

b. Adjust calibrator for minimum displacement (gage length). Minimize backlash in mechanism by going through zero point and then return.

c. Clamp extensometer onto spindles of calibrator at gage length, as described in the manual supplied with the device. Allow up to 15 minutes for extensometer to stabilize after applying excitation.

d. Press STRAIN BAL key. The STRAIN BAL lamp lights.

e. Press ENTER. After about 3 seconds, the STRAIN BAL lamp goes out indicating that balance function is completed.

f. Press STRAIN CAL key. The STRAIN CAL lamp lights . Go to Step 1 or 2 below.

1. If the extensometer is a self identifying type, the Basic Panel Display shows the maximum strain (%) or range (mils or mm) of the extensometer. Do not press ENTER.

2. If the extensometer is a non-self identifying type, the Basic Panel Display is blank. Key in the maximum strain (%) or range (mils or mm) of the extensometer on the keypad. Press ENTER. The STRAIN CAL lamp stays lit.

g. Adjust calibrator by one of the following methods:

NOTE

Adjust calibrator carefully. Do not turn it past the set point and have to reverse, as backlash will cause an error.

1. To calibrate extensometer over its maximum strain (or displacement) range, adjust calibrator to a displacement value which corresponds to full scale. For example: If using an extensometer with a 1-inch gage length and a 10% maximum strain, adjust calibrator to 0.100 inches.

2. To calibrate extensometer over a range of interest (most accurate method), adjust calibrator to maximum displacement value required. For example: If using an extensometer with a 1-inch gage length and a 10% maximum strain, and a 1% strain is the range of interest (see NOTE below), adjust calibrator to 0.010 inches.

NOTE

Do not calibrate a 2630 series strain gage extensometer below 10% of its full scale range. Otherwise, accuracy will not be within specifications.

h. On numeric keypad, key in value set on calibrator in Step g, part 1 or 2 above. If operating in units of displacement, enter value in millimeters or mils. If operating in the percent mode, enter the percent strain corresponding to the displacement of the calibrator (10.00 for 10%, 1.000 for 1%, etc.).

i. Press ENTER. After about 6 seconds, STRAIN CAL lamp goes out, the display goes blank and calibration is completed.

j. Remove extensometer from calibrator and clamp it onto specimen at gage length, as described in the manual supplied with the device.

k. Press STRAIN BAL key. The STRAIN BAL lamp lights.

l. Press ENTER. After about 3 seconds, STRAIN BAL lamp goes out and balance function is completed.

8.12.4 Strain Gage Extensometers - Operational Notes

The strain measuring accuracy of a 4200 series system is: ±0.6% of strain reading ±1 count on display or analog output to recorder (± linearity of transducer).

This specified accuracy is valid from the calibration point of an extensometer down to 2% of maximum strain (displacement). An extensometer must be recalibrated if the ambient temperature goes outside the range of +10° to +30°C (+50° to +86°F) after initial calibration.

After the extensometer has been installed on the specimen, secure the cable so it does not interfere with the movement of the extensometer. Also, keep the cable away from the drive motor housing to avoid electrical interference.

8.13 MODEL XL EXTENSOMETER

8.13.1 Introduction

The optional Instron Model XL Balanced Elastomeric Extensometer (Catalog No. 2603-068) provides accurate measurements of strain in elastomeric or other highly extensible materials.

The Model XL extensometer, shown mounted on a Model 4201 loading frame in Figure 8-6, quickly and easily clamps to a specimen and allows testing through break without damage or test interruption. The standard unit has a gage length of 20 mm (1 in.) and a differential travel of 200 mm (10 in.), or 1000%.

The XL extensometer contains an etched commutator disc which provides the means for pipping a recorder pen at 10% increments of strain.

A follower potentiometer in the unit provides a DC voltage proportional to the extensometer extension (clamp separation) that occurs during a test. This voltage is applied to an optional strain sensor conditioner board installed in the 4200 system, which provides a strain signal suitable for recording.

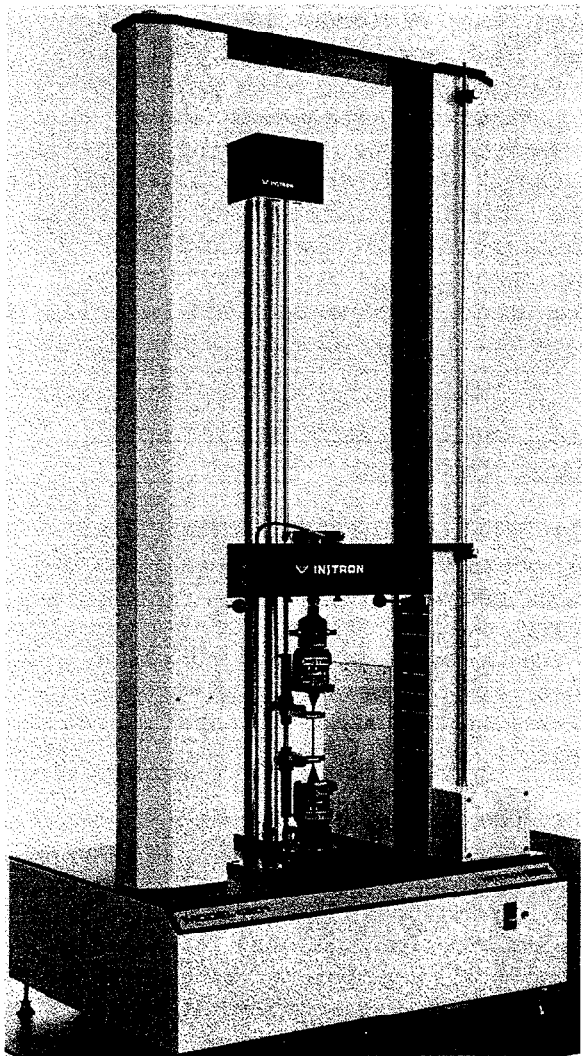

Figure 8-6. Model XL Extensometer Mounted on a Model 4201 Loading Frame

Complete installation procedures and an operating instruction manual are provided with the Model XL Extensometer.

8.13.2 Pipping Operation

If the Model XL extensometer is to be used for pipping a recorder, connect the cable provided (A463-13) with the unit between the PIP jack (J6) on the loading frame connector panel and the PIP jack on the rear of the extensometer housing. The commutator disc in the Model XL can produce pips, at 10% increments of strain, in either English or metric units. The operating instruction manual supplied with the extensometer contains the procedure for changing the units of measurement for pipping, and calibrating the initial pip.

If the basic mode of operation is to be incrementally pipping the load pen on a recorder, then attach the extensometer clamps to the specimen, as described in the Model XL operating instruction manual, and proceed with the test.

8.13.3 Calibration of Model XL for Strain Measurement

The following procedure assumes that an optional strain sensor conditoner board and cabling for use with a Model XL Extensometer have been properly installed in the 4200 series system. (Also reference Section 8.11, Strain Measurement.)

To calibrate the Model XL:

a. Press STRAIN key on Basic Panel to activate the Strain 2 channel (No. 2 lamp should be lit).

b. With the Model XL extensometer mounted in the testing position, remove test specimen, if installed.

c. Attach extensometer clamps to calibration rod (T463-54) at gage length mark (1.0 in. or 20 mm).

d. Press STRAIN BAL key. The STRAIN BAL lamp lights.

e. Press ENTER. After about 3 seconds, the STRAIN BAL lamp goes out indicating that balance function is completed.

f. Press STRAIN CAL key. The STRAIN CAL lights and the Basic Panel Display is blank, indicating that the extensometer is non-self identifying.

g. Key in the maximum strain (%) or range (in. or mm) of the extensometer on the keypad, depending upon the operating mode (Section 8.11.2). For example: enter 1000 for 1000%, 10.00 for 10 in., 200.0 for 200 mm.

h. Press ENTER. The STRAIN CAL lamp stays lit.

i. Unclamp upper extensometer arm and move it to the calibration position on the rod (10 in. or 200 mm).

j. Key in value on calibration rod (10.00 in. or 200.0 mm) or 1000% on the keyboard, depending upon the operating mode (as in Step g above).

k. Press ENTER. After about 6 seconds, STRAIN CAL lamp goes out, the display goes blank and calibration is completed.

l. Remove extensometer from calibration rod and clamp it onto specimen at gage length, as described in the manual supplied with the device.

m. Press STRAIN BAL key. The STRAIN BAL lamp lights.

n. Press ENTER. After about 3 seconds, STRAIN BAL lamp goes out and balance function is completed.

8.14 MICROCON II DATA PROCESSOR LOAD AND STRAIN CALIBRATION

8.14.1 Introduction

When the Instron Microcon II option (see Section 3.6.4) is used with a 4200 system, a Microcon Interface Board is installed in the 4200 control console. This board enables the Microcon II to sense ranged load and strain data occurring during a test. With this data and additional parameters which a user keys into the instrument prior to a test, the Microcon II automatically computes values of load, elongation, stress, strain and energy at the peak, fail, and break points of a specimen. Additional options determine offset yield, compute three types of modulus, provide data at up to ten preset points and provide statistical analysis on all measured variables.

All data is stored in Microcon II until overwritten by the next test or main power is shut off. A tape cassette option allows the parameters for a test sequence and calculations to be permanently stored, eliminating the need to enter data manually.

The use of Microcon II with a 4200 system requires a simple procedure to establish a common load and strain transducer calibration between the two instruments.

8.14.2 Calibration - Overview

Calibration of the load and strain channels in a 4200 series system can be done either electrically or mechanically, as described

in Sections 7.5, 8.12 and 8.13. Calibration of the Microcon II load or strain channels for use with a 4200 system can also involve producing a calibration signal either electrically or mechanically.

Initially, zero and balance key sequences are entered on the Microcon II to set a reference point. Then a calibrated load or strain signal is generated from the 4200 system, and this is entered into the Microcon II by another key sequence to set a common level between the two systems.

The following procedures assume that an optional interface board and cabling for use with the Microcon II have been properly installed in the 4200 series system. The user should be familiar with the operation of the Microcon II. Complete instructions are supplied with the unit.

8.14.3 Electrical Calibration of Load Channel for a Self Identified Load Cell

A calibration signal must be entered into the Microcon II during a load channel calibration procedure. The value of the signal depends upon the type of load cell installed and the system of operating units in use, as shown in Table 8-6. This signal must be entered correctly to obtain a valid calibration.

NOTE

The voltage, generated when the calibration relay in a self identifying load cell is closed (Step d. below), is the same as would be produced by an applied load equal to 50% of the maximum capacity of the cell. This signal is always the SI equivalent value (newtons) for whatever system of units is in use, as shown in Table 8-6.

Table 8-6. Calibration Signal 4200 Series Load Cells

Load Cell Maximum Capacity - Newtons	*Calibration Signal Value - SI Equivalent		
	Newtons	Pounds	KGrams
50	25	5.62	2.55
500	250	56.2	25.49
5000	2500	562	254.9
10,000	5000	1124	509.8

*To convert newtons:
1. Multiply by 0.2248089 to obtain pounds.
2. Multiply by 0.1019716 to obtain kilograms.

a. Calibrate the 4200 series load channel as described in Section 7.5.2 for Self Identifying Load Cells. The load should remain at zero. If grips and fixtures are installed, be sure to balance the system (Section 7.6).

b. Select units in use on the Microcon II to be the same as the 4200 system (SI - newtons, metric - kilograms, English - pounds).

c. Set zero and balance conditions by entering following key sequences on Microcon II:

1. [SET] [SHIFT] [0] [LOAD] [YES]
2. [SET] [LOAD] [0] [YES]

d. On 4200 system, close the load cell calibration relay by pressing LOAD CAL key and then press 0 and ENTER on keypad. The LOAD CAL and LOAD BAL lamps will both be lit when this relay is closed.

e. On Microcon II, enter calibration load value for load

cell in use (see Table 8-6) using key sequence:

[SET] [LOAD] [(Value)] [YES]

NOTE

The calibration signal appears on the LOAD readout of the optional Display Panel, if TRACK is enabled.

f. **IMPORTANT** - Complete the procedure by opening the calibration relay. Repeat the sequence used to close the relay: Press LOAD CAL, then press 0 and ENTER on the keypad. The LOAD CAL and LOAD BAL lamps will go out. A test can not be started when the calibration relay is closed.

8.14.4 Mechanical Calibration of Load Channel for a Self Identified Load Cell

The mechanical calibration of the Microcon II load channel with a self identified load cell installed consists of using a precision weight to produce a calibration signal, as in the following procedure.

a. Calibrate the 4200 series load channel as described in Section 7.5.3 for the mechanical calibration of self identified load cells. Be sure to balance the system.

b. Select units in use on the Microcon II to be the same as the 4200 system (SI - newtons, metric - kilograms, English - pounds).

c. Set zero and balance conditions in the Microcon II by entering the following key sequences into the unit:

1. [SET] [SHIFT] [0] [LOAD] [YES]
2. [SET] [LOAD] [0] [YES]

d. On the 4200 system, rehang the same calibration weight as in Step d of Section 7.5.3.

e. To complete the procedure, enter the value of the calibration weight into Microcon II using the key sequence:

[SET] [LOAD] [(Value)] [YES]

8.14.5 Electrical Calibration of Load Channel for a Non-Self Identified Load Cell

The electrical calibration of the Microcon II load channel with a non-self identified load cell installed consists of using the calibration button on the load cell to produce a calibration signal, as follows:

a. Calibrate the 4200 series load channel as described in Section 7.5.4 for the electrical calibration of non-self identified load cells. Be sure to balance the system.

b. Select units in use on the Microcon II to be the same as the 4200 system (SI - newtons, metric - kilograms, English - pounds).

c. Set zero and balance conditions by entering following key sequences on Microcon II:

1. [SET] [SHIFT] [0] [LOAD] [YES]
2. [SET] [LOAD] [0] [YES]

d. On the 4200 system, press and hold calibration button on load cell. Then enter the calibration signal weight equivalent (see Table 7-1) into Microcon II using the key sequence:

[SET] [LOAD] [(Value)] [YES]

e. Release calibration button. Procedure is completed.

8.14.6 Mechanical Calibration of Load Channel for a Non-Self Identified Load Cell

The mechanical calibration of the Microcon II load channel with a non-self identified load cell installed consists of using a precision weight to produce a calibration signal, as in the following procedure.

a. Calibrate the 4200 series load channel as described in Section 7.5.5 for the mechanical calibration of non-self identified load cells. Be sure to balance the system.

b. Select units in use on the Microcon II to be the same as the 4200 system (SI - newtons, metric - kilograms, English - pounds).

c. Set zero and balance conditions by entering following key sequences on Microcon II:

1. [SET] [SHIFT] [0] [LOAD] [YES]
2. [SET] [LOAD] [0] [YES]

d. On the 4200 system, rehang the same calibration weight as in Step g of Section 7.5.5.

e. To complete the procedure, enter the value of the calibration weight into Microcon II using the key sequence:

[SET] [LOAD] [(Value)] [YES]

8.14.7 Electrical Calibration of Strain Channel for a Self Identified Extensometer

A calibration signal must be entered into the Microcon II during a strain channel calibration procedure. The value of the signal depends upon the type of extensometer installed, the system of operating units in use (SI/metric - millimeters, English - inches) and the strain operating mode (see Section 8.11.2). This signal must be entered correctly to obtain a valid calibration.

a. Calibrate the 2630 series strain gage extensometer as described in Section 8.12.2.

b. Set Microcon II to the Gage mode.

c. Select units in use on Microcon II to be the same as the extensometer (SI/metric - mm, English - in.).

d. Set zero and balance conditions by entering following key sequences on Microcon II:

1. [SET] [SHIFT] [0] [ELONG] [YES]

2. [SET] [ELONG] [0] [YES]

e. On Microcon II, set 0 as the initial calibration data point by the key sequences:

1. [SET] [ELONG] [YES]
2. [SET] [ELONG] [0] [YES]

f. On 4200 system, close the calibration relay in the extensometer by pressing STRAIN CAL key and then press 0 and ENTER on keypad. The STRAIN CAL and STRAIN BAL will both be lit when this relay is closed.

NOTE

The voltage, generated when the extensometer calibration relay is closed, is the same as would be produced by an applied strain equal to 100% of the maximum capacity of the extensometer. This strain signal is always an equivalent value for the system of operating units in use and the strain operating mode (see Section 8.11.2).

g. On Microcon II, set the second calibration data point by entering the maximum displacement (or % strain) value for the extensometer using key sequence:

[SET] [ELONG] [(Value)] [YES]

NOTE

The calibration signal appears on the STRAIN readout of the optional Display Panel, if TRACK is enabled.

h. **IMPORTANT** - Complete the procedure by opening the calibration relay. Repeat the sequence used to close the relay: Press STRAIN CAL, then press 0 and ENTER on keypad. The STRAIN CAL and STRAIN BAL lamps will go out. A test can not be started when the calibration relay is closed.

8.14.8 Mechanical Calibration of Strain Channel for All Extensometers

The mechanical calibration of the Microcon II strain channel for any extensometer consists of manually displacing the extensometer to produce a calibration signal, as in the following procedure.

a. Calibrate the extensometer as described in the mechanical calibration procedure of Section 8.12.3 or 8.12.4, except do not remove the extensometer from the fixture.

b. Set the extensometer at gage length on the calibration fixture and press STRAIN BAL key and ENTER on keyboard.

c. Set Microcon II to the Gage mode.

d. Select units in use on Microcon II to be the same as extensometer (SI/metric - mm, English - in.).

e. Set zero and balance conditions by entering following key sequences on Microcon II:

1. [SET] [SHIFT] [0] [ELONG] [YES]

2. [SET] [ELONG] [0] [YES]

f. On Microcon II, set 0 as the initial calibration data point by the key sequences:

1. [SET] [ELONG] [YES]

2. [SET] [ELONG] [0] [YES]

g. Adjust extensometer with, or on, the fixture to the displacement required for calibration. This would be at the maximum displacement of the extensometer, or to a lesser value to obtain the most accurate calibration.

h. On Microcon II, set second calibration data point by entering value that extensometer was displaced in Step g above, using key sequence:

[SET] [ELONG] [(Value)] [YES]

i. To complete the procedure, remove extensometer from the fixture and clamp it to the specimen at gage length. Press the STRAIN BAL key on the 4200 system and then press ENTER on keypad.

8.14.9 Microcon II - Operational Notes

1. The readouts of test result values for load and strain should agree within 1% between the 4200 series instrument, a Microcon II and other peripheral devices, such as a recorder and printer. If values are not within this accuracy, the user should recalibrate each device.

2. A printer should be connected to the Microcon II rather than the 4200 series instrument. This will allow reading out the additional test data that is available from Microcon II.

3. If the Microcon II is to be used with a 4200 series system that includes the Limits Panel option, the break detection, load limit and extension (elongation) limit functions should be set up on the Microcon II rather than on the Limits Panel. These functions should be maintained in the default state (Table 6-5) on the Limits Panel to avoid possible interference between the two units.

4. When the Statistics mode of the Microcon II is in use and a test has just been completed, the following message appears on the Microcon II display if another test is attempted to be started: ENTER LAST? YES OR REJ? This message has to be answered before another test will be permitted. (Also see the **IMPORTANT NOTE** below.)

If the 4200 system (except the Microcon II) is powered down for some reason at this time (before YES or REJ has been selected), then is restarted, a "fault" condition will be indicated on the Basic Panel Display at the conclusion of the Self Test Routine. The second character of the four Self-Test Status characters displayed will be either a "2" or a "P", which indicates a fault in the Crosshead Control board (see "Self Test Routine" in Chapter 6). This "fault" condition makes the 4200 system inoperable, and is a result of the control of the system by the Microcon II.

To recover from the condition described above: select [YES] or [REJ] on the Microcon II, as applicable, then press [REJ] on the 4200 system keyboard. The Self Test Routine will repeat, and the fault condition will clear.

An alternative solution that would prevent the "fault" condition from occurring, is to first clear the control of the system by the Microcon II by selecting [YES] or [REJ], then restart the 4200 system.

IMPORTANT NOTE

Always select [YES] or [REJ] before starting another test when operating in the Statistics mode of the Microcon II. If another test is attempted to be started before entering [YES] or [REJ], the crosshead of the 4200 series instrument will move a small amount in the test direction before the Microcon II assumes control and locks out further motion. This crosshead movement is proportional to the selected crosshead speed. It can be up to 0.015 in. with a crosshead speed of 20 in./min (or up to 0.35 mm with a crosshead speed of 500 mm/min).

To recover from the condition of unwanted crosshead motion as described in the IMPORTANT NOTE above: first, select [YES] or [REJ] on the Microcon II, as applicable for the previous test, then, return to gage length (press RETURN on the control panel of the 4200 series console) and start the new test.

8.15 PIP CONTROL

The capability of event marking the load signal while it is being recorded is provided through the use of a PIP jack (J6) on the loading frame connector panel. A pip control device connected to J6 will produce a small rapid deflection, or "pip", of the recorder pen. The resulting mark on the chart serves as a convenient reference or "event marker" for indicating points of interest on a load-elongation curve for a test specimen.

The pip height is factory set at approximately 2% of full scale on a 250 mm (10-inch) wide chart (0.2 volt peak amplitude), and has a duration of 50 ms. The amplitude is not affected by the automatic ranging of the load signal. Control device options include a Remote Manual Pushbutton (Instron Catalog No. 2310-516), an XL Elastomeric Extensometer (Section 8.13), or an Incremental Extensometer (Section 8.16).

8.16 INCREMENTAL EXTENSOMETER

The Instron Incremental Extensometer option (Figure 8-7) is used to measure strain in highly extensible materials. The extensometer consists of two lightweight sections which are clipped onto a specimen at a 1-inch gage length. Equally-spaced segments on a printed circuit tape cause contact between the two sections to make and break as they are drawn apart during an elongation test.

The extensometer plugs into the PIP jack (J6) on the connector panel of the 4200 series loading frame. Each time the circuit is closed, a pip is marked on the recorder chart, as described in Section 8.15. The accurate spacing of the contacts on the tape pre-program the pips, which correspond to discrete increments of specimen extension.

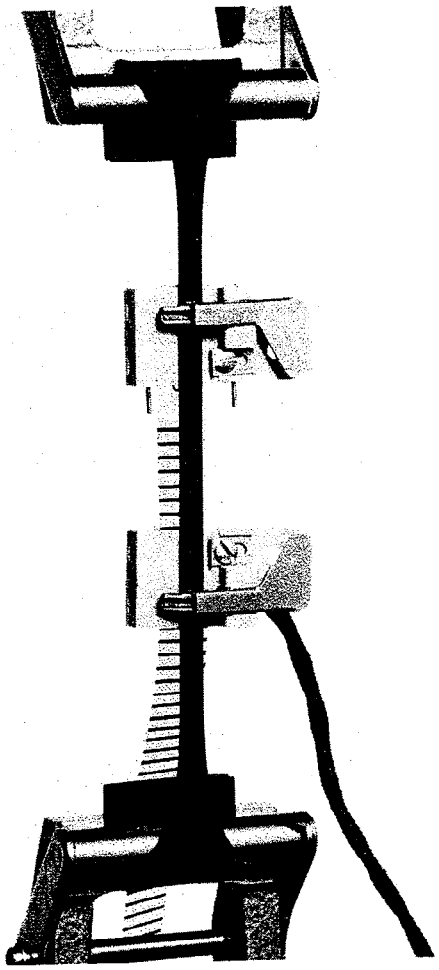

Figure 8-7. Incremental Extensometer Mounted on Specimen

Printed tapes are available for 10%, 50% and 100% increments of strain for the extensometer. Contact the nearest Instron Regional Sales Office for additional details.

9.0 MATERIALS TESTING WORK SHEET

SPECIMEN _____ _____ _____
Material (Type, Batch) Ident. No. Date

_____ _____ _____
Width/Diameter Thickness Cross-sectional Area

TEST PURPOSE AND CONDITIONS _____ _____
Test Type Tests Results Required

_____

_____

_____ _____ _____
Max. Expected Load Max. Expected Extension Temperature (°C,°F)

TEST EQUIPMENT _____ _____ _____
Loading Frame Load Cell Grips

_____ _____ _____
Recorder Type Extensometer (Strain 1) Extensometer (Strain 2)

_____ _____ _____
Printer Microcon II Computer (IEEE Interface)

_____
Other Accessories, Special Fixtures and Equipment

_____

TEST EQUIPMENT SETUP Operating Units _____
(English, Metric, S.I.)

Load Cell Calibration _____
(Self or Non-Self Identified) (Elect. or Mech)

Crosshead Control _____ _____ _____
Testing Area Crosshead Speed Gage Length

Crosshead Travel Stops _____ _____
Extension Limit (Max.) Gage Length (Min)

Area Compensation _____ Autoprint _____
(Sample No. & Setting) (Enabled/Disabled)

Energy _____ Preset Points _____
(Enabled/Disabled) (Enabled/Disabled)

Materials Testing Work Sheet (continued)

Energy Integration Variable & Preset Points Independent Variable

Preset Point Values _____ (PPT1) _____ (PPT2)

Extensometer Calibration _____ (Self or Non-Self Identified) (Elect. or Mech)

Active Strain Channel _____ (1 or 2) Strain Oper. Mode _____ (% or Displacement)

Strip Chart Recorder _____ (Chart Speed) _____ (Time/Prop Mode) _____ (% Range/Ratio)

X-Y Recorder _____ (X-Axis Drive Mode (Position/Time/Strain)) _____ (% Range)

_____ (Position Full Scale (Span)) _____ (Time Full Scale (Minutes))

Display Panel _____ (Load, Extension, Strain Monitoring (Track, Peak, Break))

Limits Panel Assignments

Variable	Maximum Limit	Minimum Limit	Crosshead Action
Load			
Extension			
Strain 1			
Strain 2			

Break Detection _____ (Crosshead Action) Cycle Action _____ (Increase Load (Up/Down))

REMARKS _____

APPENDIX A

INTRODUCTION TO TESTING

A.1 GENERAL

The purpose of this appendix is to provide the basic requirements that are essential in planning a materials testing procedure. These include the applications of the testing instrument, determining load requirements, gripping techniques, setting gage length, choosing a testing speed and the use of area compensation. A glossary of terms defining the mechanical properties and tests applicable to a 4200 series system is included as Appendix B for the convenience of the user.

The American Society for Testing Materials (ASTM) annual book of standards contains complete procedures regarding specimen preparation and testing for virtually all types of materials. These standards are universally accepted by industry, and should be consulted for more detailed information.

A.2 APPLICATIONS OF A 4200 SERIES INSTRUMENT

The test capabilities of a 4200 series instrument range from simple tension or compression testing with a recording of specimen loading versus time, to more advanced techniques, including: modulus tests, relaxation-recovery, and cyclic evaluations involving detailed calculations and data analysis. This flexibility is possible due to a broad selection of options available for use with a basic 4200 system.

For example, with the recorder and printer options, graphic plots and recordings of load versus extension or strain can be obtained. The Display Panel option allows the peak and break parameters of load, extension and strain to be monitored and stored. The Limits Panel option permits minimum and maximum travel limits of the crosshead to be controlled at selected load, extension or strain values. This enables cyclic evaluations of materials during relaxation and recovery. The Limits Panel can also provide rapid return of the crosshead to gage length after break for repetitive specimen testing.

Additionally, each 4200 series instrument has built-in preset points and integration capabilities for the evaluation of energy related properties, such as tensile energy absorption (TEA) and elastic modulus. The wide variety of materials testing applications for a 4200 series system includes:

Plastics - perform tests to ASTM-D638 and ASTM-D1623 to obtain tensile strength, percent elongation, modulus of elasticity, and peak and break values of load and strain. Perform flexural tests to ASTM-D790 for parameters such as maximum force, maximum fiber stress, flexural strength, tangent and secant modulus, and stress at specified strain. Use area compensation and peak readouts to enable printouts of maximum force or stress values. Other typical tests include: ASTM-D695 and D1621 for compression; D732 for shear strength; D1004 for tear resistance; and D1894 for friction.

Wire, foil and sheet metal - determine the tensile strength of solid wire, electrical cables, and thin sheet metal components. Also, in compression, test for crush resistance and insulation cut throughs. Obtain offset yield evaluations

using the optional Microcon II Data Analyzer or the HP-85 Computer. Some ASTM tests in this category include: E8 for metals; E132 for Poisson's ratio; E345 for metallic foil; D2633 for thermoplastic insulation; and D1351 for polyethylene insulation.

Rubber - perform tests to ASTM-D412 to obtain peak and break values of load and extension. Use preset points for modulus values, and integrate the load/elongation curve to obtain energy values. Measure strain using crosshead extension or an optional long-travel or optical extensometer. Also, test for tear resistance to ASTM-D624 and test O-rings to ASTM-D1414.

Textiles - perform tenacity and stretch tests of fabrics, yarns and cords. Determine load at set elongation (LASE) using preset points. Apply area compensation to obtain load value relationships to units such as grams/denier. Use the computer option to obtain complete statistical analyses of test results. Typical ASTM textile-related tests applicable to a 4200 series instrument include: D458 for man-made fibers: D2256 for yarn; D2653 for elastomeric yarns; and D2263 for grab tests of automotive fabrics.

A.3 LOAD REQUIREMENTS

The selection of a load cell is the first step in preparing for a tension or compression test. If the approximate tensile (or compressive) strength of the specimen is known, the choice of load cell is simplified. If the tensile strength of the material is not known, refer to a Properties of Materials handbook to obtain a close figure.

To calculate the tensile strength in force units for a specimen, multiply its tensile strength by its cross-sectional area. For example:

psi x in^2 = lbf (pounds-force)

kg/m^2 x m^2 = kgf (kilograms-force)

Pascals x m^2 = newtons

Example:

Specimen geometry: standard ASTM tensile configuration.

Material: Lexan

Tensile strength: 5200 psi (from a materials handbook)

Specimen area: 0.502 inches wide x 0.125 inches thick = 0.063 in^2.

Tensile strength: 5200 psi x 0.063 in^2 = 328 lbf

Therefore, in this example, the 5 kN (1000 lb, 500 kg) capacity load cell should be installed.

If an approximate value of tensile strength cannot be obtained, then always use the highest capacity load cell initially and perform a preliminary test at a slow speed to determine the load range required.

A.4 SELECTION OF GRIPS

The selection of grips (see Appendix C) depends upon the material, geometry and strength of the test specimen. But the tensile strength of the test specimen should be a primary consideration. If, for example, a material has a tensile strength of 500 lbf, then the pneumatic grips should not be used as these grips are designed for loads not exceeding 200 lbf. Always determine the capacity of the grips being used prior to a test and do not overload test fixtures.

Examples of gripping techniques are shown in Table A-1. In many

Table A-1. Gripping Techniques

Specimen Material	Specimen Geometry	Max. Breaking Load (pounds)	Types of Grips
Paper	1" wide	100	Screw-action or pneumatic-action with 1" x 2" flat faces.
Plastic Films	1" wide	100	Same as above. Also, line contact faces can be used.
Rigid Plastics	1" wide x 0.5" thick	1000	Wedge-action or screw-action with serrated faces.
Wire and Sheet Metal	.002 to .060" diameter	200	Screw-action or pneumatic-action with 1" x 2" flat faces or 1" x 2" serrated faces.
Cord and Yarn	.002 to .19" diameter	350	Pneumatic cord and yarn
Fabrics	1" wide or 4" wide strip	1000	Screw-action or pneumatic-hydraulic with flat faces.
Elastomers	.125 to .250" wide	150	Elastomeric

cases the operator has to experiment with several gripping techniques to eliminate or minimize slippage in the grips. For grips with interchangeable faces, such as the screw-action and pneumatic-action types, the serrated, flat and rubber-coated faces can be tried to determine the best gripping method.

A.5 ESTABLISHING GAGE LENGTH

The gage length used for a tensile test refers to the original length of the specimen or the initial distance between the grips. Whereas for a compression test, it refers to the original height of the specimen, assuming the anvil and compression table are both initially in contact with the specimen.

Establishing gage length is one of the most important decisions to be made when performing tension tests. Gage length is used as a basis for calculating percent elongation and in determining specimen strain rate, hence, it can seriously affect the test results.

Sometimes the choice of gage length is dictated by the available length of the material. Although commonly used gage lengths for paper, plastic film, wire, cord and yarns are from 4 to 10 inches (100 to 250 mm). In general: establish the largest possible gage length, consistent with the capacity of the testing instrument, in order to increase the sensitivity and accuracy of the elongation measurement.

A.6 SELECTION OF TESTING SPEED

The selection of a testing (or crosshead) speed depends upon the material being tested and the type of test. Materials that are very stiff, such as metals and rigid plastics, should be tested at a slow

speed. The other extreme is highly extensible materials, such as elastomers, which are tested at a fast speed, generally 20 inches per minute (500 mm/min). For materials in between these two extremes, an intermediate speed should be used. Table A-2 lists a range of speeds used to test various materials.

Table A-2. Typical Testing Speed Ranges for Materials

Material	Speed in/min (mm/min)
Metals	.02-1.0 (.5-20)
Wire	.2-2.0 (5-50)
Rigid Plastics	.2-2.0 (5-50)
Plastic Films	.5-20 (10-500)
Tire Cord	12 (300)
Yarn and Fabrics	12 (300)
Elastomers	10-20 (200-500)

A.7 STRAIN RATE

For certain materials the specimen strain rate is specified rather than a testing speed. But once the gage length (G.L.) has been established, the testing speed can be calculated from the strain rate.

Testing Speed = Strain Rate x G.L.

EXAMPLE

Specimen: Plastic film

Gage length: 10 inches

Strain rate (from designated test procedure): 0.5 in/in/min
Testing speed = 0.5 in/in/min x 10 in. = 5.0 in/min

Therefore, in this example, perform the tensile test on the plastic film at 5.0 in/min.

A.8 AREA COMPENSATION

A.8.1 Description

The use of area compensation when testing specimens of different cross-sectional area allows the load signal to be calibrated in terms of stress, or similar units relating force and specimen size. Stress is defined as the load on a specimen divided by the original cross-sectional area of the specimen. Other applications relating force and specimen size where area compensation could be used, include the testing of yarn or fiber to determine tenacity in grams per denier.

In a 4200 series system, area compensation values are entered as a base number (mantissa) and an exponent using two key sequences, as described in Section 7.8.4. Increasing the mantissa values from between 1.000 to 9.999 proportionally decreases the sensitivity of the load weighing system. For example, increasing the value from 1.000 to 2.000 decreases load sensitivity by $^1/_2$, so that twice as much loading on the test specimen will be required for full scale stress response. The load-stress relationship is expressed by the formula:

$$L = S \times A \text{ or } S = L/A$$

where (in English units, for example)

L = Load in pounds
S = Stress in psi
A = Cross-sectional area (in^2)

When an area compensation value is entered that corresponds to the cross-sectional area of a specimen, the load channel gain is divided by the mantissa; that is, by a number normalized between 1.000 and 9.999. As a result, the digital load signal to the optional LOAD display and the

analog load signal to a recorder are both normalized with respect to stress. This allows calibration of the recorder scale in terms of stress (normalized), with the full scale value easily changed by selecting a % RANGE on the Recorder Panel. When the normalized area value for each additional specimen is entered, the recorder scale remains calibrated. Thus, each specimen can easily be compared as all plots are on the same stress scale.

A.8.2 Determining Stress Range

The stress range indicated by full scale on a recorder chart may be determined from the following equation:

$$\text{Full Scale Stress} = \frac{\text{A.C.} \times \text{L.R.}}{\text{A}}$$

where:

A.C. = Area Compensation value - the normalized base number (mantissa) of the specimen cross-sectional area.

L.R. = Load Range - in pounds (g or kg, N or kN). Load range is determined by the load cell in use and the % RANGE selected on the Recorder Panel.

A = Cross-sectional Area (actual) of specimen

Example: Assume a specimen has an Area = 0.075 in^2; that a 100-lb capacity load cell is installed; and a 10% RANGE has been selected on the Recorder Panel. Determine the full scale stress reading as follows:

Set the mantissa of the area compensation to 7.50, that is, normalize the base number of the specimen area to a value between 1.000 and 9.999. A 100-lb capacity load cell with the % RANGE set at 10% has a full scale load range of 10 lb. Substituting these values into the equation for Full Scale Stress:

$$\frac{7.50 \times 10 \text{ lb}}{0.0750 \text{ in}^2} = 1000 \text{ psi}$$

If the % RANGE were changed to 20 (L.R. = 20) in the above example, the Full Scale Stress would be 2000 psi. This would overload the load cell (see Section A.8.3).

A.8.3 Limitations Due To Load Cell Capacity

The maximum allowable stress within the capacity of a load cell is determined by:

$$\text{Maximum Allowable Stress} = \frac{\text{L.C.}}{\text{A}}$$

where: L.C. = Load Cell maximum capacity and A = cross-sectional area of specimen.

For example, for a 100-lb load cell, and an Area = 0.075 $in.^2$, the maximum allowable stress would be 1333 psi. Thus, to determine the highest % RANGE to use that will not exceed the maximum allowable stress (S_{max}), use the equation:

$$\% \text{ RANGE} = \frac{S_{max} \times A}{\text{A.C.} \times \text{L.C.}} \times 100$$

This would be equal to 13% for the example of a 100-lb capacity load cell and a specimen area = 0.075 in^2. Hence, 10% is the highest % RANGE that could be used for calibrating a recorder to Full Scale Stress.

Do not use a full scale stress range that exceeds the maximum allowable stress. In some cases it may not be possible, and only part of the recorder scale can be used without overloading the cell. Under this condition, it is better to use a higher capacity load cell.

A.9 CHART MAGNIFICATION

When using a chart recorder with a time base, the chart or X-axis speed should be selected to give a convenient record length for a test. A record of 5 to 15 inches (125 to 375 mm) is sufficient, but it can be as long as desired.

By the use of chart magnification, the chart time axis can indicate the displacement of the crosshead in either a reduced or magnified manner. An application of Magnification Ratio is shown in the typical load-displacement curve of Figure A-1.

The chart magnification ratio (M) is the ratio of the chart time axis speed to crosshead speed, that is:

$$\text{Magnification Ratio (M)} = \frac{\text{Chart Time Axis Speed}}{\text{Crosshead Speed}}$$

The following example illustrates the selection of chart time axis and crosshead speeds, and then the Magnification Ratio required.

Example:

Material	Nylon
% extension/minute	100%
Ultimate extension (approximate)	50%

Gage length 10 in.

Crosshead speed

= Gage length x % ext./min.
= 10 in. x 100%/min.
= 10 in/min.

A 10-inch chart record is desired for the expected test duration of $^1/_2$-minute (time expected to reach ultimate extension). Therefore, the chart time axis should travel 20 inches in 1-minute, and a chart speed of 20 in/min is required. Then,

$$M = \frac{20 \text{ in/min}}{10 \text{ in/min}} = 2$$

Each inch of chart, along the time-drive axis, will indicate:

$$\frac{1}{M} = \frac{1}{2} = \text{Crosshead displacement (in.)}$$

To determine the percentage of total strain directly from the chart:

$$\% \text{ Strain} = \frac{\text{Chart displacement} \times 100}{M \times \text{Gage length}}$$

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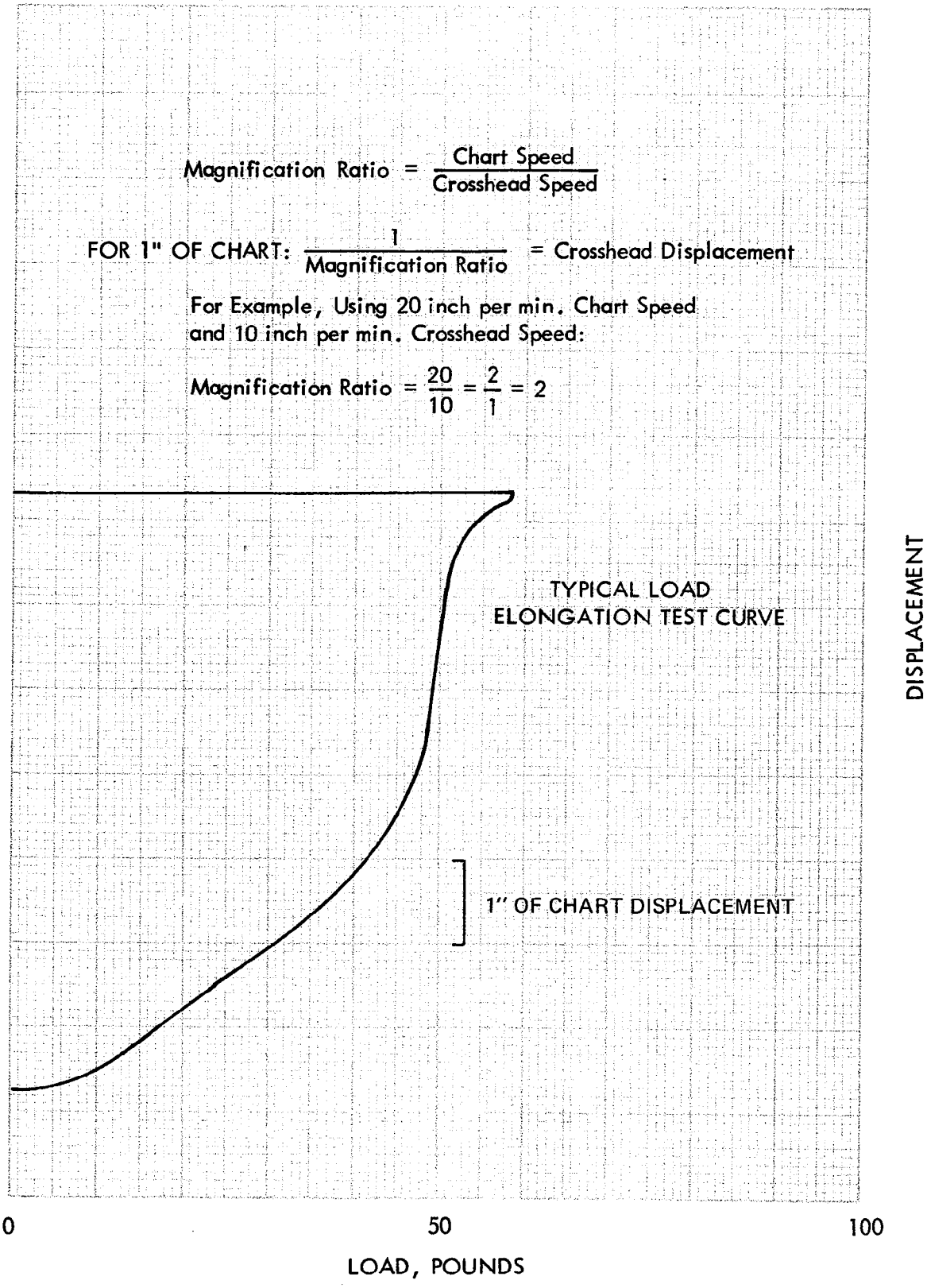


Figure A-1. Typical Load-Displacement Chart Showing Magnification Ratio

APPENDIX B

GLOSSARY OF MECHANICAL PROPERTIES AND TESTS FOR MATERIALS TESTING APPLICATIONS

The following glossary of terms related to mechanical tests of materials will help in the application of a 4200 series system. As materials are commonly specified by their properties, defining a property and measuring it is generally done by a mechanical testing procedure. Understanding these tests and their application is basic to performing them. The terms listed below are chosen because of their relation to the types of tests within the capability of a Model 4201 or 4202 testing instrument.

Bend test. Method for measuring ductility of certain materials. There are no standardized terms for reporting bend test results for broad classes of materials; rather, terms associated with bend tests apply to specific forms or types of materials. For example, materials specifications sometimes require that a specimen be bent to a specified inside diameter (ASTM A-360, steel products). Results of bend tests of welds are given as fiber elongation (ASTM E-16). And results of tests of fiberboard are reported by a description of the failure or photographs (ASTM D-1037).

Bending strength. Alternate term for flexural strength. It is most commonly used to describe flexure properties of cast iron and wood products.

Bond strength. Stress (tensile load dividided by area of bond) required to rupture a bond formed by an adhesive between two metal blocks. (ASTM D952).

Breaking load. Load which causes fracture in a tension, compression, flexure or torsion test. In tension tests of textiles and yarns, breaking load also is called breaking strength. In tensile tests of thin sheet materials or materials in form of small diameter wire it is difficult to distinguish between breaking load and the maximum load developed, so the latter is considered the breaking load.

Breaking strength. Tensile load or force required to rupture textiles (e.g., fibers, yarn) or leather. It is analogous to breaking load in a tension test. Ordinarily, breaking strength is reported as lb or lb/in of width for sheet specimens.

Cleavage strength. Tensile load (lb/in of width) required to cause separation of a 1-in. long metal-to-metal adhesive bond under the conditions set in ASTM D-1062.

Climbing drum peel test. Method for determining peel resistance of adhesive bond between a relatively flexible and rigid material. (ASTM D-1781).

Coefficient of elasticity. Alternate term for modulus of elasticity.

Cohesive strength. Theoretical stress that causes fracture in tension test if material exhibits no plastic deformation.

Compressibility. Extent to which material is compressed in test for compressibility and recovery of gasket materials (ASTM F-36). It is usually reported with recovery.

Compressibility and recovery test. Method for measuring behavior of gasket materials under short time

compressive loading at room temperature. ASTM F-36 outlines a standard procedure. Test is not designed to indicate long term (creep) behavior and should not be confused with the plastometer test.

Compression-deflection test. Non-destructive method for determining relationship between compressive load and deflection under load for vulcanized rubber. (ASTM D-575).

Compression fatigue. Ability of rubber to sustain repeated fluctuating compressive loads (ASTM D-623).

Compression set. The extent to which rubber is permanently deformed by a prolonged compressive load. (ASTM D-395). Should not be confused with low temperature compression set.

Compression test. Method for determining behavior of materials under crushing loads. Specimen is compressed, and deformation at various loads is recorded. Compressive stress and strain are calculated and plotted as a stress-strain diagram which is used to determine elastic limit, proportional limit, yield point, yield strength and (for some materials) compressive strength. Standard compression tests are given in ASTM C-528 (high strength ceramics), ASTM E-9 (metals), ASTM E-209 (metals at elevated temperatures), ASTM D-695 (plastics) and ASTM D-759 (plastics at high and low temperatures).

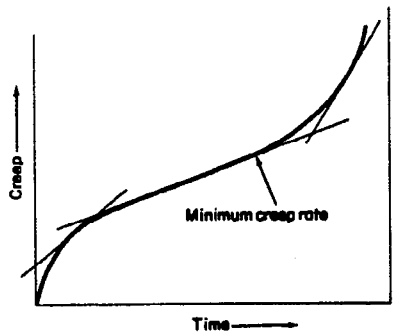
Compressive deformation. Extent to which a material deforms under a crushing load.

Compressive strength. Maximum stress a material can sustain under crush loading. The compressive strength of a material that fails by shattering fracture can be defined within fairly narrow limits as an independent property. However, the compressive strength of materials that do not shatter in compression must be defined as the amount of stress required to distort the material an arbitrary amount. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compression test.

Compressive yield strength. Stress which causes a material to exhibit a specified deformation. Usually determined from the stress-strain diagram obtained in a compression test. See also yield strength.

Creep. Deformation that occurs over a period of time when a material is subjected to constant stress at constant temperature. In metals, creep usually occurs only at elevated temperatures. Creep at room temperature is more common in plastic materials and is called cold flow or deformation under load.

Data obtained in a creep test usually is presented as a plot of creep vs time with stress and temperature constant. Slope of the curve is creep rate and end point of the curve is time for rupture. As indicated in accompanying diagram,



the creep of a material can be divided into three stages. First stage or primary creep starts at a rapid rate and slows with time. Second stage (secondary) creep has a relatively uniform rate. Third stage