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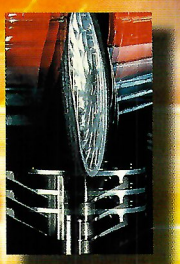
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Clip-On Gages
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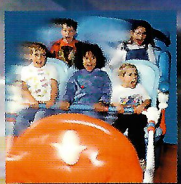
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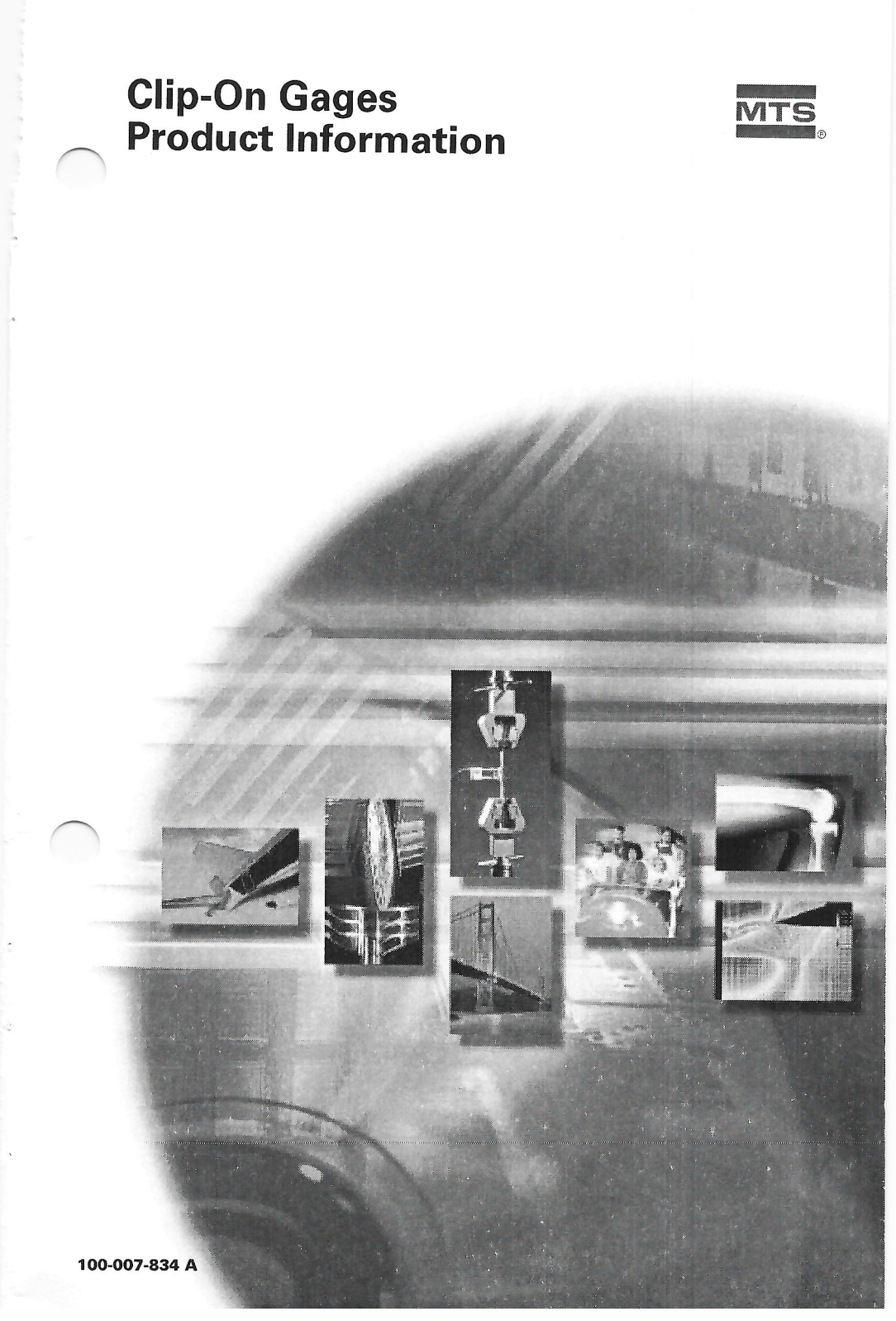






100-007-834 A

Clip-On Gages
Product Information



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Contents

Introduction 5

Functional Description 7
Accessories 9

Calibration 11

Using a Calibration Block 14
Using a Calibration Stand 16

Installation 19

Preparing a Specimen 20
Connecting the Cable 21
Attaching the Clip-On Gage to a Specimen 23

Operation 25

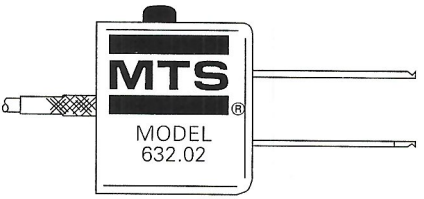
Introduction

This manual describes the MTS family of clip-on gages. Clip-on gages are extensometers designed to sense crack openings. Opening displacements and are typically used to monitor crack growth in a specimen during fracture mechanics testing.

Contents

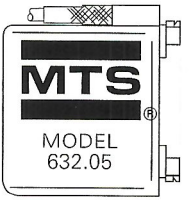
Functional Description 7

Accessories 9



Features

Several models of the clip-on displacement gage are available.



- Some clip-on displacement gages are designed specifically to meet the ASTM E399 standard and are suitable for K_{Ic}, J_{Ic}, and crack growth rates.
- Some MTS Fatigue Crack Growth Test Application clip-on displacement gages are designed to meet ASTM standard fracture mechanics tests for K_{Ic}, J_{Ic}, crack growth, and R-curve determination.
- Many of the clip-on gages can be used on a variety of specimens including compact tension, WOL, round compact tension, C-shaped, bend, and other common specimens or panels.
- Some clip-on displacement gages are designed for use at very high frequencies. Because of their sensitivity, visual monitoring of the specimen is not required. Crack growth will be apparent on the readout.

What you need to know

This manual assumes that you know how to use your system controller. See the appropriate manual for information about performing any controller-related step in this manual's procedures. You are expected to know how to:s:

- Selecting a control mode
- Manually adjusting the actuator position
- Zeroing a sensor output
- Installing a test specimen

Related documentation

This manual covers topics that are common among all clip-on gages. Specific information about a given clip-on gage is available from the drawings that are included with it.

Each clip-on gage includes the following documents:

- An installation drawing provides the specifications for your clip-on gage. It also includes detailed drawings and notes related to setting up and installing the clip-on gage.
- A Final Inspection card provides information such as the serial number, as tested excitation voltage, and other performance data.
- An Extensometer Calibration Data sheet is included when MTS calibrates the clip-on gage.
- You might have drawings for optional kits for your clip-on gage. These drawings include specifications and installation information for the given option.
- You might have a model application drawing that lists the family of clip-on gages for the model number you purchased. It lists the specification differences among the clip-on gage family. The drawing also includes the part number of the installation drawing for your clip-on gage and the wiring diagram of the connector.

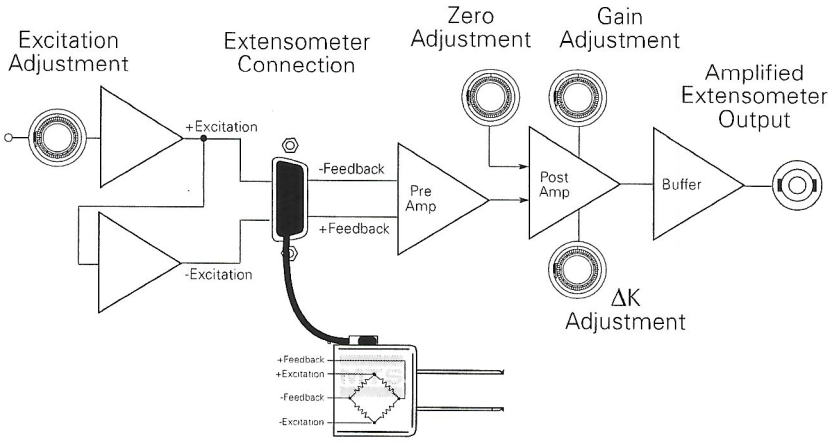
This manual is designed to be used with these documents.

Functional Description

A clip-on gage (extensometer) is a sensor attached to a specimen that measures a dimensional change (gage length or strain) that occurs in the specimen while being tested. Clip-on gages use precision resistance-type strain gages bonded to a metallic element to form a Wheatstone bridge circuit. Because they are DC devices, they require a DC conditioner for signal processing. The following describe the functions of the clip-on gages.

DC conditioning

The clip-on gage requires a DC conditioner to process the clip-on gage signal. A DC conditioner provides a DC excitation voltage to the clip-on gage. Any changes to the gage length of the clip-on gage change the excitation signal. The changed signal is output to the DC conditioner as feedback. The DC conditioner processes the signal and makes it available to the controller where the signal can be used.

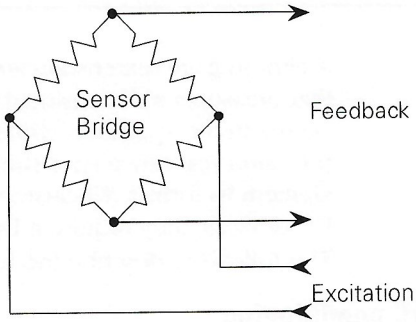


Typical Conditioning Circuit

Knife edges

Knife edges are mounted onto a specimen, or machined into a specimen. See "Preparing a Specimen" on page 20 for more information.

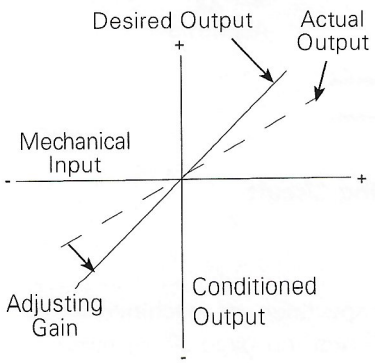
Wheatstone bridge

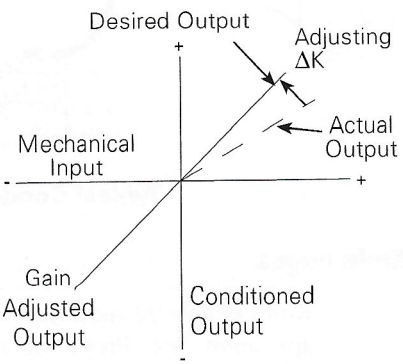


The clip-on gage uses precision, resistance type, foil strain gages bonded to a metallic element to form a Wheatstone bridge. Two knife edges on the clip-on gage arms contact the specimen. Elongation or compression of the specimen causes movement of the clip-on gage arms. This movement bends the metallic element, changing the resistance of the strain gages. The change in the balance of the Wheatstone bridge produces an electrical output that is proportional to the displacement of the clip-on gage arms.

Calibration

The DC conditioner and the clip-on gage's signal must be calibrated. Calibration ensures that the clip-on gage's signal accurately represents the gage length measure by the clip-on gage. Calibration involves adjusting the excitation voltage and gain of the DC conditioner to achieve the desired clip-on gage signal. The purpose of calibration is to equate a specific clip-on gage displacement to a specific voltage. When the clip-on gage is calibrated, it is matched to a DC conditioner. If either component of the matched pair is changed, recalibration is required.





Accessories

Accessories available for the clip-on gages include the following:

- A Model 650.03 Extensometer Calibrator can help with the local calibration of any clip-on gage. An optional fixture for clip-on gages is available for the calibrator.
- Extra sets of knife edges are available.

Calibration

This section describes how to calibrate a clip-on gage with a controller. Calibration ensures the output from the clip-on gage accurately represents the displacement measured by the clip-on gage. Two adjustment methods are described.

Contents

Using a Calibration Block 14

Using a Calibration Stand 16

Overview

The calibration process coordinates the interaction between the clip-on gage, a DC conditioning circuit, and a cable. Calibration of an clip-on gage is a two step process:

- First, a specific output of the conditioner is adjusted to a specific displacement of the clip-on gage. This is performed by adjusting the excitation voltage and amplification (gain) of the conditioner.
- The second step verifies of the output of the clip-on gage/ conditioner versus a known standard displacement over the entire range of measurement.

Certified calibration

MTS Systems Corporation offers an clip-on gage calibration service. The service offers full calibration (including verification) of your clip-on gage to ASTM E83. Further information on the verification procedure can be found in the two predominant standards for clip-on gages, ASTM E83 and ISO 9513.

Gain

The conditioner is designed to have an output of approximately ±10 V at the full-scale displacement of the desired range. Most clip-on gages can be used with this conditioner to obtain full-scale ranges down to 10% of the full travel range of the clip-on gage. (Full-scale ranges of 5% are possible, but some increase in drift and noise will result.)

In most clip-on gages the best linearity is obtained by setting the gain between 70% and 90% of the desired travel range instead of 100%. The adjustment procedures in this manual use 80% full scale as the reference value.

Delta K

Delta K (ΔK) is a feature of DC conditioners manufactured by MTS Systems Corporation. Delta K compensates for differences in symmetry between the positive and negative outputs of the clip-on gage. Gain is usually adjusted to calibrate the compression half of the clip-on gage range. Use delta K to calibrate the tension half of the clip-on gage range.

Symmetrical vs. asymmetrical clip-on gages

Some clip-on gages can have only positive output (tension only), some clip-on gages can have both positive and negative output (tension and compression). It is also possible that the clip-on gage has asymmetrical travel (such as +3 mm and -1 mm). It is important that you determine the full scale travel range of the clip-on gage before proceeding.

For example

Suppose you have a clip-on gage with an asymmetrical travel of +3 mm and -1 mm. It is desired to adjust the conditioner to have a full-scale output equal to the full travel range of the clip-on gage. In this case +3 mm would approximately equal +10 V, and -1 mm would have an output of -3.3 volts. Gain would be adjusted so that -0.6 mm would yield -2 volts, and delta k would be adjusted so that +2.4 mm would yield +8 volts while adjustments to zero are made to keep the null position of the clip-on gage at zero.

In all cases, the actual displacement should be used to determine the calculated output.

$$\left(\frac{\text{Actual Displacement}}{\text{Full-Scale Range}}\right) \times 10\ \text{V} = \text{Calculated Output}$$

Note *It might be difficult to obtain a displacement value of exactly 80% full scale. In those cases, find a displacement you can achieve and calculate new conditioner output value for the displacement. For example, suppose the calibration block is set for 7.94 mm. Then your desired output would be 7.94 V.*

The following table shows the proper conditioner output for each clip-on gage displacement of the preceding example.

% Full Scale	Travel	Output
100%	3 mm	+10 V DC
80%	2.4 mm	+8 V DC
60%	1.8 mm	+6 V DC
40%	1.2 mm	+4 V DC
20%	0.6 mm	+2 V DC
Zero	0 mm	0 V DC
-20%	-0.6	-2 V DC

Using a Calibration Block

MTS recommends using a calibration block to establish the initial gain setting of the conditioner. The calibration block is a metal block with knife edges mounted to it or machined in it. Using multiple knife edges allows you to adjust the gain for a variety of specific displacements.

Use this procedure as a guideline to calibrate other clip-on gages.

1. **Set up the controller.**

   Your test controller must be configured to use the clip-on gage signal.

   A. Connect the clip-on gage to your controller.

   B. Monitor the excitation voltage.

   C. Monitor the clip-on gage signal.

   D. Prepare to use the calibration controls on your controller.

   E. Adjust the excitation control to set the excitation to +6 V DC or the voltage specified in the clip-on gage documentation.

2. **Zero the conditioner output.**

   The arms of the clip-on gage must be in the zero reference position. This can be accomplished using a calibration block with the zero reference set in it.

   Adjust the zero control to set the clip-on gage signal to 0.00 V DC.

Note *Several clip-on gages have asymmetrical outputs. This means that the compression and tension outputs are not equal. Ensure that you are aware of the maximum ratings of the clip-on gage you are calibrating (see "For example" on page 12).*

3. Adjust compression.

A. Install the clip-on gage on the calibration block so that the clip-on gage arms are in the grooves that represent about 80% compression displacement.

B. Adjust the gain control to set the clip-on gage signal to -8 V DC (or 80% of your calculated output).

4. Readjust the zero and compression.

Repeat Step 2 and Step 3 until the zero and gain outputs can be measured without readjustment.

5. Adjust tension.

Install the clip-on gage in the calibration block so arms are in the 80% tension displacement position (or the maximum positive travel).

- If the clip-on gage signal is above +8 V DC (or your calculated output), adjust the ΔK (delta K) control for an clip-on gage signal of +8 V DC.
- If the clip-on gage signal is below +8 V DC (or your calculated output), the ΔK adjustment cannot be made. Return the ΔK adjustment to its original setting and use the gain control to increase the voltage halfway from its present value to +8 V DC (this splits the difference between compression and tension).

This completes the initial gain adjustment procedure using a calibration block.

Using a Calibration Stand

This method requires a tool such as the Model 650.03 Calibrator from MTS Systems Corporation. Use this procedure as a guideline to calibrate other clip-on gages.

Note *The Model 650.03 Calibrator from MTS Systems Corporation can be configured to accept any clip-on gage. Ensure the appropriate fixture is mounted to the calibrator and set it up for the compressed gage length. The fixture for clip-on gages is MTS part number 031-508-501.*

1. Set up the controller.

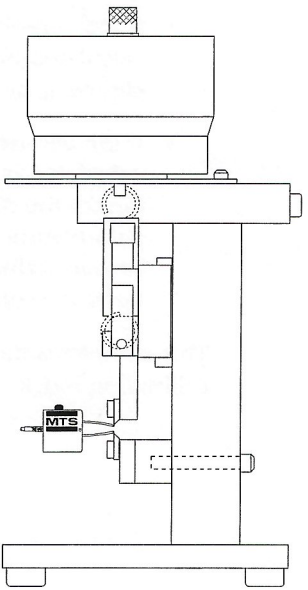
Your test controller must be configured to use the clip-on gage signal.

A. Connect the clip-on gage to your controller.

B. Monitor the excitation voltage.

C. Monitor the clip-on gage signal.

D. Attach the clip-on gage to the calibrator. This figure shows a typical installation.



Each clip-on gage can use a variety of extensions, attachments, and other mounting accessories.

E. Prepare to use the calibration controls on your controller.

F. Adjust the excitation control to set the excitation to +6 V DC or the voltage specified in the clip-on gage documentation.

2. Zero the conditioner output.

The arms of the clip-on gage must be in the zero reference position (which should be the compressed gage length).

Adjust the zero control to set the clip-on gage signal to 0.00 V DC.

Note *Several clip-on gages have asymmetrical outputs. This means that the compression and tension outputs are not equal. Ensure that you are aware of the maximum ratings of the clip-on gage you are calibrating (see "For example" on page 12).*

3. Adjust compression.

A. Adjust the calibrator between zero and 100% compression of the clip-on gage's full-scale range three times. This exercises the clip-on gage to remove any hysteresis.

B. Adjust the calibrator for the 80% compression setting (or the range being calibrated) and note the voltmeter reading.

- If the meter reading is less than -8 V DC you can adjust gain. Adjust the gain control to set the clip-on gage signal to -8 V DC (or 80% of your calculated output).
- If you cannot adjust the gain control to set the clip-on gage signal to -8 V DC, you can change the excitation voltage.

4. Readjust the zero and compression.

Repeat Step 2 and Step 3 until the zero and gain outputs can be measured without readjustment.

5. Adjust tension.

A. Adjust the calibrator between zero and 100% tension of the clip-on gage's full-scale range three times. This exercises the clip-on gage to remove any hysteresis.

B. Adjust the calibrator for 80% tension (or for the maximum positive travel) of the range you are calibrating.

- If the clip-on gage signal is above +8 V DC (or your calculated output), adjust the DK (delta K) control for an clip-on gage signal of +8 V DC.
- If the clip-on gage signal is below +8 V DC (or your calculated output), the DK adjustment cannot be made. Return the DK adjustment to its original setting and use the gain control to increase the voltage halfway from its present value to +8 V DC (this splits the difference between compression and tension).

This completes the initial gain adjustment procedure using a calibration stand.

Installation

This section describes how to install a clip-on gage onto a prepared specimen.

Contents

Preparing a Specimen 20

Connecting the Cable 21

Attaching the Clip-On Gage to a Specimen 23

⚠ WARNING **Handling the clip-on gage while it is selected as the active control mode can cause the actuator to move unpredictably.**

Unpredictable actuator movement can cause personnel injury or damage to the test equipment.

Ensure the clip-on gage is not active when handling it.

Post installation

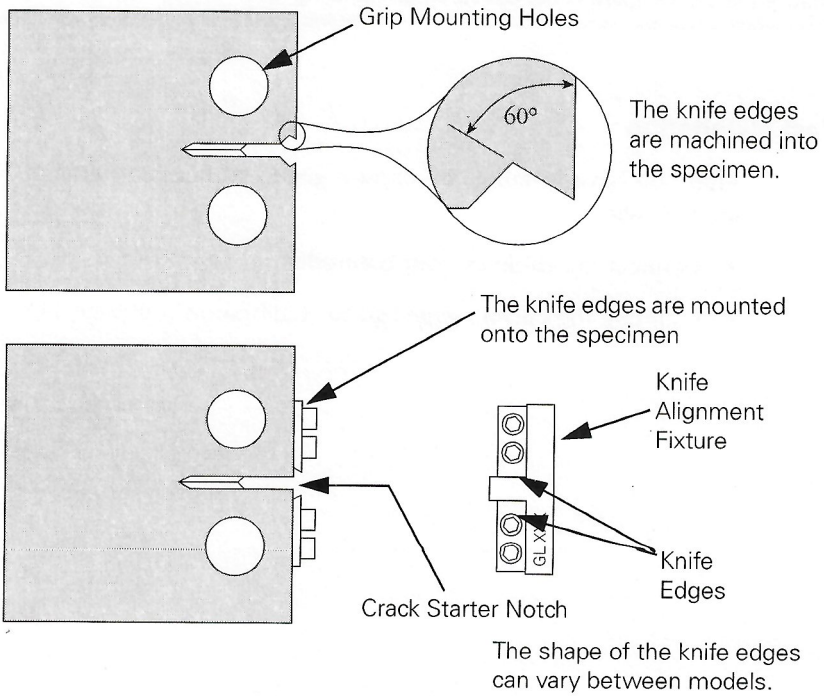
After you have installed the clip-on gage you need to perform the following:

- Connect the cable to your controller.
- Calibrate the clip-on gage (go to "Calibration" on page 11).

Preparing a Specimen

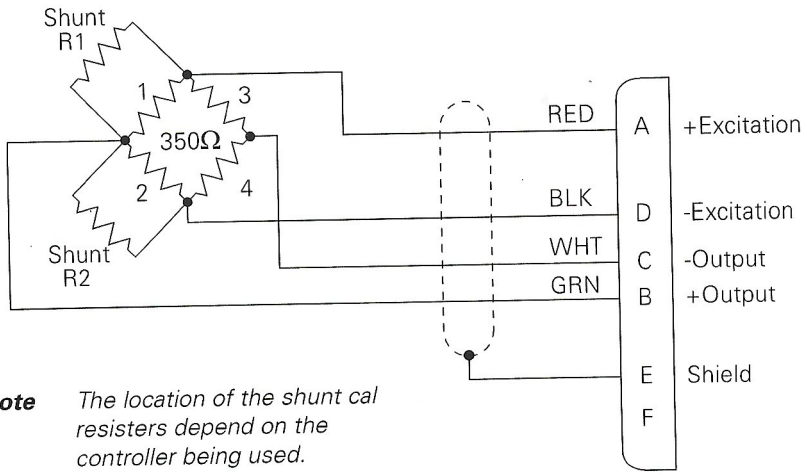
The specimen must be prepared to accept the clip-on gage. The following must be done to prepare the specimen for use with a clip-on gage:

- The specimen size and shape must conform to standards.
- Holes must be drilled to accommodate the grips.
- A crack starter notch must be created according to standards.
- Knife edges must be added to the specimen.
  - Depending on the model of the clip-on gage and the specimen standard, knife edges are either machined into the specimen or attached to the specimen.
  - If the knife edges are attached to the specimen, use the alignment fixture to establish the edge length and knife edge alignment.



Connecting the Cable

The clip-on gage cable connects to a controller via an extension cable. The clip-on gage assembly includes a small cable and connector. An extension cable is installed between the clip-on gage connector and the system controller. Ensure that the clip-on gage is connected to the appropriate controller connector. The controller connector must be associated with a DC conditioning circuit. The following figure shows the circuitry and connector pin assignments form the clip-on gage.



Note *The location of the shunt cal resisters depend on the controller being used.*

Clip-on gage Electrical Connections

- The location of the shunt resistors differs with each controller. See your controller manual for the more information about the shunt calibration resistors.
- The location of the bridge balancing circuitry differs with each controller. See your controller manual for the more information about the bridge balancing circuitry.
- The cable attached to the clip-on gage can be from 660 mm (22 in) to 1525 (60 in) long. An extension cable or an adaptor cable may be needed to reach the controller.

1. Attach the plastic connector holder, provided with the clip-on gage, to the load unit column.

2. Connect the connector, attached to the cable extending from the clip-on gage, to the mating connector on the appropriate system cable.

Note *An adapter cable (part number 039-704-601) is available which allows connection between the PT connector on the clip-on gage cable and an Amphenol connector on an existing system cable.*

3. Mount the connector assembly in the plastic connector holder.

Attaching the Clip-On Gage to a Specimen

Refer to the drawings that came with the clip-on gage for any model specific information related to attaching the gage to a specimen.

Prerequisite

The specimen must be prepared to accept the gage. See "Preparing a Specimen" on page 20. The specimen must also be installed into the load unit or test machine.

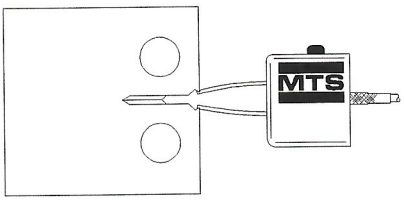
Procedure

The clip-on gage clips between the knife edges on the specimen. Observe the following caution. The following figure shows three types of attachment methods.

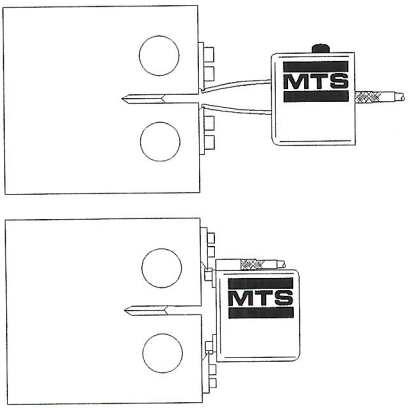
⚠ CAUTION **Attaching a clip-on gage to a specimen requires you to squeeze the arms of the clip-on gage.**

Over-compression of a clip-on gage will damage the unit. See the drawing for your clip-on gage for an over travel caution.

Squeeze the arms of the clip-on gage just enough to engage the knife edges. The clip-on gage drawing has an over travel specification.



The knife edges are machined into the specimen.



The knife edges are mounted to the specimen.

Operation

Operation of any of a clip-on gage consists of zeroing the sensor output after it has been attached to a specimen. It is also good practice to establish sensor limits for the clip-on gage.

Prerequisite

Before operating the clip-in gage, the signal from the clip-on gage must be calibrated (see "Calibration" on page 11). The clip-on gage must also already be attached to a specimen and connected to a controller (see "Installation" on page 19

Sensor zero

The purpose of zeroing the sensor output is to identify the starting position of the extensometer to the system controller. An extensometer usually needs to be zeroed or (at least checked) after it has been installed.

For example, suppose the extensometer is installed and it is not at its calibrated zero position, the controller can be programmed to accept the current output from the extensometer as the zero output.

See your controller manual for information to establish the extensometer zero output signal. The electrical output of the extensometer is adjusted so that zero strain equals zero volts output.

Sensor limits

Sensor limits help protect a clip-on gage by establishing an operating range within the extensometer's capacity. Each clip-on gage has a travel specification which can be used to define the operating range of the clip-on gage. Refer to the drawings that came with the clip-on gage.

See your controller manual for information to establish the sensor limits. The electrical output of the extensometer is monitored by the controller and can stop the test should the extensometer exceed a defined limit.



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