M10-94400-1
Issue C April 1995

Instron
Model 4400
Universal Testing System

Operator’s Guide

INSTRON

Amendment Incorporation Record			
Amendment Number	Brief Description of Content	ECR Numberr	Person Incorporating Amendment
1	Reverse Strain Mode Switch Settings	B3887	NCW
2			
3			
4			
5			
6			
7			
8			
9			
10			

Amendment Incorporation Record			
Amendment Number	Brief Description of Content	ECR Numberr	Person Incorporating Amendment
11			
12			
13			
14			
15			

Revision Record	
Revision	ECR No.

Materials testing systems are potentially hazardous.

Materials testing involves inherent hazards from high forces, rapid motions and stored energy. You must be aware of all moving and operating components which are potentially hazardous, particularly the actuator in a servohydraulic testing system or the moving crosshead in an electromechanical testing system.

Whenever you consider that safety is compromised, press the Emergency Stop button to stop the test and isolate the testing system from hydraulic or electrical power.

Carefully read all relevant manuals and observe all Warnings and Cautions. The term Warning is used where a hazard may lead to injury or death. The term Caution is used where a hazard may lead to damage to equipment or to loss of data.

Ensure that the test set-up and the actual test you will be using on materials, assemblies or structures constitutes no hazard to yourself or others. Make full use of all mechanical and electronic limits features. These are supplied for your safety to enable you to prevent movement of the actuator piston or the moving crosshead beyond desired regions of operation.

The following pages detail various general warnings that you must heed at all times while using materials testing equipment. You will find more specific warnings and cautions in the text whenever a potential hazard exists.

Your best safety precautions are to gain a thorough understanding of the equipment by reading your instruction manuals and to always use good judgement.

Warning

Disconnect the electrical power supply before removing the covers to electrical equipment.

Disconnect the equipment from the electrical power supply before removing any electrical safety covers or replacing fuses. Do not reconnect the power source while the covers are removed. Refit covers as soon as possible.

Disconnect power supplies before removing the covers to rotating machinery.

Disconnect the equipment from all power supplies before removing any cover which gives access to rotating machinery. Do not reconnect any power supply while the covers are removed unless you are specifically instructed to do so in the manual. If the equipment needs to be operated to perform maintenance tasks with the covers removed, ensure that all loose clothing, long hair, etc. is tied back. Refit covers as soon as possible.

Shut down the hydraulic power supply and discharge hydraulic pressure before disconnecting any hydraulic fluid coupling.

Do not disconnect any hydraulic coupling without first shutting down the hydraulic power supply and discharging stored pressure to zero. Tie down or otherwise secure all pressurized hoses to prevent movement during system operation and to prevent the hose from whipping about in the event of a rupture.

Warning

Shut off the supply of compressed gas and discharge residual gas pressure before disconnecting any compressed gas coupling

Do not release gas connections without first disconnecting the gas supply and discharging any residual pressure to zero.

Use protective shields or screens if any possibility exists of a hazard from the failure of a specimen, assembly or structure under test.

Use protective shields whenever a risk of injury to operators and observers exists from the failure of a test specimen, assembly or structure, particularly where explosive disintegration may occur. Due to the wide range of specimen materials, assemblies or structures that may be tested, any hazard resulting from the failure of a test specimen, assembly or structure is entirely the responsibility of the owner and the user of the equipment.

Protect electrical cables from damage and inadvertent disconnection.

The sudden loss of controlling and feedback signals which can result from a disconnected or damaged cable causes an open loop condition which may drive the actuator or crosshead rapidly to its extremes of motion. Protect all electrical cables, particularly transducer cables, from damage. Never route cables across the floor without protection, nor suspend cables overhead under excessive strain. Use padding to avoid chafing where cables are routed around corners or through wall openings.

Warning

Wear protective clothing when handling equipment at extremes of temperature.

Materials testing is often carried out at non-ambient temperatures using ovens, furnaces or cryogenic chambers. Extreme temperature means an operating temperature exceeding 60 °C (140 °F) or below 0 °C (32 °F). You must use protective clothing, such as gloves, when handling equipment at these temperatures. Display a warning notice concerning low or high temperature operation whenever temperature control equipment is in use. You should note that the hazard from extreme temperature can extend beyond the immediate area of the test.

Take care when installing or removing a specimen, assembly or structure.

Installation or removal of a specimen, assembly or structure involves working inside the hazard area between the grips or fixtures. Keep clear of the jaws of a grip or fixture at all times. Keep clear of the hazard area between the grips or fixtures during actuator or crosshead movement. Ensure that all actuator or crosshead movements necessary for installation or removal are slow and, where possible, at a low force setting.

Warning

Do not place a testing system offline from computer control without first ensuring that no actuator or crosshead movement will occur upon transfer to manual control.

The actuator or crosshead will immediately respond to manual control settings when the system is placed off-line from computer control. Before transferring to manual control, make sure that the control settings are such that unexpected actuator or crosshead movement cannot occur.

Keep clear of the operating envelope of a robotic device unless the device is de-activated.

The robot in an automated testing system presents a hazard because its movements are hard to predict. The robot can go instantly from a waiting state to high speed operation in several axes of motion. During system operation , keep away from the operating envelope of the robot. Deactivate the robot before entering the envelope for any purpose, such as reloading the specimen magazine.

Table of Contents

Chapter **Page**

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Chapter **Page**

Table of Contents (continued)

Chapter **Page**

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

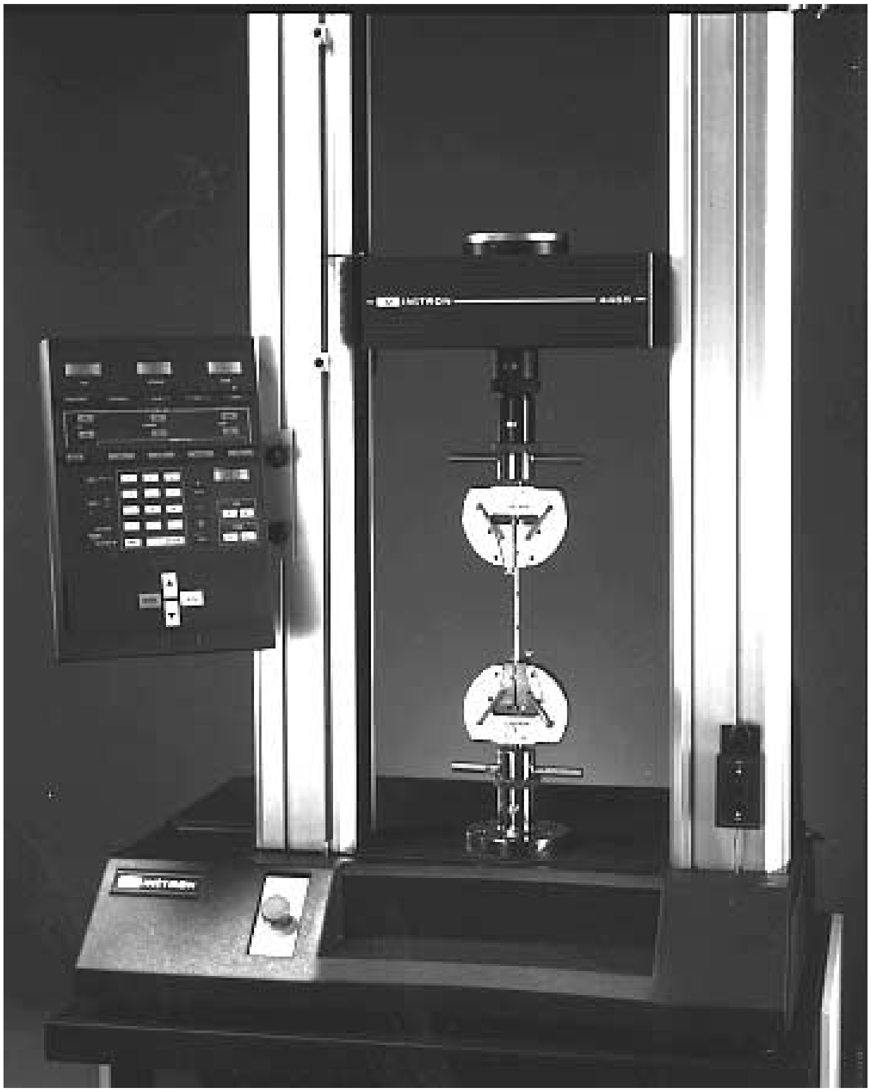
Chapter **Page**

List of Illustrations

List of Tables

Table Page

List of Tables (continued)



Frontispiece. Series 4400 Universal Testing System

Chapter 1
Introduction

Outline

The Instron Series 4400 Universal Testing Instruments are electromechanical systems employing the latest printed circuit board technology to provide a small, light and efficient testing system. This manual describes the functions and operation of the Control Console. Other manuals include Load Frame operating instructions for each of the Series 4400 systems and an IEEE Interface User's Guide.

This chapter describes:

- The features and functions of the Series 4400 Systems
- The physical layout of the system
- Some of the optional accessories available for the system

Introduction

The Instron Series 4400 Universal Testing Instrument is a materials testing instrument designed to test the strength of a wide variety of materials. The system is made up of a load frame, in which a specimen of the test material is mounted, that applies a tension or compression load to the specimen, and a control console that provides the calibration, test setup, and test operating controls. The control console is compact enough to mount directly on the load frame, eliminating the need for a separate support table or workbench.

The Series 4400 Control Console includes an operator's front panel with controls that offer complete communications with the system through a numeric keypad, push-button selection switches and Liquid Crystal Displays (LCDs).

The Console front panel is divided into sections according to functional groupings of controls. For example, a Main section contains a numeric keypad and digital display for data input, a Limits section sets up the electronic limits, and a Display section contains LCD displays of real-time values of test parameters. These panel sections are described more fully later in this chapter.

Optional interfacing is available for an X-Y or a strip chart recorder, a printer, and a programmable computer. These options may be specified with your initial order or added later to expand the capabilities of your testing system.

About this Manual

The purpose of this manual is to provide a basic understanding of the Control Console and its principles of operation. It contains specifications, cable installation, component and control descriptions, operating details for both basic and optional features, and maintenance. Appendices contain an introduction to materials testing and a glossary of terms related to materials testing.

In addition to this manual, there is also a manual covering the installation, maintenance, and parts list for the load frame. Accessories, such as the strip chart and X-Y recorders, printer, and most grips and extensometers, come with their own separate instruction manuals.

Product Support

If you encounter any problems with using or maintaining your testing instrument, or if you want to order accessories or parts, you can obtain answers to your questions or place orders by calling Instron Service, using the list below:

In the United States:	1-800-473-7838
In Canada:	1-800-461-9123
In all other regions of the world:	Nearest Instron Service Office

A listing of international Instron Sales and Service offices, including addresses and telephone numbers, can be found on the back cover of this manual.

General Characteristics

The Series 4400 control system is made up of two major subsystems: a crosshead drive and control system, that applies tensile or compressive loading to a specimen; and a highly sensitive load weighing system, that measures the loading of a specimen. Figure 1-1 is a functional block diagram showing the interfacing of these two systems, and the signal flow within the overall instrument. During a test, results occur as tracked (instantaneous) values of load, extension and strain or, after a test, as stored break and peak values of these parameters. Total energy and load and energy values at preset points are also available as stored parameters. Several choices of analog and digital output devices are available as options for viewing and recording test results.

The control console provides control, data acquisition and data readout functions for the load frame. All operations are directed by a microprocessor-based central processing unit (CPU). The crosshead control network allows programmable crosshead speeds and provides digital control of the crosshead position. The operating mode of the console data entry and readout functions can be in English, metric or SI units, as selected by a switch. A status indicator on the main panel shows the system of units selected.

The action of the moving crosshead during a test - stop, return, or cycle - can be controlled manually by pushbutton switches, or automatically by the functions provided by the Limits feature. These functions may be based on the applied load, extension or strain, or to a detected specimen break.

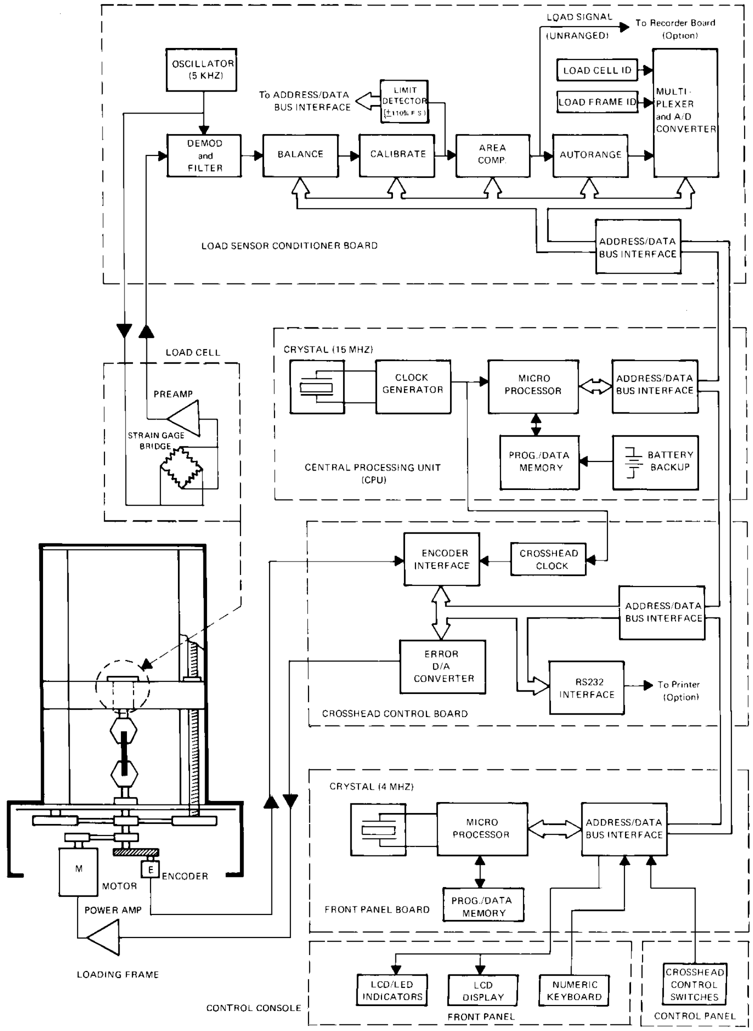


Figure 1-1. Functional Block Diagram

A CPU-controlled sensor conditioner in the load weighing system allows calibration and balance procedures to be performed automatically, after you initiate them at the front panel. The sensor conditioner provides both an unranged analog and an automatically ranged digital load signal output suitable for several types of optional readout devices.

Optional readouts for test results include interfacing for an X-Y recorder, a strip chart recorder, and an 80 character-width printer.

The console also has provisions for an IEEE-488 interface. This is a General Purpose Instrument Bus (GPIB) which allows remote supervisory control of test procedures through a programmable computer.

Console Components

The Series 4400 Control Console contains a single printed circuit board on which are mounted all of the electrical components, including the front panel switches and displays, and rear panel connectors.

The console printed circuit board is the interface for all connections to the console. The interconnecting cables from the load frame and load cell, and cabling from optional recorders, printers, and strain measuring devices plug into connector locations on the rear of the board.

Since the console receives its electrical power from a d.c. power supply in the load frame, there is no need for bulky power supplies and cooling fans, and thus a compact size has been achieved.

The Console itself is mounted on the load frame by means of a special bracket. A friction locking device on the bracket rides in grooves in the crosshead column covers on the load frame, allowing the console to be moved to any convenient working height. The bracket is symmetrical, allowing the console to be mounted on either the right-hand or left-hand column on the frame.

The main components of the control console are shown in Figure 1-2. Access to the interior of the console is described in Chapter 4.

Front Panel

The Front Panel (Figure 1-2) is divided into four major sections. The Main section contains a numeric keypad for data entry of system setup parameters, an LCD display for the numeric input, pushbuttons for such functions as crosshead speed selection, and gauge length setting, among others. The Display section contains LCD displays of real-time values of Load, Extension, and Strain, while the Limits section sets electronic limits for the system. The last section is the Crosshead Control section, in which manual controls for crosshead positioning are located.

Main Panel Section

The Main Panel section consists of test function entry keys, a numeric keypad and a 4-digit LCD display. Status indicators on the left-hand side of the panel, when lit, signify that a fault has occurred. The current units (S.I., English, metric) in use by the testing system are also shown in this area. The panel provides the following functions:

- Load cell calibration
- Crosshead speed selection
- Gauge length
- Area compensation
- Testing area definition
- Strain transducer calibration
- Printer operation
- IEEE bus enable/disable
- Special Software - Diagnostics

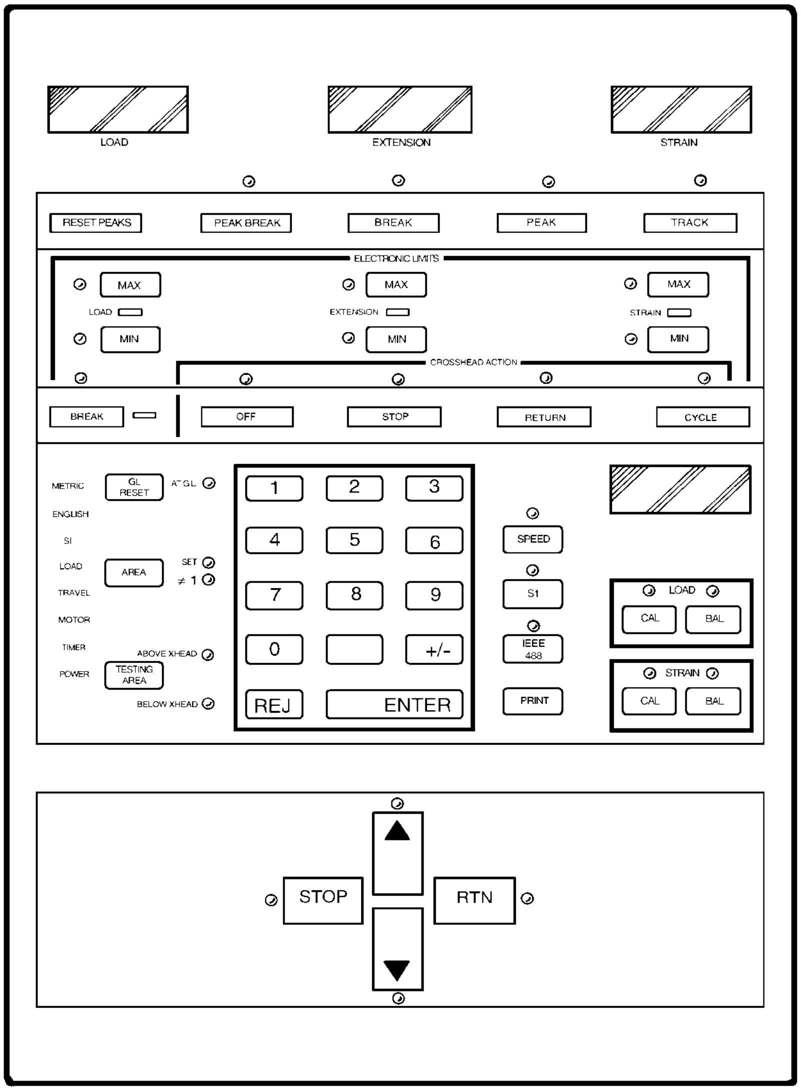


Figure 1-2. Control Console Front Panel

Display Panel Section

The Display Panel section contains three 4-digit LCD displays and control keys to allow load, extension, and strain to be tracked during a test, and the peak and break values of these parameters to be observed. All values are computed and saved at the end of each test and may be viewed as needed during and after the test. An indicator lamp shows the active selection key.

Limits Panel Section

The Limits Panel section allows you to specify what action the system takes when maximum and minimum values of load, extension or strain occur during a test. The electronic Limits function acts to protect valuable specimens, grips, and test fixtures from the effects of crosshead overtravel and possible collision.

You should always set limits and assign a crosshead action before starting a test. Enter limits values using the keypad and view them on the Main Panel Display.

Descriptions of the Limits Panel control functions are found in Table 4-3.

The Limits Panel section allows a crosshead action to be specified that is independently based on the following limit conditions during a test:

LOAD - minimum, maximum
EXTENSION - minimum, maximum
STRAIN - minimum, maximum
BREAK - detection

The action assigned to a limit can be:

STOP - stop crosshead at current position.
RETURN - return crosshead to gauge length.
CYCLE - change direction of crosshead motion at the limit.
OFF - no action

An indicator lamp lights at the active limit and at the related crosshead action key. A STATUS indicator lamp is lit whenever a limit is set to control a crosshead action. Whenever a STOP or RETURN action occurs as the result of a limit, the related STATUS lamp flashes.

Crosshead Control Section

The crosshead control keys, located at the bottom of the Front Panel are used for manually controlling crosshead functions. The STOP, UP, DOWN and RETURN keys each have an associated indicator lamp which is lit when the function of the key, as described below, is controlling the crosshead.

STOP - crosshead stops.
UP - crosshead moves up at programmed speed.
DOWN - crosshead moves down at programmed speed.
RETURN - crosshead returns at a speed which increases exponentially to maximum and then decreases exponentially to stop crosshead at gauge length.

Internal Status Indicators

A series of Light Emitting Diode (LED) indicators are mounted on the circuit board inside the console, but are visible through a window cutout in the rear panel. These indicators report the condition of power supply voltages, the pass/fail condition of some CPU functions during the Self-Diagnostic Test, and on the activity of CPU circuits during normal operation. Refer to Chapter 8, Maintenance, for a detailed description of the Status LEDs.

Recorders

You have a choice of using an X-Y recorder or a strip chart recorder as a readout device. The X-Y recorder allows two test parameters, often Load versus Strain, to be plotted against each other. A strip chart recorder, on the other hand, plots one parameter versus time. Since crosshead speed can be converted directly into time, the speed of the strip chart can be correlated with crosshead speed and a plot of a test parameter, such as Load or Strain, versus crosshead speed can be obtained.

Load and strain ranging are performed at the front panel of the recorder itself. This allows you to select an operating range for each parameter from a predefined list of gain factors. The operating range of the recorder is defined as the percentage of the maximum capacity of the installed load cell that causes a full scale reading on the recorder.

The specific recorders available for the Series 4400 Testing System are:

XY/YT Plotter	Cat. No. 2310-901

Single Pen Strip Chart Recorder Cat. No. 2310-904

Double Pen Strip Chart Recorder Cat. No. 2310-905

Console Internal Functions

In addition to the operator interface and cabling interface functions described previously, the console circuit board provides a number of internal functions to complete the testing system. These functions include a Central Processing Unit (CPU), a Crosshead Control function, a Load Sensor Conditioner, a Strain Sensor Conditioner, and an IEEE-488 Interface function. These functions are described in the following sections.

Central Processing Unit (CPU)

The CPU is a computer chip that provides the main processing functions for the console. A digital bus originating in this section allows communication with and control of all other operations, including optional interfacing for peripheral devices. Battery backup in this section allows nonvolatile parameter storage.

Crosshead Control Function

This function provides the interfacing between the load frame and console for the crosshead control signals. The encoder output signal provides crosshead position (extension) information that is conditioned and the crosshead position (extension) determined by the functions in this section. An error signal is developed when the extension is compared with the commanded crosshead speed and fed back to the crosshead drive system.

Load Sensor Conditioner

This function provides interfacing between the load transducer (load cell) and the console. Functions that this section supplies are excitation to a load cell, processing of its output signal, and providing calibrated analog and digital load weighing information to the console and readout devices.

Strain Sensor Conditioner

This function is located on an optional plug-in board and is similar to the Load Sensor Conditioner. It provides interfacing between strain measuring extensometers and the console, and is available as an AC Strain Conditioner (Catalog No. 2210-863). This conditioner is used with strain gauge extensometers, rationalized long-travel extensometers, and linear variable displacement transducers (LVDTs). An AC/DC version (Catalog No. 2210-865) is used with video extensometers and high resolution digital (HRD) automatic extensometers.

IEEE-488 Interface

This function allows a Series 4400 testing system to be remotely controlled by an external personal computer through a General Purpose Instrument Bus (GPIB). This microprocessor-based pc board interacts directly with the CPU, thus enabling a supervisory program to control console and load frame functions. The external computer must be able to transfer program messages to and receive measurement messages and status from the test instrument. Complete programming information is supplied with the IEEE-488 interface option kit.

Chapter 2
Specifications

This chapter lists physical and electrical specifications for the Series 4400 Control Console. Load Frame specifications and specifications for the system as a whole are given in the load frame manual.

Introduction

The following table lists physical and electrical specifications for the Series 4400 Control Console. Specifications for the Load Frame and its components are given in the load frame manual.

Since system specifications depend, to a large extent, on the system transducers (load cell, extensometers, etc.) in use, and the load capacity of the load frame, it is not possible to list system specifications for all possible combinations of load frames and transducers.

The generalized specifications in this chapter will help you to determine whether your system will meet your individual testing requirements. If you have any questions about specifications, your regional Instron Sales Engineer will be happy to assist you.

Specifications

Components

Standard:

- Main Panel
- Display Panel
- Limits Panel
- Load Sensor Conditioner
- RS-232 Interface

Options:

- Strain Sensor Conditioner
- IEEE-488 Interface
- Strip Chart Recorder
- X-Y Recorder
- Printer

Power Requirements

+5 Vd.c.
+15 Vd.c.
-15 Vd.c.
(All voltages supplied from Load Frame, must be free of spikes, surges, or sags exceeding 10% of the average voltage)

Operating Performance

Load Weighing Accuracy

±0.01% of full scale or ±0.5% of reading (whichever is greater) ±1 count on the load display.
Load weighing system meets or surpasses the following standards: ASTM E4, BS1610, DIN 51221, ISO 7500/1, EN10002-2, AFNOR AO3-501

Strain Measurement Accuracy

±0.05% of full scale or ±0.5% of reading (whichever is greater) ±1 count on the strain display

Strain measurement system meets or surpasses the following standards: ASTM E83, BS3846, ISO 9513, EN1002-4

Environmental Requirements

Operating temperature:
+10 to +38 °C (+50 to +100°F)
(other ranges available on request)

Storage temperature:
-40 to +60 °C (-40 to +140°F)

Relative Humidity:
10% to 90% non-condensing

Atmosphere:
Use in normal laboratory conditions.

Note: *Protective measures may be required if excessive dust, corrosive fumes, electromagnetic fields or hazardous conditions are present.*

Materials

Enclosure:	Structural foam
Keyboard:	Cleanable mylar surface with silicon rubber switches.

Dimensions

Height:	406.4 mm (16 in.)
Width:	280 mm (11 in.)
Depth:	58.2 mm (2.3 in.)

Weight 2.7 kg (6 lb) approx.

Chapter 3
Installation

Outline

This chapter contains instructions for installing the Series 4400 Console on the load frame and for cabling optional accessories. Installation instructions for the load frame itself are contained in the load frame instruction manual.

You will use this chapter to find out how to:

- Connect system cables
- Mount the Console
- Open the console for servicing

General Considerations

Installation of a basic Series 4400 testing instrument is described in the load frame manual for the system. This chapter describes how to access the interior of the console and install cabling for optional devices. The basic cables, Load and Frame, are installed at the factory.

As part of the preparation for a testing routine, you should connect any cabling required for peripheral readout and control accessories *before* powering up the system. These accessories include strain measuring devices, a recorder, printer and a computer. Any panels or circuit boards required to use these accessories have usually been installed previously at the factory.

Console Connections

Mounting the Console

The Series 4400 Console is attached to a console mounting bracket that is, in turn, mounted on one of the load frame columns, either directly in grooves in the column cover (table models) or on an extension of the column cover (floor models). On floor model load frames, the column cover extension can be mounted on either the right-hand or left-hand load frame column, specified at the time of purchase, but this can be changed later, if necessary. The console is attached to the mounting bracket with screws, and the bracket can rotate around a vertical axis to provide a comfortable viewing angle for the console.

Attaching the Console

The console mounting bracket is in two parts; a sliding bracket that attaches to the load frame, and a pivot bracket that attaches to the Control Console. A 15° tilt bracket is also provided so that the console can be tilted back from vertical for more comfortable operation.

Attach the console to the pivot bracket first, then attach the pivot bracket to the sliding bracket. The whole assembly is then mounted on the load frame. Use the following procedure to assemble all parts:

(a) Place the console against the pivot bracket, and align the mounting holes. (If you wish to use the 15° tilt bracket, attach it to the console before attaching the console to the pivot bracket).

(b) Insert a socket head cap screw in each of the four mounting holes and hand tighten.

(c) With all screws in place, tighten the screws evenly until all are secure.

(d) Attach the sliding bracket to the pivot bracket using the pins provided.

(e) Lightly tighten the thumbscrews (these will be tightened firmly when the console is mounted on the load frame and a comfortable viewing position has been selected).

Mounting the Console Bracket

To mount the console on the load frame column:

(a) Place the console bracket against the side of the column (or column extension) so that the T-nuts of the friction devices are in the grooves of the load frame column cover.

(b) Slide the bracket up or down in the groove to a convenient height for comfortable operation. Tighten both friction knobs by hand, but avoid over-tightening.

(c) Loosen the rotational securing screws and rotate the bracket to one of four positions for a comfortable viewing angle. Tighten the thumbscrews firmly, but do not over-tighten.

(d) Go to the next section to install cables.

Connector Panel

The connector panel for the Series 4400 Control Console (Figure 3-1) is located on the rear of the console unit. The components on this panel are described below. The load frame, load cell, strain channel and recorder cables connect directly to the console at connectors provided for the purpose. All of the connectors are standard D-shell connectors.

TEST - Connector used by Instron Service personnel for testing the IEEE-488 interface. An IEEE-488 Service Test printed circuit board, which is available only to service personnel, is required to run this test.

IEEE 488 - the connector for cabling from the IEEE compatible digital interface to a programmable computer.

RS-232 OUT - a connector used mainly for output to a printer with an RS-232 interface capability. Can also be used for other RS-232 devices.

FRAME - a connector for cabling between the load frame and the control console.

STRAIN - a connector for cabling from a strain measuring extensometer.

ANALOG OUT - the parallel outputs of the signals used for recorder operation, made available for signal monitoring purposes on devices such as a recorder.

LOAD - a connector for cabling from the load cell transducer.

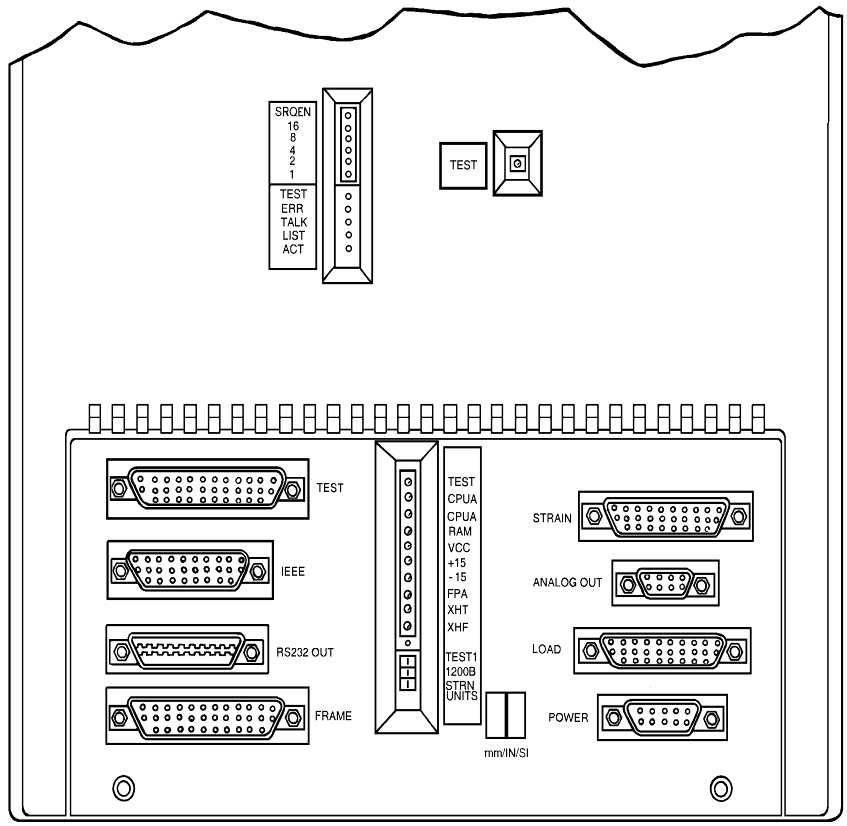


Figure 3-1.   Console Rear Panel Connectors

POWER - the d.c. connector for control console main power. The input voltage to the console is supplied from the load frame, where a d.c. power supply is located that provides d.c. power for the entire system.

mm/IN/SI switch **-** a 3-position rocker switch for setting the operating units (S.I., English, or metric) of parameters in the load and extension channels.

Installing Cables

For Series 4400 systems, cabling to the console includes cables for load frame interface, a load cell, an extensometer, and a d.c. power cable. In addition, options such as a recorder, a printer and a computer also connect to the rear panel of the console, using the cables provided with these options.

To install cables:

(a) Match the individual cables with their proper connectors on the rear panel of the console (see Figure 3-1).

(b) Press the cable connector into its mating connector on the rear panel. Use a small screwdriver to insert and tighten the cable connector screws. If you do not do this, cables may fall off during a test.

Caution

Do not allow the cables to droop in a haphazard manner from the rear of the console.

(c) When all cables have been connected, dress the cables into the cable clips provided on the console mounting bracket, as shown in Figure 3-2. This will ensure that the cables will not catch on the load frame, grips, or testing fixtures while the crosshead is moving.

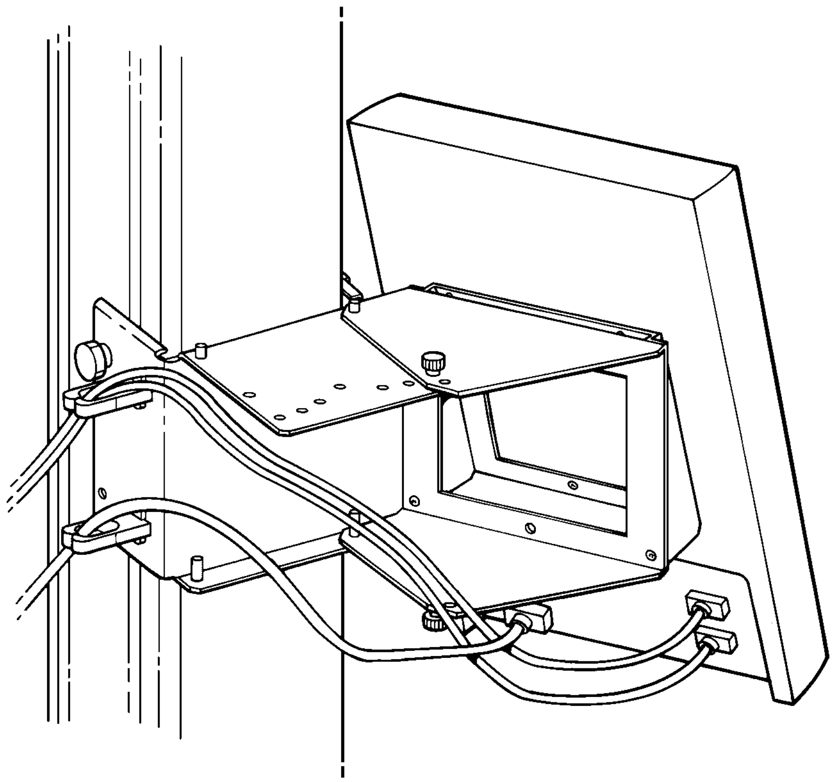


Figure 3-2. Rear Panel Cable Arrangement

Cabling for Optional Equipment

Cables

For Series 4400 systems, a recorder, printer and computer connect directly to the rear panel of the console, using the cables provided with these options (see Table 3-1). The cables for load and strain measuring devices plug into connectors on the devices themselves, as described in the system load frame manual. Thus, you usually will not have to open the console as part of the installation procedure.

Table 3-1. Series 4400 Console Option Cables

OPTIONAL ACCESSORY	CABLE ASSEMBLY	CONSOLE CONNECTOR
X-Y Recorder	A570-26	ANALOG OUT
Strip Chart Recorder	A570-26	ANALOG OUT
Extensometers (all types)	(Supplied with Extensometer)	STRAIN
Printer	(Supplied with Printer)	RS-232
Computer	144-1-35	IEEE

Analog Output Connector

The Analog Output connector on the rear panel of the console is used to connect to a chart recorder, a strip chart recorder, or other data acquisition device. This connector is a 9-pin, miniature, female “D” connector, that has the pin assignments shown in Table 3-2.

Table 3-2. Analog Output Connector Pin Assignments

Pin Number	Signal
Metal Shell	Chassis Ground
1	Load
2	Strain
3	No Connection
4	Pip
5	Run
6	Analog Ground
7	Analog Ground
8	Digital Ground
9	No Connection

The pinout appears as follows, looking at the connector:

```
5 4 3 2 1
 9 8 7 6
```

The Load and Strain output pin signals are ±10 volts, relative to Analog Ground. +10 volts corresponds to tension full scale.

The PIP pin connection is an active low TTL signal relative to Digital Ground. The signal is driven by a contact closure fed into the Pip Jack on the console.

The Run pin connection is an active high TTL signal relative to Digital Ground. The signal goes high when a test is running.

Opening the Console

Under normal conditions, it should not be necessary to open the console. There are no user-serviceable components or adjustments inside the console case, but if it should become necessary to check for loose internal connections or wiring, or to install an option board, you can open the console as follows (also see Figure 3-3):

Warning

Do not remove covers from the console without first shutting off main power and disconnecting the a.c. power cable at the load frame.

(a) Disconnect all cables to the rear of the console. Label all cables before removing them for identification, if necessary.

(b) Remove the console from its mounting bracket by removing the three screws in the rear cover of the console.

(c) To open the console, remove six screws located on the rear panel of the console.

(d) Place the console face down on a work surface. Lift the rear cover off of the console.

(e) The main printed circuit board is attached to the back of the front panel with six screws. The keys and pushbuttons are part of three rubber stampings sandwiched between the printed circuit board and the front panel. If you are replacing a key or pushbutton, you must replace the entire rubber sheet containing that key.

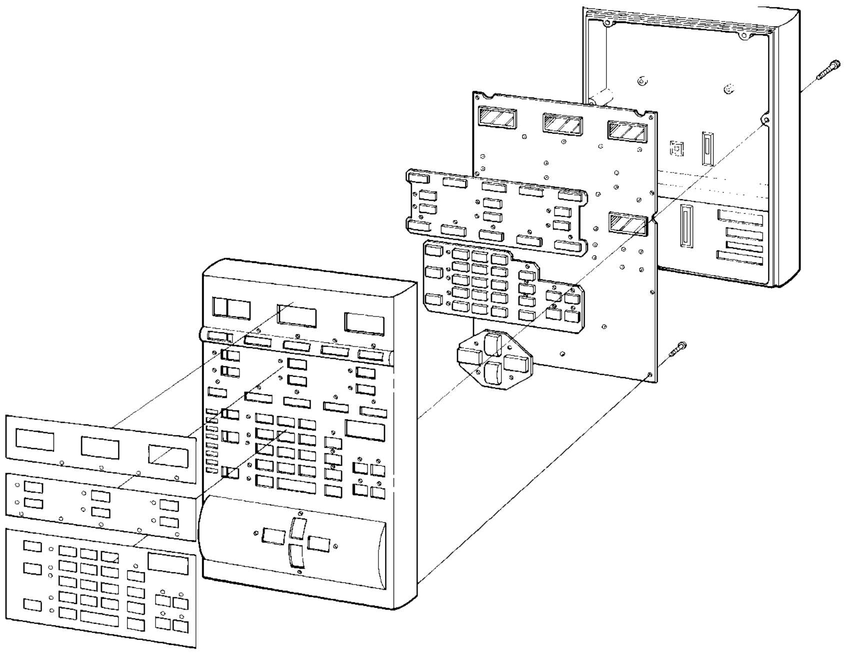


Figure 3-3. Access to Interior of Console

(f) Reassemble the console in reverse order of the steps to disassemble. Be sure to replace *all* screws.

(g) Remount the console on its mounting bracket.

(h) Reinstall cabling removed in step (a). Be sure to tighten all connector screws to prevent connectors from falling loose during operation.

Chapter 4
Function Of Controls

Outline

This chapter describes the function of front panel controls and how data resulting from a test is saved. It then describes the Self-Test routine and how you can use it to make sure your system is operating properly. The chapter then describes how to select and change system operating units.

Preliminary Considerations

The purpose of this chapter is to provide details of the operational features of the Series 4400 Control Console, so the application of each device and its purpose in the calibration and operation of the system will be understood.

The operational capabilities of a Series 4400 testing instrument depend upon the installed options and the peripheral readout and control devices that have been selected to be used with the system. Complete installation instructions are supplied with any option ordered later to expand a system.

This chapter contains the function of all controls and indicators on the main panel that supply the operator interface to the instrument. Also included are descriptions of the system data storage capability and self-test feature.

Function Of Controls

Main Panel

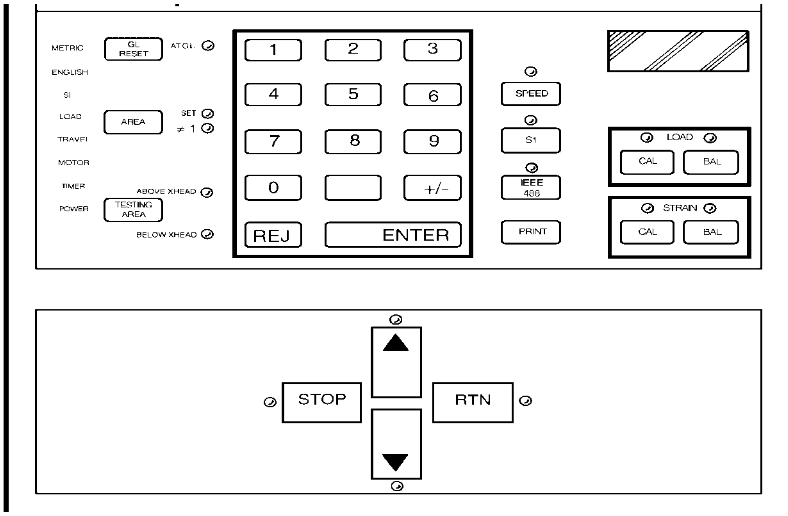


Figure 4-1. Main Panel

Table 4-1. Main Panel Functions

CONTROL or INDICATOR	FUNCTION
Numeric Keypad	(a)Numeric Keys, 0 through 9, allow entry of: 1. Value of calibration signal for manually calibra- transducers. 2. Desired crosshead speed. 3. Area compensation value. 4. Maximum and minimum electronic limits for load,extension, and strain. 5. Preset points.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
Numeric Keypad (continued)	(b) +/- key defines the values of load, extension, and strain as + for tension testing and - for compression testing. This key is also used when entering the electronic limits. (c)REJect key allows the rejection of an incorrect input on keypad before pressing ENTER key. (d)ENTER key must be pressed to change any system variable entered on keypad or to complete a transducer calibration or balance.
Display	A 4-digit display used to view system variables in the range from .0001 to .9999. “EEEE” is shown if an overflow of the display register occurs. A “——” is shown when the system is uncalibrated and no valid data can be read. “LOSS” is shown if the non-volatile memory is reset to a default state. All keypad entries (0-9, +/-) are read on this display.
AT G.L.	Gauge length indicator LED is lit whenever crosshead is at gauge length. Lamp flashes when power is initially turned on, or a momentary power loss occurs to indicate a loss of gauge length information. Pressing G.L..RESET key or moving crosshead by pressing UP, DOWN, RETURN or JOG stops the flashing.
G.L. RESET	Gauge length reset key, when pressed, causes current crosshead position to be entered as the gauge length. Also, any EXTENSION readout will be set to zero. Pressing this key causes the AT G.L. LED to stop flashing.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
AREA SET ≠ 1	Enables an area compensation circuit which divides both displayed load value and output voltage to a recorder by a set value between 1.000 and 9.999. When this key is pressed, the SET LED lights and an area value can be entered on the keypad. After the ENTER key is pressed, if the value of area compensation is other than 1.000, the ≠1 LED lights and the SET LED stays on. Area compensation is temporarily set to 1.000 during a load cell calibration procedure. The default value of area compensation is 1.000.
TESTING AREA BELOW XHEAD ABOVE XHEAD	Defines the location in the load frame (above/below crosshead) to be used for specimen testing. This function is necessary for the proper operation of cycling limits and pneumatic grips. To change this function, the S1 key must be enabled and “SL” must be on the Main Panel Display (refer to SI KEY description). The BELOW XHEAD or ABOVE XHEAD LED lights to indicate the selection.
SPEED	Allows a desired crosshead speed to be entered on the numeric keypad. If the load frame has not been identified, the display will show “——” when this key is pressed.
LOAD CAL	Initiates a load cell calibration procedure. The LOAD CAL key LED is lit during calibration or when a load calibration relay is closed. A flashing LED indicates a calibration error. A test cannot be started during a calibration procedure, and calibration is locked out during a test.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
LOAD BAL	Sets a load cell balance, or zero, during a calibration procedure or when balancing out the tare of grips and fixtures before starting a test. The LOAD BAL key LED is lit during a balance operation or if a load calibration relay is closed. A flashing LED indicates a calibration or balance error. A test cannot be started during a balance operation, and the balance function is locked out during a test.
STRAIN CAL	Initiates an extensometer calibration procedure. The STRAIN CAL key LED is lit during calibration or when an extensometer calibration relay is closed. A flashing LED indicates a calibration error. A test cannot be started during a calibration procedure, and calibration is locked out during a test.
STRAIN BAL	Sets an extensometer balance, or zero, during a calibration procedure or when balancing out the tare of grips and fixtures before starting a test. The STRAIN BAL key LED is lit during a balance operation or if a load calibration relay is closed. A flashing LED indicates a calibration or balance error. A test cannot be started during a balance operation, and the balance function is locked out during a test.
METRIC ENGLISH SI	Status indicators that show the operating units for the load and strain channels. The indicator that is lit shows the current status of the units, as determined by the positioning of a switch mounted on the rear connector panel of the console. The selection of units determines the scaling of displays and the input to a recorder. After switching units, the Main Panel display will show “LOSS”, indicating that nonvolatile memory is reset to the default state and stored test data is lost. Load and strain channels must be recalibrated and all electronic limits reset.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
LOAD	Fault indicator that lights when a load overrange (102% or greater of load cell maximum capacity) occurs. The crosshead stops and the indicator flashes until the overload is cleared by pressing the UP or DOWN key or a JOG key on the load frame, whichever direction decreases the measured load.
TRAVEL	Fault indicator that lights when the overtravel limits for the moving crosshead are actuated. The crosshead is stopped when this indicator is lit.
MOTOR	Fault indicator that functions as described below. This indicator is lit steadily for the following conditions: 1. Motor drive enabling sequence (5 sec. duration). 2. Motor drive cannot be enabled. 3. Load frame cannot be identified. 4. Load frame power supply failure. 5. Crosshead second level travel limit tripped. 6. Emergency stop switch tripped. This indicator flashes for the following conditions: 1. Drive motor overheats. 2. Drive loop failure (stall, etc.) The MOTOR status indicator will remain on (steady or flashing) after the condition/fault is cleared, except after the 5-sec motor drive enable sequence. Perform the key sequence [S1] [1] [ENTER] to restore the indicator to standby (off) condition.
TIMER	Fault indicator that lights when the CPU malfunctions and a special circuit shuts off the crosshead drive motor. Usually, momentarily shutting down the system power clears this condition. This LED also lights if the +/- 15 Vd.c. console power supply fails.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
POWER	Fault indicator that lights if a momentary power failure occurs. Momentarily shutting down system power clears this condition.
PRINT	Obtain a printout of the current test at any time, or a printout of the last test when no test is running.
IEEE	Status indicator that is lit when an IEEE-488 option is set to receive keyboard commands from an external computer. The indicator does not light if the IEEE option is not installed.
S1	Enables or disables system options, as follows: (a)System reset option - clearing of nonvolatile memory. Press S1, then 0 and ENTER on keypad. This sequence clears the nonvolatile memory, setting all variables to a default state, and thereby resetting the system to a known condition. Also, any previously stored data will be lost. The Main Panel Display will show “LOSS” after this type of reset key sequence is entered. (b)System reset option - no clearing of nonvolatile memory. Press S1, then 1 and ENTER on the keypad. This sequence is a“warm restart” of the system which is used to to reset certain fault conditions, without resetting nonvolatile memory to the default state; that is, all previously entered parameters will remain in storage. An exception is when this sequence is used to enable a change in system operating units.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
S1	(c) Diagnostic Monitor - Press S1, then 2 and ENTER on keypad. This sequence initiates the diagnostic troubleshooting routine which is part of the Resident Test Program for the Series 4400 console (refer to Resident Test Program for details and exiting procedure). *Note* *The Diagnostic Monitor feature should be used by qualified maintenance personnel only.* (d) Energy option - press S1, then 3 and + /- on the keypad. With an optional printer installed, this sequence provides an energy printout after a test. The Main Panel Display must show “SL 3" for this option to be enabled, and”SL-3" to be disabled, which is the default condition. The key sequence [S1] [3] [+/-]...[+/-] toggles between these two conditions. (See Item (g) below for the selection of the Energy Integration Variable.) (e)Preset Point option - press S1, then 4 and +/-. This sequence provides a printout of load and energy at three preset points (PPT1, PPT2, PPT3) versus an independent variable after a test. These values can be used to determine modulus of elasticity. (See Item (f) below for the selection of independent variable.) The Main Panel Display must show “SL 4" for this option to be enabled and ”SL-4" to be disabled, which is the default condition. The key sequence [S1] [4] [/]...[/] toggles between these two states.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
S1 (continued)	(f) Set Preset Point Values - if the values of the Preset Points (PPT1, PPT2) are to be other than the default values as shown in Table 4-5, then the following key sequences are used to enter new values (where PPT1 and PPT2 are indicated, enter the actual numerical value on the keypad of the independent variable: Extension in inches or millimeters, or strain in percent): [S1] [41] PPT1 [ENTER] [S1] [42] PPT2 [ENTER] [S1} [43] PPT3 [ENTER] (g)Select Energy Integration Variable and Preset Points Independent Variable - the key sequence [S1] [5] [/]...[/] toggles the selection of energy and preset points variable between Extension and Strain (that is, the active strain channel). The Main Panel Display will show “SL 5" for Extension and ”SL-5" for Strain. The default variable is Strain, if this option is installed. If Strain is not installed, then Extension is the default variable. (h)Autoprint option - press S1, then 6 and + /- on keypad. With an optional printer installed, this sequence provides an automatic printout each time a test ends. The Main Panel Display must show “SL 6" for this option to be enabled, and ”SL-6" to be disabled (continued) which is the default condition. The key sequence [S1] [6] [+/-]...[+/-] toggles between these two conditions. (i) TESTING AREA enable - press S1, “SL” will show on the Main Panel Display and the TESTING AREA function can be changed.

Table 4-1. Main Panel Functions (continued)

CONTROL or INDICATOR	FUNCTION
S1 (continued)	(j) Air Kit Option – provides automatic grip control for pneumatic grips. The key sequence [S1][7][+/–] enables or diables grip control, and the Main Panel Display shows “SL 7 when enabled and ”SL–7" when disabled. The key sequence [S1][7][n][+/–], where “n” is a number between 1 and 4, or [S1][7][v], where “v” is a value entered at the keypad, enables or disables various options under automatic grip control and sets values for Pretension or Excess Tension Levels (see Chapter 6 for details). (k) Miscellaneous [S1] [8] [+/–] Cycle Counter Printout [S1] [8] [1] Cycle Limit [S1] [8] [2] Enter Pip Delay Value [S1] [8] [3] Display Cycles/Pip (l) Firmware Date - [S1] [9] [ENTER] displays the date the firmware installed on this system. (m) Cycle Count Display - [S1] [+/–] displays the cycle or pip count in the setup display.
UP DOWN STOP RETURN	The pushbutton switches (keys) used for manually controlling the crosshead. Each key has an LED that is lit when the function of the key is active. STOP - crosshead stops. UP - crosshead moves up at programmed speed. DOWN - crosshead moves down at programmed speed. RETURN - crosshead returns at a speed that increases exponentially to maximum and then decreases exponentially to stop the crosshead at gauge length.

Display Section

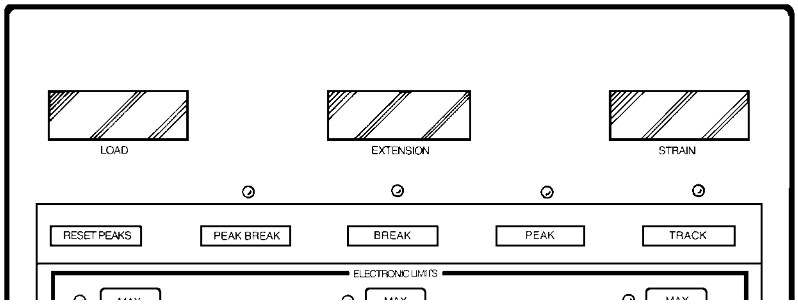


Figure 4-2. Display Section

Table 4-2. Display Section Functions

CONTROL or INDICATOR	FUNCTION
LOAD DISPLAY	A 4-digit display which indicates + and - values of load between .0001 and 9999. The display shows "——" when the load cell is uncalibrated; is blank without data; and shows "EEEE" when overranged.
EXTENSION DISPLAY	A 4-digit display which indicates + and - extension values between .0001 and 9999 from gauge length. The display shows "——" if the load frame has not been identified, and is blank if no data is available.
STRAIN DISPLAY	A 4-digit display which indicates strain values between .0001 and 9999. The display shows "——" if the strain channel is not calibrated, "EEEE" if it is overranged, and is blank if strain is not installed or no data is available.
TRACK	Sets the displays to show instantaneous values of load, extension and strain. The displays are updated every 300 msec during a test. The TRACK LED is lit when this key is active. (Peak and break values are recorded even though tracking is active.)

Table 4-2. Display Section Functions (continued)

PEAK	Sets the displays to show load, extension and strain values that occur at the peak load during a test. These values are held on the display at the end of a test. When a test begins, the displays show current tracking values until a “peak” load is reached. The PEAK LED is lit when this key is active.
BREAK	Sets the displays to show load, extension and strain at specimen break, where break is defined as just prior to break detection. When a test begins, the displays are blank and remain blank until the break criteria is met. The BREAK LED is lit when this key is active.
PEAK BREAK	Sets the LOAD display to show the peak load value for a test and the EXTENSION and STRAIN displays to show values that occur at specimen break. The LED at this key is lit when the key is active.
RESET PEAKS	This key is used during a test to reset the stored peak values of load, extension, and strain to the values at the current load. The peak storage is then continuously updated to the values at the next peak load that occurs during the remainder of the test. This key does not change which values are selected to be displayed (Break, Peak, or Track) and it is functional only when a test is in progress.

Limits Section

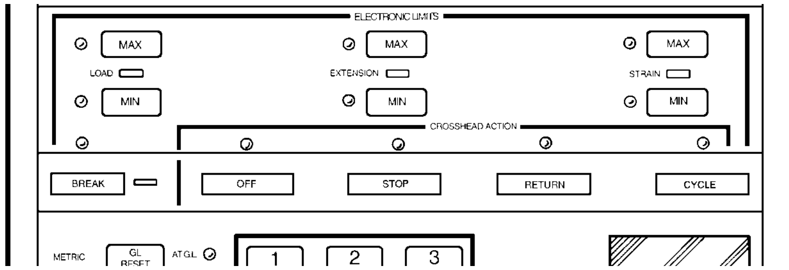


Figure 4-3. Limits Section

Table 4-3. Limits Section Functions

CONTROL or INDICATOR	FUNCTION
LOAD MAX/MIN EXTENSION MAX/ MIN STRAIN MAX/MIN BREAK	Electronic limits which permit an action to be independently assigned to the maximum and minimum values of load, extension or strain, or to detect break. An LED to the left of each key lights when the key is pressed. This shows that the key has enabled the numeric keypad and a limit value can be entered and viewed on the display (except BREAK, as this has an unknown numeric value). If the Recorder is installed, the STRAIN limits are functional only if STRAIN is selected for the X-axis of the X-Y recorder.
OFF STOP RETURN CYCLE	Crosshead actions that can be selected to occur at the electronic limits. The actions are: OFF - no action STOP - stop crosshead when limit occurs RETURN - return crosshead to gauge length CYCLE - change crosshead travel direction Whenever a limit key LED is lit, a CROSSHEAD ACTION key LED is lit also. To change the action, press a different key.

Table 4-3. Limits Section Functions (continued)

STATUS LEDs	A rectangular STATUS LED is located to the right of the BREAK key and one each between the LOAD, EXTENSION, and STRAIN MAX/MIN limit keys. When a limit or break detection is selected to cause a crosshead action (except OFF), the related STATUS LED lights. When either a STOP or RETURN action occurs, the STATUS LED will flash and stay flashing until recycled by starting a new test. If the current value of load, extension or strain is beyond the assigned limit ranges, then the crosshead control key (UP or DOWN) which would increase the out-of-range error is disabled. If this disabled key is pressed, the crosshead will not move and the related limit status LED flashes. The flashing continues until the enabled key (UP or DOWN) is pressed and the crosshead is moved in a direction to decrease the out-of-range error.

Data Storage

Nonvolatile Memory

The data storage capability of a Series 4400 control console includes a nonvolatile memory; that is, data remains in storage, even though main power is removed, due to battery backup. The retention period of the nonvolatile memory, with a fully charged battery, is up to ninety days without refreshing.

The variables and system functions stored in nonvolatile memory are shown in Table 4-4. Listed in the table is the default value or condition of each variable or function. These default values are restored whenever the system is reset by the key sequence described below.

System Reset

To reset the system, press S1 on the Main Panel, then press 0 and ENTER on the keypad. The nonvolatile memory will be cleared, including data from a previous test, and all variables, limits and system functions will be reset to their default values, as shown in Table 4-4. The Main Panel Display will show “LOSS”.

Volatile Memory

The following variables or system functions are volatile; that is, the value of the variable or function condition will be restored to a default state whenever main power is removed:

Table 4-4. Variables and Functions in Nonvolatile Memory

VARIABLE or FUNCTION	DEFAULT VALUE or CONDITION		
Crosshead Speed	0		
Area	1.000		
Calibration (Both Zero and Scale)	Uncalibrated		
Testing Area	BELOW XHEAD		
Peak/Track/Break	TRACK		
Load Limit Action (Both MAX and MIN	0/OFF		
Extension Limit Action (Both MAX and MIN)	0/OFF		
Strain Limit Action (Both MAX and MIN	0/OFF		
Break Action	OFF		
Break Storage LD, EX, SN, EN	0 (Blank display)		
Peak Storage LD, EX, SN, EN	0 (Blank display)		
Preset Points	PPT1	PPT2	PPT3
Extension (in.)	1	3	10
Extension (mm)	20	60	200
Strain (%)	100	300	1000

Table 4-4. Variables and Functions in Nonvolatile Memory (continued)

VARIABLE or FUNCTION	DEFAULT VALUE or CONDITION
Preset Points Independent Variable	Strain (active channel)
Energy Independent Variable	Strain (active channel)
Autoprint Option	Disabled (Reenter S1 - - - sequence)
Preset Points Printout	Suppressed (Reenter S1 - - - sequence)
Energy Printout	Suppressed (Reenter S1 - - - sequence)

The tracked variables are never stored, but are updated every 50 milliseconds during a test.

The Gauge Length will also default to present crosshead position whenever main power is removed.

Resident Test Program Overview

The Series 4400 control consoles contain a Resident Test Program which is a feature designed to provide support for several levels of automatic testing of the console. This test program includes a Self Test Routine, a Cyclic Self Test and a Diagnostic Monitor.

Note: *The Self Test Routine is a basic test intended to inform you of the operational status of the system console, and is fully described in Chapter 5. The Cyclic Self Test and Diagnostic Monitor are intended for use by qualified maintenance personnel as troubleshooting aids, so this section provides only a brief description of these features.*

The Self Test Routine is performed automatically when main power is applied to the system. Its purpose is to provide you with an initial survey of the operating condition of the console. It tests the console hardware and prevents the startup of normal operation if there are failures on the basic circuit board in the console.

When main power is applied to the Series 4400 system, all lamps (LEDs) on the front panel of the console light and all displays (LCDs) show a number. This action lasts several seconds and allows you to make a visual check of these functions. After the first part of this test, the Main Panel Display shows a coded number which indicates the operational status of the major functional sections of the console. The coded number also indicates whether an option is installed or not.

If all circuit boards pass the self test, the coded number disappears and normal operation can begin. If not, the resulting number on the Main Panel Display remains and only a continuation of the Resident Test Procedure can be run.

If an installed optional board contains severe faults, as determined by the Self Test, it may be shown as not installed, thereby permitting normal operation to begin. A board designated as not installed by the Self Test is also considered absent by the operating program and its associated features are disabled.

The Cyclic Self Test is identical to the Self Test Routine previously described, except that it is continuously repeated. Its purpose is to assist in locating intermittent failures by long term testing of the console functions. When the test is stopped, all failures occurring during the running period can be identified by interpreting the resulting number that appears on the Main Panel Display.

Note: *The Cyclic Self Test is for use by qualified maintenance personnel. If it is started accidentally (by pressing S1 twice when the Self Test Routine number is displayed), it can be exited to resume normal operation, if there are no failures, by pressing ENTER on the keypad whenever the Self Test number is again displayed.*

The Diagnostic Monitor is the main troubleshooting mode of the Resident Test Program. It provides interaction with console circuits via front panel controls, and allows a detailed list of errors to be scanned which can directly indicate component failures.

Note *The Diagnostic Monitor is for use by qualified maintenance personnel, but limited use is described in Chapter 9 for the readout of error messages.*

If the Diagnostic Monitor mode is entered accidentally (by pressing S1 once when the Self Test Routine number is displayed, or by pressing S1 then [2] on the keypad during normal operation), the word HELP will appear on the Main Panel Display. This mode can be exited to resume normal operation, if there are no failures, by either pressing REJ (Reject) or by the following procedure:

Press S1 to enter the Cyclic Self Test, wait until the Self Test result number is displayed, then press ENTER on the keypad.

Self Test Routine

This section provides information about the automatic self test feature of the Series 4400 console.

The Self Test Routine consists of two parts as described in this section. It is initiated when power is applied to the control console, and cannot be bypassed. The purpose of the Self Test Routine is to assure that the console performs reliably before allowing normal operation (also refer to the Calibration Overview, page 5-8). The duration of the self test is only several seconds, and it requires no operator input or interaction other than observation of the results of the two-part sequence. If there are no failures indicated, normal operation can start immediately after the test.

Self Test - Part 1

Apply main power to the console using the system power switch on the loading frame. Within 2 seconds, all front panel LEDs light at the same time, including the status indicators and the crosshead control panel switch LEDs. Also, at the same time, all front panel displays (LCDs) show the following numeric coding for 5 to 10 seconds.

-1.8.8.8.8

During this first part of the self test, you should scan the panels and check that all LEDs light and all LCDs display the proper number. If service is required, report the exact condition.

Self Test - Part 2

After the first part of the Self Test Routine, all LEDs turn off and the LCDs become blank. This condition persists for 2 to 5 seconds. During this second part, you should again scan the panels and check that all LEDs go off and LCDs are blank. *DO NOT* press any of the crosshead control switches, as a short circuit test occurs during this part.

When the Self Test Routine has been completed, the Main Panel Display shows a four-digit test result, as described in the Section “Self Test Result Display”. All other LCDs should be blank and LEDs should be off, except as described in the operating procedures of Chapter 6.

Self Test Result - No Failures

The four-digit test result, which appears on the Main Panel Display after the Self Test Routine, disappears after about 5 seconds if no board failures are detected. Normal system operation can then begin, as described in Chapter 6. Also, operation can begin more quickly, if desired, by pressing ENTER on the keypad before the test result disappears.

The REJECT and S1 keys are active when the test result is displayed, but would not normally be used at this time. Pressing REJECT recycles the Self Test Routine, and pressing S1 activates the Diagnostic Monitor which should be used only by qualified maintenance personnel.

In the case of no failures, the test result is useful only in determining what optional circuit boards are installed in the console. This can be interpreted from the description of the test result in Section “Self Test Result Display”. If this information is necessary, record the test result at this time.

Self Test Result - Failures

When failures have been detected during the Self Test, the test result shows on the Main Panel Display. However, normal operation cannot be started and pressing ENTER on the keypad has no effect. Record the test result, as it provides important service information.

In the case of failures, where one or more bad circuit boards have been found, only two keys are active on the front panel of the console, REJECT and S1. If you press REJECT, the Self Test Routine restarts in the same manner as if main power was switched off and then on. (An exception to this is the POWER and TIMER indicators. If these LEDs were lit before recycling the self test, then retesting can occur only if main power is switched on and off.)

It is possible that no failures will occur when the Self Test Routine is rerun, but a failure on the first run indicates a possible marginal condition which you should report.

Pressing the S1 key will activate the Diagnostic Monitor which is used to further investigate the cause of any failures detected during the self test. This mode should be used only by qualified maintenance personnel.

Self Test Result Display

The four-digit test result, displayed at the end of the Self Test Routine, is designed to show the three possible conditions of the one main and two optional circuit boards in the control console (refer to Table 4-5). These conditions are 1) Good, 2) Bad or, in the case of options, 3) Not Used. This application of the Main Panel Display is done by addressing each segment of the LCD figures.

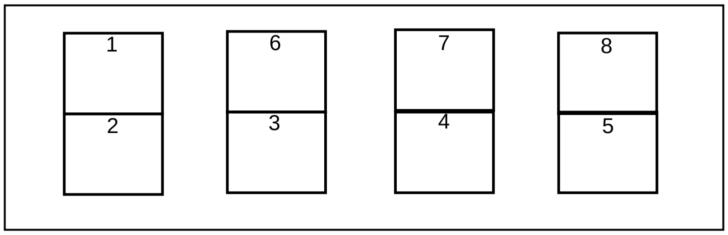


Figure 4-4. Console Section Numbers Assigned to Main Panel Display for Self Test Result

Each half of each digit in the display represents a functional section in the console. The top halves are assigned to optional sections and the bottom halves to basic sections (except Nos. 4, 7, and 8), as shown in Figure 4-4. The numbers in each digit correspond to the listing in Table 4-5.

Table 4-5. Control Console Sections

Section No.	Functional Name	Basic or Option
1	IEEE-488 Interface	Option
2	Central Processing Unit (CPU)	Basic
3	Crosshead Control	Basic
*4	(Not Used)	- -
5	Load Sensor Conditioner	Basic
6	Strain Sensor Conditioner	Option
*7	(Not Used)	–
8	(Not Used)	–

*Section No. 4 is not included in the Resident Self Test feature. It always shows in the Self Test as “good” even though this section is not used. Sections 7 and 8 will always show as “Not Used”.

The method in which each half digit of the display is coded to represent a functional section condition is by deleting a segment of the digit for a “good” or “bad” indication, or by displaying all segments if a section is not used. This is shown in Figure 4-5.

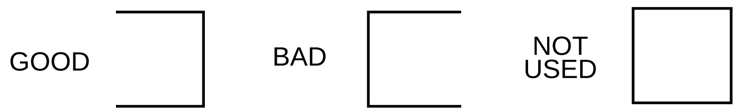


Figure 4-5. Coding of Display Results for Self Test Result

As a result of the coding, the four digits in the display can be one of the characters shown in Figure 4-6 (an exception is shown in Table 4-6).

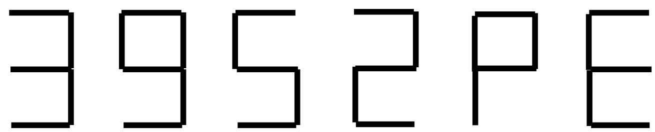
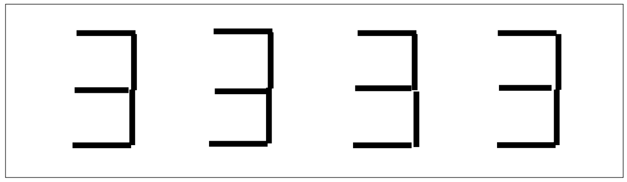


Figure 4-6. Characters Displayed in Self Test Result

Table 4-6 shows all of the possible characters that could appear in each digit of the 4-digit Main Panel Display. Any combination of these characters could make up the Self Test Result. Table 4-6 also indicates, within each half character, the functional section number and its condition that caused the half character. The examples below show possible self test results and the meaning of each.

Example No 1. All sections in use and all good.



Example No 2. IEEE Board not in use and
Crosshead Control Section bad.

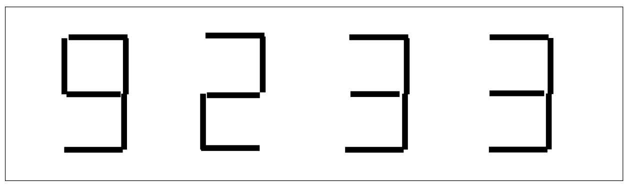


Table 4-6. Characters Possible in Self Test Result for Each Digit of Main Panel Display

1st Digit	2nd Digit	3rd Digit	4th Digit
1G 2G	6G 3G	*NOT POSSIBLE	*NOT POSSIBLE
1NI 2G	6NI 3G	7NI *4	8NI 5G
1B 2G	6B 3G	*NOT POSSIBLE	*NOT POSSIBLE
1G 2B	6G 3B	*NOT POSSIBLE	*NOT POSSIBLE
1NI 2B	6NI 3B	*NOT POSSIBLE	8NI 5B
1B 2B	6B 3B	*NOT POSSIBLE	*NOT POSSIBLE

Notes

Version Number

The system firmware, which is the resident program that is stored in non-volatile memory, has been updated on several occasions over the life of the Model 4400 Testing System. In order for some of the option functions and features described in Chapter 6 to work properly, the firmware must have a certain version date. This requirement is noted in the description of the options in Chapter 6.

To determine the version date of your firmware, use the following key sequence at the front panel of the console:

S1, 9, ENTER

When the S1 and 9 are pressed, the setup display on the Main Panel shows “SL 9". Then, when the 1 is pressed, the display shows the month and year of the installed firmware:

“12–93"

If the firmware has been customized just for your system, a leading minus sign is added to the displayed date:

“–12–93"

Selecting Operating Units

Switching Units

The operating units (English, metric, S.I.) in use in a Series 4400 system is controlled by the position of the units selection switch, marked “mm/IN/SI” located on the rear panel of the console. The switch is a rocker type; depressing the left-hand side sets the units to metric, the center position is English units, and depressing the right-hand side sets the units to SI.

You should normally set the units selection switch before powering up the system. When system power is applied, the choice of units is shown by the units indicator on the Main Panel. If this switch has been changed since the last time the system was powered up, the Main Panel Display shows “LOSS”. This indicates that nonvolatile memory is reset to the default state and stored test data is lost.

Note *You must recalibrate the load and strain channels and reset the electronic limits if “LOSS” appears on the display panel.*

If you change the units selection switch position with power applied to a calibrated system, the front panel units indicator will not change. *You must perform ONE of the following procedures to make the units change valid:*

(a) Cycle main power off then on.

(b) Enter the system reset sequence: Press S1, then press [0] and [ENTER] on the keypad.

(c) Enter the “warm start” sequence: Press S1, then press [1] and [ENTER] on the keypad.

After you switch units and perform one of the above procedures, the Main Panel display will show “LOSS”, indicating that nonvolatile memory is reset to the default state and stored test data is lost.

Note *After you change operating units for a calibrated system, you must recalibrate the load and strain channels and reset all limits (Load, Extension, and Strain).*

Operating Units for Self Identified Load Cells and Load Frames

The units that are used for load, extension and speed are listed in Table 4-7.

Table 4-7. Operating Units for Self-Identified Load Cells

PARAMETER	ENGLISH	METRIC	S.I.
*Load	LB KLB MLB	GF KGF KKGF	N KN MN
Extension	IN	MM	MM
Speed	IN/MIN	MM/MIN	MM/MIN

Legend for Table 4-7:

LB = pounds	N = Newtons
KLB = LB x 10	KN = N x 10
MLB = KLB x 10	MN =K N x 10
GF = grams force	IN = inches
KGF = GF x 10	MIN = minutes
KKGF = KGF x 10	MM = millimeters

Function of Controls

The units shown in Table 4-7 provide the scaling for the Display Panel and recorder options, and are the units that appear on a printout of test results.

Note *When Area Compensation is not equal to 1.000, the load signal to the LOAD display and recorder are scaled by 1/AREA (normalized). A printout will show load units/Area, e.g., LB/A.*

The units in use depend upon the selection of English, metric or S.I. type, as described in the previous section. The units shown for load and extension appear only if the load cell and load frame, respectively, are self-identified.

Operating Units for Non-Self Identified Load Cells and Load Frames

If the load cell (or load frame) in use is not self-identified, then the units for load (or extension and speed) print as:

"LD" for Load
"EX" for Extension
"SP" for Speed

If the load cell in use is not self-identified, the scaling of the load parameter for the LOAD display, recorder and printer options depend upon the full scale value of the cell; you enter the full scale value during the calibration procedure. Also, if Area Compensation is not equal to 1.000, load is scaled by 1/Area and LD/A would be printed.

If the load frame is not self identified, then the scaling of the extension parameter for the EXTENSION display, recorder and printer options and the speed parameter depend upon the units in use (inches or millimeters); you must record this separately.

Area

There are no units associated with Area Compensation (AREA on the Main Panel). A printout of test results always lists Area values. This feature is fully described on page 5-38.

Energy Units

The units shown on a printout of Energy depend upon the current units in use for load and extension (English, metric, S.I.). Also, energy units are printed as being divided by Area (*1/A*) whenever Area is not equal to 1.000.

Energy units consist of the combination:

$$X * \frac{Y\,Z}{A}$$ where:

X = units of Load (LB, etc.)

Y = variable of distance (Extension or Strain)

Z = units of distance (in., etc.)

A = 1/Area (used when A = 1.000)

Examples of Energy units printout:

English units	*LB*EX in./A*
Metric units	*kGf*EX mm/A*
S.I. units	*N*EX mm/A*

Chapter 5
System Operation

Outline

This chapter details the procedures involving pretest parameters common to all tests. Additional procedures for system options can be selected from Chapter 6.

Operating Considerations

A typical test worksheet, which enables you to preplan a test program, is included in Chapter 7. With the blank spaces filled in where applicable, the worksheet serves as a permanent record for future reference. This record is important even for repetitive testing routines during which parameters may remain unchanged for a period of time. Even though most parameters are stored in the non-volatile memory, these would revert to a default value if you enter the system reset sequence, [S1] [0] [ENTER].

Appendix A to this manual provides supplementary information if you need assistance in planning a materials testing procedure. A section on the introduction to testing contains details about determining load requirements, establishing gauge length and choosing a testing speed.

Appendix B is a glossary of mechanical properties and tests for materials testing applications which you can reference for specific materials testing terms.

Pretest Procedures

The Test Setup Procedures in the following list help you to prepare your Series 4400 testing system to run basic tension and compression tests. Follow the procedures sequentially, since many of them require that other procedures be performed first. Each listed procedure is covered in detail later in this chapter. Refer to Chapter 4 if you need further explanations of control or display functions. Chapter 6 provides operating procedures for optional accessories.

1. Install a load cell (Refer to load frame manual)
2. Install grips (Refer to grips manual)
3. Connect accessories (page 3-9)
4. Set operating units switch (page 4-32)
5. Turn instrument on (page 5-4)
6. Monitor Self Test (page 5-5)
7. System reset (page 5-7)
8. Calibrate and Balance system (page 5-8)
9. Set Display Panel displays (page 5-26)
10. Set gauge length (page 5-28)
11. Set Electronic Limits (page 5-30)
12. Set crosshead limit stops (page 5-34)
13. Set crosshead speed (page 5-35)
14. Set Area Compensation (page 5-38)
15. Install test specimen (page 5-42)
16. Set testing area (page 5-43)
17. Start test (page 5-45)

Turn Instrument On: Warm-up

To turn on power to the Series 4400 instrument, set the main power switch on the load frame to ON. The complete testing system receives power, but any external accessories, such as a recorder or a printer, must be turned on separately.

When power is applied to the system, an automatic Self Test Routine runs as described on page 4-23.

You must allow a warm-up period of at least 15 minutes to assure load cell stability. This warm-up period is also necessary whenever you change a load cell.

Note *In some cases, grips and fixtures may have to be installed on the load frame after calibration, depending upon the procedure used and the type of load cell installed.*

Self Test Routine At Power Up

The following sequence occurs during the automatic self test of the Series 4400 system when main power is applied. Monitor this routine closely, as it provides assurance of the reliability of the system before proceeding with test programs. (Refer to page 4-23 for details of this feature and user interaction.)

(a) Turn instrument on. Scan all sections of the Front Panel during the Self Test Routine and observe the following action:

(1) All LEDs light, including the control switches and backlit status indicators, and all displays show "-1.8888" for up to 10 seconds.

(2) All LEDs go out and all displays are blank for up to 5 seconds.

(3) The Self Test Result shows on Main Panel Display for up to 5 seconds, then disappears (see Note below). If the Self Test Result remains on the display, then the system cannot be operated and corrective maintenance is required.

Note *You can repeat the Self Test Routine by pressing the Reject key (REJ) on the keypad during the time when the Self Test Result shows on the Main Panel Display. This allows you to observe the LED test again, and, if a fault condition is random or spurious, may allow a Self Test Routine to pass a second try. If a second try is required often, it could indicate a marginal condition or an intermittent failure.*

(b) After a successful Self Test, observe the following actions (depending upon options installed):

(1) On the Main Panel:

a. The STOP switch is lit.

b. The display is blank, or it shows “LOSS” if the operating units or the strain mode has been changed before turning power on.

c. The AT G.L. LED is flashing.

d. An operating units status indicator is lit.

e. A TESTING AREA indicator is lit.

(2) On the Display Section of the panel:

a. A display mode selection key LED is lit.

b. If no prior values were stored, the displays show:
LOAD, “——”; EXTENSION, “.000";
STRAIN, ”——".

(3) On the Limits Section of the panel, a Limits Status LED may be lit.

The particular LEDs and indicators that are lit at the end of a Self Test Routine vary depending upon the state of the system. That is, variables and functions may not be at the default state (refer to Table 4-5) due to a previous test which would be stored in the nonvolatile memory.

If you enter the System Reset sequence as described on page 5-7, the default state is restored.

System Reset At Initial Power Up

When you initially power up your Series 4400 system, we recommended that you enter a System Reset sequence at the end of the Self Test Routine. This ensures that system data storage is at the default state (Table 4-5).

To enter a System Reset:

Press S1 on the Main Panel,

then press “0" and ”ENTER" on the keypad.

The Main Panel Display shows “LOSS” after this sequence, which indicates that any previously stored conditions and data are lost.

Load Calibration

Overview

The Load Measurement function of the Series 4400 System consists of a precision load cell transducer, mounted on the load frame crosshead, and a Load Sensor Conditioner, located on a section of the console printed circuit card.

The calibration procedure precisely calibrates the load weighing system for the load cell in use. The system then is able to provide an accurate load signal which is automatically ranged during a test over 100% (X1), 50% (X2), 20% (X5) and 10% (X10) ranges of the load cell maximum capacity.

A 15 minute warm-up period with system power on and all circuits functioning, must be allowed before performing the calibration procedure. This assures that load cell creep is at a minimum.

The calibration procedure you use depends on the type of load cell installed. Load cells can be one of the following types:

(a) Self identifying and electrically calibrated.

(b) Self identifying and manually calibrated.

(c) Non-self identifying and electrically calibrated.

(d) Non-self identifying and manually calibrated.

The procedures for calibrating all four types of load cells are given in this section. These procedures, for the most part, require you to enter simple key sequences.

Calibration also completes an operating reliability check of the Load Sensor Conditioner (see Self Test Routine, on page 4-23).

The system responds to a bad calibration procedure by flashing the BAL or CAL LEDs. If either of these LEDs flash, you must correct the error before proceeding. The section “Calibration and Balance Errors” on page 5-16 includes a table of possible causes and solutions.

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

Note *Instron recommends that you check calibration at least once a day during continuous operation of your testing system.*

Electrical Calibration of Self Identifying Load Cells

To calibrate the load weighing system with a self identifying electrically calibrated tension or compression load cell installed:

Note *When electrically calibrating a self identifying load cell, the balance operation is performed automatically.*

(a) Press LOAD CAL key. The Main Panel Display shows the maximum capacity of the cell and the LOAD CAL LED lights.

(b) Press ENTER on the keypad. After about 6 seconds, the LOAD CAL LED goes out and the display goes blank indicating that calibration is completed. (Go to “Balance Load Weighing System” on page 5-15.)

Manual Calibration of Self Identifying Load Cells

Note *When manually (deadweight) calibrating a load cell, use a precision weight that is traceable to a particular class as defined by the National Bureau of Standards.*

To calibrate the load weighing system manually with a self identifying load cell installed:

(a) Do one of the following:

(1) If you are using a tension load cell, install a pin or other device in the load cell coupling for hanging a calibration weight.

(2) If you are using a compression load cell, set the cell on its cap on the base of the load frame. Install an anvil on the load cell coupling.

(b) Press the LOAD BAL key. The LOAD BAL LED lights.

(c) Press ENTER on the keypad. After about 3 seconds, the LOAD BAL LED goes out indicating that the balance function is completed.

(d) Hang a calibration weight from the tension cell coupling, or set the weight on the anvil of the compression cell.

Note *The calibration weight should be equivalent to no less than 40% of the maximum value of the highest range to be used of the installed load cell. Otherwise, the load weighing system may not be within the specified 1% accuracy.*

EXAMPLE:

If a 2518 Series cell is installed and is to be used over its full capacity in metric units (50 kg), then the calibration weight should be no less than 20 kg.

(e) Press the LOAD CAL key. The Main Panel Display shows the maximum capacity of the cell and the LOAD CAL LED lights

(f) On the numeric keypad, key in the actual value of the calibration weight in the system of units in use (S.I., English or metric).

(g) Press ENTER. After about 6 seconds, the LOAD CAL LED goes out and the display goes blank indicating that calibration is completed.

(h) Remove calibration weight and fixture from the load cell. If you are calibrating a compression cell, install it in the crosshead.

(i) Press the LOAD BAL key. The LOAD BAL LED lights.

(j) Press ENTER. After about 3 seconds, the LOAD BAL LED goes out indicating that the balance function is completed (see Load Weighing System Balance on page 5-15.)

Electrical Calibration of Non-Self Identifying Load Cells

To calibrate the load weighing system with a non-self identifying electrically calibrated tension or compression load cell installed:

(a) Press the LOAD BAL key. The LOAD BAL LED lights.

(b) Press ENTER. After about 3 seconds, the LOAD BAL goes out indicating that the balance function is completed.

(c) Press the LOAD CAL key. The LOAD CAL LED lights, but the Main Panel Display goes blank indicating that the load cell cannot be identified.

(d) On the numeric keypad, key in the maximum capacity of the highest range of the cell in the system of units in use (S.I., English or metric).

(e) Press ENTER.

Note *The calibration point for electrically calibrated load cells is the maximum capacity of the next to the highest range of the cell. For the Instron low capacity tension load cells, this number would be as shown in Table 5-1 (for example, 200 for the type 2512-101 cell).*

(f) On the numeric keypad, key in the value of the calibration point (refer to the Note above) in the system of units in use (S.I., English or metric).

(g) Press and hold calibration button on the load cell. Press ENTER.

Table 5-1. Low Capacity Load Cells Calibration Data

TENSION CELL CATALOG NO.	MAXIMUM CAPACITY	CALIBRATION POINT
2512-136	50 g	20 g
2512-101	500 g	200 g
2512-122	5 N	2 N

(h) After about 6 seconds, the LOAD CAL LED goes out and the display goes blank indicating that calibration is completed. Release the calibration button.

(i) Press LOAD BAL key. The LOAD BAL LED lights

(j) Press ENTER. After about 3 seconds, the LOAD BAL LED goes out indicating that the balance function is completed. (Go to “Load System Balance” on page 5-15.)

Manual Calibration of Non-Self Identifying Load Cells

Note *When manually (deadweight) calibrating a load cell, use a precision weight that is traceable to a particular class as defined by the National Bureau of Standards.*

System Operation

To calibrate the load weighing system manually with a non-self identifying load cell installed:

(a) Do one of the following:

(1) If you are using a tension load cell, install a pin or other device in the coupling of the cell for applying a calibration weight.

(2) If you are using a compression load cell, set the cell on its cap on the base of the load frame. Install an anvil on the cell coupling.

(b) Press the LOAD BAL key. The LOAD BAL LED lights.

(c) Press ENTER. After about 3 seconds, the LOAD BAL LED goes out indicating that the balance function is completed.

(d) Press LOAD CAL key. The LOAD CAL LED lights, but the Main Panel Display goes blank indicating that the load cell cannot be identified.

(e) On the numeric keypad, key in the maximum capacity of the highest range of the cell in the system of units in use (S.I., English or metric).

(f) Press ENTER

(g) Hang a calibration weight from the tension cell coupling, or set a weight on the anvil of a compression cell).

Note *The calibration weight should be equivalent to no less than 40% of the maximum value of the highest range to be used of the installed load cell. Otherwise, the load weighing system may not be within the specified 1% accuracy.*

EXAMPLE:

If a 2518-204 cell is installed and is to be used over its full capacity in English units (200 lb), then the calibration weight should be no less than 80 lb.

(h) On the numeric keypad, key in the actual value of the calibration weight in the system of units in use (S.I., English or metric).

(i) Press ENTER. After about 6 seconds, the LOAD CAL LED goes out indicating that calibration is completed.

(j) Remove calibration weight and fixture from the load cell. If you are calibrating a compression cell, install it in the crosshead.

(k) Press the LOAD BAL key. The LOAD BAL LED lights.

(l) Press ENTER. After about 3 seconds, the LOAD BAL LED goes out indicating that the balance function is completed.

Load Weighing System Balance

You may install grips and fixtures before or after calibration, depending upon the type of load cell installed. Also, you may change grips or fixtures between tests, in which case system calibration does not have to be repeated. However, it is necessary to balance out the tare weight of grips and fixtures whenever these are added or changed and the system has been calibrated.

Note *Always balance a calibrated load weighing system whenever grips and fixtures are added or changed.*

To balance the load weighing system:

(a) Press the LOAD BAL key. The LOAD BAL LED lights.

(b) Press ENTER. After about 3 seconds, the LOAD BAL LED goes out and the balance function is completed. (see next Section if LOAD BAL LED flashes.)

Calibration And Balance Errors

Your Series 4400 system reports when a problem exists in a transducer calibrating or balancing procedure. This warning is easily identified by the flashing of the LOAD CAL or LOAD BAL LEDs for load cells, or the STRAIN CAL or STRAIN BAL LEDs for extensometers. Also, if the system cannot properly read the identification of an identifiable transducer, the Main Panel Display is blank.

Table 5-2 shows the probable causes and solutions for a flashing CAL or BAL LED for either a load or strain transducer, and several other possible calibration problems.

Table 5-2. Transducer Calibration/Balance Errors

CALIBRATION OR BALANCE ERROR	PROBABLE CAUSE	SOLUTION
CAL LED flashes after a self identifying transducer is calibrated automatically	1. Transducer is not connected. 2. Transducer is defective. 3. Transducer interface board is defective.	1. Check all cable connections. 2. Try another transducer. 3. Run Self Test Routine.
CAL LED flashes after a transducer is mechanically calibrated using a weight or calibration fixture.	1. Transducer is not connected. 2. Transducer is defective. 3. Transducer interface board is defective. 4. Wrong full scale or calibration setting value entered on keypad.	1. Check all cable connections. 2. Try another transducer. 3. Run Self Test Routine. 4. Check all figures and re-enter.
BAL LED flashes after a transducer is calibrated or balanced. System was unable to balance out tare weight of grips or fixtures.	Tare weight is over 100% of transducer capacity.	Remove tare weight by using lighter grips or fixtures.
When LOAD CAL key is pressed: (1) the wrong value of transducer capacity appears on the Main Panel display; or (2) No value appears at all.	1. Operating units have not been changed to the required type. 2. Transducer is not self-identifying.	1. Check units indicator for proper type. If wrong, turn off power, change units, then turn power on and recalibrate. 2. Use mechanical calibration procedure.
CAL LED remains on.	1. ENTER key was not pressed. 2. Wrong calibration sequence used.	1. Press ENTER. 2. Redo calibration procedure.

Strain Calibration

Overview

Strain measurement on the Series 4400 system makes use of an optional Strain Sensor Conditioner board. This Strain channel can accept a wide variety of strain transducers, including strain gauge extensometers, LVDT extensometers, Crack Opening Displacement gauges, and several types of specialized extensometers for specific applications.

The functions of the Strain channel are similar to the Load Sensor Conditioner described in Chapter 4. The output is either an unranged, or an automatically ranged, 0 to 10 Vd.c. full scale strain signal. The strain signal can be monitored during a test, can be used for X-Y recording of load-strain data, can be used with strain limits to control crosshead action, and can be used in a printout obtained of peak, break and preset point values.

Strain Operating Mode

The operating mode for the Strain channel can be set to either Percent Strain (%) or, depending on the type of extensometer, to displacement in inches or millimeters.

Note *Always be aware of the strain operating mode when monitoring the signal, when setting up for strain recording, and when using strain limits.*

To change the strain operating mode, you must change the setting of a DIP switch on the rear of the console. This switch is part of a three-section DIP switch located between the rows of cable connectors at the lower rear panel of the console (see Figure 8-1). The bottom, number 3 switch is marked STRAIN UNITS.

To change the position of the Strain Mode switch, push on one side of the switch with a pointed tool, such as a ball point pen. To set the mode to displacement units, push the switch to the side marked “ON"; and for Percent, push it toward the side marked ”3".

If you change the strain mode setting while the system is powered down, the Main Panel display shows “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 you change the strain operating mode with power applied to the system, there is no indication on the front panel. *You must perform ONE of the following procedures to make the change valid:*

(a) Cycle main power off, then on, *or*

(b) Enter the system reset sequence: Press [S1], then [0] and ENTER on the keypad, *or*

(c) Enter the “warm start” sequence: Press [S1], then [1] and ENTER on the keypad.

After you switch the strain operating mode and perform one of the above procedures, the Main Panel display shows “LOSS”, indicating that nonvolatile memory is reset to the default state and stored test data is lost.

Note *After you change the strain operating mode for a calibrated system, you must recalibrate the* *load and strain channels and reset all limits (Load, Extension, and Strain).*

Strain Gauge Extensometers

Instron manufactures a host of different types of extensometers and other strain measuring devices, most of which can be used with the Series 4400 Testing System. In the following sections, the discussion will center on Instron's Series 2630 Extensometers, but the calibration procedures described apply equally well to other types of extensometers and strain gauges.

The Instron Series 2630 Strain Gauge 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 gauge lengths of 10, 25, or 50 mm (1/2, 1, or 2 in.). Operating instructions are included with each extensometer.

The calibration procedure for an extensometer compares the strain measuring system of a Series 4400 instrument against a precise voltage, 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 varies depending upon the type of extensometer installed and the method used:

1. Self identifying and electrically calibrated.

2. Self identifying and manually calibrated.

3. Non-self identifying and manually calibrated.

If the calibration procedure fails for any reason, the system flashes the STRAIN BAL or STRAIN CAL LEDs. If either of these LEDs is blinking, you must correct the error before proceeding (refer to page 5-16).

Note *For maximum accuracy of strain measurement, extensometers should be manually calibrated over the range of interest, as described on page 5-22*

The following procedures, describing the calibration of strain gauge extensometers, assume that the devices have been properly installed and cabled in a Series 4400 system.

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

You cannot start a test while the STRAIN CAL or STRAIN BAL lamp is lit, and, conversely, the calibration and balance functions are locked out while a test is running.

Electrical Calibration of Self Identifying Strain Gauge Extensometers

Note *When electrically calibrating a 2630 Series self-identifying strain gauge extensometer, the balance operation is performed automatically.*

To electrically calibrate a 2630 Series self-identifying strain gauge extensometer:

(a) Clamp the extensometer onto the specimen at gauge length, as described in the manual supplied with the extensometer. Allow up to 15 minutes for the extensometer to stabilize after applying excitation.

(b) Press the STRAIN CAL key. The Main Panel Display shows the maximum strain (%) or range (mils or mm) of the extensometer, and the STRAIN CAL LED lights.

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

Manual Calibration of Strain Gauge Extensometers

To manually calibrate a 2630 Series self-identifying, or non-self identifying, strain gauge extensometer:

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

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

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

(d) Press the STRAIN BAL key. The STRAIN BAL LED lights.

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

(f) Press the STRAIN CAL key. The STRAIN CAL LED lights. Go to Step 1 or 2 below.

(1) If the extensometer is a self-identifying type, the Main 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 Main 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 LED stays lit.

(g) Adjust the 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 the extensometer over its maximum strain (or displacement) range, adjust the calibrator to a displacement value which corresponds to

full scale. For example: If using an extensometer with a 1-inch gauge length and a 10% maximum strain, adjust calibrator to 0.100 inches.

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

Note *Do not calibrate a 2630 Series strain gauge extensometer below 10% of its full scale range. Otherwise, the accuracy will not be within specifications.*

(h) On the keypad, key in the value set on the calibrator in Step g, part 1 or 2 above. If the strain operating mode is displacement, enter the value in millimeters or mils. If the strain operating mode is percent, 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, the STRAIN CAL LED goes out, the display goes blank and calibration is completed.

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

(k) Press the STRAIN BAL key. The STRAIN BAL LED lights.

(l) Press ENTER. After 3 seconds, the STRAIN BAL LED goes out and the balance function is completed.

Strain Gauge Extensometers - Operating Notes

The strain measuring accuracy of a Series 4400 system is 0.5% of the strain reading, ±1 count, on the display or the 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 +38°C (+50 to +100°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.

Display Panel

Description

The Display Panel at the top of the control console has three 4-digit LCD displays which allow the current value of load, extension, and strain to be tracked for observation during a test. The tracking value on each display is not stored at the end of the test.

Additional functions enable the values of load, extension, and strain at peak load and at specimen break to be saved for viewing on the displays at the end of a test. The peak and break values are stored in nonvolatile system memory until overwritten by the next test, or when the system is reset.

When Area Compensation is in use, the gain of the load signal applied to the LOAD display is divided by the specimen area value (see page 5-38). Hence, when Area Compensation is not equal to 1.000, the LOAD display indicates the normalized value of stress.

Descriptions of the Display Panel control and indicator functions are contained in Table 4-2.

Operation

(a) Press the TRACK key to track load, extension and strain on the displays at any time during a test. The TRACK LED lights and the three displays show the constantly changing values while the test is in progress. The storage of peak and break values is not interrupted when the TRACK key is pressed. These functions are always recorded.

(b) Press the PEAK key to set the displays to show load, extension and strain values that occur at the peak load during a test. This can be done at any time, either before, during, or at the end of a test when the values are stored. The PEAK LED is lit when this function is active.

(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 remain blank until a break condition occurs. The BREAK LED 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 LED 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.

Establish Gauge Length

Gauge length is the distance between the contact points of the upper and lower grips on the specimen at the start of a test, and establishes the initial length of the specimen. The choice of a suitable gauge length depends upon the material under test (see Appendix A, Introduction to Testing). To ensure a uniformity in specimen length, this spacing must be the same for all similar tests. This requires that the moving crosshead return and stop at a preset limit, or gauge length, at the conclusion of each test.

On Series 4400 systems, gauge length, the current spacing between grips or fixtures, is entered into memory whenever the G.L. RESET key is pressed. This feature provides a very accurate gauge length setting.

To set a specific gauge length:

(a) Drive the crosshead up or down, as required, using the JOG keys on the Frame Control Panel. Use a ruler to determine the exact spacing between contact faces of upper and lower grips, or anvil and compression plate.

(b) Press the G.L. RESET key to enter the gauge length into system memory.

An alternate method to set gauge length is as follows:

(a) Carefully bring the grip faces (or anvil and compression plate) together until they just touch, using the JOG keys.

(b) Press the G.L. RESET key to reset the EXTENSION display to zero.

(c) Drive the crosshead up with the JOG key until the required spacing is displayed (in inches or millimeters), and again press the G.L. RESET key to enter the new gauge length into system memory.

If the AT G.L. LED had been flashing, indicating that a power shutdown or system reset had occurred, it becomes steady when the G.L. RESET key is pressed. This LED goes out whenever the crosshead is moved from gauge length, but relights when the crosshead is returned.

Note *Once gauge length has been set, the crosshead will always return to this position upon a RETURN command.*

Electronic Limits

You should set the electronic limits and assign a crosshead action to them before starting a test. Enter limits values using the keypad and view them on the Main Panel Display.

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

Operating Notes - Limits Panel

(1) To enable either the load or strain channel limits, the respective channel must be calibrated.

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

(3) When the operating mode for the Strain channel is changed (see page 5-18), any Strain limits previously set on the Limits Panel default to “0" and the related crosshead action defaults to ”OFF". The STATUS LED, which may be lit to indicate that the limits for the strain channel are active, goes out. Each limit must be reset using values stated in terms of the new operating mode, and the crosshead action selected.

(4) 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 Area Compensation on page 5-38). 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 MAX LOAD LIMIT to 100
(Note: Actual load = 200 lb.)

Before setting stress limits, become familiar with the limitations due to load cell capacity as described in Appendix A.

Operation

To set a limit and a crosshead action on the Limits Panel:

(a) Press the LOAD, EXTENSION or STRAIN limit key (MIN or MAX) for the required limit. The related LED lights and the current limit value appears on the Main Panel Display.

(b) Enter the value, and the sign if negative (refer to Notes 1 and 2 below), of the limit on the keypad. The displayed number flashes 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 Series 4400 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 the keypad. The number stops flashing.

(d) Press the CROSSHEAD ACTION key for the limit just entered. Indicator LEDs (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 gauge length if specimen breaks.
Enter the key sequence:
[LOAD MIN] [2] [0] [0] [ENTER] [STOP] [BREAK] [RETURN]

Whenever one of the limit condition LEDs, or the BREAK LED, is lit, one of the four crosshead action key LEDs will light. 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.*

You can check the limit settings by pressing each limit key and reading the setting on the Main 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 LED flashes to inform you why the action occurred (except at the CYCLE and OFF actions). The LED continues to flash until the next test is started.

Set Crosshead Travel Limit Stops

The crosshead travel limit stops are a safety feature that you should set after establishing gauge length and before starting a test. Refer to the load frame manual for your system for the location of these devices.

If a system failure prevents the crosshead from stopping automatically at gauge length (or at optional electronic limits), the travel limit stops will be contacted by an actuator on the crosshead, a limit switch will open, and the crosshead will stop.

Caution

Always set the crosshead travel limit stops before starting a test.

Set the upper limit stop to a point just beyond the expected maximum travel (extension) in the UP direction when tension testing, or just before gauge length when compression testing. Tighten the stop securely on the limit switch rod.

Set the lower limit stop to a point just beyond the expected maximum travel (extension) in the DOWN direction when compression testing, or just before gauge length when tension testing. Tighten the stop securely on the limit switch rod.

Set Crosshead Speed

The testing (crosshead) speed you select depends upon the type of material being tested. Some examples of typical speeds are given in Appendix A, Introduction to Testing. Usually, a testing rate is specified as one of the following:

- Specimen strain rate in inches per inch per minute (or mm/mm/min).
- Percentage of specimen extension or compression per minute.
- As crosshead speed in inches (or mm) per minute.

When selecting a crosshead speed, you should consider the following:

- Characteristics of the specimen material.
- Total elongation or compression of specimen during the test.
- Maximum speed of recorder response.

To maintain speed accuracy in a Series 4400 system, do not exceed the maximum speed at the crosshead loading shown in the specification for the load frame.

Note *If a crosshead speed is entered beyond the specified maximum range of the Series 4400 system, it is not accepted. The maximum speed for the system is automatically set.*

Set crosshead speed as follows:

(a) Press the SPEED key. A number appears on the Main Panel Display (either the default value or a previously set speed appears).

(b) Enter the required speed on the keypad (up to four digits and a decimal point). The displayed number flashes, indicating that it has not been entered into the system.

(c) Press ENTER. The number stops flashing.

Note *You can change crosshead speed at any time during a test by entering the above sequence.*

Crosshead Jog Control

A Crosshead Jog Control unit is available for moving the crosshead up and down in small increments or at slow speed while loading specimens or installing grips and fixtures. The Jog Control unit is a small, hand-held box on the end of a cable, containing a rocker switch. When the switch is pressed in the direction of the UP arrow, the crosshead will move at a constant speed in an up direction as long as the switch is held. There is a similar action in the down direction when the switch is held in the direction of the DOWN arrow.

The Jog Control parallels the action of the UP and DOWN switches on the Main Panel, but may be more convenient to use since it can be moved close to test space on the load frame while installing grips or loading specimens.

Area Compensation

Area Compensation is a feature of the Series 4400 system that allows the load signal to be calibrated in terms of stress (Load/Area). Thus, specimens of similar material but different cross-sectional area can be tested and a relationship established between the applied force and the specimen size. Appendix A, Introduction to Testing, contains a description of area compensation.

A Series 4400 system accepts values of area compensation ranging from 9.999×10^{-50} minimum to 9.999 x 1050 maximum. The default value is 1.000×10^{0}, as expressed in scientific notation. However, you enter the actual number through the keypad using floating point format with values ranging between 9.999E-50 to 9.999E50. The default value is 1.000E00 in this format.

An area compensation value is entered by two key sequences. The initial sequence enters a base number, or mantissa, between 1.000 and 9.999. This number is the normalized value of the specimen cross-sectional area.

EXAMPLE:

Specimen cross-sectional area:
$A = 0.156\ in^2 = 1.56 \times 10^{-1}$
Enter 1.56 (normalized value) as the mantissa.

After the first key sequence, the letter “E” and two digits appear on the display; this is the current exponent (power of 10) of the area value stored in nonvolatile memory. The second key sequence enters the exponent of the area value in the form of two digits ranging from -50 to 50, where the absence of the “+” sign denotes a positive number.

EXAMPLE:

Specimen cross-sectional area:

$A = 0.156\ in^2 = 1.56 \times 10^{-1}$

Enter -01 as the exponent of the area value.

The load signal output to the LOAD display and to a recorder is divided by the mantissa of the area value only. Therefore, stress (*Load/Area*) as indicated by these two devices is normalized in relation to actual stress. However, with the load sensitivity adjusted in proportion to specimen size, (area compensated) the recorder scale remains accurately calibrated in terms of stress (force per unit area).

Caution

Always determine the Maximum Allowable Stress for the load cell in use to avoid overloads when area compensation is used. (Important - see Appendix A, page A-12)

The parameters of stress (*L/A*) and energy are printed using the mantissa and exponent of the area value (refer to page 6-26). Thus, actual stress based on the original cross-sectional area of the specimen can be read directly with an optional printer.

Set area compensation by entering the following key sequences:

(a) Press AREA key. The SET LED lights, and a number appears on the Main Panel Display (either the default value or the value of a previously set area compensation).

(b) Enter the mantissa (base number) of the desired area compensation on the keypad. This must be a number between 1.000 and 9.999, which is the normalized value of the specimen cross-sectional area. The displayed number flashes, indicating that it has not been entered into the system.

(c) Press ENTER. If the number entered is not 1.000 and the exponent is not E00, then the ≠ 1 indicator will light. The entered number disappears and the display shows “E” and two digits.

(d) Enter exponent of area compensation number at the keypad (refer to Note 1 below). This must be a number between -50 and 50. The system limits larger numbers to these values. If the required exponent is a positive number, simply enter the number directly. If the required exponent is a negative number, press the +/- key unless the currently displayed number is already a negative quantity. The number flashes until it has been entered into the system.

(e) Press ENTER. The exponent disappears and the number set in Step (b) reappears. Repeatedly pressing ENTER causes the displayed value to alternate between the mantissa and the exponent.

Notes

1. Always record the load (stress) and energy data stored from a previous test before changing the exponent of the area compensation value. Otherwise, this data will be in error as it is immediately assigned the value of a newly *entered exponent.*

2. I f the maximum and minimum load limits are used, they should be reset in accordance with the increased or decreased load channel sensitivity due to area compensation (the normalized value only, not the exponent) (see Operating Note (4) on page 5-31).

3. Area compensation is temporarily set to 1.000E00 (1.000 x 10) during a load cell calibration procedure. Any prior set value is restored when the procedure is completed.

Install Specimen

Install a test specimen in the grips for tension testing, or on the compression platen or other fixture for compression testing.

The gauge length has been set at this point, so do not move the crosshead. If the specimen does not fit, either trim it or change the gauge length. Tighten the upper grip first. If this causes a preload, do not perform a balance procedure to compensate for it, as this is the initial loading on the specimen.

Set Testing Area

It is important that you set the TESTING AREA function on the Main Panel properly so that the automatic overload detection circuit will stop a test if the load cell is overranged. If pneumatic grips are being used with an optional Air Kit, or cycling is to be done using the Limits Section of the panel, it is essential to set the TESTING AREA properly. The default state for the TESTING AREA function is BELOW XHEAD.

Caution

Ensure that the TESTING AREA function is properly set before starting a test. If it is not and a load overrange condition is detected, the LOAD fault indicator flashes but the crosshead does not stop, and damage to the load cell could occur.

For normal operation, set the TESTING AREA function to BELOW XHEAD. This applies to compression load cells also.

The TESTING AREA function should be changed for one of the following two conditions only:

(a) The sign of the output signal of the installed load cell is positive (+) for compression (applies to 2511-200 Series compression cells only.)

(b) The load cell, except for a 2511-200 series compression cell, is mounted for testing above the moving crosshead (requires special fixturing).

Note *When using a 2511-200 series compression cell and the TESTING AREA function is set to ABOVE XHEAD, any strain extensometer used must also have a positive (+) output when compressed. If the sign of the extensometer is not the same as the sign of the load cell, the strain limits do not function properly. Choose another extensometer of the proper polarity or call an Instron Regional Sales and Service Office for additional extensometers.*

To change TESTING AREA, enable it by initially pressing S1. The Main Panel Display shows “SL”. You can press the TESTING AREA key and change the function to BELOW AHEAD or ABOVE XHEAD while this condition is active.

Note *The TESTING AREA key stays enabled, with “SL” remaining on the display, until you enter another key sequence such as: [S1] [0] through [S1] [6], [SPEED] or [AREA].*

Run a Test

The output of a test with only a load cell installed is a load signal of 0 to ±10 Vd.c. This signal can be monitored on the Display Section of the panel, and recorded if an optional Recorder or Printer is installed. These and other optional accessories are described in Chapter 6.

Start a test by pressing the UP key on the Main Panel for a standard tension test, or the DOWN key for a standard compression test.

Chapter 6
System Options

Outline

This chapter describes the function of some optional accessories and internal functions that can be used with a Series 4400 System. Peripheral items may be included with the system when you purchase it, or added later to expand its capabilities. Optional internal functions are available for specialized testing applications.

Introduction

The options described in this chapter are either external accessories that can be added to the system (Recorders, Printer) or are built into the system (Energy option, Preset Points option, Air Kit option, Pip Control option, etc.). Those that are built into the system are considered options because they are not necessary for routine operation of the system, but can enhance the functionality of the system in special testing situations.

External accessories can be added to the system at any time. Installation is merely a matter of cabling the accessory to the system, and connectors are provided on the back of the console for these devices. All of these external devices have their own instruction manuals, which are supplied with them.

Built-in options are activated from the console front panel. In the sections of this chapter that follow, these features are described, and operating instructions are given.

Strip Chart Recorder

Description

The optional Instron Strip Chart Recorder produces a plot of an input signal, usually load or strain, against time. The chart itself, driven by an internally-timed stepping motor, moves past a recording pen, which, in turn, is driven by the input signal. Since crosshead speed can be converted directly to time, the resulting plot is thus a plot of load or strain versus crosshead speed.

The recorder has a bi-directional chart with selectable speeds in the internal time drive mode. The range of speeds is 1.0 to 100 cm/min (0.05 to 50 in/min), forward and reverse.

The Recorder is available with one or two input channels (and recording pens). If it has one input channel, the input to that channel will always be Load. If the recorder has two input channels, Load will be applied to Channel 1, and Strain to Channel 2.

The input from the Series 4400 system is a -10 to +10 Vd.c. load or strain signal, which is automatically ranged to full scale by the testing system. Switch-selectable ranges and a variable gain control on the Recorder front panel can be used for range expansion.

The Series 4400 system provides an automatic chart stop signal at a crosshead “return” command. Pipping of the pen (event marker) is possible through a PIP contact on the recorder connector.

The recorder is supplied with 250 mm wide, metric-scaled paper. The paper can be either fan-fold or roll paper. Paper scaled in U.S. Customary units is available from Instron. The recorder can be operated in either English or metric units, switch-selectable on the rear panel of the recorder.

Specifications

The following are the operating specifications for the Strip Chart Recorder:

Measurement Ranges:	1, 2, 5, 10, 20, 50, 100, 200, 500 mv 1, 2, 5, 10, 20, 50 V
Chart Width:	250mm
Roll Paper:	approx. 16m or 25m
Writing System:	Fiber-tip pens
Input circuitry:	Asymmetric
Range Expansion:	40% (gain control)
Counter Voltage:	Manually: =100/-100%, contin.
Accuracy:	±0.35% (≥ 10 µv)
Linearity of Potentiometer:	±0.25%
Reproducibility:	±0.25%
Full Scale Deflection Time:	≤0.35 sec.
Maximum Writing Speed:	1m/sec
Reference Voltage:	Electronically stabilized
Input Impedance	
DC Volts, mv Ranges:	30 MΩ

DC Volts, V Ranges:	2 MΩ
AC Volts, mv Ranges:	20 KΩ, in series with 1 μf
AC Volts, V Ranges:	2 MΩ
Permitted Source Impedance	
mv Ranges:	20 kΩ
V Ranges:	5 kΩ
Temperature Drift of Zero Line	
mv Ranges:	approx. 0.5 μv/K
V Ranges:	approx. 50 μv/K
Long Term Drift:	1 μv/month
Overload Protection:	
mv Ranges:	±60V
V Ranges:	±60V
Chart Drive (Crystal Controlled Stepping Motor)	
Chart Speeds	1, 2, 5, 10, 20, 50, 100 cm/min
	1, 2, 5, 10, 20, 50, 100 cm/hr
	1.2, 3, 6, 12, 30, 60 cm/min
	1.2, 3, 6, 12, 30, 60, 120 cm/hr
	(all speeds forward and reverse)
Input Voltage	100, 110, 220, 240 Va.c. ±10%

Ordering information for Strip Chart Recorder supplies is given in Table 6-1

Table 6-1. Strip Chart Recorder Supplies

Part Number	Description	Quantity
3750-135	Fan Fold Paper, metric units	10/box
3750-137	Fan Fold Paper, U.S. Customary units	10/box
3750-136	Roll Paper, metric units	10 rolls/box
2750-138	Roll Paper, U.S. Customary units	10 rolls/box
3740-147	Pens, red Pen 1 for all recorders	5 pens/pkg
3740-148	Pens, black Pen 1 for all recorders	5 pens/pkg

Power Requirements

The Strip Chart Recorder is set at the factory to accept a main power input of 120 ±10 Va.c., single phase. A 3-wire power cable for this voltage is included. If the power source to be used is not 120 ±10 Va.c., the power input switch on the underside of the recorder can be set for other voltages in the range of 100 to 240 Va.c. (refer to Table 6-2).

To adapt the Strip Chart Recorder for a different line voltage, set the input power switch to the proper input voltage for your location. Be sure the line fuse is the

Table 6-2. Recorder Line Voltage Selection

If Line Voltage is:	Set a.c. input connector to:
120 ±10 Vac 100 ±10 Vac 220 ±10 Vac 240 ±10 Vac	

proper value for the line voltage in use (see the Recorder manual).

If the Strip Chart Recorder is to be adapted for 200-240 Va.c. operation, you must alter the power cable by installing a male plug on the power cable that is specified for that power source outlet. Observe the following CEE wire color code for the cable:

Brown - high (live)
Light Blue - low (neutral)
Green & Yellow - earth/ground

Installation

To use the recorder with a Series 4400 system, place the recorder on any horizontal, flat, relatively level work surface near the load frame. The recorder is designed to operate in a horizontal position, so do not prop it up vertically or on a slant.

Determine the line voltage of the mains supply, and if necessary, set the line voltage selector on the recorder as described in the previous section.

Plug the recorder input cable (A570-26), provided with the unit, into the ANALOG OUT connector on the rear of the console. Connect the other end of the cable into the 9-pin D-shell connector on the right-rear corner underneath the recorder.

Operation

The Series 4400 system does not provide any control functions for the recorder; it merely supplies an analog data signal which is scaled and plotted by the recorder. Thus, operation of the recorder is covered in an Operating Instructions Manual supplied with the recorder, where you will find the necessary control settings, setup, and operating information. The following sections give the procedures for using the recorder with the Series 4400 Testing System. The procedures given are for a one pen (single channel) recorder, and thus all values are given in terms of load. Scaling and calibration procedures for the second channel (Strain) are identical to the load channel procedures.

Pen Scaling

Pen scaling can be set at the recorder so that zero and full scale fall exactly at the edges of the chart. If these two points are accurate, then the scale divisions printed on the chart can be used to accurately determine the value of all other points on the test curve.

To scale the recorder pen for a load signal:

(a) Press the 0 (ZERO) button on channel 1 of the recorder. This removes all input signals and shorts the input for a no-signal condition.

(b) Use the VAR control to set the pen exactly on the left edge of the chart. This will be more precise if the chart is moving, since the pen will draw a line instead of making a dot.

(c) Select a scale factor on the RANGE switch which gives full scale deflection of the pen. Check that the pen falls exactly on the right edge of the chart.

Pen Calibration

Pen calibration assures that the pen position coincides exactly with the load cell signal. The method used to calibrate the pen depends on the type of load cell in use. If a self-identifying load cell is installed, the procedure is to apply a precision calibration voltage to the pen channel by closing the calibration relay, and then adjusting the pen to the chart using the variable control on the recorder. If a non-self identified load cell is installed, a precision calibration weight is hung from the load cell and the pen adjusted with the variable control. The specific procedures are as follows:

(a) If a non-self identified load cell is installed, hang a precision weight, within the range of the load cell, from the cell and observe the pen deflection. The amount of pen deflection depends on the RANGE switch setting, which sets the chart full scale value.

(b) Adjust the CAL variable control on the recorder to set the pen to exactly the value of the precision weight.

(c) If a self-identified load cell is installed, the above procedure can be used or, by closing the load cell calibration relay, a precision load signal will be applied to the recorder (refer to the Note and Example below).

(1) To close the load cell relay, press the LOAD CAL key on the Series 4400 front panel, then press 0 and ENTER. The LOAD CAL and LOAD BAL LEDs are both lit when this relay is closed.

Table 6-3. Calibration Signal for Load Cells

LOAD CELL MAXIMUM CAPACITY	*CALIBRATION SIGNAL VALUE - SI EQUIVALENT		
	NEWTONS	POUNDS	KILOGRAMS
50 N	25	5.62	2.55
500 N	250	56.2	25.49
5 kN	2 500	562	254.9
10 kN	5 000	1 124	509.8
50 kN	25 000	5 620	2 549
150 kN	75 000	16 861	7 648
300 kN	150 000	33 721	15 296
600 kN	300 000	67 443	30 592

*To convert newtons:
1. Multiply by 0.224 808 9 to obtain pounds.

(2) **IMPORTANT** – After checking pen deflection, open the calibration relay by repeating the key sequence to close the relay: press LOAD CAL, 0, ENTER on the keypad. The LOAD CAL and LOAD BAL LEDs go out. A test cannot be started when the calibration relay is closed.

Note *The voltage generated when the load cell calibration relay is closed is the same as would be produced by an applied load equal to 50% of the maximum capacity of the cell when using*

SI units, as shown in Table 6-3. In Metric units, the calibration voltage is 50.9% of full scale, while in U.S. Customary units, this voltage is 56.2% of full scale (51.9% for a 600 kN Load Cell).

EXAMPLE

Assume a 5 kN (1000 lb, 500 kg) load cell is installed and English units are in use. A RANGE of 100 is selected for a recorder full scale value of 1000 lb. The pen will deflect an equivalent of 562 lb. (52.6% of full scale) when the calibration relay is closed. This signal appears on the LOAD display if TRACK is selected.

X-Y Recorder

Description

The optional Instron X-Y Recorder is another type of recorder that plots two variables against each other. Unlike the Strip Chart Recorder, the X-Y Recorder's chart is stationary, and plots are made with one or two moving pens. Load versus Strain, Load versus Extension, and Load versus Time are common plots that are made with this device.

The Instron X-Y Recorder has single-range X and Y axes which require -10 to +10 Vd.c. input signals for full scale. The X-axis has a 38 cm (15 in.) span, and the Y-axis has a 25 cm (10 in.) span. The input on the Y-axis from a Series 4400 system is a load signal which is automatically ranged to full scale; you can select a gain factor on the Recorder Panel. The X-axis can be set to track an extensometer signal or the recorder's internal time base. Pipping of the pen (event marker) is possible through a PIP contact on the rear panel connector (refer to page 6-41).

The recorder can be operated in English or metric units, using a front panel switch. A supply of 11 x 17 inch graph paper, compatible with the calibrated units, is provided with the recorder.

An instruction manual is supplied with the recorder and should be referred to for unpacking, specifications, paper and pen loading, theory of operation, routine maintenance and troubleshooting procedures.

Specifications

The following is a complete set of specifications for the X-Y Recorder:

Calibrated Ranges:	0.5, 1, 2, 5, 10, 20 mv/cm 0.05, 0.1, 0.2, 0.5, 1, 2 V/cm
Variable Range Expansion:	up to 250% (sensitivity increase)
Zero Line Shift:	Over entire writing width ±100%
Input Impedance:	2 MΩ
Max. Source Impedance:	5 kΩ
Measuring Error:	±0.25%
Temperature Drift of Zero Line:	approx. 0.5µv/K, mv ranges approx. 50 µv/K, V ranges
Max. Input Voltage:	±50 V
Max. Voltage between Inputs and Ground:	±50 V
Overload capacity of Inputs:	±50 V
50 Hz Suppression:	31 dB
60 Hz Suppression:	36 dB
Common-mode Rejection CMRR:	130 dB @ 1 kΩ
Paper Size:	DIN A4
Usable Writing Area:	210 x 290mm
Pen Type:	HP Pens

Paper Hold-down:	Electrostatic
Max Writing Speed	
X-Axis:	70 cm/sec
Y-Axis:	100 cm/sec
Cutoff Frequency @ -3dB	
X-Axis:	1.4 Hz (280 mm)
Y-Axis:	3 Hz (200 mm)
Power Consumption	
Operating:	25 VA
Standby:	10 VA
Input Voltage:	100, 110, 220, 240 Va.c. ±10%
Dimensions (WxHxD)	379.5x150x372 mm
Weight:	7 kg approx.

Ordering information for X-Y Recorder supplies is given in Table 6-4

Table 6-4. Recorder Supplies

Part Number	Description	Quantity
3750-139	Sheet Paper, metric units	100 sheets/pkg
3750-140	Sheet Paper, U.S. Customary units	100 sheets/pkg
3750-144	Pens, blue	5 pens/pkg
3750-145	Pens, red	5 pens/pkg
3750-146	Pens, black	5 pens/pkg

Installation

Power Requirements

The X-Y Recorder is set at the factory to accept a main power input of 120 ±10 Va.c., single phase. A 3-wire power cable for this voltage is included. If the power source to be used is not 120 ±10 Va.c., the power input switch on the underside of the recorder can be set for other voltages in the range of 100 to 240 Va.c. (refer to Table 6-2).

To adapt the X-Y Recorder for a different line voltage, set the input power switch to the proper input voltage for your location. Be sure the line fuse is the proper value for the line voltage in use (see the Recorder manual).

If the X-Y Recorder is to be adapted for 200-240 Va.c. operation, you must alter the power cable by adding a male plug that is specified for that power source outlet. Observe the following EEC wire color code for the cable:

Brown - high (live)
Light Blue - low (neutral)
Green & Yellow - earth/ground

Signal Input Connection

To use the X-Y Recorder with a Series 4400 system, plug the cable (A570-26) provided with the unit into the connector on the underside of the recorder and into the ANALOG OUT connector on the rear panel of the Series 4400 console.

Note *The recorder must be electrically grounded to operate properly.*

Operation

The Series 4400 system does not provide any control functions for the recorder; it merely supplies analog data signals which are scaled and plotted by the recorder. The following sections give the procedures for using the recorder with the Series 4400 Testing System. The procedures given are for a one pen (single channel) recorder, and thus all values are given in terms of load. Scaling and calibration procedures for the second channel (Strain) are identical to the load channel procedures.

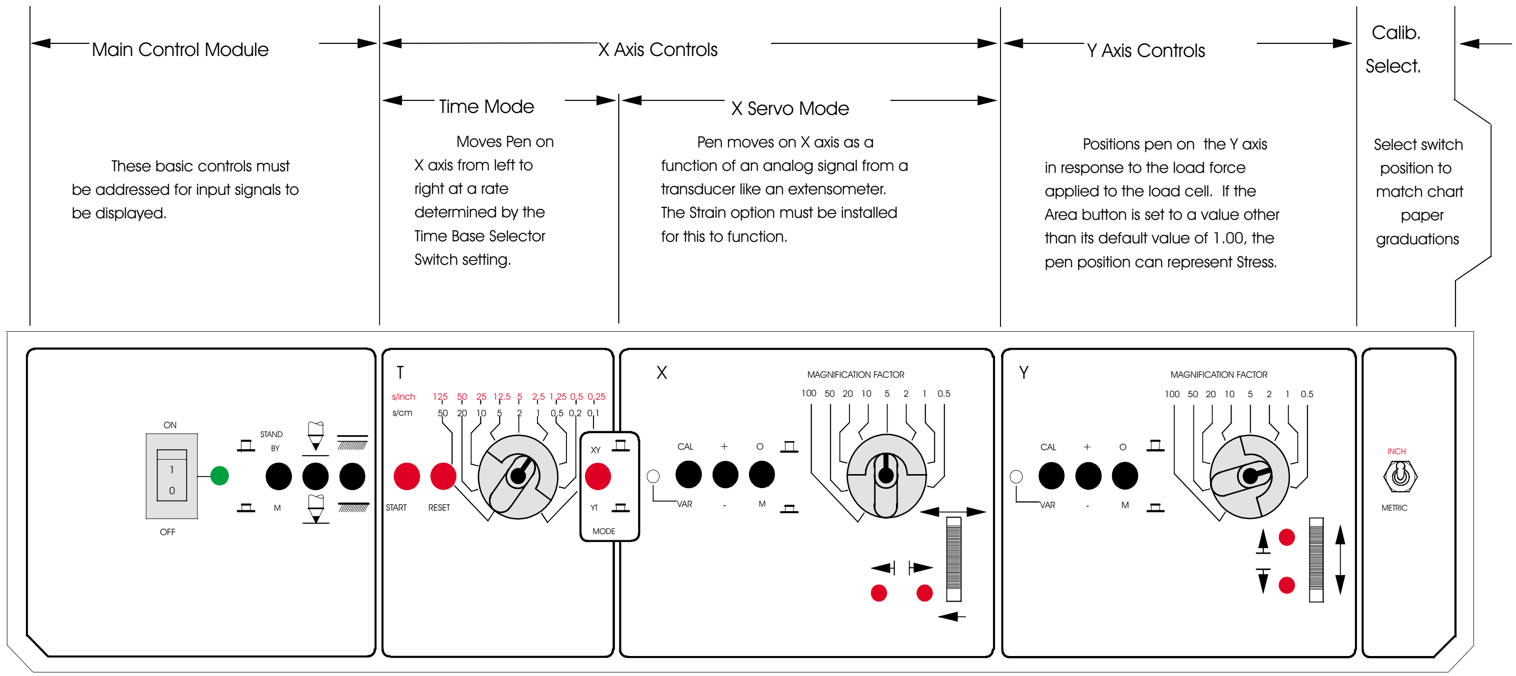
Initial Setup

Refer to Figure 2-1 for the function of the Recorder front panel controls. All controls specified in the following procedures are located on the front panel of the Recorder, unless otherwise noted. Use the following procedure to set up the initial operating conditions for the Recorder:

(a) Turn on the Recorder by pressing the ON/OFF switch to the I position. The green light beside the power switch comes on.

(b) Select the system of measurement units for the Recorder by setting the INCH/METRIC switch to the units desired.

(c) Press the STANDBY/M switch to the Down (M) position.



	Stand By/ Measure switch	Pen Lift	Electrostatic paper hold-down	Calibrate/Variable span switch	Polarity Switch	Enable/Disable switch
	Input disabled pen up-right	Pen Up	paper hold-down OFF	Pre-set Mag. Factor ON	+ Up Y-axis + Rt, X-axis	Input Disabled
PUSHBUTTON UP	STAND BY			CAL	+	O
PUSHBUTTON DOWN	M			VAR	-	M
	Input enabled Pen to Input position	Pen Down	paper hold-down ON	Adjustable Mag. Factor ON	- Up Y-axis - Rt, X-axis	Input Enabled

Figure 6-1 Model 4400 X-Y Recorder Panel

(d) Press the Pen Lift switch to the Up (pen up) position.

(e) Place a sheet of chart paper on the platen of the Recorder with the lower edge of the sheet against the bottom paper stop, and its left edge against the left paper stop. Press the Paper Hold-down switch to the Down (On) position.

(f) Press the X-Y/Y-T MODE switch to the Up position for X-Y operation, or to the Down position for Y-T operation.

Calibration

Calibration of the Recorder consists of setting the pen position for zero and full-scale on the chart. Pen calibration assures that the pen position coincides exactly with the transducer (load cell or extensometer) signal. The method used to calibrate the pen depends on the type of transducer in use.

If a self-identifying transducer is installed, the procedure is to apply a precision calibration voltage to the pen channel by closing the calibration relay, and then adjusting the pen to the chart using the variable control on the recorder.

If a non-self identified transducer is installed, a precision calibration weight is hung from the load cell, or an extensometer calibrator displaces the extensometer a known amount, and the pen is adjusted with the variable control.

When the zero and full scale pen positions fall exactly at the edges of the chart, the scale divisions printed on the chart can then be used to accurately determine the value of all other points on the test curve.

The X-Axis and Y-Axis Modules are essentially identical and both are calibrated in the same way. Use the following procedure for both types of Modules:

(a) Set the polarity switch (+/–) to your required polarity as follows:

X-Axis:

+ (button UP) = increasing signal toward top of chart
– (button DOWN) = increasing signal toward bottom of chart

Y-Axis:

+ (button UP) = increasing signal toward right of chart
– (button DOWN) = increasing signal toward left of chart

(b) Set the pen to the zero position by pressing the O/M button so that is pops up to O (Up position). This disables the input and sets the pen to the edge of the chart. If the pen is not exactly on the edge of the chart (press the Pen Lift switch to lower the pen to see where it touches the paper), use the thumbwheel on the Axis Module to adjust the pen position. Note that the Y-Axis thumbwheel will move the pen up and down, while the X-Axis thumbwheel moves it left and right.

(c) After the pen has been zeroed, press the O/M switch to M. If you fail to do this, you will not be able to read any input signals.

(d) Set the MAGNIFICATION FACTOR switch to 1.

(e) Set the CAL/VAR switch to VAR.

(f) If a self-identified transducer is installed, closing the transducer calibration relay will apply a precision transducer signal to the recorder (refer to the Note and Example below).

(1) To close the load cell or extensometer relay, press the LOAD CAL or STRAIN CAL key on the Model 4400 front panel, then press 0 and ENTER. The LOAD CAL and LOAD BAL or STRAIN CAL and STRAIN BAL LEDs are both lit when this relay is closed.

(2) Using the VAR screwdriver adjustment on the Recorder Module, adjust the pen position exactly to the calibration voltage.

(3) **IMPORTANT** – After setting pen deflection, open the calibration relay by repeating the key sequence to close the relay: press LOAD CAL, 0, ENTER or STRAIN CAL, 0, ENTER on the keypad. The LOAD CAL and LOAD BAL or STRAIN CAL and STRAIN BAL LEDs go out. A test cannot be started when the calibration relay is closed.

Note *The voltage generated when the load calibration relay is closed is the same as would be produced by an applied load equal to 50% of the maximum capacity of the cell when using SI units, as shown in Table 6-3. In Metric units, the calibration voltage is 50.9% of full scale, while in U.S. Customary units, this voltage is 56.2% of full scale (51.6% for 600 kN Load Cells).*

(g) If a non-self identified transducer is installed, hang a precision weight, within the range of the load cell, from the cell, or displace the extensometer with the calibrator, and observe the pen deflection.

(h) Adjust the CAL variable control on the recorder to set the pen to exactly the value of the precision weight or extensometer deflection.

Time Base Operation

You can use the X-Y Recorder in a time-based mode, if desired. The Y-Axis signal is plotted against a recorder-generated time base which can be correlated with crosshead speed. The time scale can be switch-selected for a range of 0.1 seconds per centimeter to 50 seconds per centimeter or 0.25 seconds per inch up to 125 seconds per inch.

Since the Model 5500 uses chart speeds in units of inches/minute or centimeters/minute, and the Recorder Time Scale is in units of seconds/inch or seconds/centimeter, Table 6-5 gives speed conversions between the two.

Table 6-5. Chart Speed Conversions

	Chart Speeds								
Sec/In	0.25	0.5	1.25	2.5	5	12.5	25	50	125
In/Min	240	120	48	24	12	4.8	2.4	1.2	0.48
Sec/Cm	0.1	0.2	0.5	1	2	5	10	20	50
Cm/Min	600	300	120	60	30	12	6	3	1.2

To set up the Time Base on the Recorder, do the following:

(a) Press the X-Y/Y-T MODE switch down to Y-T.

(b) Choose a chart speed that correlates with the Model 4400 testing speed. Look up that speed in Table 6-3 and set the Recorder Time Base Selector switch to the corresponding speed.

(c) Press the RESET button on the Time Base Module. The pen will lift and return to the left edge of the chart.

Note *The pen will return automatically when it reaches the end of its travel.*

The Recorder is now ready for testing system operations.

Normal Operation

To record a plot of the Model 4400 Test, do the following:

(a) Set up the Recorder as in the previous Sections.

(b) Check that the STANDBY/M switch is in the M position, that the CAL/VAR switch on both X and Y Modules is in the VAR position, and that the O/M switch on both X and Y Modules is in the O position.

(c) Press the Pen Lift switch to the Pen Down position. The pen will not go down immediately, but will go down automatically when the test starts.

(d) Press the UP or DOWN button on the Main Panel of the Model 4400 Console. In both the X-Y and Y-T Modes, this starts the test at the load frame and starts the Recorder.

Printer

Description

The printer option for a Series 4400 System provides a hard copy record of test parameters and results. The 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 on page 6-

The printer is set up for and supplied with 9 1/2 x 11 inch fan-fold paper. Additional pads of paper are available from Instron.

Installation

To use the printer with the Series 4400 System, plug the signal cable provided with the unit into the RS-232 connector on the rear panel of the console.

The printer and the Series 4400 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 the baud rate in the printer, refer to the manufacturer's manual provided with the unit.

To change the baud rate in a Series 4400 System requires changing a switch position on a 3-section DIP switch assembly located on the lower rear of the control console (see Figure 8-2). The No. 2 switch of the DIP switch assembly, marked 1200 baud, controls the system baud rate. The switch is accessed through an opening in the rear cover of the console. To change to 300 baud, push down on the OPEN side of the switch with a pointed tool, such as a ball point pen.

Operation

An operating instructions manual is supplied with the printer. This section provides the additional procedures required to use the unit with the Series 4400 System.

(a) To obtain a printout at any time, press the PRINT key on the Main Panel.

(b) To obtain a printout automatically at the end of a test, enter the key sequence [S1] [6] [+/–] on the keypad. The Main 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 occurs after every test as long as the option is enabled.

Note *All crosshead commands are locked out during a printout.*

Printout Format

The format of the Printer output consists of up to nine 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, and Energy. If Strain is not used, the Strain field (No. 4) is omitted.

Line 2 – lists Peak data.

Line 3 – lists Break data. If specimen bread 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 – Preset Point 3 data. If Preset Points are suppressed, line 6 is omitted.

Line 7 – Crosshead Speed and Area (Area Compensation)

Line 8 – Energy (total). If Energy is suppressed, the Energy field (No. 5) and line 8 are omitted.

Line 9 – Cycle Count/Pip Count.

Printer Units

The units that appear on a printout depend upon the selection of operating units (English, metric, SI). 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).

The units that will appear in the printout of the Strain field are shown in Table 6-6.

Table 6-6. Strain Units Printout

Extensometer Type	Strain Mode	Strain Units
Self-identified	Percent Displacement (English) Displacement (met	% MILS 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 appear in the printout of the Energy field and for Total Energy are shown in Table 6-7.

Table 6-7. Energy Units Printout

Independent Variable	Extensometer Type	Energy Units
EXTENSION	(Not Applicable)	
English		LB*EX IN/A (Notes 1 and 3)
Metric		KGF*EX MM/A
SI		KN*EX MM/A

Notes

Table 6-8. Printout with Strain as Independent Variable

	LB/A	IN	MILS	LB*SI
PEAK =	-1.616E02	5.469	23.54	-7.69E00
BREAK =	-9.745E01	5.482	23.45	-7.69E00
PPT1 =	-2.953E-01		10.00	-2.870E00
PPT2 =	-2.953E-01		20.00	5.827E00
SPEED =	5.000 IN/MIN		AREA = 2.00E-01	
TOTAL ENERGY =		-7.737E00	LB*SI MILS/A	

Table 6-8 shows a typical printout with Strain as the independent variable and Strain 1 as the active channel.

Table 6-9 shows a typical printout with Extension as the independent variable. (Note that AREA is greater than 1.00 in both printouts, so the Load and Energy fields show division by “A”.)

Table 6-9. Printout with Extension as Independent Variable

	LB/A	IN	MILS	LB*SI
PEAK =	-2.315E02	3.453	23.97	-4.019E02
BREAK =	-2.303E02	3.466	24.00	-4.057E02
PPT1 =	-1.830E02	1.000		-3.874E01
PPT2 =	-1.830E02	3.00		3.095E02
SPEED =	5.000 IN/MIN		AREA = 2.00E-01	
TOTAL ENERGY =		-7.737E00	LB*EX IN/A	

Notes

AC/DC Strain Conditioner

The AC/DC Strain Conditioner Option is an add-on printed circuit board that allows the use of extensometers, such as the Instron Video Extensometer, the High Resolution Digital (HRD) Extensometer, and other strain transducers that use d.c. excitation and signal processing. This conditioner can also be used as a normal a.c. conditioner, accepting inputs from Instron's normal line of extensometers.

In order for the AC/DC Strain Conditioner to operate properly in the Model 4400 Testing System, the Model 4400 Console must have an updated main printed circuit board, which has the Instron Part Number A570-66. If the console has an updated board, there should be a small sticker on the outside of the console cover with this part number on it.

The AC/DC Strain Conditioner also requires an updated version of the system firmware. The firmware must have a date of March, 1994 or later. To determine if your system contains this or a later version, press the key sequence [S1] [9] [ENTER], and a date will appear in the main display. If this key sequence does not work, your system contains an older version of the firmware, and the AC/DC Strain Conditioner will not work. You can upgrade your firmware by ordering Catalog Number 3750-064, which will ensure that you receive the latest version of the Model 4400 Firmware release.

Specifications

AC/DC Strain Conditioner

Catalog Number	2210-865
Input	Differential ±11V maximum 10 Kohm max impedance
Calibration	±7 to ±11 Volts, full scale sum of signal and imbalance must not exceed ±11 V input maximum
Input Selection (DC vs AC)	Automatic by jumper in adapter cable

Installation

If the AC/DC Strain Conditioner Option has not already been installed, you can do it yourself by following these steps:

(a) Shut off all electrical power to the system.

(b) Disconnect all cables from the rear of the console. Tag each cable if you are not sure where they will go when you replace them.

(c) Remove the console from the load frame by disconnecting the two halves of the mounting bracket.

(d) Lay the console face down on a flat, smooth surface. Use a cloth or pad under the console if the work surface is rough or dirty.

(e) Remove the six M4 socket head screws that attach the rear cover to the console case, and retain these screws. Lift off the rear cover and set it aside. It is not necessary to remove the mounting bracket from the rear cover.

(f) Orient the new Strain Conditioner printed circuit card so that the four mounting holes in the card align with four plastic posts protruding from the back of the main printed circuit board. The connector on the Strain Conditioner card should align with the connector labeled X3 on the main board. Press the Strain Conditioner card onto the posts; when pressed firmly, the card will “snap” into place – no other mounting hardware is required. Ensure the connectors mate fully.

(g) Replace the rear cover of the console, using the six M4 socket head screws removed in Step (e).

(h) Remount the console on the load frame and reconnect all cables removed in Step (b).

Operation

There are no specific operating instructions for the AC/DC Strain Conditioner, since it is operated in the same manner as a normal Strain channel. There are a few operating notes, however:

- When using a DC Extensometer, it must be connected to the Model 4400 Console with the special cable supplied with the conditioner (Catalog Number 2210-864). This cable has a BNC connector on one end that connects to the extensometer. There is a 25-pin D connector on the other end that connects to the STRAIN connector on the rear of the Model 4400 Console. The 25-pin D connector contains jumpers that tell the Model 4400 that a DC Extensometer is attached.

- When using a DC Extensometer, the Strain channel is calibrated in the same manner as a normal Strain channel. See the calibration instructions in Chapter 5 of this manual.

Preset Points

Description

The Preset Points option allows you to specify the values of up to three independent variables at three preset points for recording the values of three dependent variables. Preset Points data is accessible through the RS-232 connector on the rear panel, but there is no provision for displaying it on the front panel. The printer must be available to print out Preset Points data.

The Preset Points are set up 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 6-1 is a typical test curve showing the data obtainable at preset points.

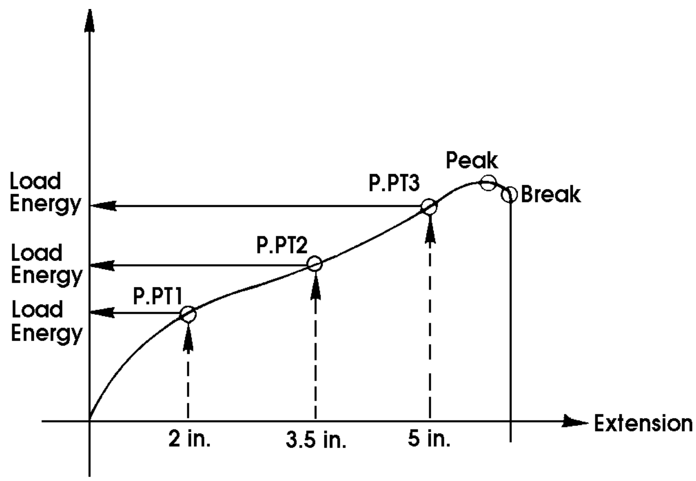


Figure 6-1. Typical Test Curve with Preset Points

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 or extension if the strain option is no installed.

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

[S1] [5] [+/–]

The main 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, PPT3) are:

	PPT1	PPT2	PPT3
Extension (in.)	1	3	10
Extension (mm)	20	60	200
Strain (%)	100	300	1000

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]

[S1] [43] PPT3 [ENTER]

Where PPT1, PPT2, and PPT3 are indicated, enter the actual numerical value of the independent variable; Extension in inches or millimeters; or Strain in either percent, mils, or millimeters.

To obtain a printout of load and energy (refer to the next section, “Energy”) at the preset points, enter the key sequence:

[S1] [4] [+/–]

The Main 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.

Note *The key sequence [S1] [4] [+/–] does not disable the Preset Point function of the IEEE-488 supervisory program.*

Energy

Description

The Energy option allows you 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 three preset points. 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 data is accessible through the RS-232 connector on the front panel. The printer must be available to print out Energy data.

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 strain, but extension becomes the independent variable if strain is not used.

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

[S1] [5] [+/–]

The Main 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.

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

[S1] [3] [+/–]

The Main Panel Display will show either:

SL–3 to suppress printout, or

SL 3 to enable printout

Toggle the [+/–] key until the required display appears.

Cycle Counter

A Cycle Counter function is another feature of the Model 4400 Console that counts and displays crosshead reversals of direction. Each time the crosshead changes direction as a result of a limit action, a key press at the console, or an IEEE Command, the cycle count is incremented by 0.5 counts. Keep in mind that a full cycle of crosshead motion includes two crosshead reversals; one when it reaches the end of its travel in a positive direction, and another when it reaches the end of its travel in a negative direction. The count is reset to zero at the start of each test, and the maximum count is 9999.

A count of Pip events (see the next Section "Pip Control") is also maintained. This count is set to zero at the start of a test, and increments by one for each Pip sensed.

A cycle count limit is also available. This limit will cause the crosshead to stop when the count limit is reached. This action is not programmable, and a RETURN action is not available. A cycle limit value of zero indicates no action (*i.e.*, the limit is ignored).

The front panel can display both the cycle count and the Pip count. The selection of which counter to display is performed with a [S1] [8] [+/–] key sequence. as follows:

"S8–3" = display Cycle Count (default)

"S8 3 = display Pip Count

To see the selected display, press [S1] [+/–]. The setup display on the Main Panel shows the selected count value until some other key is pressed which takes over the setup display. Simply press [S1] [+/–] again to return to the count display.

The cycle limit action can be set on the front panel by pressing [S1] [8] [1] . When the S1 and 8 are pressed, the setup display will show “S1 8". When the 1 is pressed following this, the current limit value will be shown. A new value can be entered at this time.

The cycle count and the Pip count can be included in the printout report from the printer. To enable the counter line in the printout, press [S1] [8] [+/–], as follows:

S1–8 = disable Counter printout (default)

S1 8 = enable Counter printout

The printout line appears as:

CYCLES = 123.5   PIPS = 40.00

Pip Control

The capability of event marking the load signal while it is being recorded is provided through the use of a PIP jack on the rear connector panel of the testing system. A pip control device connected to the PIP jack will produce a small, rapid, vertical 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.

A pip control device can be one built into an extensometer, or as simple as a hand-held button switch. Control device options include a Remote Manual Pushbutton (Instron Catalog No. 2310-516), an Instron XL Elastomeric Extensometer, or an Instron Incremental Extensometer.

The pip height is factory set at approximately one chart division on a 250 mm (10 inch) wide chart. The amplitude is not affected by the automatic ranging of the load signal.

A pip filter is included in the Pip Control circuit to suppress spurious pips from such devices as the Incremental Extensometer. When the Pip signal is sensed going from the open condition to the closed condition, as when a conductive band of the Incremental Extensometer first passes under the contacts, a pip is reported to the IEEE Bus and a blanking delay is started. During the delay, the Pip signal is ignored. When the delay ends, the search for the next active transition resumes.

A variable blanking period can be entered, either from the front panel or from a computer connected to the

IEEE Bus. To enter a delay from the front panel, use the key sequence:

[S1] [8] [2]

When the S1 and 8 are pressed, the setup display will show “S1 8". When the 2 is pressed, the current delay value will be shown. A new value can be entered at this time.

The delay value is entered in units of seconds with a resolution of 0.005 seconds. The delay is saved in non-volatile memory. The default value is zero, which allows Pips to be sensed at the maximum rate. The maximum rate for reporting of pips is one every 50 milliseconds (the maximum IEEE report rate). The maximum delay is 9999 seconds.

By proper selection of the delay, the extra pips due to momentary loss of contact on the conductive band will be eliminated. The proper delay is a function of the test speed and the width of the conductive band. The conductive bands on the Incremental Extensometer are 1/32 inch wide.

For test speeds in inches per minute:

$$Delay = \frac{2}{Speed}$$

For test speeds in millimeters per minute:

$$Delay = \frac{50}{Speed}$$

Table 6-10 gives examples of test speeds versus typical pip blanking delays.

Table 6-10. Example Pip Delay Values vs Test Speeds

Test Speed (in/min)	Delay (seconds)
above 20	0
20	0.100
1	2.000
0.1	20.00
below 0.0002	9999
Test Speed (mm/min)	Delay (seconds)
above 1000	0
100	0.500
50	1.000
1	50.00
0.1	500.0
0.005	9999

Air Kit Option

Overview

The Air Kit Option is a set of hardware and firmware to provide control and operation of pneumatic grips in several manual and semi-automatic modes during testing sessions. It consists of a Pneumatic Control Box, a Footswitch assembly, and interconnecting electrical cables and air hoses. It does not include the grips or the air supply. The air kit connection on the load frame, internal wiring, circuits, and firmware are part of the Model 4400. A complete description of the Air Kit, its specifications, installation, manual operation, maintenance, and parts breakdown are all given in the Pneumatic Grip Control manual, M10-82701-1.

Early Model 4400 Consoles did not have the required grip control firmware. These systems require a separate firmware upgrade to operate an aftermarket (not purchased with the testing system) Air Kit Option. If you are not certain whether your system contains the grip control firmware, use the grip control key sequences given later in this section to see if the functions are present.

Description

In the Model 4400, the upper and lower pneumatic grips are actuated by air pressure controlled by two solenoid valves in the Pneumatic Control Box. The grips are passive in that they do not require pneumatic or electrical controls as part of the grips themselves. In operation, the grip jaws close when air pressure is applied and the solenoid activated, and open when the solenoid valve is deactivated and air pressure released.

The Pneumatic Control Box is mounted on one of the columns of the load frame. This unit contains the solenoid valves and a small printed circuit board. It is the hub of the pneumatic and electrical connections; one hose provides pressurized air, and two hoses provide controlled pressure to the upper and lower grips. One electrical cable connects to the footswitch, and another connects to the load frame.

The footswitch assembly contains two foot pedals for opening and closing the grips. Each pedal operates a momentary electrical switch, which in turn operates the solenoid valves. The role of the CLOSE pedal in the closing sequence for the grips depends on the mode of operation selected, but the OPEN pedal always causes both grips to open.

Operation

The Air Kit Option operates in several modes, selected from the Console front panel or through the GPIB Computer Interface from an external computer. The functions are listed in Table 6-11, along with their default settings.

In addition, one other function is the Pretension Hysteresis level, which is set at 50% of the Pretension level. This value is fixed, and cannot be adjusted.

Grip Control Enable/Disable overrides all of the other settings. It must be enabled for any of the automatic features to operate. This control provides a convenient means of disabling automatic operation while maintaining a combination of automatic settings for later reuse.

Table 6-11. Air Kit Functions

Setting	Default
Grip Control Enable/Disable	Disabled
Pretension Enable/Disable	Disabled
Excess Tension Enable/Disable	Disabled
Automatic Start Enable/Disable	Disabled
Automatic Release Enable/Disable	Disabled
Pretension Level	0
Excess Tension Level	0

The Pretension, Excess Tension, Automatic Start, and Automatic Release functions enable or disable their respective features. They are independent, except that the Excess Tension function will not operate unless Pretension is also enabled.

The Pretension and Excess Tension levels can be set independently of their respective enable controls, but will have no effect while disabled.

Manual Operation

The grips can be operated in a fully manual mode if Grip Control is set to Disabled, or if all of the other functions are disabled.

As described in the Pneumatic Grip Control manual, in manual operation, the CLOSE foot pedal is pressed once to close the upper grip. It is pressed again to close the lower grip. The OPEN foot pedal opens both grips simultaneously when pressed. There is no other interaction with the Model 4400 System in full manual mode.

Grip Control Function Operation

To enable the Grip Control function:

(a) Press [S1] [7]. Read the current state of the Grip Control function from the Main Panel Display.

(b) The Main Panel Display will show:
"S1 7" if Grip Control is enabled.
"S1–7" if Grip Control is disabled.

(c) Use the [+/–] key to toggle between the enabled and disabled state.

Pretension and Excess Tension Operation

If the Grip Control function is enabled and Pretension is enabled, the closure of the lower grip is based on obtaining the load level set by the Pretension Level. Further, once the lower grip is closed, the load must stay above the Pretension Hysteresis level and, if it is enabled, below the Excess Tension level. The load level is measured through the console load weighing system. A load cell must be installed and calibrated.

The operating sequence starts when the material is placed in the upper grip. The CLOSE foot pedal is pressed to close the upper grip. The material is then fed through the lower grip and pulled to apply pretension. When the set level is reached, the lower grip closes automatically. The load signal is monitored until a test starts (by whatever means). If the load falls below the Pretension Hysteresis level, or rises above the Excess Tension level, both grips open. Both grips can be opened at any time by pressing the OPEN foot pedal. Once both grips are open, a new sequence can begin.

To enable or disable the Pretension function, do the following:

(a) Press [S1] [7] [1]. Read the current state of Pretension from the Main Panel Display.

(b) The Main Panel Display will show:
“S7 1" if Pretension is enabled.
”S7–1" if Pretension is disabled.

(c) Use the [+/–] key to toggle between the enabled and disabled state.

To enable or disable the Excess Tension function, do the following:

(a) Press [S1] [7] [2]. Read the current state of Excess Tension from the Main Panel Display.

(b) the Main Panel Display will show:
“S7 2" if Excess Tension is enabled.
”S7–2" if Excess Tension is disabled.

(c) Use the [+/–] key to toggle between the enabled and disabled state.

Automatic Start Operation

When the Grip Control function and Automatic Start are enabled, the crosshead will start automatically in the direction of increasing load as soon as both grips are closed (by whatever means).

This is useful with or without Pretension operation. If Pretension is disabled, the test will start when the foot pedal is pressed the second time to close the lower grip. With Pretension enabled, the test will start when the Pretension Level is reached and the lower grip closes (automatically), provided the load stays within the Pretension Hysteresis and Excess Tension ranges.

To use Automatic Start:

(a) Press [S1] [7] [3]. Read the current state of Automatic Start from the Main Panel Display.

(b) The Main Panel Display will show:
"S7 3" if Automatic Start is enabled.
"S7–3" if Automatic Start is disabled.

(c) Use the [+/–] key to toggle between the enabled and disabled state.

Automatic Release Operation

When both the Grip Control function and Automatic Release are enabled, both grips will open when a test ends (by whatever means). This avoids the need to press the OPEN pedal to start the next manual or pretension sequence.

To use Automatic Release:

(a) Press [S1] [7] [4]. Read the current state of Automatic Release from the Main Panel Display.

(b) The Main Panel Display will show:
"S7 4" if Automatic Release is enabled.
"S7–4" if Automatic Release is disabled.

(c) Use the [+/–] key to toggle between the enabled and disabled state.

Set Pretension Level

To set the Pretension Level, do the following:

(a) Press [S1] [7] [5].

(b) After the [5] key has been pressed, read the current Pretension Level on the Main Panel Display.

(c) To change the Pretension Level, enter the load value for the Pretension Level on the numeric keypad on the console. Press [ENTER] to complete the sequence.

Set Excess Tension Level

To set the Excess Tension Level, do the following:

(a) Press [S1] [7] [6].

(b) After the [6] key has been pressed, read the current Excess Tension Level on the Main Panel Display.

(c) To change the Excess Tension Level, enter the load value for the Excess Tension Level on the numeric keypad on the console. Press [ENTER] to complete the sequence.

Time Delays

As mentioned earlier, the grip status feedback to the console is from the solenoid, not the grip faces. A one second time delay is used to allow the grips time to open and close in the above sequences.

Continuous Pretension Testing

To set up for continuous Pretension testing, do the following:

(a) Set a Pretension Level and enable Pretension.

(b) Set an Excess Tension Level and enable Excess Tension (this step is optional).

(c) Enable Automatic Start.

(d) Enable Automatic Release.

(e) Enable Grip Control.

(f) Set a break action of RETURN.

With these settings, you can run a single test by simply loading a specimen in the upper grip, press the CLOSE pedal, apply the Pretension force, and step back while the test runs.

Chapter 7
Test Check List

Test Check List

This Materials Test Check List is included as an aid for you to preplan a test program. It can also serve as a record for completed tests. The format of the list is only a suggestion. A different format may better suit the requirements of your particular types of tests.

SPECIMEN ______________________________
Material (Type, Batch)

______________________ ______________
Identification No. Date

______________ ______________ ______________
Width/Diameter Thickness Cross-sectional Area

TEST PURPOSE and CONDI- ______________________
Test Type

____

TEST RESULTS RE- ______________________________

____

____

____

______________ ______________ ______________
Maximum Load Maximum Extension Temperature (°C, °F)

TEST EQUIP- ________________ Load Frame Type ________________ Test Area

________________ Load Cell Type ________________ Specimen Grips Type

________________ Extensometer (Strain) ________________

________________ Recorder ________________ Printer ________________ Computer

________________ Other Accessories, Special Fixtures, Equipment

TEST EQUIPMENT ________________ Test Reference No.

System Operating Units ________________ S. I., Metric, English

Load Cell Calibration ________________ Self/Non-Self ID ________________ Auto/Manual

Crosshead Control ________________ Speed ________________ Gauge Length

Crosshead Travel Stops ________________ Max. Limit (Extension) ________________ Min. Limit (Gauge Length)

Area Compensation ________________ Sample No. and Setting

Energy ______________ Preset Points ______________
Enable/ Disable Enable/ Disable

____
Energy Integration Variable

____
Preset Points Independent Variable

Preset Point Values ______________ ______________
Preset Point 1 Preset Point 2

Extensometer Calibration ______________ ______________
Self/Non-Self ID Auto/Manual

Strain Operating Mode ______________________________
Percent (%) or Displacement

Strip Chart Recorder __________ __________ __________
Chart Speed Time/Proportional % Range Ratio

X-Y Recorder ______________ ______________
X-Axis Drive Mode Position/ Time/ Strain

______________ ______________
% Range Position Full Scale (Span)

____
Time Full Scale (Minutes)

Autoprint ______________ Printer Baud Rate ______________
Enable/Disable

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

Limits Assignments

Variable	Max Limit	Min Limit	Crosshead Action
Load	______	______	______
Extension	______	______	______
Strain	______	______	______

Break Detection ______________________
Crosshead Action

Cycle Action ______________________
Increase Load (Up/Down)

REMARKS ______________________

Chapter 8
Maintenance

Overview

This chapter describes some maintenance procedures you can perform to keep your testing system in good working order. If you encounter problems, a list of error messages, and front and rear panel fault indications are given to help you solve the problem.

In this chapter, you will learn:

- What preventive maintenance procedures should be performed periodically
- What to look for when things don't work right
- What to do when you find the fault

Introduction

General

The Control Console for a Series 4400 testing system is a precision electronic device that is designed for long term trouble-free operation with only minimum periodic maintenance. A Resident Test Program features an automatic Self Test Routine, as described elsewhere in this manual, which provides assurance of console reliability each time you power up the instrument.

If the console does malfunction, this chapter describes how to display and read error messages using the Diagnostic Monitor mode of the Resident Test Program. The functioning of test LEDs on the rear of the console is also described.

Included in this chapter is an interconnection drawing of the Series 4400 console.

Special Maintenance Considerations

The control console contains a single printed circuit board, on which are located all the features and functions of the system. Instron maintains a stock of factory-tested replacement boards that can be used to replace a defective board in your system. There are no complex, time-consuming troubleshooting procedures, and no highly technical replacement of defective parts. This means that repairs can be effected quickly and easily, minimizing your system downtime.

If you need help with any maintenance problem connected with your Series 4400 system, contact the factory or your Instron regional Sales and Service Center.

Preventive Maintenance

Cleaning - Control Console

Periodically clean the exterior surfaces of the Control Console with a soft, lint-free cloth. To remove grime, dampen the cloth with water and a mild detergent. *Do not* use strong cleaners or solvents on any part of the unit, and do not allow cleaning water to leak into the interior of the console.

If your Series 4400 system is operating in a dusty environment, vacuum all surfaces and air ports as required.

Error Messages

Overview

The Resident Test Program, described in Chapter 4, contains a Diagnostic Monitor as the main troubleshooting mode. This monitor also allows you to display a list of error messages relating to failures which may have occurred during the self test or cyclic test modes of the program. By using this feature of the monitor, you can communicate to an Instron service representative the exact nature of a failure, thus expediting repair procedures.

Displaying Error Messages

If the Self Test Routine detects a failure, the result appears on the Main Panel Display. This result remains on the display, and normal operation cannot be started. To determine the type of failure, start the Diagnostic Monitor by pressing “S1”. The word “HELP” appears on the display, which is an acronym for the four types of commands the monitor provides: Help, Error, Look, Put. The Error command lists the errors found for each functional section of the console during Self Test.

Note *When “HELP” displays, if you repeat pressing [ENTER] the command type advances until “L” and “P” alternate. If you repeat pressing [REJ], the previous command type appears until “H” and “E” alternate. Help, Look and Put commands are for use by trained personnel and are beyond the scope of this manual.*

When “HELP” is on the display, press [ENTER] to change the display to “E”. This indicates that the Error type command is in effect.

The “E” type commands are numbered 0 through 9, except “4” and “7”, which are not used. You must enter one of these numbers on the keypad, followed by [ENTER] to execute an “E” command. E0 lists error messages in all functional sections, E1 to E8 lists error messages for sections 1 through 8 (except 4 and 7), respectively, and E9 prints the list of error messages.

Table 8-1 lists the functional sections in the Series 4400 control console.

Table 8-1. Sections of the Control Console

Section No.	Functional Name	Basic or Option
1	IEEE-488 Interface	Option
2	Central Processing Unit (CPU)	Basic
3	Crosshead Control	Basic
4	(Not Used)	- -
5	Load Sensor Conditioner	Basic
6	Strain Sensor Conditioner	Option
7	(Not Used)	—
8	Recorder Interface	Option

The following examples show the use of “E” commands after entering the Diagnostics Monitor as described previously.

EXAMPLE NO. 1:

To display errors for each Section sequentially, 1 through 8:

(a) When the “E” command displays, press [0] [ENTER]. The display shows “E 1. - -” if no error exists in Section 1. If an error exists, a message displays that relates to a failed test as shown in Table 8-2.

(b) Record any error message, then repeat pressing [ENTER] to display messages for any additional errors in Section 1.

(c) After all error messages are shown for Section 1, the program automatically steps to Section 2 when you press [ENTER]. Continue the procedure, as in Steps (a) and (b) above, for all sections through No. 8.

(d) After all error messages display for Section 8, and you press [ENTER], the display shows “L” for the Look command. Press [REJ] to return to the “E” command.

(e) To escape from the Diagnostic Monitor, press “S1” to start the Cyclic Self Test. When the Self Test number displays, press [ENTER].

EXAMPLE NO. 2:

To display errors for a particular section:

(a) To select Section No. 3 error message list, for example, when the “E” command displays, press [3] [ENTER]. The display shows “E 3. - -” if no error exists on Section 3. If an error exists, a message displays that relates to a failed test as shown in Table 8-2.

Table 8-2. Error Messages

CIRCUIT BOARD	MESSAGE	FAILED TEST
IEEE-488	E1.00	I/O Port Test
	E1.01	Memory Initialization State Bit Test
	E1.02	Two Port Ram Test
	E1.03	Normal Mode State Bit Test
	E1.04	Compatibility Code Test
CPU	E2.01	PROM 0 Test - Checksum
	E2.02	PROM 0 Test - Start Address
	E2.03	PROM 0 Test - Program Version
	E2.04	PROM 0 Test - Program Number
	E2.10 to E2.17	Same as E2.01 to E2.04 for PROM 1/PROM 2
	E2.20 to E2.27	Same as E2.01 to E2.04 for PROM 2/PROM 4
	E2.30 to E2.37	Same as E2.01 to E2.04 for PROM 3/PROM 6
	E2.40 to E2.47	Same as E2.01 to E2.04 for PROM 4/None
	E2.50	Option Table Test (Version 1 only)
	E2.51	I/O Port Test
	E2.52	Front Panel Interface Test - Handshake
	E2.53	Front Panel Interface Test - Data
	E2.54	Front Panel Interface Test - Compatibility
	E2.55	Interrupt Controller Test - Mask Register
	E2.56	Interrupt Controller Test - Service Register
	E2.57	Interrupt Controller Test - Request Register
	E2.71	RAM Test - Foreground (Data) Error
	E2.72	RAM Test Background (Address) Error
	E2.81	PROM F Test - Checksum
	E2.82	PROM F Test - Start Address
	E2.83	PROM Test - Compatibility
	E2.84	PROM Test - Program Number
Crosshead Control	E3.00	I/O Port Test
	E3.01	Timer Interrupt Test
	E3.02	UP Encoder Counter/Logic Test
	E3.03	DOWN Encoder Counter/Logic Test
	E3.04	Error DAC Test - 0
	E3.05	Error DAC Test - Full Scale
	E3.06	Watchdog Timer Test
	E3.07	Crosshead Switch Short Test

Table 8-2. Error Messages (continued)

CIRCUIT BOARD	MESSAGE	FAILED TEST
Load Sensor Conditioner	E5.00	I/O Port 1 Test
	E5.01	I/O Port 0 Test
	E5.02	A/D Run/Hold/Status Test
	E5.03	A/D 0 Volts Test
	E5.04	A/D 5 Volt Test
	E5.05	Load Section ID Test
Strain Sensor Conditioner	E6.01	I/O Port 1 Test
	E6.02	I/O Port 0 Test
	E6.03	A/D Run/Hold/Status Test
	E6.04	A/D 0 Volts Test
	E6.05	A/D 5 Volt Test
	E6.06	Strain Section ID Test
Recorder Interface	E8.00	I/O Port Test (Option Test)

(b) Record any error message, then repeat pressing [ENTER] to display messages for any additional errors on Section 3.

(c) After all error messages display for Section 3, and you press [ENTER] the display shows “E.3 - -” for the end of the list. Press [ENTER] again to return to the “E” command level.

(d) To display error messages for another section, enter the section number as in Step (a) above, then repeat Steps (b) and (c).

(e) To escape from the Diagnostic Monitor, press “S1” to start the Cyclic Self Test. When the Self Test number displays, press [ENTER].

EXAMPLE NO. 3:

To print out error messages for all sections (with your printer connected to the PRINTER port on the rear of console):

When the “E” command displays, press [9] [ENTER].

Table 8-2 lists error messages and the related failed test for the “E” type commands.

Rear Panel Indicators

Rear Panel Indicators

General

The printed circuit board used in the Series 4400 console is divided into functional sections. These functions include Main Panel, Display Panel, Limits Panel, Load Sensor Conditioner, and the like, and they operate more or less independently of one another. The functional sections are monitored by LEDs and display panel indicators, and the unique combination of LEDs that are lit and the results displayed on the front panel help to pinpoint faults.

There are certain types of failures that may cause unusual operation of the LEDs and displays on the console front panel. These failures could occur in the CPU or Front Panel sections of the circuit board; the condition of the latter is not reported by the Self Test result. If erratic operation of the front panel occurs, or normal operation is prevented due to a failure reported by the Self Test, then the state of the rear panel indicators (LEDs) can be used for further diagnosis.

The LEDs are visible on the on the rear of the console though window openings in the rear cover. There are three sets of indicators; one for the main console circuit board, one for the Strain Sensor Conditioner board when it is present, and one for the IEEE-488 Computer Interface board when it is present. The following sections describe the function of these indicators, and Figure 8-1 shows their location.

Maintenance

Power Supply Condition Indicators

Three LEDs indicate the condition of the three console power supply voltages from the load frame: +5 Vd.c., +15 Vd.c. and -15 Vd.c. Each LED is lit when its respective power supply voltage is present, and it is off if that power supply has failed.

If the Self Test does not function, this may indicate a loss of the +5 V supply, so check its LED first.

If a ±15 V supply fails, the Self Test result will show a failure of one or more sections of the circuit board, and the backlit status/fault indicators on the Main Panel will not light.

If an LED is dimly lit, this indicates a drop in voltage level from its power supply. The intensity of an LED is a coarse indicator and it will not be apparent for a small drop in voltage level.

Green Test LEDs

Each circuit section which has its input and output under control by the CPU has a green TEST LED. These LEDs are on during the first part of the Self Test and off during the second part. When the Self Test concludes, a lit TEST LED indicates its section is good; if the LED is not lit, the section did not pass the test. During normal operation all green TEST LEDs are lit. However, some flickering may be seen on certain green LEDs which is due to software telemetry. For example, the flicker of the green LED on the CPU section is caused by system interrupt response. Figure 8-2 shows a closeup view of the details of the main console indicators.

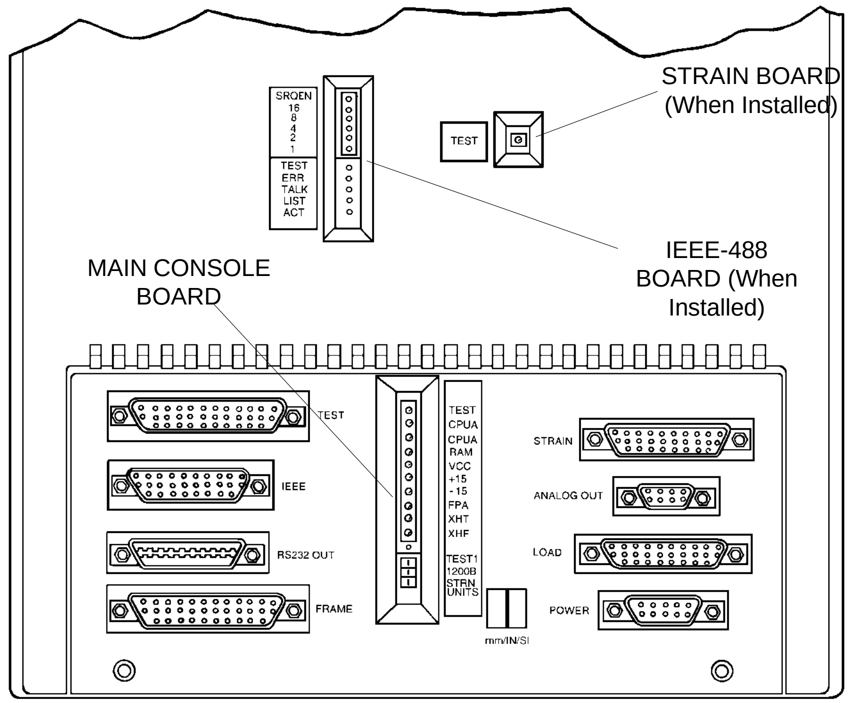


Figure 8-1. Rear Panel Indicators

Red Activity LEDs

Each section with a microprocessor has a red ACTIVITY LED; these include the CPU, the IEEE-488 Interface section, and the Front Panel section. During normal operation, the ACTIVITY LEDs flash about once per second to indicate that the processor is running. A steady on or off ACTIVITY LED indicates a serious failure. Continuous rapid flashing of the CPU ACTIVITY

LED just after power on or system reset indicates a RAM problem.

Red Latch Indicator LEDs

The latch indicators include the red CPU A RAM LED and the red Crosshead Control FAULT LED. These LEDs are never on except when a latch has been triggered and a system reset (main power turned off and then on) is required.

The RAM latch protects memory in case of a power failure; the POWER status indicator on the Main Panel also lights when this occurs.

The FAULT latch prevents the crosshead drive power amplifier from being enabled if the watchdog timer fails;

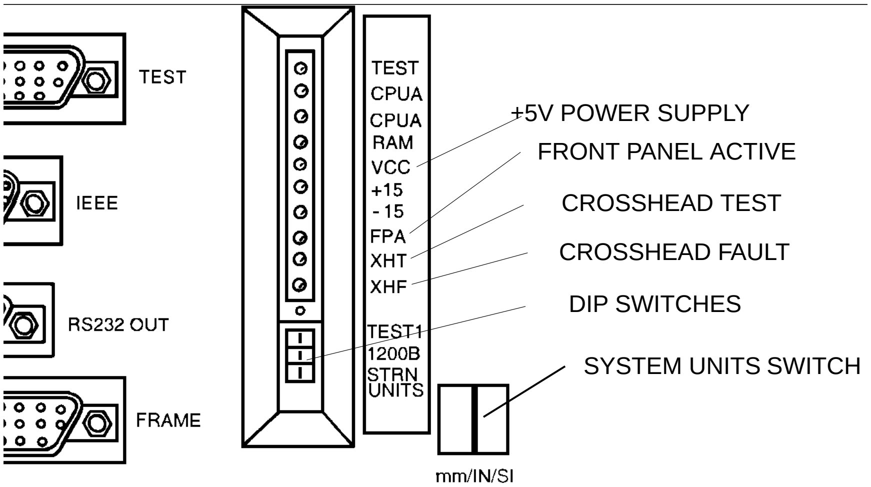


Figure 8-2. Closeup Detail of Console Status and Fault Indicators

the TIMER status indicator on the Main Panel also lights when this occurs.

IEEE-488 Interface Indicators

The IEEE-488 section has additional indicators that are exclusive for its particular functions; these are the red ERROR, LISTENING, and TALKING LEDs.

During the Self Test Routine after system power is applied, the IEEE section undergoes a series of tests. If a failure is encountered, a descriptive error code displays on the three LEDs and the red ACTIVITY LED, as shown in Table 8-3. A section failure is also shown in the Self Test report number on the Main Panel display. If all tests pass, the red ACTIVITY LED flashes.

Table 8-3 shows the on/off state of the four LEDs if certain failures occur. The initial test checks that the four LEDs are functioning.

Table 8-3. LED Error Codes for IEEE-488 Section

LED NAME				DESCRIPTION
ERROR	TALKING	LISTENING	ACTIVITY	
on	on	on	on	LED test
on	off	off	off	CPU RAM/Timer error
on	off	off	on	D-P Memory data error
on	off	on	off	PROM error
on	on	off	off	GPIB Driver error
on	on	on	off	D-P Memory Control error

Summary of Operating Sequence for Rear Panel Indicators

The moment after main power is applied, or a system reset occurs, the green TEST LEDs for each circuit section light. At the end of this initial period, the self test of the processor on the CPU section (No. 2) begins. The green TEST LEDs remain on and the red ACTIVITY LED on the CPU is on. After about 2 seconds, the green LED's and the CPU ACTIVITY LED go out.

At the end of the Self Test Routine, when the code comes up on the Main Panel display, the green TEST LED for each section (except the CPU) that passes the test light and the green LED for any section that fails the test remains off. If the CPU section passes its self test, its red ACTIVITY LED flashes; otherwise it will be steady on, or off. If the CPU section achieves successful communication with the Front Panel section, its green TEST lights.

Shortly after Self Test begins, the Front Panel section has its own self test. When this is complete, the red ACTIVITY LED for this section flashes. If the section fails the test, the red LED remains off.

If the processor in the IEEE-488 Interface section passes the self test, its red ACTIVITY LED flashes. The green TEST LED for this section lights if the section passes main self test. Thus, the ACTIVITY LED could flash and the TEST LED could be off, indicating that the processor is running but the interface to the CPU processor is faulty. If the IEEE section processor has a fault (ACTIVITY LED off), the CPU processor senses this and the TEST LED remains off. The previous section describes the action of the other LEDs for this section.

Fault Indications

The fault indicators on the Main Panel light under certain conditions occurring during system operation. The chart below lists the probable cause of these conditions and the action to be taken.

Table 8-4. Fault Indications

FAULT INDICATOR	CAUSE	CORRECTIVE ACTION
POWER (Drive disabled)	Momentary power loss.	Cycle power off/on.
TIMER Drive disabled)	CPU malfunctions or loss of +/- 15 Vd.c. power.	Cycle power off/on. Note Self Test result.
LOAD (flashes) (Crosshead stops)	Load overrange greater than 102% of cell capa- city with AREA ≅ 1; or greater than 115% if AREA is set much larger than 1.	Reduce load by UP, DOWN or JOG keys (only proper direction is en- abled). Indicator flashes until a new test is started.
TRAVEL (Crosshead stops)	Upper or lower crosshead travel limit reached	Back off from limit by UP, DOWN or JOG keys (only proper direction is enabled).
MOTOR (Drive disabled. Indicator on steady.)	1. Motor drive enabling se- quence (5 sec. duration) 2. Motor drive cannot be enabled. 3. Load frame cannot be identified. 4. Load frame power supply failure. 5. Crosshead second level travel limit tripped. 6. Emergency stop switch tripped. 7. Door interlock open.	Wait 5 sec. If speed shows as "———-", check frame-to-console cabling. Do a System reset.*
MOTOR (Drive disabled. Indicator flashing.	1. Drive motor overheated. 2. Drive loop failure. 3. Drive stall.	Do a system reset.* If flash- ing restarts, allow motor to cool and reset*. Check for a mechanical jam if fault persists (requires service).

*To reset system, cycle power off/on or perform the key sequence [S1] [0] [ENTER] which clears memory, or the sequence [S1] [1] [ENTER] which saves current memory.

Appendix A
Test Planning

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 gauge length, choosing a testing speed and the use of area compensation. A glossary of terms defining the mechanical properties and tests applicable to a Series 4400 system is included as Appendix B for your convenience.

The American Society for Testing and 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.

European and Asian users will find that the various British, DIN, ISO, and other standards will also help in your test planning. In most cases, the ASTM standard has an equivalent or similar European standard.

Applications

The test capabilities of a Series 4400 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 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 allows the peak and break parameters of load, extension and strain to be monitored and stored. The Limits Panel permits minimum and maximum travel limits of the crosshead to be controlled at selected load, stress, 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 gauge length after break for repetitive specimen testing.

Additionally, each Series 4400 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 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 specimen dimensioning 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, 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 IEEE-488 Interface and a 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 specimen dimensioning to obtain load value relationships to units such as grams/denier. Use a computer through the IEEE-488 interface to obtain complete statistical analyses of test results. Typical ASTM textile-related tests applicable to a Series 4400 instrument include: D458 for man-made fibers: D2256 for yarn; D2653 for elastomeric yarns; and D2263 for grab tests of automotive fabrics.

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.

Material: Lexan

Tensile strength: 5200 psi (from a materials handbook)

Specimen area: 0.502 in. wide x 0.125 in. thk = 0.063 in.

Tensile strength = 5200 psi x 0.063 in. = 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.

Selection Of Grips

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

Table A-1. Gripping Techniques

SPECIMEN MATERIAL	SPECIMEN GEOMETRY	MAX. BREAK LOAD (LB)	TYPES OF GRIPS AND FACES
Paper	25 mm (1 in.) wide	100	Screw-action or Pneumatic (25 x 50 mm flat faces)
Plastic Films	25 mm (1 in.) wide	100	Same as above. Also, line contact faces can be used.
Rigid Plastics	25 mm wide x 12.5 mm thick (1 in. wide x .5 in. thick)	1000	Wedge-action or screw-action with serrated faces.
Wire and Sheet Metal	.50 to 1.5 mm diameter (.002 to .060 in.)	200	Screw-action or pneumatic-action with 25 mm x 50 mm flat or serrated faces.
Cord and Yarn	.50 to 4.8 mm diameter	350	Pneumatic cord and yarn grips.
Fabrics	25 mm or 100 mm wide strip (1 in. or 4 in.)	1000	Screw-action or pneumatic-hydraulic with flat faces.
Elastomers	mm to 6 mm wide (.125 to .250 in.)	150	Elastomeric

Establishing Gauge Length

The gauge 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 gauge length is one of the most important decisions to be made when performing tension tests. Gauge 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 gauge length is dictated by the available length of the material, although commonly used gauge lengths for paper, plastic film, wire, cord and yarns are from 4 to 10 inches (100 to 250 mm). In general: establish the longest possible gauge length, consistent with the capacity of the testing instrument, in order to increase the sensitivity and accuracy of the elongation measurement.

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 Various 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)

Strain Rate

For certain materials, the specimen strain rate is specified rather than a testing speed. But once the gauge 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

Gauge length: 10 in. (250 mm)

Strain rate (from designated test procedure):
0.5 in/in/min (0.5 mm/mm/min)

Testing speed = 0.5 in/in/min x 10 in. (250 mm)
= 5.0 in/min (125 mm/min)

Therefore, in this example, perform the tensile test on the film at 5.0 in/min (125 mm/min).

Area Compensation

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 Series 4400 system, area compensation values are entered as a base number (mantissa) and an exponent using two key sequences, as described in Chapter 5. 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 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.

Determining Stress Range

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

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

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 ; 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:

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

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* (refer to Section A.7.3).

Limitations Due To Load Cell Capacity

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

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

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:

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

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.

Note *Do not use a full 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 cell.

Chart Magnification

When using a strip-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.

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:	50% (approximate)
Gauge length:	250 mm

Crosshead speed:
= Gauge length x % ext./min.
= 250 mm x 100%/min.
= 250 mm/min.

A 250-mm 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 500 mm in 1 minute, and a chart speed of 500 mm/min is required. Then:

$$M = \frac{500\ ^{mm}/_{min}}{250\ ^{min}/_{min}} = 2$$

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

$$\frac{1}{M} = \frac{1}{2} = \textit{Crosshead Displacement (mm)}$$

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

$$\%\ Strain = \frac{\textit{Chart displacement} \quad x\ 100}{M\ x\ \textit{Gauge length}}$$

Appendix A
Test Planning

Appendix B
Glossary

The following glossary of terms related to mechanical tests of materials will assist you in the application of your testing system. As materials are commonly specified by their properties, defining a property and measuring it is generally done by a mechanical testing procedure. The procedures cited here refer to American Society for Testing and Materials (ASTM) standards and test methods. Most of these standards have an equivalent DIN or ISO standard.

Understanding these tests and their applications is basic to performing them. The terms listed in this glossary are chosen because of their relation to the types of tests within the capability of a Series 4400 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). A bend test for ductility of welds is given in ASTM E-190. 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 divided by area of bond) required to rupture a bond formed by an adhesive between two metal blocks. (ASTM D-952).

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.

Bulk Modulus of Elasticity.

Ratio of stress to change in volume of a material subjected to axial loading. Related to Modulus of Elasticity (E) and Poisson's Ratio (r) by the following equation:

$$K = \frac{Er}{3(1-2r)}$$

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 a rigid material. (ASTM D-1781).

Coefficient of Elasticity.

An alternate term for modulus of elasticity.

Cohesive Strength.

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

Complex Modulus.

Measure of dynamic mechanical properties of a material, taking into account energy dissipated as heat during deformation and recovery. It is equal to the sum of static modulus of a material and its loss modulus. In the case of shear loading, it is called dynamic modulus.

Compressibility.

Extent to which a 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. This test is not designed to indicate long term (creep) behavior and should not be confused with the plastometer test.

Compression-Deflection Test.

Nondestructive 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). This 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-773 (high strength ceramics), ASTM E-9 (metals), ASTM E-209 (metals at elevated temperatures) and ASTM D-695 (plastics).

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.

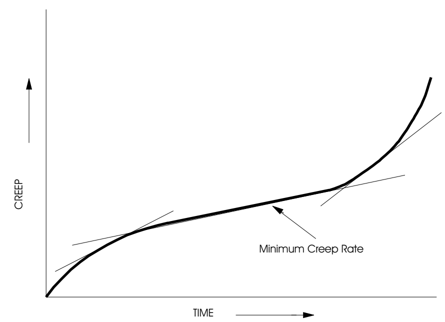
Compressive Yield Strength.

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 the 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 (tertiary) creep has an accelerating creep rate and terminates by failure of material at time for rupture. See also stress-relaxation.

Creep Limit.

Alternate term for creep strength.

Creep Rate.

Time rate of deformation of a material subject to stress at a constant temperature. It is the slope of the creep vs time diagram obtained in a creep test. Units usually are in/in/hr or % of elongation/hr. Minimum creep rate is the slope of the portion of the creep vs time diagram corresponding to secondary creep.

Creep Recovery.

Rate of decrease in deformation that occurs when load is removed after prolonged application in a creep test. Constant temperature is maintained to eliminate effects of thermal expansion, and measurements are taken from time load is zero to eliminate elastic effects.

Creep Rupture Strength.

Stress required to cause fracture in a creep test within a specified time. An alternate term is stress rupture strength.

Creep Strength.

Maximum stress required to cause a specified amount of creep in a specified time. Also used to describe maximum stress that can be generated in a material at constant temperature under which creep rate decreases with time. An alternate term is creep limit.

Creep Test.

Method for determining creep or stress relaxation behavior. To determine creep properties, material is subjected to prolonged constant tension or compression loading at constant temperature. Deformation is recorded at specified time intervals and a creep vs time diagram is plotted. Slope of the curve at any point is creep rate. If failure occurs, it terminates the test and time for rupture is recorded. If the specimen does not fracture within test period, creep recovery may be measured. To determine stress relaxation of material, specimen is deformed a given amount and decrease in stress over prolonged period of exposure at constant temperature is recorded. Standard creep testing procedures are detailed in ASTM

E-139, ASTM D-2990 and D-299 (plastics) and ASTM D-2294 (adhesives).

Crush Resistance.

Load required to produce fracture in a glass sphere subjected to crush loading. (ASTM D-1213).

Crushing Load.

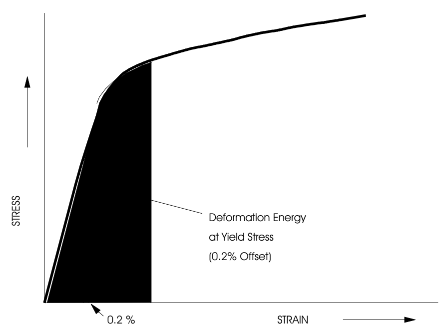
Maximum compressive force applied during a compression or crushing test. For materials that do not shatter, crushing load is defined as the force required to produce a specified type of failure.

Crushing Strength.

Compressive load required to cause a crack to form in a sintered metal powder bearing (ASTM B-438 and B-439). Cold crushing strength of refractory bricks and shapes is the gross compressive stress required to cause fracture. (ASTM C-133).

Deformation Energy.

Energy required to deform a material a specified amount. It is the area under the stress-strain diagram up to a specified strain.



Deformation Under Load.

Measure of the ability of rigid plastics to withstand permanent deformation and the ability of nonrigid plastics to return to original shape after deformation. Standard test methods for determining both types of deformation under load are given in ASTM D-621. For rigid plastics, deformation (which can be flow or flow and shrinkage) is reported as % change in height of specimen after 24 hours under a specified load. For nonrigid plastics, results are reported as % change in height after 3 hours under load and recovery in the 1-1/2 hour period following removal of the load. Recovery is % increase in height calculated on basis of original height.

Delamination Strength.

Measure of the node-to-node bond strength of honeycomb core materials. It is equal to the tensile load applied to a honeycomb panel at fracture divided by its width times its thickness (ASTM C-363).

Dry Strength.

Strength of an adhesive joint determined immediately after drying or after a period of conditioning in a specified atmosphere. (ASTM D-2475).

Ductility.

Extent to which a material can sustain plastic deformation without rupture. Elongation and reduction of area are common indices of ductility.

Dynamic Creep.

Creep that occurs under fluctuating load or temperature.

EASL

Elongation at a specified load.

Eccentricity of Loading.

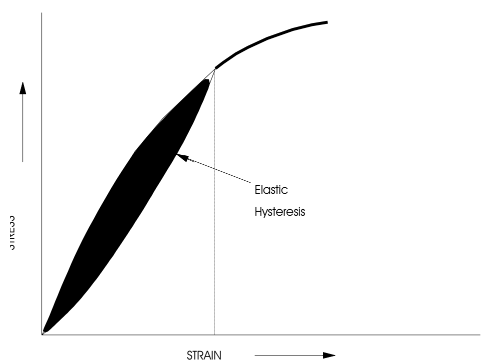
Distance between the actual line of action of compressive or tensile loads and the line of action that would produce a uniform stress over the cross section of the specimen.

Edge Tearing Strength.

Measure of the resistance of paper to tearing when folded over a V-notch beam and loaded in a tensile testing machine. Results are reported in lb or kg. (See Tear Resistance.)

Elastic Hysteresis.

Difference between strain energy required to generate a given stress in a material and elastic energy at that stress. It is the energy dissipated as heat in a material in one cycle of dynamic testing. Elastic hysteresis divided by elastic deformation energy is equal to damping capacity.

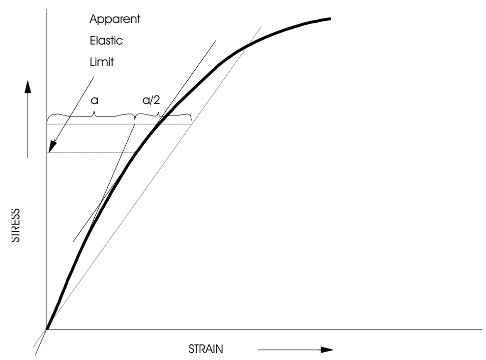


Elastic Limit.

Greatest stress that can be applied to a material without causing permanent deformation. For metals and other materials that have a significant straight line portion in their stress/strain diagram, elastic limit is approximately equal to proportional limit. For materials that do not exhibit a significant proportional limit, elastic limit is an arbitrary approximation (the apparent elastic limit).

Elastic Limit, Apparent.

Arbitrary approximation of the elastic limit of materials that do not have a significant straight line portion on a stress/strain diagram. It is equal to the stress at which the rate of strain is 50% greater than at zero stress. It is the stress at the point of tangency between the stress-strain curve and the line having a slope, with respect to the stress axis, 50% greater than the slope of the curve at the origin.



Elasticity.

Ability of a material to return to its original shape when load causing deformation is removed.

Elongation.

Measure of the ductility of a material determined in a tension test. It is the increase in gage length (measured after rupture) divided by original gage length. Higher elongation indicates higher ductility. Elongation cannot be used to predict behavior of materials subjected to sudden or repeated loading.

Embrittlement.

Reduction in ductility due to physical or chemical changes.

Endurance.

Alternate term for fatigue limit.

Engineering Stress.

Load applied to a specimen in a tension or compression test divided by the cross-sectional area of the specimen. The change in cross-sectional area that occurs with increases and decreases in applied load, is disregarded in computing engineering stress. It is also called conventional stress.

Extensometer.

Instrument for measuring changes in linear dimensions. Also called a strain gauge. Frequently based on strain gauge technology.

Fatigue.

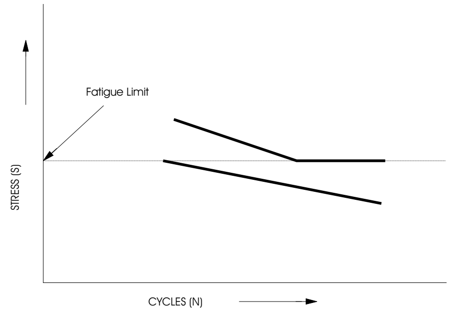
Permanent structural change that occurs in a material subjected to fluctuating stress and strain. However, in the case of glass, fatigue is determined by long-term static testing and is analogous to stress rupture in other materials. In general, fatigue failure can occur with stress levels below the elastic limit.

Fatigue Life.

Number of cycles of fluctuating stress and strain of a specified nature that a material will sustain before failure occurs. Fatigue life is a function of the magnitude of the fluctuating stress, geometry of the specimen and test conditions. An S-N diagram is a plot of the fatigue life at various levels of fluctuating stress.

Fatigue Limit.

Maximum fluctuating stress a material can endure for an infinite number of cycles. It is usually determined from an S-N diagram and is equal to the stress corresponding to the asymptote of the locus of points corresponding to the fatigue life of a number of fatigue test specimens. An alternate term is endurance limit.



Fatigue Notch Factor.

Ratio of fatigue strength of a specimen with no stress concentration to fatigue strength of a specimen with a notch or other stress raisers. Fatigue notch factor is usually lower than the theoretical stress concentration factor because of stress relief due to plastic deformation. An alternate term is strength reduction ratio.

Fatigue Ratio.

Ratio of fatigue strength or fatigue limit to tensile strength. For many materials, fatigue ratio may be used to estimate fatigue properties from data obtained in tension tests.

Fatigue Strength.

Magnitude of fluctuating stress required to cause failure in a fatigue test specimen after a specified number of cycles of loading. Usually determined directly from the S-N diagram.

Fatigue Strength Reduction Factor.

An alternate term for fatigue notch factor.

Fatigue Test.

A method for determining the behavior of materials under fluctuating loads. A specified mean load (which may be zero) and an alternating load are applied to a specimen and the number of cycles required to produce failure (fatigue life) is recorded. Generally, the test is repeated with identical specimens and various fluctuating loads. Loads may be applied axially, in torsion, or in flexure. Depending on amplitude of the mean and cyclic load, net stress in the specimen may be in one direction through the loading cycle, or may reverse direction.

Data from fatigue testing often are presented in an S-N diagram which is a plot of the number of cycles required to cause failure in a specimen against the amplitude of the cyclical stress developed. The cyclical stress represented may be stress amplitude, maximum stress or minimum stress. Each curve in the diagram represents a constant mean stress.

Most fatigue tests are conducted in flexure, rotating beam, or vibratory type machines. Fatigue testing is generally discussed in “Manual on Fatigue Testing,” ASTM STP 91-A. ASTM D-671 details a standard procedure for fatigue testing of plastics in flexure.

Fiber Stress.

Stress through a point in a part in which stress distribution is not uniform. For example, the stress in a beam under bending load varies from compression to tension across the beam. It is more meaningful in determining the properties of the beam material to consider the maximum stress generated in the outer fibers of the beam. Similarly, stress in a beam under twist loading is a maximum in the material furthest from the axis of twist.

Flex Resistance.

Ability of foam rubber to sustain repeated compressive loads without damage to cell structure. (ASTM D-1055).

Flexural Modulus of Elasticity.

Alternate term for modulus in bending.

Flexural Strength.

Maximum fiber stress developed in a specimen just before it cracks or breaks in a flexure test. Flexural yield strength is reported instead of flexural strength for materials that do not crack in the flexure test. An alternate term is modulus of rupture.

Flexure Test.

Method for measuring behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Specimen is supported on two knife edges as a simple beam and load is applied at its midpoint. Maximum fiber stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram, and maximum fiber stress at failure is flexural strength. Flexural yield strength is reported for materials that do not crack. Standard test procedures are given in ASTM D-790 (plastics) and ASTM C-674 (fired whiteware). ASTM D-797 (elastomers), ASTM A-438 (cast iron) and ASTM D-86 (glass).

Flow Stress.

Stress required to cause plastic deformation.

Fracture Stress.

True stress generated in a material at fracture.

Fracture Test.

Visual test wherein a specimen is fractured and examined for grain size, case depth, etc.

Hardness.

Measure of a material's resistance to localized plastic deformation. Most hardness tests involve indentation, but hardness may be reported as resistance to scratching (file test), or rebound of a projectile bounced off the material (scleroscope hardness). Some common measures of indentation hardness are Brinell Hardness Number, Rockwell Hardness Number, ASTM Hardness Number, Diamond Pyramid Impact Test Hardness Number, Durometer Hardness, Knoop Hardness, and Pfund Hardness. A table relating various types of hardness values of metals is given in ASTM E-140. Hardness often is a good indication of tensile and wear properties of a material.

Hooke's Law.

Stress is directly proportional to strain. Hooke's law assumes perfectly elastic behavior. It does not take into account plastic or dynamic loss properties.

Kink Test.

Method for determining ductility of metal wire. A short section of wire is looped and drawn in tension to produce a kink. Relative ductility is indicated by the occurrence or non-occurrence of failure and extent to which kink may be opened up without failure.

Knot Strength.

Tenacity of a fiber in which an overhand knot is tied. Knot strength is a measure of a fiber's sensitivity to compressive and shear stresses.

LASE.

Load At Specified Elongation.

Load-Deflection Diagram.

Plot of load vs corresponding deflection.

Maximum Fiber Stress.

Maximum tensile or compressive stress in a homogeneous flexure or torsion test specimen. For a specimen loaded as a simple beam at its midpoint, maximum fiber stress occurs at mid-span and may be calculated by the formula (for rectangular specimens):

$$S = \frac{3PL}{2bd^2}$$

where S is maximum fiber stress; P, load; L, span; b, width of the beam; and d, depth of the beam. For a circular cross section member loaded in torsion, maximum fiber stress may be calculated by the following formula:

$$S = \frac{Tr}{J}$$

where T is twisting moment; r, original outer radius and J, polar moment of inertia of original cross section.

Mean Stress.

Algebraic difference between maximum and minimum stress in one cycle of fluctuating loading, as in a fatigue test. Tensile stress is considered positive and compressive stress negative.

Minimum Bend Radius.

Minimum radius to which a sheet or wire can be bent to a specified angle without failure.

Modulus.

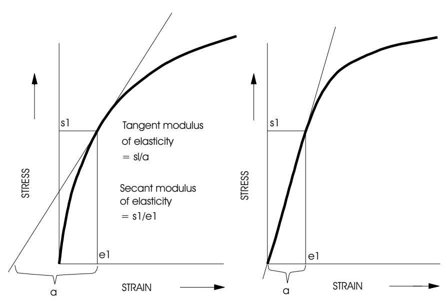
Alternate term for modulus of elasticity, often used in connection with rubber.

Modulus in Bending.

Ratio of maximum fiber stress to maximum strain, within elastic limit of stress-strain diagram obtained in flexure test. Alternate term is flexural modulus of elasticity.

Modulus of Elasticity.

Rate of change of strain as a function of stress. The slope of the straight line portion of a stress-strain diagram. Tangent modulus of elasticity is the slope of the stress-strain diagram at any point. Secant modulus of elasticity is stress divided by strain at any given value of stress or strain. It also is called stress-strain ratio. Tangent and secant modulus of elasticity are equal, up to the proportional limit of a material.



Depending on the type of loading represented by the stress-strain diagram, modulus of elasticity may be reported as: compressive modulus of elasticity (or modulus of elasticity in compression); flexural modulus of elasticity (or modulus of elasticity in flexure); shear modulus of elasticity (or modulus of elasticity in shear); tensile modulus of elasticity (or modulus of elasticity in tension); or torsional modulus of elasticity (or modulus of elasticity in torsion). Modulus of elasticity may be determined by dynamic testing, where it can be derived from complex modulus.

Modulus used alone generally refers to tensile modulus of elasticity. Shear modulus is almost always equal to torsional modulus and both are called modulus of rigidity. Moduli of elasticity in tension and compression are approximately equal and are known as Young's modulus. Modulus of rigidity is related to Young's modulus by the equation:

$$E = 2G(1+r)$$

where E is Young's modulus (psi), G is modulus of rigidity (psi) and r is Poisson's ratio. Modulus of elasticity also is called elastic modulus and coefficient of elasticity.

Modulus of Rigidity.

Rate of change of strain as a function of stress in a specimen subjected to shear or torsion loading. It is the modulus of elasticity determined in a torsion test. Alternate terms are modulus of elasticity in torsion and modulus of elasticity in shear.

Apparent modulus of rigidity is a measure of the stiffness of plastics measured in a torsion test (ASTM D-

1043). It is “apparent” because the specimen may be deflected past its proportional limit and the value calculated may not represent the true modulus of elasticity within the elastic limit of the material.

Modulus of Rupture.

Ultimate strength determined in a flexure or torsion test. In a flexure test, modulus of rupture in bending is the maximum fiber stress at failure. In a torsion test, modulus of rupture in torsion is the maximum shear stress in the extreme fiber of a circular member at failure. Alternate terms are flexural strength and torsional strength.

Modulus of Strain Hardening.

Alternate term for rate of strain hardening.

Modulus of Toughness.

The work done on a unit volume of material as a simple tensile force is gradually increased from zero to the value causing rupture is defined as the Modulus of Toughness. This may be calculated as the entire area under the stress-strain curve from the origin to rupture. Toughness of a material is its ability to absorb energy in the plastic range of the material.

Necking.

Localized reduction of cross-sectional area of a specimen under tensile load. It is disregarded in calculating engineering stress but is taken into account in determining true stress.

Nominal Stress.

Stress calculated on the basis of the net cross section of a specimen without taking into account the effect of geometric discontinuities such as holes, grooves, fillets, etc.

Offset Yield Strength.

Arbitrary approximation of elastic limit. It is the stress that corresponds to the point of intersection of a stress-strain diagram and a line parallel to the straight line portion of the diagram. Offset refers to the distance between the origin of the stress-strain diagram, and the point of intersection of the parallel line and the 0 stress axis. Offset is expressed in terms of strain (often 0.2%).

Operating Stress.

Stress imposed on a part in service.

Overstressing.

Application of high fluctuating loads at the beginning of a fatigue test and lower loads toward the end. It is a means for speeding up a fatigue test.

Peel Resistance.

Torque required to separate an adhesive and adherend in the climbing drum peel test (ASTM D-1781). It is a measure of bond strength.

Peel Strength.

Measure of the strength of an adhesive bond. It is the average load per unit width of bond line required to part bonded materials where the angle of separation is 180 degrees and separation rate is 6 in/min (ASTM D-903).

Plastic Deformation.

Deformation that remains after the load causing it is removed. It is the permanent part of the deformation beyond the elastic limit of a material. It also is called plastic strain and plastic flow.

Plasticity.

Tendency of a material to remain deformed, after reduction of the deforming stress, to a value equal to or less than its yield strength.

Plasticity Number.

Index of the compressibility of rubber at elevated temperatures. Equal to 100 times the height of a standard specimen, after a 3 to 10 minute compression by a 5 kg load (ASTM D-926).

Poisson's Ratio.

Ratio of lateral strain to axial strain in an axial loaded specimen. It is the constant that relates modulus of rigidity to Young's modulus in the equation:

$$E = 2G(r+1)$$

where E is Young's modulus; G, modulus of rigidity; and r, Poisson's ratio. The formula is valid only within the elastic limit of a material. A method for determining Poisson's ratio is given in ASTM E-132.

Proof Stress.

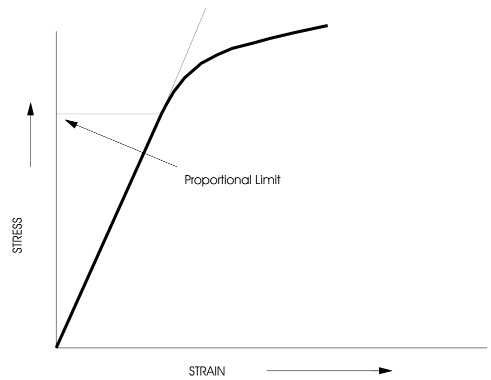
Stress that will cause a specified permanent deformation.

Proportional Limit.

Highest stress at which stress is directly proportional to strain. It is the highest stress at which the curve in a stress-strain diagram is a straight line. Proportional limit is equal to elastic limit for many metals.

Rate of Strain Hardening.

Rate of change of true stress as a function of true strain



in a material undergoing plastic deformation. An alternate term is modulus of strain hardening.

Recovery.

Index of a material's ability to recover from deformation in the compressibility and recovery test (ASTM F-36), the deformation under load test (ASTM D-621) and the plastometer test (ASTM D-926). In the compressibility and recovery test, it usually is reported with compressibility and given as %. It is calculated by dividing the difference between recovered thickness and thickness under load, by the difference between original thickness and thickness under load. In the deformation under load test, it indicates the extent to which a nonrigid plastic recovers from prolonged compressive deformation at an elevated temperature. It is given as %, and is calculated by dividing the difference between height recovered 1-1/2 hours after load is removed and height after three hours of loading, by the change in height under load. In the plastometer test, it indicates the extent to which an elastomer recovers from compressive loading at an elevated temperature. It is equal to plasticity number minus recovered height.

Recovery Test.

Method for measuring compressibility and recovery of gasket and seal materials (ASTM F-36).

Reduction of Area.

Measure of the ductility of metals obtained in a tension test. It is the difference between original cross-sectional area of a specimen and the area of its smallest cross-section after testing. It is usually expressed as % decrease in original cross-section. The smallest cross-section can be measured at or after fracture. For metals, it usually is measured after fracture and for plastics and elastomers, it is measured at fracture.

Relative Modulus.

Ratio of the modulus of a rubber at a given temperature to its modulus at 73° F. It is determined in the Gehman torsional test.

Relaxation.

Rate of reduction of stress in a material due to creep. An alternate term is stress relaxation.

Residual Elongation.

Measure of ductility of plastics. It is the elongation of a plastic specimen measured 1 minute after rupture in a tension test.

Rupture Resistance.

Indication of ability of rubber to withstand tensile loading. It is the load required to rupture a rubber specimen under conditions set out in ASTM D-530.

Rupture Strength.

Nominal stress developed in a material at rupture. It is not necessarily equal to ultimate strength. And, since necking is not taken into account in determining rupture strength, it seldom indicates true stress at rupture.

S-N Diagram.

Plot of stress (S) against the number of cycles (N) required to cause failure of similar specimens in a fatigue test. Data for each curve on an S-N diagram are obtained by determining fatigue life of a number of specimens subjected to various amounts of fluctuating stress. The stress axis can represent stress amplitude, maximum stress or minimum stress. A log scale is almost always used for the N scale and sometimes for the S scale.

Secant Modulus of Elasticity.

Ratio of stress to strain at any point on curve in a stress-strain diagram. It is the slope of a line from the origin to any point on a stress-strain curve.

Shear Modulus of Elasticity.

Tangent or secant modulus of elasticity of a material subjected to shear loading. Alternate terms are modulus of rigidity and modulus of elasticity in shear. Also, shear modulus of elasticity usually is equal to torsional modulus of elasticity. A method for determining shear modulus of elasticity of structural materials by means of a twisting test is given in ASTM E-143. A method for determining shear modulus of structural adhesives is given in ASTM E-229.

Shear Strength.

Maximum shear stress that can be sustained by a material before rupture. It is the ultimate strength of a material subjected to shear loading. It can be determined in a torsion test where it is equal to torsional strength. The shear strength of a plastic is the maximum load required to shear a specimen in such a manner that the resulting pieces are completely clear of each other. It is reported in psi based on the area of the sheared edge (ASTM D-732). The shear strength of a structural adhesive is the maximum shear stress in the adhesive prior to failure under torsional loading (ASTM E-229). Methods for determining shear strength of timber are given in ASTM D-143 and ASTM D-198.

Splitting Resistance.

Measure of the ability of felt to withstand tearing. It is the load required to rupture a slit felt specimen by gripping lips of the cut in jaws and pulling them apart (ASTM D-461). An alternate term is tear resistance.

Springback.

Degree to which a material returns to its original shape after deformation. In plastics and elastomers, it is also called recovery.

Stiffness.

Measure of resistance of plastics to bending. It includes both plastic and elastic behavior, so it is an apparent value of elastic modulus rather than a true value (ASTM D-747).

Strain.

Change per unit length in a linear dimension of a part or specimen, usually expressed in % Strain, as used with most mechanical tests, is based on original length of the specimen.

True or natural strain is based on instantaneous length, and is equal to:

$$\ln \cdot \frac{l}{l_o},$$

where l is the instantaneous length and l_0 is the original length of the specimen. Shear strain is the change in angle between two lines originally at right angles.

Strain Energy.

Measure of energy absorption characteristics of a material under load up to fracture. It is equal to the area under the stress-strain curve, and is a measure of the toughness of a material.

Strain Hardening Exponent.

Measure of increase in hardness and strength caused by plastic deformation. It is related to true stress and true strain by the equation:

$$\sigma = \sigma_0 \delta^{\eta}$$

where σ is true stress, σ_0 is true stress at unit strain, δ is true strain and η is strain hardening exponent.

Strain Point.

Temperature at which internal stress in glass is substantially relieved in about 1 hour. (ASTM C-336).

Strain Rate.

Time rate of elongation.

Strain Relaxation.

Alternate term for creep of rubber.

Strength Reduction Ratio.

Alternate term for fatigue notch factor.

Stress.

Load on a specimen divided by the area through which it acts. As used with most mechanical tests, stress is based on original cross-sectional area without taking into account changes in area due to applied load. This sometimes is called conventional or engineering stress. True stress is equal to the load divided by the instantaneous cross-sectional area through which it acts.

Stress Amplitude.

One-half the range of fluctuating stress developed in a specimen in a fatigue test. Stress amplitude often is used to construct an S-N diagram.

Stress Concentration Factor.

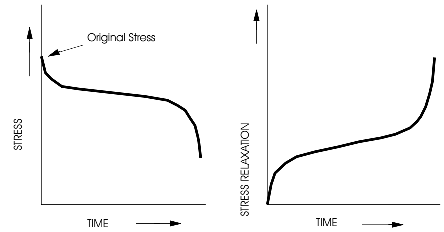
Ratio of the greatest stress in the area of a notch or other stress raiser to the corresponding nominal stress. It is a theoretical indication of the effect of stress concentrators on mechanical behavior. Stress concentration factor usually is higher than the empirical fatigue notch factor or strength reduction ratio, because it does not take into account stress relief due to local plastic deformation.

Stress Ratio.

Ratio of minimum stress to maximum stress in one cycle of loading in a fatigue test. Tensile stresses are considered positive and compressive stresses negative.

Stress Relaxation.

Decrease in stress in a material subjected to prolonged constant strain at a constant temperature. Stress relaxation behavior is determined in a creep test. Data often is presented in the form of a stress vs time plot. Stress relaxation rate is the slope of the curve at any point.

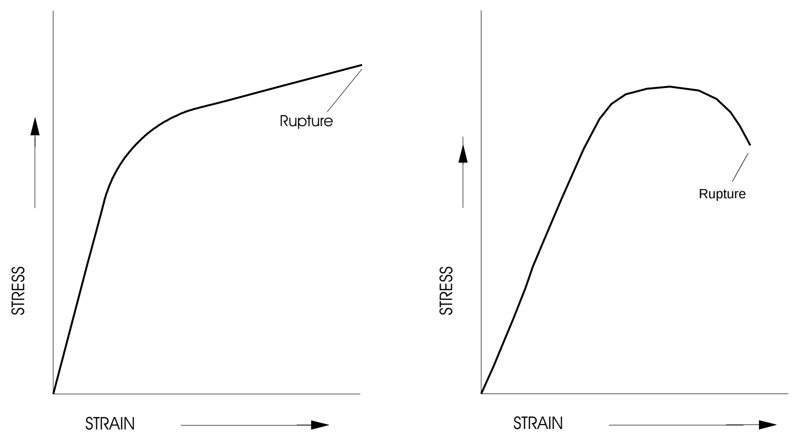


Stress Rupture Strength.

Alternate term for creep strength.

Stress-Strain Diagram.

Graph of stress as a function of strain. It can be constructed from data obtained in any mechanical test where load is applied to a material, and continuous measurements of stress and strain are made simultaneously. It is constructed for compression, tension and torsion tests.



Stress-Strain Ratio.

Stress divided by strain at any load or deflection. Below the elastic limit of a material, it is equal to tangent modulus of elasticity. An alternate term is the secant modulus of elasticity.

Stripping Strength.

Alternate term for peel strength.

Tangent Modulus of Elasticity.

The instantaneous rate of change of stress as a function of strain. It is the slope at any point on a stress-strain diagram.

Tear Length.

Measure of the drawability of sheet metal. Two small parallel slots are cut in the edge of the sheet to form a tab which is gripped and torn from the sheet. The variation in length of tabs torn in different directions is an indication of crystal orientation in the sheet (tabs torn in the direction of orientation are longer). The degree of orientation is an indication of difficulty to be expected in drawing the sheet to uniform shapes.

Tear Resistance.

Measure of the ability of sheet or film materials to resist tearing. For paper, it is the force required to tear a single ply of paper after the tear has been started.

Three standard methods are available for determining tear resistance of plastic films: ASTM D-1004 details a method for determining tear resistance at low rates of loading; a test in ASTM D-1922 measures the force required to propagate a pre-cut slit across a sheet specimen; and ASTM D-1038 gives a method for determining tear propagation resistance that is recommended for specification acceptance testing only.

Tear resistance of rubber is the force required to tear a 1-inch thick specimen under the conditions outlined in ASTM D-624. Tear resistance of textiles is the force required to propagate a single-rip tongue-type tear (starting from a cut) by means of a falling pendulum apparatus (ASTM D-1424).

Tearing Strength.

Tensile force required to rupture a pre-slit woven fabric specimen under the conditions outlined in ASTM D-2261 and ASTM D-2262. Edge tearing strength of paper is the force required to tear a specimen folded over a V-notch and loaded in a tensile test machine.

Tenacity.

Force required to break a yarn or filament, expressed in grams per denier. It is equal to breaking strength divided by denier.

Tensile Modulus of Elasticity.

Tangent or secant modulus of elasticity of a material subjected to tensile loading. Alternate terms are Young's modulus and modulus of elasticity in tension. It can be measured in a tension test or in a dynamic test where it is related to resonant frequency on a cylindrical rod by the equation:

$$E = \frac{4\pi^2 l^2 \rho f^2}{k^2 j^4}$$

where E is modulus of elasticity; l, length of the rod; ρ, density; f, resonant frequency; k, radius of gyration of the rod about an axis normal to the rod axis and plane of motion (d/4 for cylindrical rods); and j, a constant dependent on the mode of vibration. Tensile modulus of elasticity is approximately equal to compressive modulus of elasticity within the proportional limit.

Tensile Strength.

Ultimate strength of a material subjected to tensile loading. It is the maximum stress developed in a material in a tension test.

Tension Impact Test.

Method for determining energy required to fracture a specimen under shock tensile loading (ASTM D-1822).

Tension Set.

Extent to which vulcanized rubber is permanently deformed after being stretched a specified amount for a short time. It is expressed as a % of the original length or distance between gage marks (ASTM D-412).

Tension Test.

Method for determining behavior of materials under axial stretch loading. Data from test are used to determine elastic limit, elongation, modulus of elasticity, proportional limit, reduction in area, tensile strength, yield point, yield strength and other tensile properties. Tension tests at elevated temperatures provide creep data.

Procedures for tension tests of metals are given in ASTM E-8. Methods for tension tests of plastics are outlined in ASTM D-638, ASTM D-2289 (high strain rates), and ASTM D-882 (thin sheets). ASTM D-2343 outlines a method for tension testing of glass fibers; ASTM D-897, adhesives; ASTM D-412, vulcanized rubber.

Time for Rupture.

Time required to rupture specimen under constant stress and temperature in a creep test.

Torsion Test.

Method for determining behavior of materials subjected to twisting loads. Data from a torsion test is used to construct a stress-strain diagram and to determine elastic limit torsional modulus of elasticity, modulus of rupture in torsion, and torsional strength. Shear properties are often determined in a torsion test. (ASTM E-143).

Torsional Deformation.

Angular displacement of specimen caused by a specified torque in torsion test. It is equal to the angular twist (radians) divided by the gauge length (in.).

Torsional Modulus of Elasticity.

Modulus of elasticity of material subjected to twist loading. It is approximately equal to shear modulus and also is called modulus of rigidity.

Torsional Strain.

Strain corresponding to a specified torque in the torsion test. It is equal to torsional deformation multiplied by the radius of the specimen.

Torsional Strength.

Measure of the ability of a material to withstand a twisting load. It is the ultimate strength of a material subjected to torsional loading, and is the maximum torsional stress that a material sustains before rupture. Alternate terms are modulus of rupture and shear strength.

Torsional Stress.

Shear stress developed in a material subjected to a specified torque in torsion test. It is calculated by the equation:

$$S = \frac{Tr}{J}$$

where T is torque, r is the distance from the axis of twist to the outer-most fiber of the specimen, and J is the polar moment of inertia.

True Strain.

Instantaneous % of change in length of specimen in mechanical test. It is equal to the natural logarithm of the ratio of length at any instant to original length.

True Stress.

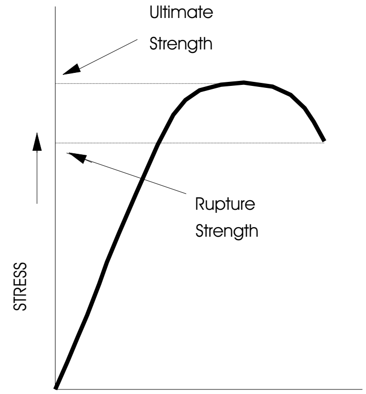
Applied load divided by actual area of the cross section through which load operates. It takes into account the change in cross section that occurs with changing load.

Ultimate Elongation.

Alternate term for elongation of material at rupture under tensile loading.

Ultimate Strength.

Highest engineering stress developed in material before rupture. Normally, changes in area due to changing load and necking are disregarded in determining ultimate strength.



Wet Strength.

Breaking strength of paper saturated with water. Also, the strength of an adhesive bond after immersion in water.

Yield Point.

Stress at which strain increases without accompanying increase in stress. Only a few materials (notably steel) have a yield point, and generally only under tension loading.

Yield Point Elongation.

Strain at yield point of a material. It is an indication of ductility.

Yield Strength.

Indication of maximum stress that can be developed in a material without causing plastic deformation. It is the stress at which a material exhibits a specified permanent deformation and is a practical approximation of elastic limit. Offset yield strength is determined from a stress-strain diagram. It is the stress corresponding to the intersection of the stress-strain curve, and a line parallel to its straight line portion offset by a specified strain. Offset for metals is usually specified as 0.2%, i.e., the intersection of the offset line and the 0-stress axis is at 0.2% strain. Offset for plastics is usually 2%.

Yield Strength Elongation.

Strain corresponding to yield strength of material. It is an indication of ductility.

Yield Value.

Stress in an adhesive joint at which a marked increase in deformation occurs without an increase in load.

Young’s Modulus.

Alternate term for modulus of elasticity in tension or compression.

Index

D

E

F

G

H

I

J

L

S

T

U