Honeywell

# Caliper Measurement

## System Manual

6510020327 Rev 01

# Caliper Measurement

July, 2012

## Confidentiality Statement



## Notice



## Trademarks



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# Contents

# List of Figures

# List of Tables

# Introduction

The purpose of this manual is to introduce Honeywell's Contacting Caliper Measurement. This sensor measures the thickness of a moving sheet by determining the separation between upper and lower contacts of the sensor as they independently follow sheet contours. Software then translates the separation into direct measurement of thickness.

Caliper Measurement model numbers covered by this manual are:

**Q4290 Series**

- Q4290-61
- Q4290-62
- Q4290-63
- Q4290-64
- Q4290-65
- Q4290-66
- Q4290-67
- Q4290-68
- Q4290-70

**Q4293 Series**

- Q4293-52
- Q4293-54
- Q4293-55

- Q4293-58
- Q4293-59
- Q4293-60

For more information and descriptions of the Models, see Appendix B.

# Audience

This manual is intended for use by technicians and maintenance personnel and assumes that the reader has some knowledge of the operation of a paper machine and a basic understanding of mechanical, electrical and computer software concepts.

# About This Manual

This manual contains these chapters and appendixes:

Chapter 1, **System Overview**, describes caliper operating principles and system specifications.

Chapter 2, **EDAQ,** describes the principles and operation of the Ethernet Data Acquisition (EDAQ) board.

Chapter 3, **Installation,** describes the installation and set up tasks for the sensor.

Chapter 4, **Software Configuration Parameters,** describes the configuration parameters related to the caliper system.

Chapter 5, **Reference and Sample,** describes reference displays and typical sampling for the caliper system.

Chapter 6, **Calibration,** describes the displays available for calibrating the caliper sensor system.

Chapter 7, **Preventive Maintenance,** describes a schedule for recommended ongoing maintenance tasks

Chapter 8, **Tasks,** describes procedures for maintenance, diagnostic, and troubleshooting tasks.

Chapter 9, **Troubleshooting,** describes symptoms, alarms, possible causes, and links to associated diagnostic or troubleshooting tasks.

Chapter 10, **Storage, Transportation and End of Life,** describes methods for storing, transporting and disposing of sensor components

Chapter 11, **Glossary,** describes the terms and acronyms used in this manual.

Appendix A, **Caliper Types,** describes the different types of caliper sensors and their components.

Appendix B, **Part Numbers,** lists the part numbers for caliper model assemblies and their components.

# Conventions

The following conventions are used in this manual:

ATTENTION — Text may appear in uppercase or lowercase except as specified in these conventions.

| | |
|---|---|
| **`Boldface`** | Boldface characters in this special type indicate your input. |
| `Special Type` | Characters in this special type that are not boldfaced indicate system prompts, responses, messages, or characters that appear on displays, keypads, or as menu selections. |
| *Italics* | In a command line or error message, words and numbers shown in italics represent filenames, words, or numbers that can vary; for example, filename represents any filename.<br>In text, words shown in italics are manual titles, key terms, notes, cautions, or warnings. |
| **Boldface** | Boldface characters in this special type indicate button names, button menus, fields on a display, parameters, or commands that must be entered exactly as they appear. |
| lowercase | In an error message, words in lowercase are filenames or words that can vary.<br>In a command line, words in lowercase indicate variable input. |
| Type | Type means to type the text on a keypad or keyboard. |
| Press | Press means to press a key or a button. |
| **`[ENTER]`** or **`[RETURN]`** | **`[ENTER]`** is the key you press to enter characters or commands into the system, or to accept a default option. In a command line, square brackets are included; for example:<br>**`SXDEF 1 [ENTER]`** |
| **`[CTRL]`** | **`[CTRL]`** is the key you press simultaneously with another key. This key is called different names on different systems; for example, **`[CONTROL]`**, or **`[CTL]`**. |

| | |
|---|---|
| **`[KEY-1]-KEY-2`** | Connected keys indicate that you must press the keys simultaneously; for example, **`[CTRL]-C`**. |
| Click | Click means to position the mouse pointer on an item, then quickly depress and release the mouse button. This action highlights or “selects,” the item clicked. |
| Double-click | Double-click means to position the mouse pointer on an item, and then click the item twice in rapid succession. This action selects the item “double-clicked.” |
| Drag X | Drag X means to move the mouse pointer to X, then press the mouse button and hold it down, while keeping the button down, move the mouse pointer. |
| Press X | Press X means to move the mouse pointer to the X button, then press the mouse button and hold it down. |
| ATTENTION | The attention icon appears beside a note box containing information that is important. |
| CAUTION | The caution icon appears beside a note box containing information that cautions you about potential equipment or material damage. |
| WARNING | The warning icon appears beside a note box containing information that warns you about potential bodily harm or catastrophic equipment damage. |

# 1. Caliper Measurement Overview

## 1.1. Definition of Caliper

Caliper, as defined by the paper maker, is a measure of sheet thickness. The lab standard for making a caliper measurement is TAPPI 411[1] done at about 7 psi and over a relatively small contact area. On many grades of paper these conditions produce a permanent indentation, and T411 is therefore considered a *destructive* test. The T411 conditions are too extreme for purposes of on line caliper measurement since they would result in sheet damage on virtually any product.

The objective of the Honeywell caliper measurement is to predict from an online measurement what the paper will read in a TAPPI gauge. For the reasons noted above, this online measurement is carried out at a much lower pressure, typically a few tenths of a psi.

## 1.2. Principle of Operation

Honeywell’s caliper sensor measures the thickness of lightweight paper on high-speed paper machines using a unique low-pressure contacting technique.

The sheet is clamped between two sensing elements, one in the upper head and the one in the lower head. The sensing elements on both sides of the sheet slide on the paper and are held in place by an arm and an actuating mechanism consisting of rubber bellows.

The bellows can be pressurized to extend the contacting elements onto the sheet, while an air-driven vacuum pump creates a partial vacuum in the bellows to retract the elements from the sheet.

[1] Technical Association of the Pulp and Paper Industry – professional organization dedicated to the pulp and paper industries.

Air pressure to the bellows is controlled by a regulator and solenoid valve on each actuator body. The actuation pressure is adjustable to suit individual application requirements: insensitivity to sheet speed, buildup resistance, and so on. All moving parts are lightweight for optimum responsiveness.

The upper sensing element is precision machined from solid sapphire. A U-shaped piece of ferromagnetic matrial is flush-mounted with the sapphire surface. Windings about this core using Litz wire connect to an oscillator PCB attached to the upper caliper chassis.

The oscillator circuit induces magnetic flux through the ferrite U-core, the sheet, and to the passive ferromagnetic sensing element in the lower head. The resonant frequency of the oscillator is proportional to the spacing between the U-core in the upper sensing element and the passive ferrite element in the lower, thus measuring the thickness of the sheet. The greater the distance between the sensing elements, the higher the frequency output.

The sensor calibration algorithm converts the sensor’s frequency output to caliper at laboratory gauge pressure. The sensor is insensitive to moderate changes in temperature, humidity, and sheet composition.

# 1.3. Types of Caliper

The caliper sensor can be classified into two families and is mainly differentiated by the shape of the sensing element.

- Round-button caliper
- Unifoil caliper (that is, square button)

The term ‘button’ refers to the shape of the sensing element that makes contact with the sheet. The round-button caliper is an older-style design that uses a metal actuation arm.

**Figure 1-1 Round Button Caliper (upper)**

The Unifoil caliper is a newer design and has a square button with an aerodynamic foil in the upper sensing element (See Figure 1-2). This foil allows the user to operate the caliper with low actuation pressure without worrying about "flying" of the caliper button due to a lifting effect caused by the sheet’s laminar air layer.

The "light touch" design is often useful in situations where delicate sheets and tearing is a concern. The Unifoil caliper also uses Mylar actuation arms that contribute minimal mass to the system, enabling fast response to caliper changes and accurately tracks the sheet motion.

Rubber bellows supporting the sensing elements allow the sensor to accommodate varying sheet passline, flutter, and edge curl.

**Figure 1-2 Unifoil Caliper Barrel (upper)**

# 1.4. Specifications

| | |
|---|---|
| **Range:** | 25.4 - 1270 microns |
| **Repeatability (2-sigma):** | 0.25% of reading or 0.25 micron, whichever is greater |
| **Accuracy (2-sigma):** | 1% of reading or 2.5 microns, whichever is greater (Round-Button) |
| | 1% of reading or 1 micron, whichever is greater (Unifoil) |
| **Dynamic Correlation (2-sigma):** | 2% of reading or 2.5 microns, whichever is greater (assuming good test procedures and equipment) |
| **Maximum Gap:** | 12 mm |
| **Maximum Ambient Temperature:** | 100º C when located in a temperature controlled sensor enclosure. |
| **Measurement Area:** | 16 mm diameter (Round-Button)<br>19 mm CD x 25 mm MD (Unifoil) |

# 2. EDAQ

The Ethernet Data Acquisition (EDAQ) board is responsible for converting all analog and digital signals to and from sensors to Ethernet messages.

It replaces the functionality of the National Instrument cards seen in previous Honeywell scanner systems.

The board is based on an ARM CPU running the Linux Operating Sysem and an FPGA that controls real-time data acquisition. [1]

The EDAQ board contains a large number of input/output systems, including

- Analog Inputs (16 12 bits @ 4KHz, 8 @ 1 Hz),
- Analog Outputs (2 @ 12 bits),
- Digital Inputs (16 @ 24V logic),
- Digital Output (16 @ 24 V logic),
- Frequency input (400 Hz -500 KHz),
- Three serial ports,
- USB (presently unused) and
- Ethernet.

Except for a few dedicated signals such as the Green Light (radiation safety), all sensor signals connect through the EDAQ to the new Experion MX MSS by Ethernet.

[1] The EDAQ contains software licensed under third party licenses including the Gnu Public License (GPL). A copy of that software and its source code can be obtained from **http://honeywell.com/ps/thirdpartylicenses**.

The EDAQ contains sensor specific code for all sensors. All EDAQs, including the EDAQ performing Frame Motion Control (in the end bell) and the head alley EDAQ are identical and can be interchanged.

## 2.1. Physical Layout

Figure 2-1 and Figure 2-2 show the EDAQ PCBA (p/n 6581500030) as it is mounted next to a sensor. To the left are the Digital and Analog I/O, which connect directly to a sensor. Below these two large connectors is a 16 pin expansion connector that is only used when the EDAQ is attached to the frame controller expansion board (p/n 6581500032).

To the right are Ethernet, some diagnostic LEDs, serial connections and temperature inputs. There are no test points for use in the field. An RS-232 serial debug port is available (115200 kbs, no flow control, 8N1) that may be connected to any PC running a serial terminal program. For diagnostic purposes, service personal may be asked to connect a serial cable between this debug port and the RS-232 of any neighboring EDAQ.

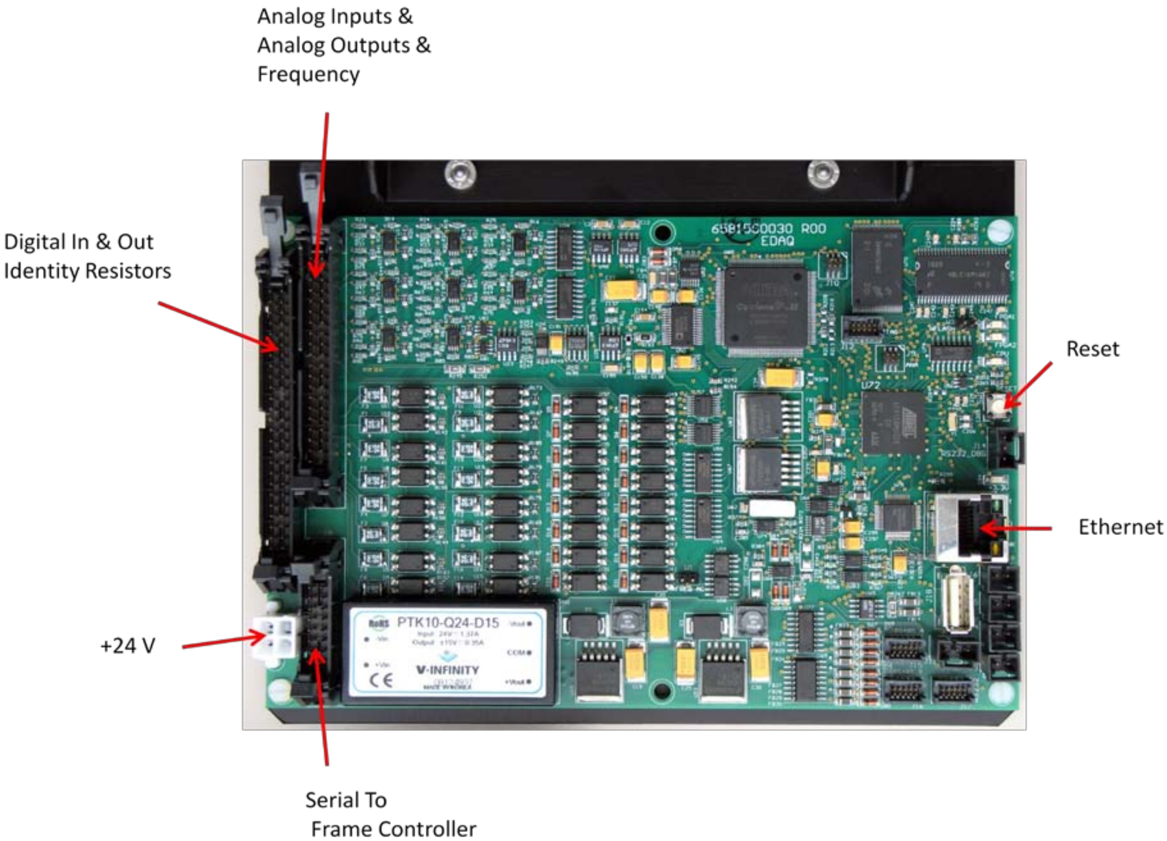



**Figure 2-1 Top view of EDAQ board**

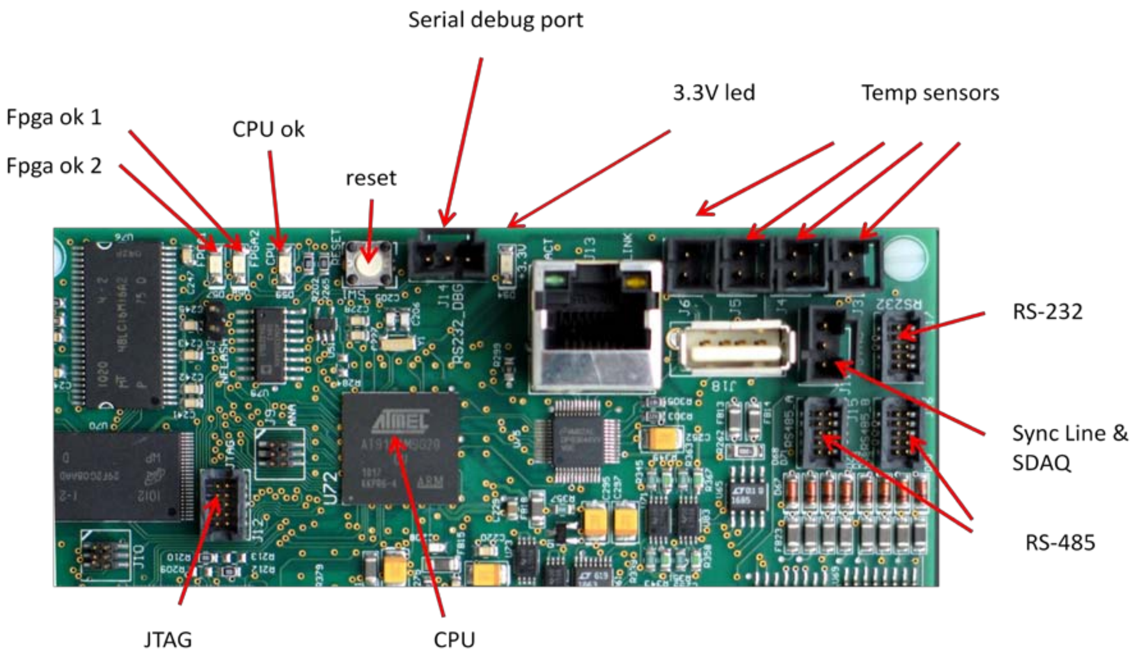



**Figure 2-2 Enlarged view of the top right corner of the EDAQ to show LEDs and I/O connectors**

# 2.2. Hardware Status Information

There are four diagnostic LEDs on the EDAQ. See Figure 2-2.

- 3.3 V LED. When lit, this indicates that all power supplies on board are functional. The signal is derived from the 3.3 V power supply, which in turn is derived from the 15 V power supply, which is derived from the +24V input.

- CPU OK LED. This LED is under control of the central ARM CPU. It will be lit when the main sensor application (edaqapp) is running on the CPU

- Fpga ok 1 (not used at present)

- Fpga ok 2. This LED will blink if the FPGA is loaded and running code

In addition, the Ethernet connector contains two LEDs: amber indicating good link to the switch, green indicating activity on the network.

# 2.3. EDAQ reset

A soft reset of the EDAQ may be performed through a Web interface running on the scanner MSS. This interface may be accessed from a RAE station (see Section 2.6).

A hardware reset can be performed by pressing the white button next to the debug cable. This resets both the CPU and FPGA and is equivalent to a power on/off.

# 2.4. EDAQ Sensor Identification and IP addressing

All EDAQs, assuming their firmware (flash code) is the same, are identical. EDAQs can be freely interchanged between sensors and the scanner end bell.

Each EDAQ contains all the code for all supported sensors and loads the appropriate software depending on the identification ID code read at boot time. Two resistors are used to uniquely identify the EDAQ.

For sensor-connected EDAQs, there is a sensor model resistor embedded in the cable harness connecting the sensor to the EDAQ. This resistor determines the Function Code. Function Codes are unique for each sensor model to the extent that the EDAQ needs to differentiate the models (for example, all Source 9 Basis Weight Measurement Sensors presently have the same Function Code, regardless of radioactive isotope).

In addition, the head power distribution board connects a resistor value to each port (sensor module platform). In addition, the head power distribution board has a resistor for each EDAQ platform connector. This determines the position of the EDAQ in the head. The EDAQ can self-identify both its position and function.

Refer to the Scanner System Manual to troubleshoot if the EDAQ does not identify itself properly or how to find the correct resistor values.

Every EDAQ has a unique IP address on the scanner network. If the EDAQ can identify its position, it will set its IP address to 192.168.0.XYZ (where XYZ is the position number in the head. The Frame Controller EDAQ (FC-EDAQ) always sets itself to IP number 192.168.0.2. The MSS is always 192.168.0.1 on the scanner network and usually 192.168.10.(n+100) (where n is the number of MSSs on the same MX Experion network) on the Experion MX LAN. The MSS is assigned 192.168.10.101 at the factory, but this can be set to any IP address by using the MSS web page. Refer to the MSS chapter in your Scanner manual.

If an EDAQ fails to determine a position, it requests an address of the local DHCP server (which is either running on the FC-EDAQ or the MSS). Any laptop will get an IP address once plugged into any of the scanner Ethernet switches.

# 2.5. Obtaining Status Information

## 2.5.1. Experion MX Platform

An overall status page is available from a RAE Station under the MSS Setup Diagnostics tab. Choose the MSS Summary Page.

Figure 2-3 shows, on the left, a list of all expected EDAQs with three types of status indicators (from left to right):

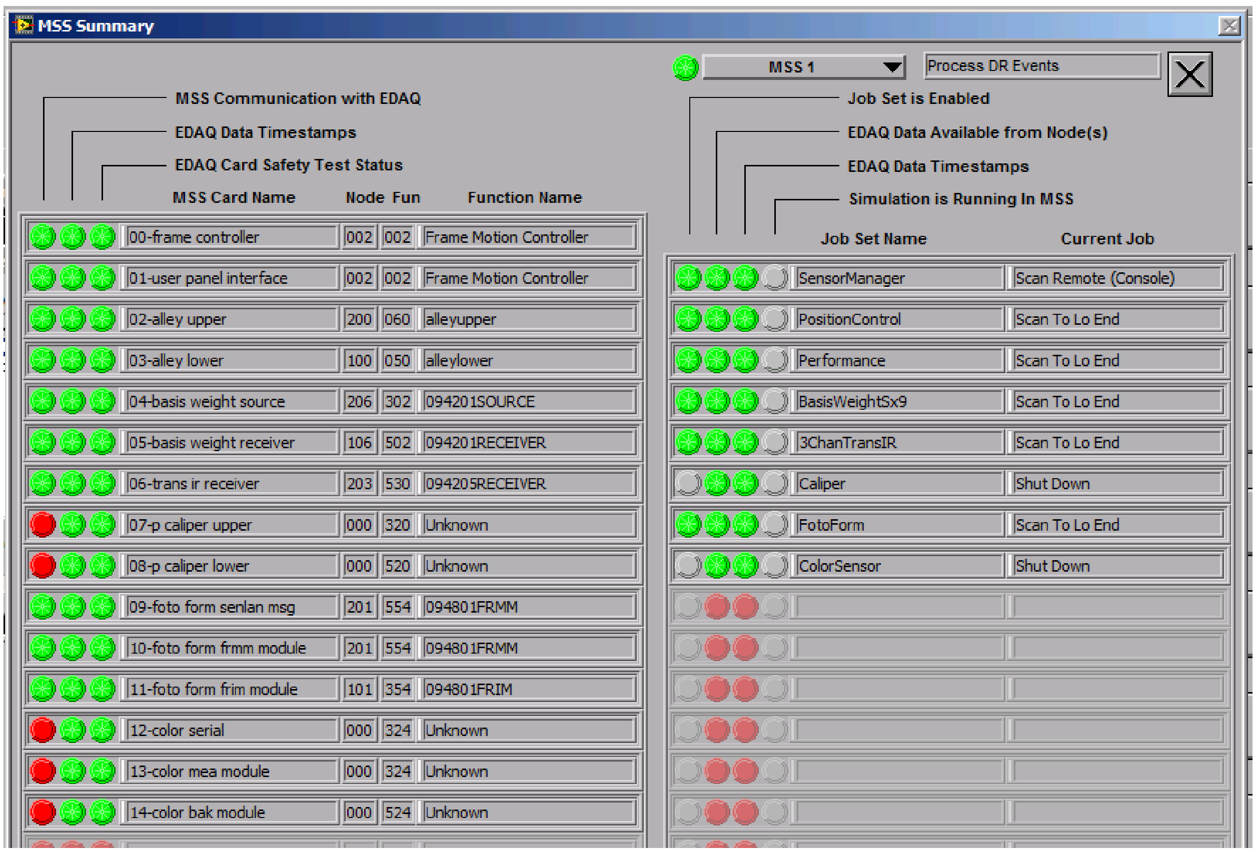



**Figure 2-3 MSS Diagnostic page displaying EDAQ status**

**Table 2-1 MSS Summary Display Status Indicators and their meanings**

| Column | Description (when green) |
|---|---|
| MSS Communication with EDAQ | EDAQ is communicating (through the EDAL protocol) with the MSS |
| EDAQ Data Timestamps | Data that the MSS is expecting from that EDAQ is being supplied at the expected rate |
| EDAQ Card Safety Status | EDAQ is not reporting any errors such as interlock or motion control issues |

Sensors that are part of the RAE database but are not enabled on the scanner show the left most column indicator as red (caliper in the above example).

# 2.6. MSS and EDAQ Web Pages

Much more detail is available on the MSS and the EDAQs, which all run web-servers and can display server pages containing information on the state of the system. As a general rule, consult the MSS web pages first. They are accessible in three different ways:

- From RAE by going to the MSS Diagnostic tab, clicking on MSS Monitor, choosing the appropiate MSS and clicking on MSS web page
- By opening a browser on any computer connected to the Experion MX level network and using the address *http://192.168.10.101/mss.php* (the first MSS on the LAN) or the address set up for the MSS in the Experion MX system
- By opening a browser on any computer connected to the scanner LAN switch and using the address *http://192.168.0.1/mss.php* or *http://192.168.10.101* (for the 1st MSS on the system)

Figure 2-4 is the main MSS web page.

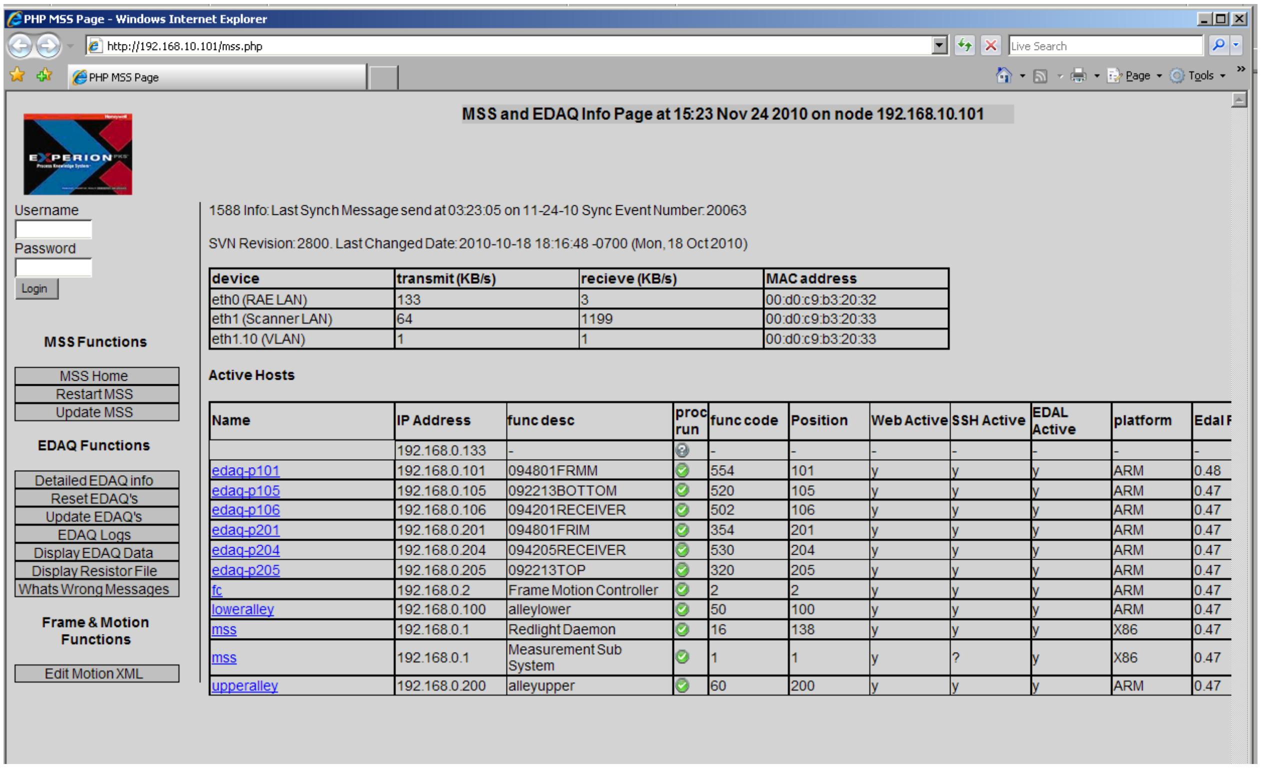



**Figure 2-4 Main MSS web page**

The left panel shows a column of options divided into:

- MSS functions
- EDAQ functions
- Frame and Motion Functions

Enter the username (admin) and password for advanced diagnostic options that are not necessary for normal operation and not discussed in this manual.

The main panel shows two tables. The top table contains transmission volume information to and from the MSS. The device labelled **eth1** (Scanner LAN) typically shows it receiving a few MBs. The MAC addresses of the MSS are also shown – the **eth0** address is that required in the RAE setup.

The second table lists all EDAQs discovered on the Scanner LAN, their IP numbers, a brief description (related to model number), a program status column, the associated Function Code, Position Code and whether the communication protocols are running (http, ssh and Edal, the proprietary sensor data transmission protocol).

The EDAQ network name is specified by edaq-p*XYZ* where *XYZ* is both its position and last octet of the IP address. The EDAQs attached to the head power distribution boards are known as *upper* and *lower* alley respectively. The FC-EDAQ is known as *fc*.

The Proc/Run status column is green if all processes known to run on the EDAQ are present. Hovering the cursor over the status indicator brings up a list of running and stopped processes.

More detailed information on each EDAQ can be obtained by clicking **Detailed EDAQ Info** on the left panel.

The resulting table (see Figure 2-5) shows a number of technical details that are not discussed in this document. Important columns include **Process Load** (usually less then <0.5), **local time** (matches MSS time clock shown at top) and **Offset From MSS** (less than 50 uS a few minutes after start up).

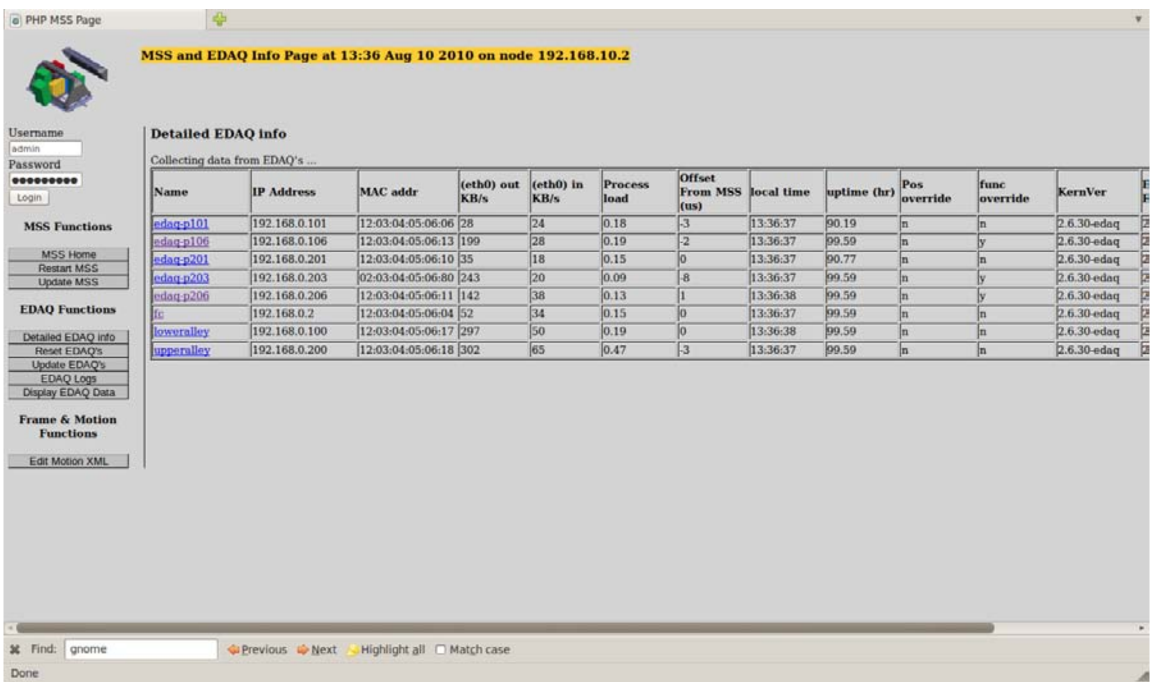



**Figure 2-5 Partial display of EDAQ detailed information**

# 3. Installation

The procedure in this chapter is for the installation of an inboard caliper sensor.

ATTENTION

The outboard caliper option is still in development for Experion MX and this manual will be updated when it becomes available.

## 3.1. Mounting and Electrical Connections

Upper and lower caliper assemblies are mounted to the sensor plate by way of four #10 screws and four insulating shoulder washers. Two yellow cables are connected to the upper caliper assembly by way of round 7-pin connectors, one for solenoid control and one for the oscillator PCB (see Figure 3-1) that carries the caliper signal. Only the solenoid control cable is used on the lower caliper assembly to activate the solenoid.

These cables must not be reversed. In addition to making the sensor non-functional, reversal can lead to damage (blown protection diodes) on the oscillator PCB. The cables are labeled **1** and **2** both on the cables and on the sensor. See Figure 3-2.

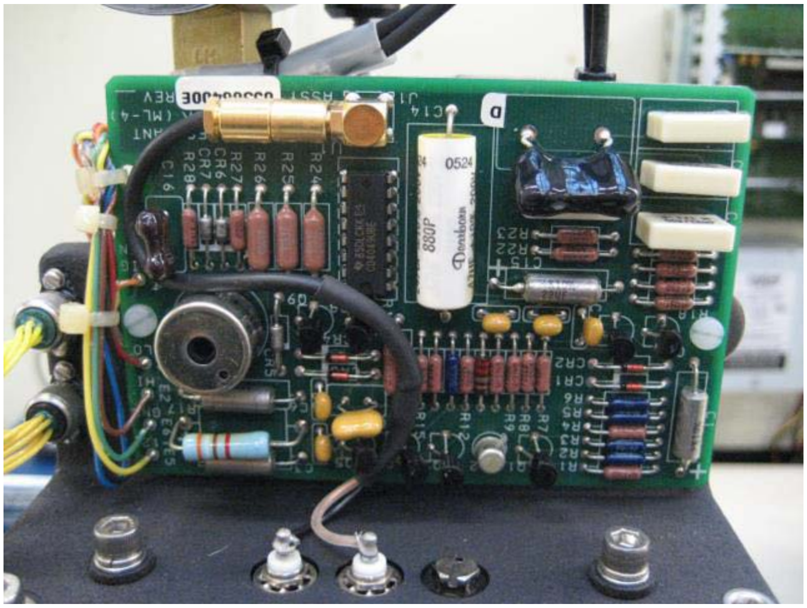


**Figure 3-1 Caliper Oscillator Board**

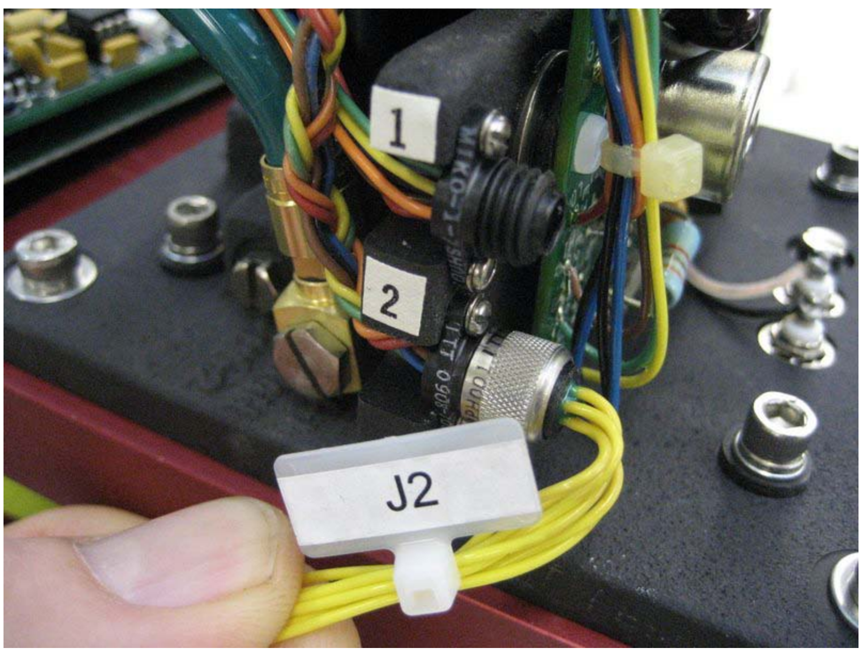



**Figure 3-2 7-Pin Connectors with Matched Labels**

In the upper caliper assembly the other end of these two cables are connected to the EDAQ wiring harness by two white Molex connectors as shown in Figure 3-3. A similar connection for the lower caliper sensor is made for the solenoid actuation; In this case there is only one white Molex connector.

Make sure that the W1 jumper on EDAQ board is installed whenever the board is used for the caliper sensor.

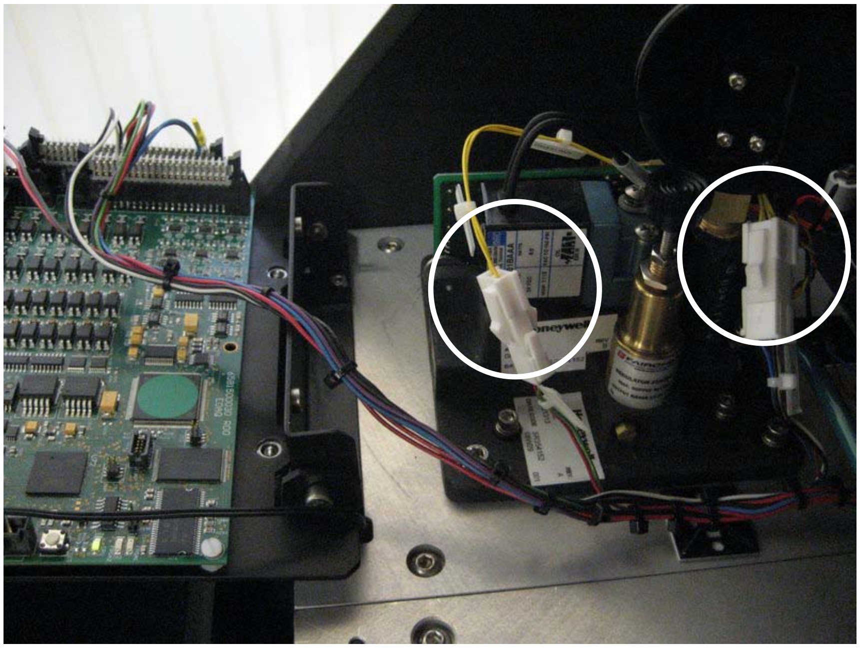


**Figure 3-3 Connection of caliper cables to the EDAQ wiring harness**

# 3.2. Pneumatics

Air pressure for sensor actuation and retraction is supplied by an air hose in each head. The pressure in this hose should be 40 psi to assure proper sensor actuation and retraction. Typically the air is supplied through a regulator/filter to avoid contaminant buildup inside the sensor.

See Figure 3-4 for a diagram of the caliper sensor pneumatics.

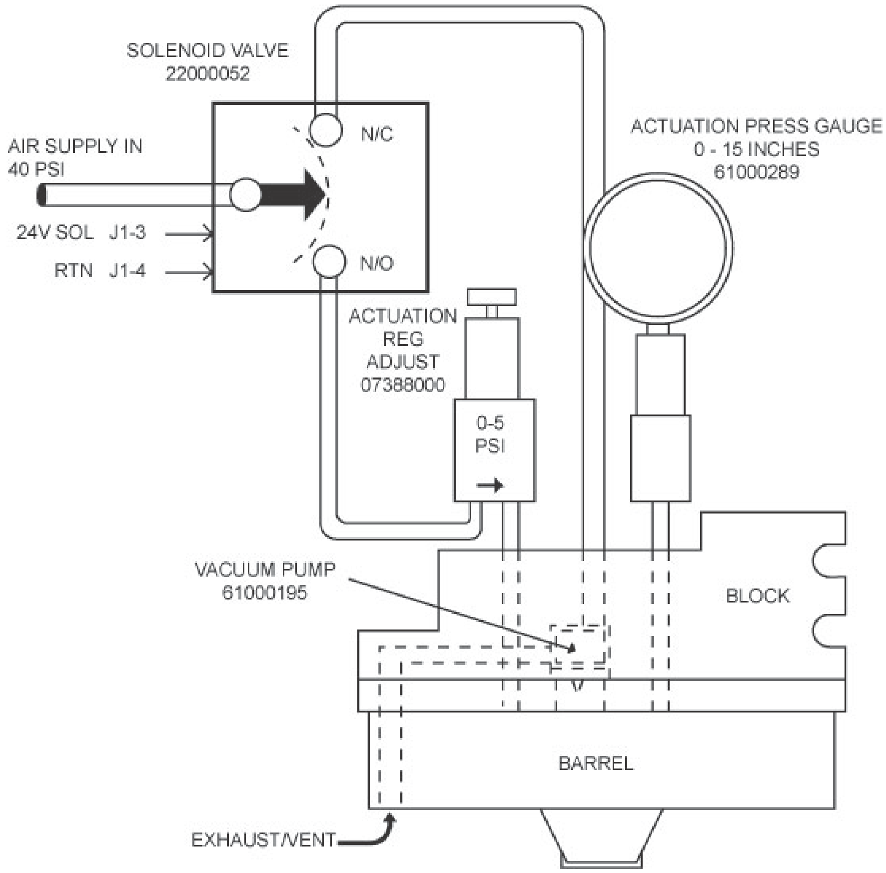



**Figure 3-4 Caliper Sensor Pneumatics**

# 3.3. Solenoid Operation

When energized, a solenoid actuator positions a valve to direct air flow into the bellows (extend caliper) and also to block exhaust vents. The solenoid is energized by a contact closure (ground).

Figure 3-5 shows the air flow through the valve when the solenoid is energized.

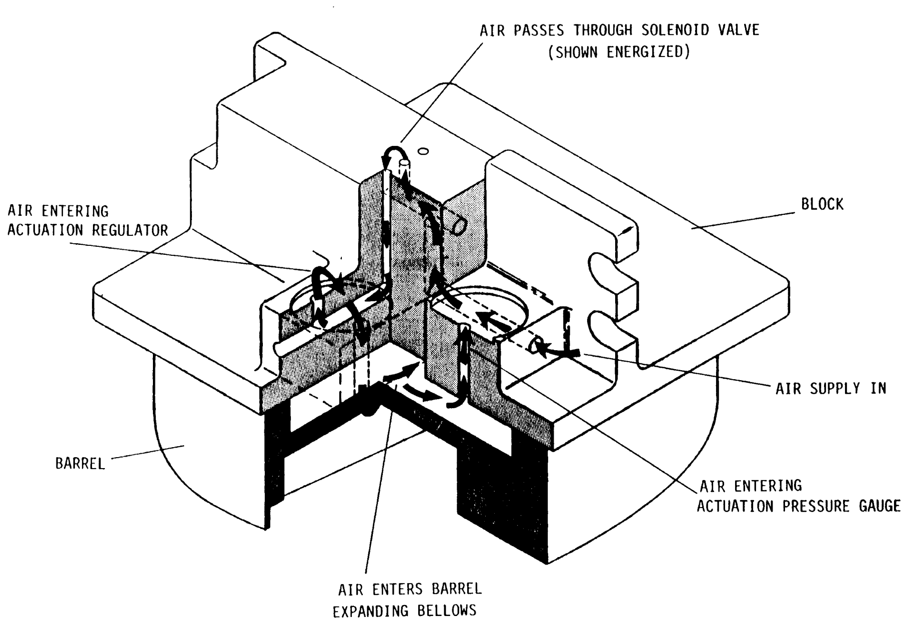



**Figure 3-5 Air Flow - energized solenoid with arm actuated**

When the solenoid is de-energized, air is directed to the exhaust vents by the valve, and by means of a Venturi, pulls air from the bellows (retract caliper). Figure 3-6 shows the air flow through the valve when the solenoid is de-energized.

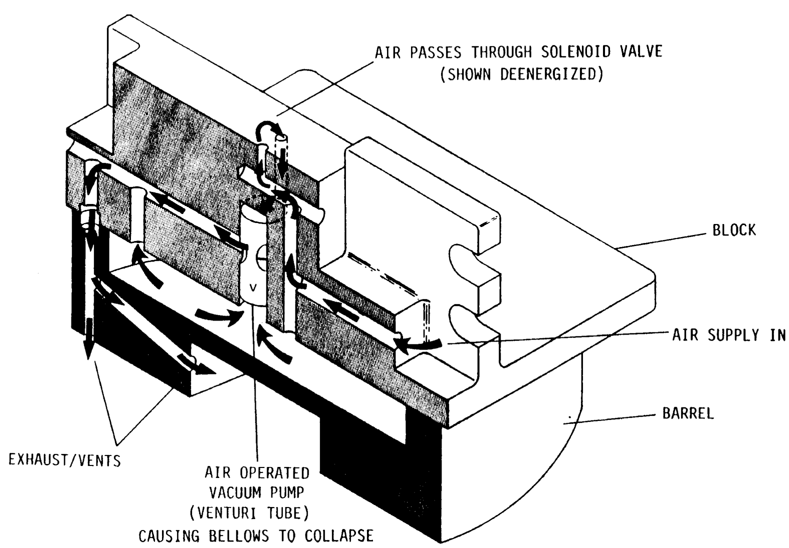



**Figure 3-6 Air Flow - de-energized solenoid with arm retracted**

# 3.4. Sensor Button Alignment Procedure

1. Adjust the external air regulator for a nominal pressure of 40 psi and a flow of 0.5 to 1 CFM. This may be decreased to about 20 psi if the exhaust from the sensor is disturbing the sheet.

2. Using the sensor diagnostic frames of the system, set up for a Caliper **SAMPLE**.

3. Press the **SAMPLE** button.

4. Adjust the upper caliper regulator to the proper setting for the type of sheet or environment. **Nominal value is six inches of water.** For some high speed machines pressures above ten inches is required, while some delicate sheets might require pressure below five inches.

   Do not exceed ten inches of water for caliper assemblies using soft bellows, or twelve inches of water for hard bellows.

   Similarly, do not go below four inches of water on either bellow type as you risk caliper measurement errors.

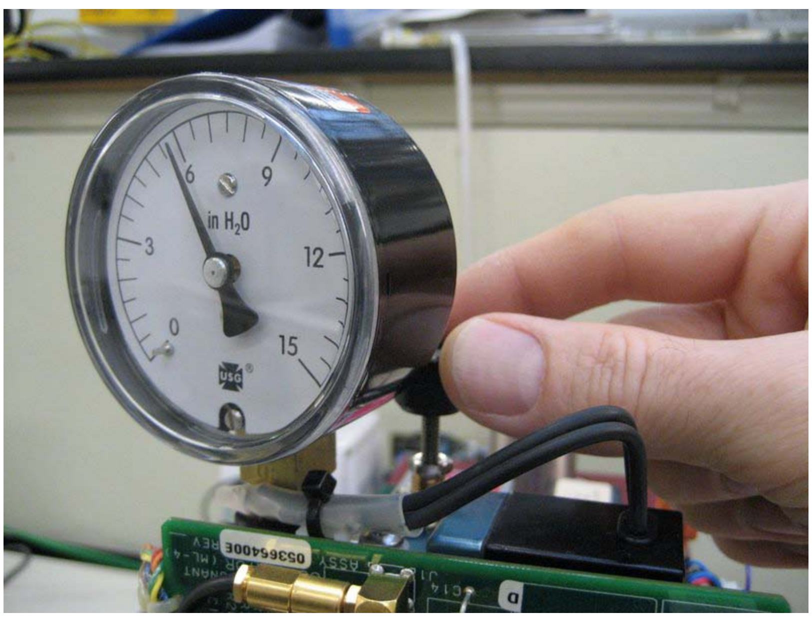



**Figure 3-7 Adjustment of actuation pressure on the upper sensor**

5. Adjust the lower caliper regulator so that the buttons meet squarely in the middle of the gap. Check that the upper and lower bellows can be raised or lowered flush with the sheet guide.

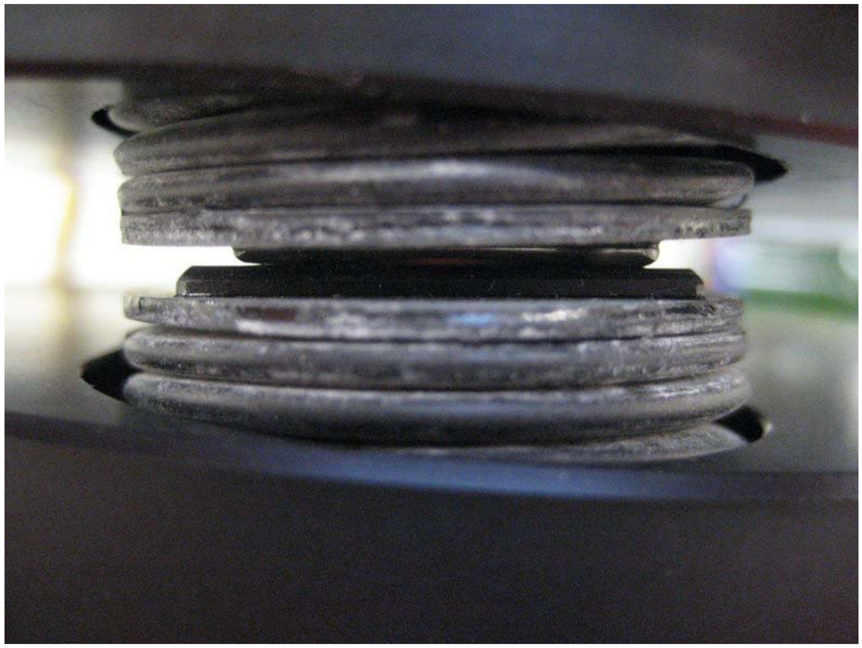


**Figure 3-8 Alignment of sensor buttons inside the gap**

6. Visually inspect the buttons. Ensure the upper button is aligned directly on top of the lower button. If not, loosen the four mounting holes that hold the upper sensor assembly to to the mounting plate and rotate the upper sensor until the buttons are aligned.

7. The bellows may angle a bit in order to ensure the buttons are aligned properly. Once paper is in the gap, the bellows align themselves accordingly.

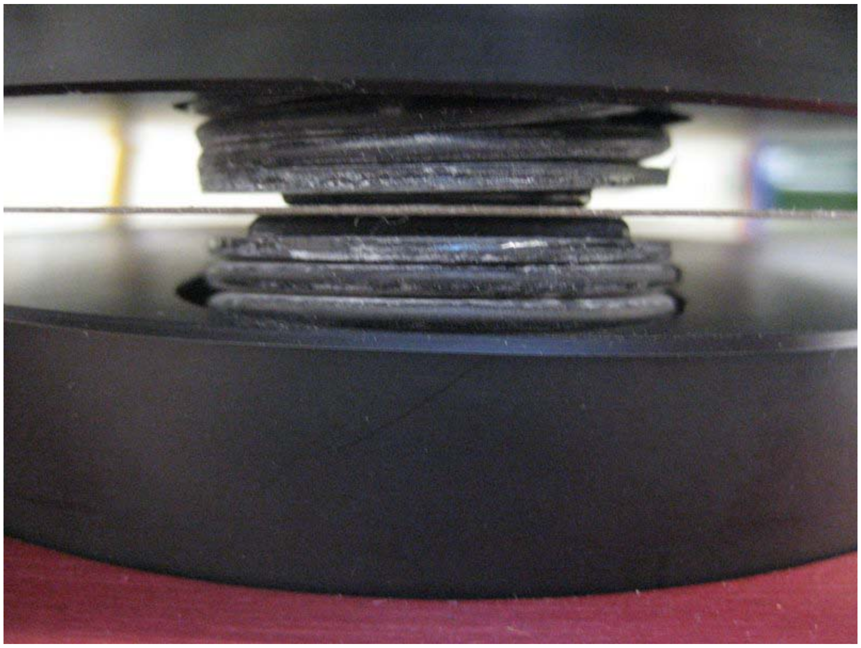


**Figure 3-9 Bellows realign when product is in the gap**

Note: Lateral misalignment of the buttons by more than a millimeter or two can result in caliper profiles that are highly sensitive to scanner misalignment.

8. When alignment is complete, re-tighten the securing screws on the upper caliper sensor.

9. Using a sheet of stiff material between the caliper buttons, again press the **SAMPLE** button. While raising and lowering the sheet, observe that for every movement of the upper bellows, the lower bellows extend or retract and follow the movement.

10. Adjust the air pressure to increase or decrease pressure as required. Ideally when on sheet, both contacts should touch the sheet, but without sufficient pressure to score it.

ATTENTION

It is crucial that the nuts be tightened on the regulators after the pressure has been set to prevent the pressure from drifting or becoming unstable.

# 3.5. X-Y Profile Test

When the installation and alignment procedures above are completed and the sensor is calibrated (see Chapter 6), do a static scanning test of the caliper sensor with a piece of product taped down inside the gap.

Look for any correlations between the X or Y head sensor alignment data with the caliper measurement.  Large fluctuations in caliper that correlate to scanner misalignment are usually due to poor alignment of the caliper buttons or a scanner alignment issue. Random fluctuations in caliper can be caused by large particulates between the buttons and can be minimized by cleaning these buttons before doing this test.

# 4. Software Configuration Parameters

This chapter outlines the configuration parameters related to Honeywell's caliper measurement using the Experion MX software platform. Understand and configure your system according to your needs before calibrating or operating the sensor in a real-time process.

The parameters found in this section are in the **Sensor Maintenance → Caliper Sensor Processor** section of the Experion MX software interface. More general help about the operation of this display can be obtained by clicking on the Page Help button in the top right-hand corner of the display.

## 4.1. General Configuration

Historically, the caliper sensor frequency was converted to a count value that was defined as the number of counts received over a 100ms gate time. For example, a caliper frequency of 75 kHz would generate a count value of 7500 (that is, 75000 $s^{-1}$ * 0.1s). For the sake of consistency with older systems, newer systems continue to report and use caliper signals in counts.

There are a number of non-grade dependent general configuration parameters for the sensor that can be accessed by selecting General Configuration in the pull-down menu of the Configuration Parameters panel. See Figure 4-1.

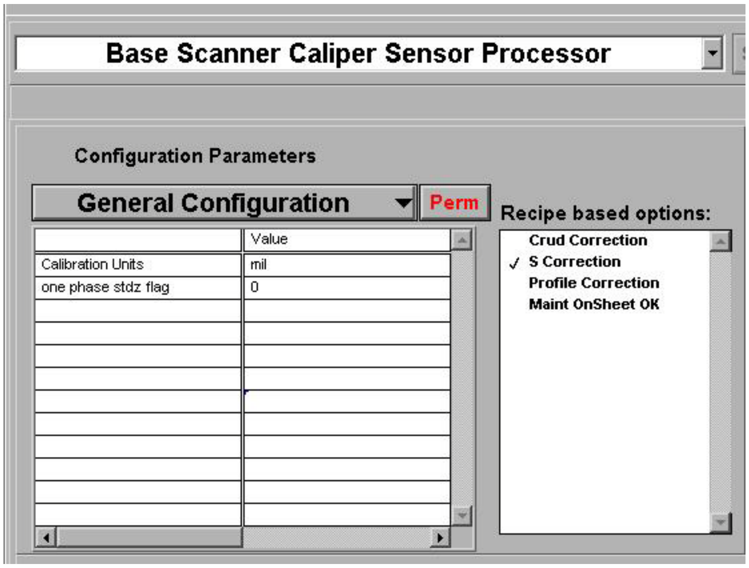



**Figure 4-1 General Configuration**

## 4.1.1. Calibration Units

Defines the unit values for your calibration. Usually either set to millimeters or mils.

ATTENTION

The customer/display units are set independently by way of the **Units Setup** display, which has an entry for caliper as well as many other sensors. The caliper entry in the Units Setup display is used to translate from the internal system units of millimeters into the desired output unit.

## 4.1.2. One Phase Standardize

Determines whether the caliper sensor is closed during standardize or left open the full time. It is a flag with a value of 0 or 1.

If 0, the full two-phase open-reading and closed-reading standardize is done; if 1, only the open-reading phase is done. Unless crud correction is enabled, the closed counts are used as a diagnostic at most, and closing the sensor with nothing in the gap adds unnecessary wear and tear on the caliper buttons. Unless crud correction is being done, set this flag to 1.

# 4.2. Recipe Based Options

This menu consists of four flags that can be toggled on and off by double-clicking on them.

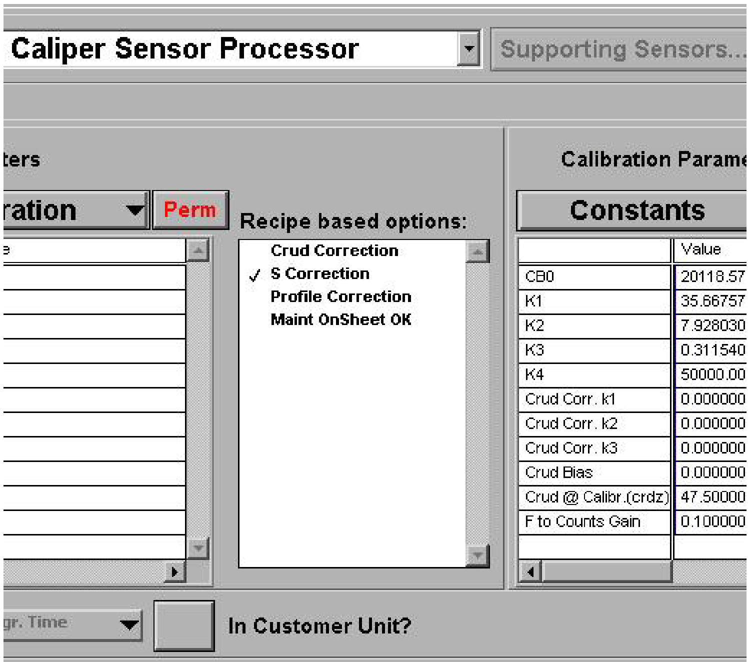



**Figure 4-2 Recipe Based Options**

## 4.2.1. Crud Correction

The crud correction algorithm attempts to use the closed caliper count obtained at standardize to introduce a corrective offset when build-up (crud) on the caliper buttons is an issue. In many cases, however, the amount of build-up changes erratically between each standardize and this correction technique is unreliable.

Crud correction is not recommended unless the crud is proven to build up in a very predictable way.

ATTENTION

Crud correction requires that a two-phase standardize be done (the **one phase stdz** flag noted above is set to 0), and that appropriate nonzero crud-corrector calibration coefficients be entered into the Calibration Parameters dialog (see Subsection 4.3). If either of these conditions is not met, the crud corrector shows up as either 0.000, blank, or NaN, and no actual crud correction will be made.

### 4.2.2. S Correction

S is a drift corrector computed from the open counts at standardize:

S = CB0/CB

Here, CB0 is the time-zero open counts value, and CB is the open counts value from the most recent standardize. The **S-Correction** can be enabled or disabled but is typically close to 1.000 and very stable.

There are rare cases where this corrector introduces undesirable variability into the absolute caliper reading and the system runs better without it.

### 4.2.3. Profile Correction

If checked, a profile correction is applied; if unchecked, no profile correction is applied. It is extremely rare that a profile corrector is needed or desirable for caliper and this entry is virtually always left unselected.

ATTENTION

If a profile corrector is ever required for caliper, it must be built and entered into the system manually since there is no reliable way to build this corrector based on, for example, scanning on a fixed sheet.

### 4.2.4. Maint OnSheet OK

If selected, scanning tests are permitted in Maintenance mode even when there is no sheet in place to define realistic edge positions.

The caliper open/close positions are set using the entries in the **Positional Setup** menu (see Section 4.6).

## 4.3. Calibration Parameters

The equation which relates caliper output to sensor counts is given by

$$\text{Caliper} = K1 / \{[K4 / (S * \text{counts})]^2 - K2\} - K3 + K5$$

Where K1, K2, K3, and K4 are grade-independent constants determined in the calibration.

K1 to K3 are determined using the calibration algorithm discussed in Chapter 6. At least three samples must be used to determine these three unknowns.

K4 is typically set to 50,000 and does not change.

K5 is an additive grade-dependent offset. See Section 4.4.

The S corrector was discussed in Subsection 4.2.2.

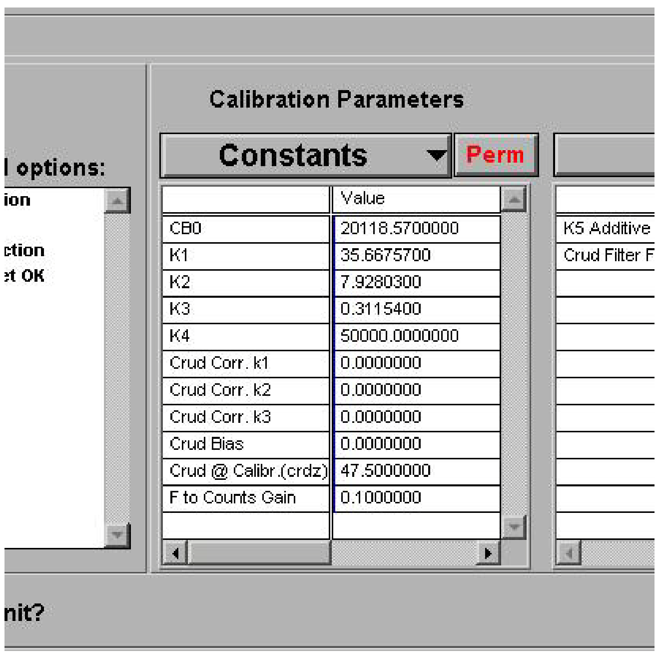



**Figure 4-3 Calibration Constants**

## 4.3.1. CB0, K1, K2, K3, K4

CB0 is the time-zero open counts value.

If the calibration that determined K1, K2, and so on (whether done at a manufacturing facility or in the field) has been done in mm, the **Calibration Unit** must be entered as mm as well. Similarly for mils or microns.

## 4.3.2. Crud Corr. K1, K2, K3

These are coefficients for the crud correction. Typically there is no crud correction and these coefficients should be left at zero.

If crud correction is desired, the crud calibration coefficients (Crud Corr. K1, K2, K3) must be obtained using a sample set “including” zero thickness. As a result, these coefficients may or may not be identical to the standard K1, K2, K3 values.

If the crud correction coefficients are nonzero, a crud value is computed and displayed at standardize/reference time even if the crud corrector is disabled. Even though a crud value is displayed under these conditions, a corrector is not applied to sample or on-sheet values unless the crud corrector is enabled.

### 4.3.3. Crud Bias, Crud @ Calibr.

These are included for historical reasons, but in virtually all cases should be left at zero so that the crud is directly calculated from the standardize values.

### 4.3.4. F to Counts Gain

This is the time interval in seconds assumed for converting frequency to counts. Leave the value set at 0.100s (that is, 100ms).

## 4.4. Grade Dependent Calibration Parameters

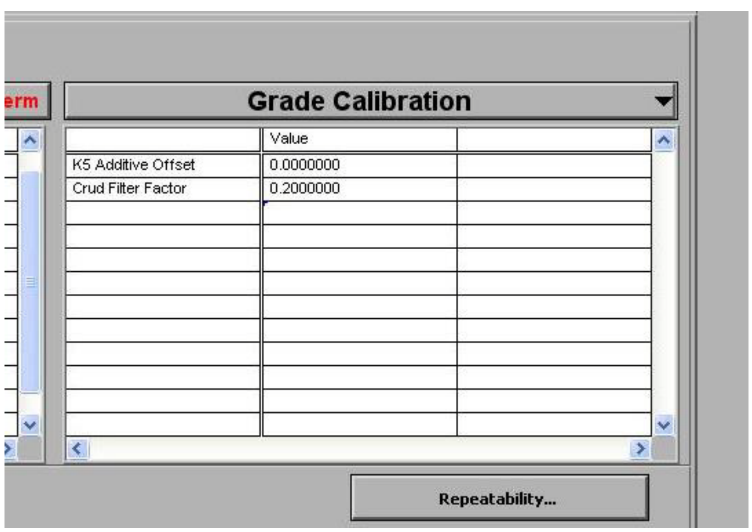



**Figure 4-4 Grade Calibration**

## 4.4.1. K5 Additive Offset

The grade-dependent additive offset is used to adjust on-sheet dynamic caliper values.

## 4.4.2. Crud Filter Factor

The filter factor for the crud corrector. If less than 1.00, the crud corrector determined at standardize time is filtered with those from previous standardizes. No filtering is performed during a reference, even if multiple references are requested.

# 4.5. Limits

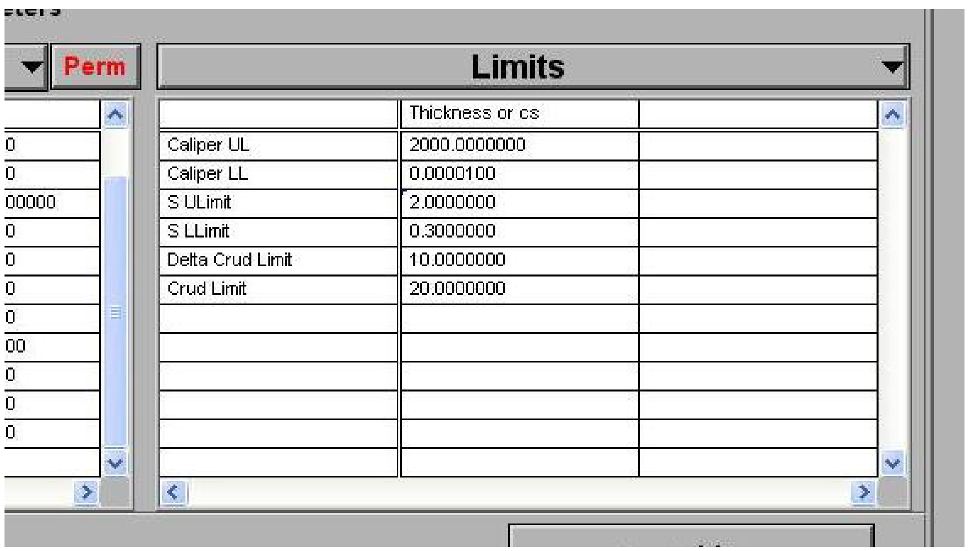



**Figure 4-5 Limits**

## 4.5.1. Caliper UL, Caliper LL

While these limit checks generate alarms, they cause no other action to be taken, such as disabling the sensor.

## 4.5.2. S Ulimit, S Llimit

An alarm is generated if the S-factor determined at standardize time is outside these upper and lower limits.

### 4.5.3. Delta Crud Limit

If crud correction is enabled, an alarm is generated if the change in crud between successive standardizes exceeds this value.

### 4.5.4. Crud limit

If crud correction is enabled, an alarm is generated if the crud exceeds this value.

## 4.6. Positional Setup

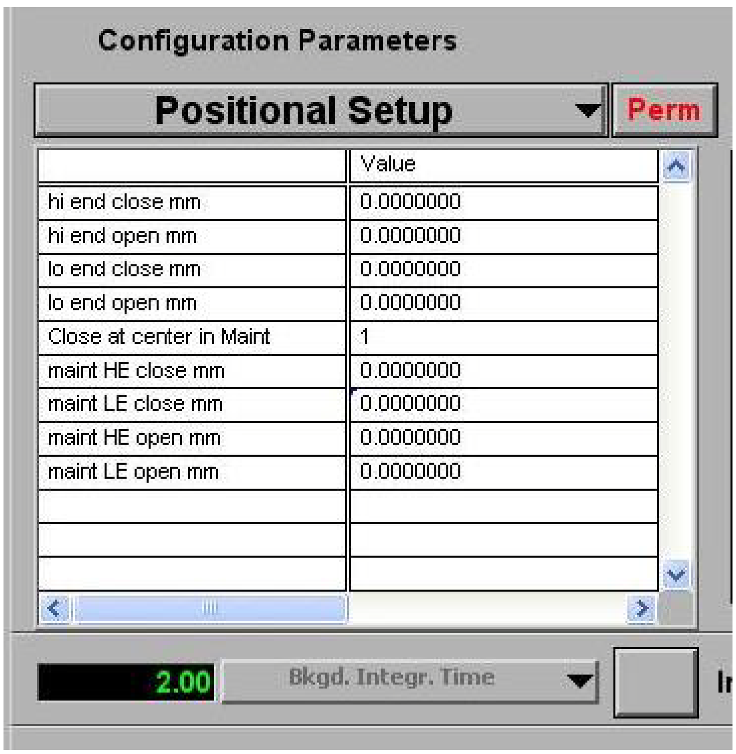



**Figure 4-6 Positional Setup**

### 4.6.1. Hi End Close / Lo End Close

Gives the distances in from the edge of the sheet at the two ends of the scanner that the caliper sensor will close when scanning on-sheet. A zero value represents closing exactly at the edge, but this is not recommended as it could tear the sheet or cause damage to the sensor.

## 4.6.2. Hi End Open / Lo End Open

Gives the distances in from the edge of the sheet that the sensor will open while scanning off-sheet. An entry of zero for the open values will cause the caliper to scan all the way to the edge of the sheet.

## 4.6.3. Maint HE Open/Close

It is possible to specify open and close positions for maintenance operations when no sheet is present. These are set through the **maint HE open mm**, **maint HE close mm**, **maint LE open mm**, and **maint LE close mm** parameters.

These open and close positions take effect if the **Maint OnSheet OK** flag is enabled. See Subsection 4.2.4. The open and close positions are defined as distances in from the edge but since no real edge is typically present in Maintenance mode, the *edge* is instead defined by the **LE Scan Position** and **HE Scan Position** entered on the **Scanner Positioning** display.

## 4.6.4. Close at Center of Maint.

Set this to 1 in order to close the caliper gauge at the center of the maintenance positional limits and override the normal interpretation of the Maintenance close parameters.

# 5. Operations: Reference and Sample

Figure 5-1 through Figure 5-4 show typical Maintenance mode displays.

Figure 5-1 displays the result of a Reference done with the full two-phase standardization (**one phase stdz** flag set to 0). Even though the Crud Correction is disabled, the crud calculation (that is, the caliper computed from the closed reading) is still performed and displayed.

Figure 5-2 displays the result of a Reference done with a one-phase standardization (**one phase stdz** flag set to 1). The closed count data are not present.

Figure 5-3 and Figure 5-4 display the results of Sample operations done with and without crud correction, respectively. Since crud correction is not enabled in Figure 5-3, its value shows as NaN. The effect of the crud corrector when enabled is apparent in Figure 5-4.

For Reference, the displayed values include:

- Open Freq
- Open Counts (computed based on the F to Counts Gain)
- S Correction
- Closed Freq
- Closed Counts (computed based on the F to Counts Gain)
- Crud (based on closed counts and the crud calibration coefficients) [1]

[1] Crud values are printed out if the crud calibration coefficients are nonzero, even if crud correction is disabled. However, even though a crud value is displayed under these conditions, a corrector is not applied to sample or on-sheet values unless the crud corrector is enabled

- Filtered crud
- Tweak (equal to the negative of the filtered crud: this is what is subsequently added to the "raw" on sheet caliper if the crud corrector is enabled)

For Sample, the displayed values include:

- Sample frequency
- Sample counts (computed based on the F to Counts Gain)
- S-correction (from the most recent standardize or reference, if S-correction is enabled)
- Uncorrected caliper (in customer units if "In Customer Unit?" is checked; otherwise, in millimeters)
- Crud correction (NaN unless enabled)
- Caliper (includes crud correction, if enabled)

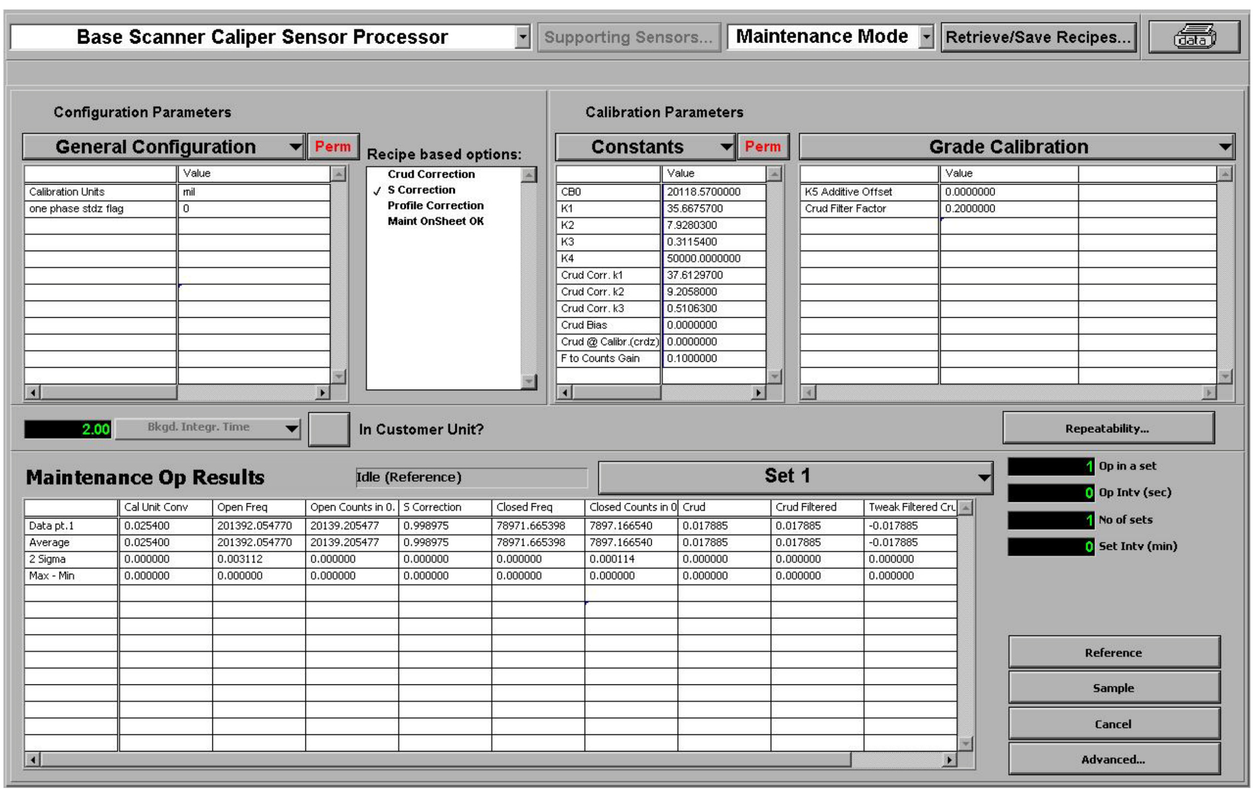



**Figure 5-1 Result of Reference Done with Full Two-Phase Standardization**

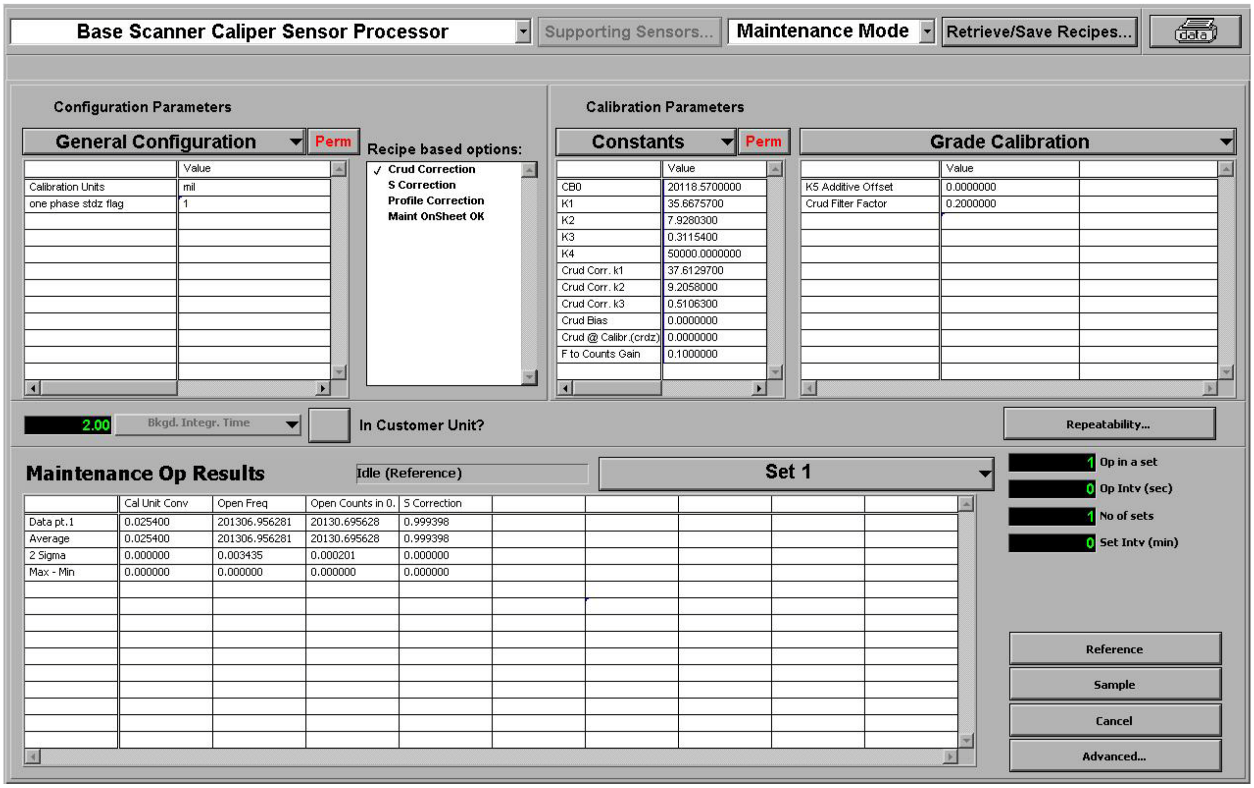



**Figure 5-2 Result of Reference Done with One-Phase Standardization**

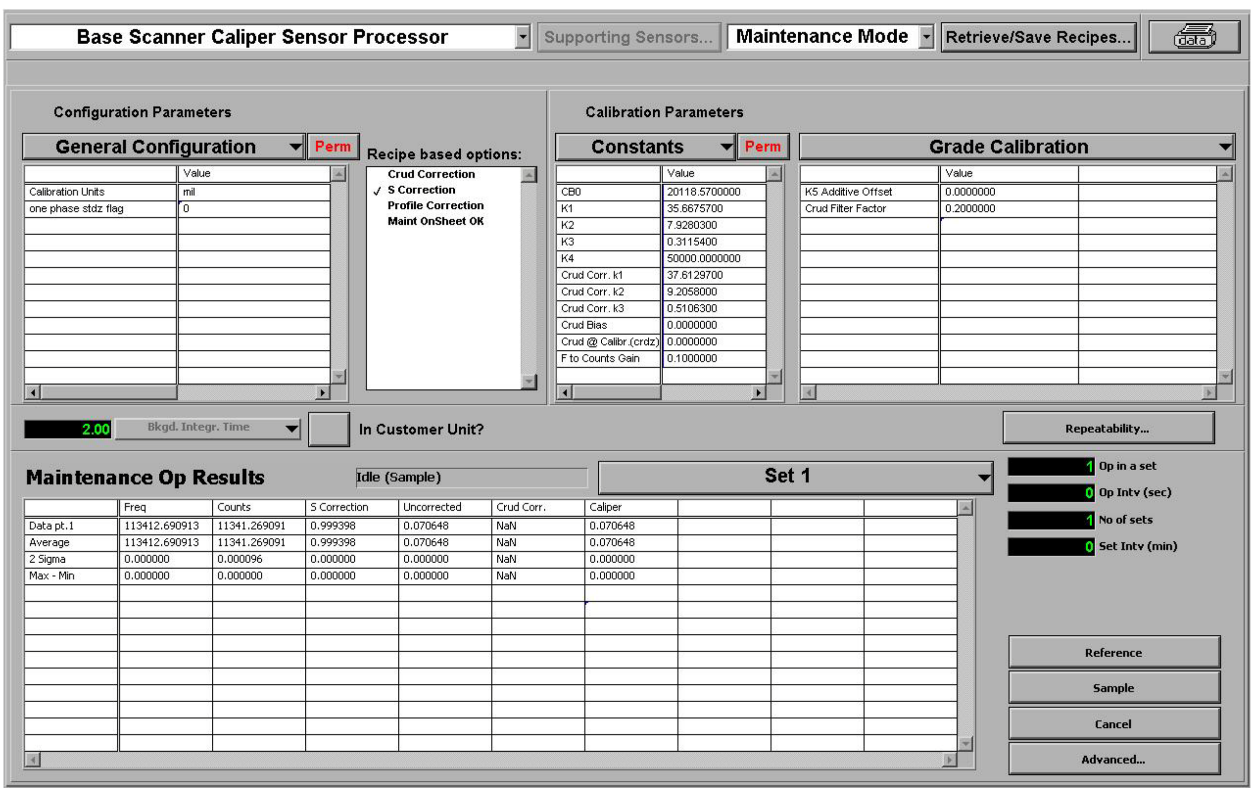



**Figure 5-3 Result of Sample Operation with Crud Corrector Disabled**

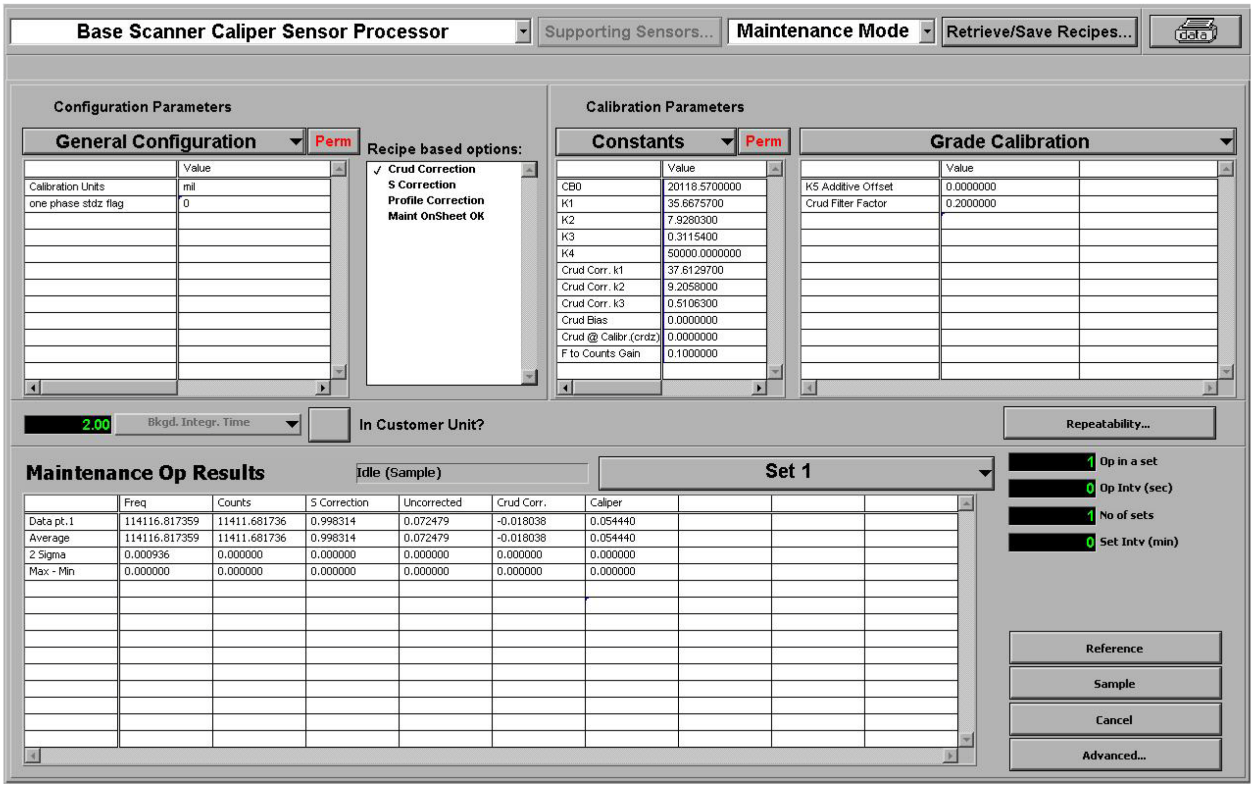



**Figure 5-4 Result of Sample Operation with Crud Corrector Enabled**

# 5.1. On Sheet Maintenance Display

While scanning or in single-point operation, the **Sensor Maintenance** display shows real-time readings and calculations useful in scanning diagnostics and troubleshooting. Various database constants are still visible, but are changeable only in **Maintenance** mode, not in **Production** mode. Figure 5-5 shows the scanning display when crud correction is disabled; Figure 5-6, when it is enabled.

The results of the most recent standardize are on the left of the display. These include the most recent crud value and the *tweak* value, which equals the negative of the filtered crud. The crud values are shown anytime the crud calibration coefficients are nonzero and the full two-phase standardization is enabled, even if the crud correction itself is disabled. If crud correction is disabled, however, this corrector is not applied to the actual on-sheet readings.

The rest of the screen is devoted to real-time results obtained during the specific operation selected in the middle right-hand pull-down selector. At at a specific bin number while scanning if Position Snapshot is selected, at a single-point location if Single Point is selected, or averaged over a period of time on a periodic basis if Periodic Snapshot is selected. For Periodic Snapshot the readings are not constrained to occur only on sheet; therefore, strange values can appear if all or part of the Periodic Snapshot was made off sheet. For this reason, Periodic Snapshot is not always a useful display, and in some systems is not enabled.

The center of the display gives the raw input values.

The far right portion details the rest of the caliper calculation: uncorrected caliper, Tweak (the filtered crud correction), profile correction, and final caliper value. Tweak and Profile Correction are displayed as NaN if they are not enabled.

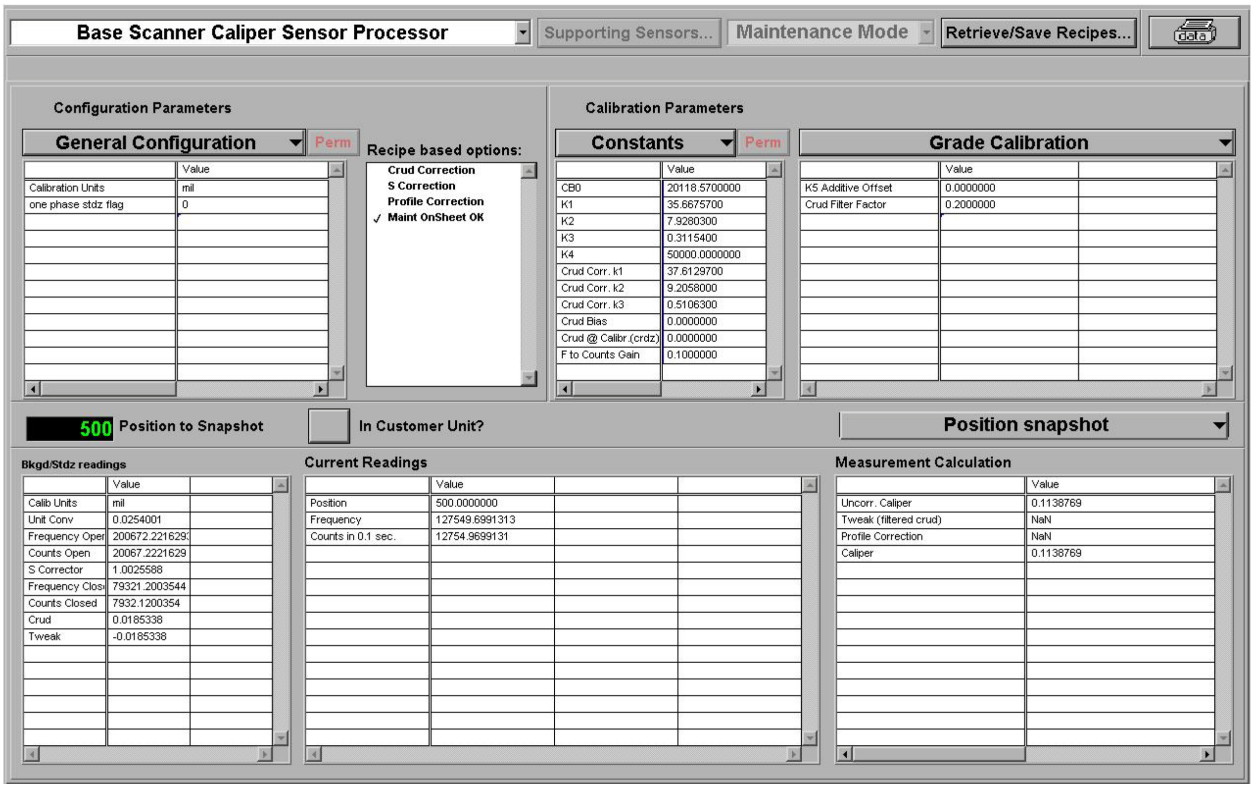



**Figure 5-5 Real-Time Input and Calculation Values for Diagnostics and Troubleshooting – Crud Correction Disabled**

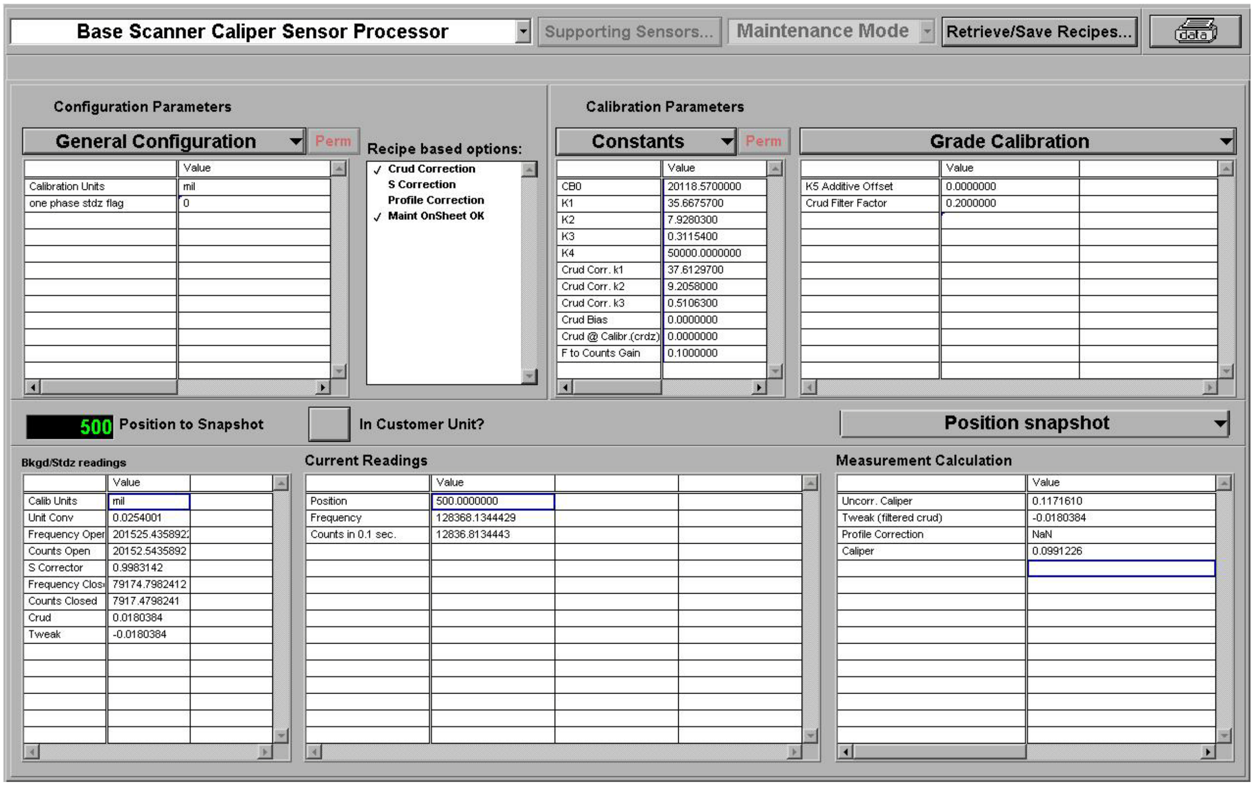



**Figure 5-6 Real-Time Input and Calculation Values for Diagnostics and Troubleshooting – Crud Correction Enabled**

# 5.2. Limits

There are two sets of generic limits used by the caliper sensor; alarm limits and validity limits. These limits should be manipulated using the Measurement Setup display shown below to be properly restored the next time the grade is loaded.

- alarm low limit
- alarm high limit

If the caliper is not within these grade-dependent limits, an alarm is generated and the points where the limit error occurs are shown in red on the profile display. No other specific action is taken (for example, rejecting specific points, taking the scanner off-sheet, disabling the sensor, and so on).

- high limit
- low limit
- min percent valid

If the caliper reading is not within these grade-independent limits, it is flagged as a bad reading (though at present no other action is taken in terms of rejecting the point, and so on). If the percent of good readings does not exceed the **min percent valid** number, an alarm is generated.

| ATTENTION | These high and low limits represent relative differences above and below the nominal value, not absolute numbers. For example, if high and low limits are both 1.0 and the nominal is 4.0, acceptable values lie between 3.0 and 5.0. |
|---|---|

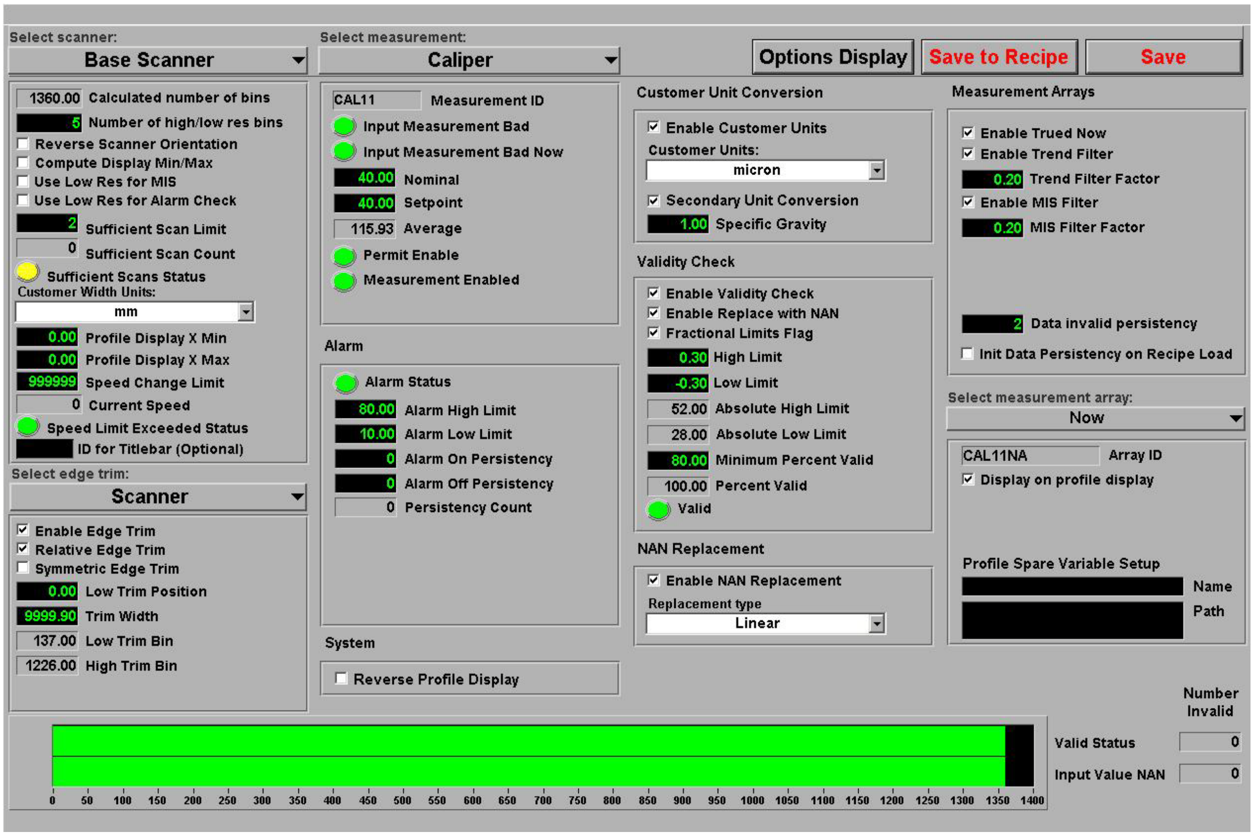



**Figure 5-7 Caliper Sensor Measurement Setup Limits**

# 6. Calibration

This display can be reached by clicking the **Advanced** button on the Sensor Maintenance display while in Maintenance mode. It permits the user to perform convenient and reliable calibrations and verifications online without external spreadsheets or other tools.

The display can be toggled between Calibration and Verification modes through the menu box at the top right of the display. Figure 6-1 shows the display in Calibration mode, with several sample data points already completed.

Each desired sample must be added using the Add Sample button. Its lab caliper must be entered or modified using the **Lab Caliper** field (Changing an entry in the **Lab CAL** column of the Sensor Data table has no effect).

To avoid confusion, select the **Customer Units** checkbox on the main **Sensor Maintenance** display to enter the sample caliper values in normal units rather than in millimeters. In Figure 6-1, five samples have been entered, including one with zero caliper.

Lab caliper values can also be retrieved through the **Copy Clps...** button (if the same set of caliper values exists in the **Verification** display) or through the **Open File** button (if there is a previously stored data set with the same lab caliper values). Using either of these methods results in any existing data in the Sample Table being overwritten. When using the Open File button, a *.dat* file (as stored by this advanced display) must be selected since a spreadsheet or text file will not be read properly.

Once the lab values have been entered, the cursor can be put on the first row of the data set and samples read one by one by the caliper sensor. The samples can be requested from the console but would generally be requested by clicking the **Sample** button at the scanner. As each sample is completed, the system automatically moves to the next data row, and also displays the sample data on the graph. It is possible to choose the variables to be plotted on the x and y axes, but most commonly the graph shows Counts plotted against Lab Caliper or the reverse. Samples can be re-run by selecting the row of interest and re-running the sample.

After all of the samples have been read, a fit to the data is done by clicking the **Curve Fit** button. This does a full non-linear best fit to all selected data, not just a three-point fit to three points as was typically done in the past. When this button is clicked, a fit to the data will be displayed (Figure 6-2) and, if desired, you can experiment with including or excluding points in the fit. Points are included or excluded by selecting or deselecting the box to the left of the sample data. Exit the Curve Fit utility by clicking the **Curve Fit** button off. However, if it is desired that the fit coefficients be saved and applied online, click the **Accept** button. This also turns off the Curve Fit utility and returns to data entry/sample mode. If **Accept** was clicked during curve fitting, then the coefficients can now be applied by clicking **Apply New Coefficients**. This action prompts for storage of the coefficients into Permanents and makes them active immediately.

Verification Mode in the **Advanced Display** (Figure 6-3) allows you to read samples of known thickness and to compare their measured and actual values. If the samples are the same as those from which a calibration was generated, you can copy the lab values from the Calibration Mode by clicking **Copy Clps...**. Otherwise, the Lab values can be entered manually through the Lab Caliper entry box or loaded from an existing file. Place the cursor in the first row of the Sample Data table and the samples read in order. As they are read, the data points appear on the graph and the error in the reading is also visible in the **Sample Data** table. Typically, errors of about 0.2 mil or less are considered adequate for static testing. As indicated in Figure 6-3, it is possible to display the errors in the points on the y-axis. This is also possible in Calibration Mode.

Data can be stored to disk in either Calibration or Verification modes by clicking **Save File**. You are prompted in turn for two file names:

- a *.dat* file that will be readable later by the Advanced display; and
- a *.txt* file that can be read by external text editors or spreadsheets, but is not compatible with being read back into the Advanced display.

The file name supplied can be the same for these two files, since one is stored with a *.dat* extension and the other with a *.txt* extension.

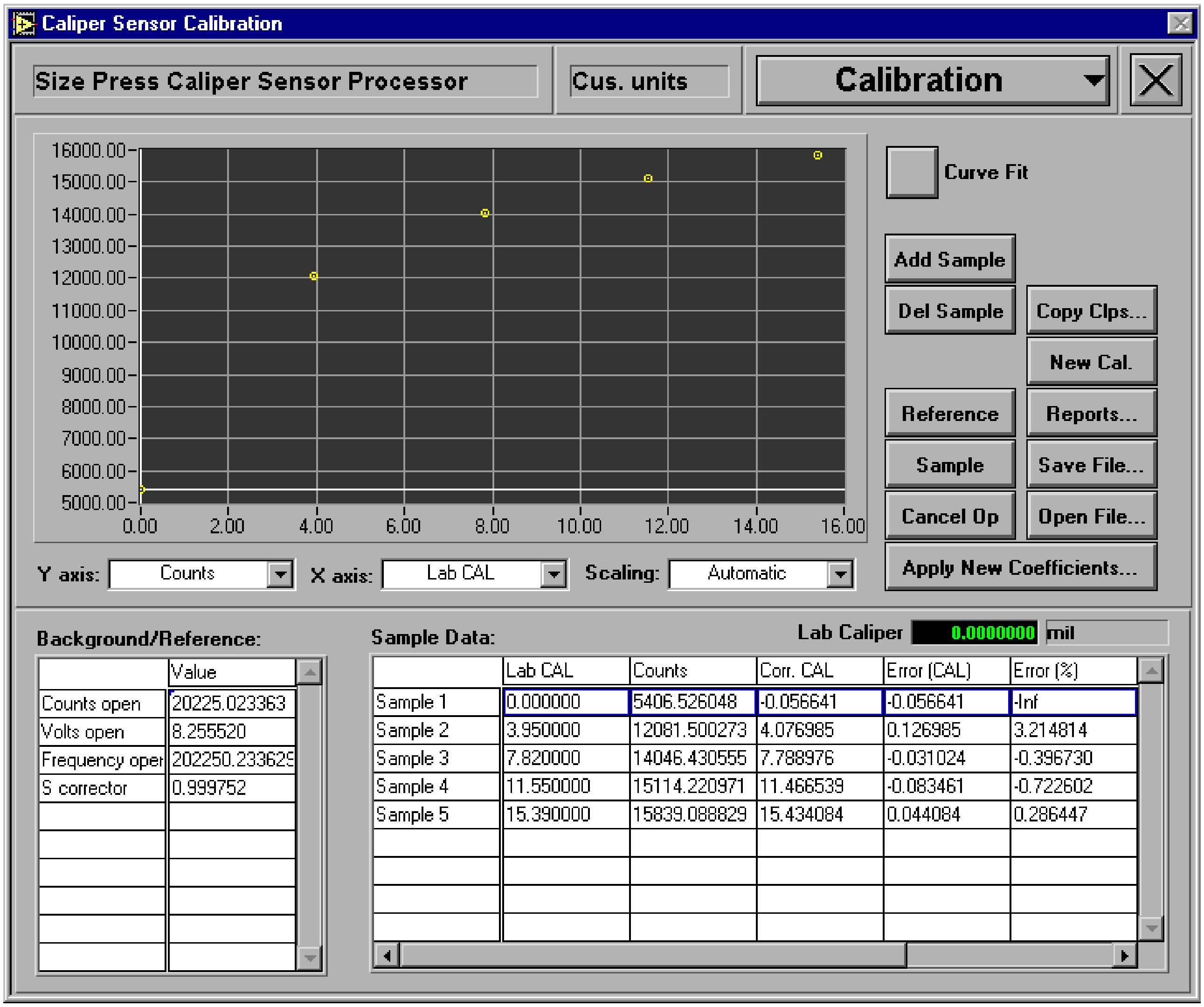



**Figure 6-1 Advanced Display in Calibration Mode**

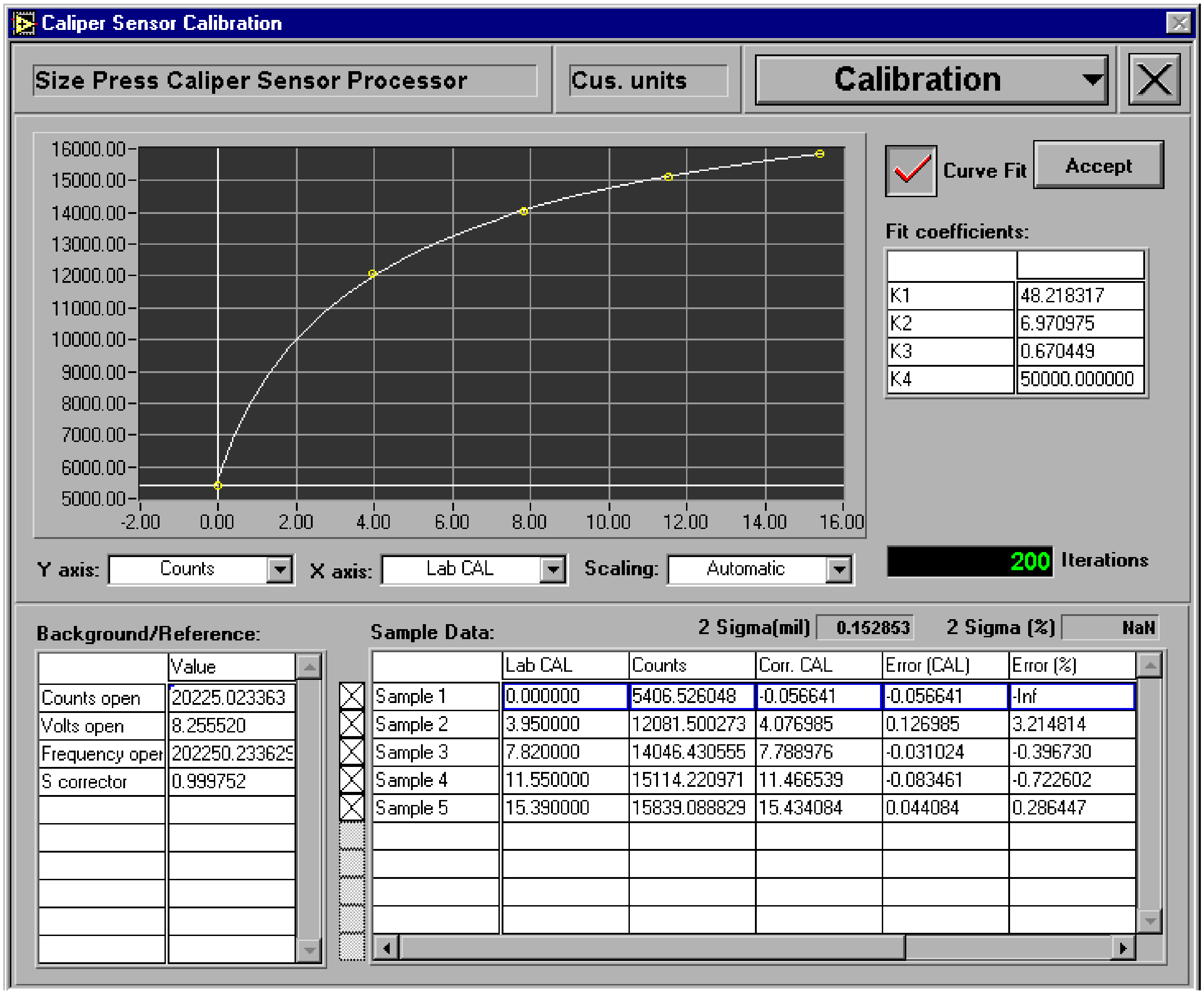



**Figure 6-2 Advanced Display in Calibration Mode with Curve Fit On**

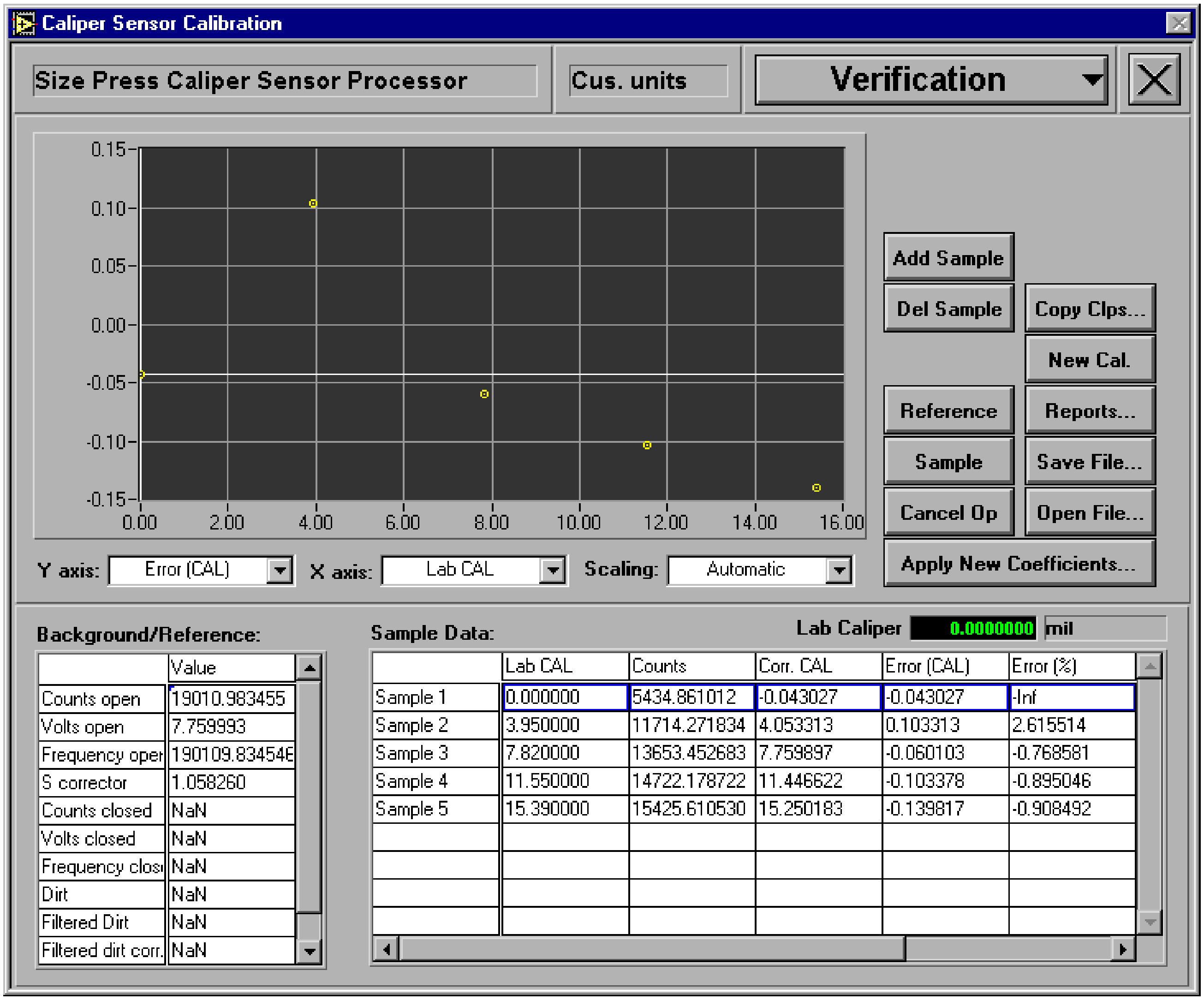



**Figure 6-3 Advanced Display in Verification Mode**

# 7. Preventive Maintenance

The frequency of preventive maintenance procedures may need to be adjusted depending on your operating environment.

**Table 7-1 Preventive Maintenance Internal checklist**

| Procedure | Daily | Weekly | Months | | Years | | | Task Details |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 6 | 1 | 3 | 5 | |
| | | | | | | | | |
| Clean Buttons | X | | | | | | | See Section 8.1 |
| Inspect Bellows | | X | | | | | | See Section 8.2 |
| Inspect Buttons for Damage or Wear | | X | | | | | | See Section 8.3 |
| Inspect Caliper Retraction | | X | | | | | | See Section 8.4 |
| Check Button Alignment | | | X | | | | | See Section 8.5 |
| Clean Air Vent | | | X | | | | | See Section 8.6 |
| Clean Vacuum Pump | | | | X | | | | See Section 8.7 |

# 8. Tasks

This chapter contains procedures for maintaining optimal caliper function or troubleshooting issues with the sensor.

ATTENTION

Activity Numbers that appear in the Task description tables are for use of the sensor diagnostics display only and do not reflect model numbers for the tasks. To determine whether the Task applies to your sensor, check **Applicable Models**.

If a value in the Task description table is blank, that means it is not applicable to that task.

## 8.1. Clean Buttons

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-001 | **Applicable Models:** | All |
| **Type of procedure:** | Maintain | **Expertise Level:** | Operator |
| **Priority Level:** | Average | **Cautions:** | High Temperature |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 day |
| **Duration (time period):** | 5 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Kerosene, paper towel or rag | | |

CAUTION

If the operating temperature is extreme, wait 30-60 seconds before cleaning to allow the buttons to cool down. Otherwise, cracking can occur (see Prevent Button Cracking).

CAUTION

Never use anything other than kerosene to clean the caliper buttons or you may damage the rubber bellow material resulting in premature failure. If the mill does not permit kerosene, please ask your Honeywell service representative for a suitable substitute.

Precise caliper measurement requires clean buttons. Dirty buttons can affect the measurement, the way the sensor rides on the sheet, and also makes the sensor more sensitive to alignment effects.

1. If necessary, manually clean the upper and lower caliper buttons with kerosene and a rag.
2. If scraping is required, care must be taken not to damage either the bellows or the buttons.

If the caliper has extreme build-up or is in a situation where manual cleaning is no longer adequate:

- Try increasing the actuation pressure to initiate self-cleaning through sheet friction.
- Consider a different caliper configuration with lower friction. Honeywell Engineering can help to find a configuration that best suits your needs.

# 8.2. Inspect Bellows

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-002 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 week |
| **Duration (time period):** | 10 minutes | **# of People Required:** | 1 |

| | | | |
|---|---|---|---|
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Flashlight | | |

Inspect the caliper bellows:

1. Disconnect the air to the sensor.
2. Split the heads.
3. Pull the buttons away from the caliper barrel to get a clear view of the bellow surface.
4. Look for any signs of holes or slicing in the bellows.

If a hole is found, the caliper sensor may not actuate or retract properly and could cause measurement issues or further damage to the sensor. Replace this barrel assembly (See Remove Caliper Barrel)

Bellow failure can also be a result of:

- A dirty vacuum pump (See Clean Vacuum Pump) that prevents the arm from fully retracting into the barrel assembly.
- Plugged air-vent (See Clean Air Vent) that prevents the Venturi from working properly and prevents the arm from fully retracting into the barrel assembly.
- Low air pressure (See Check Air Pressure)
- Excessive sheet movement that allows the sheet edge to nick the bellows as the sensor come off-sheet. Have the caliper sensor retract earlier in these situations.

| | |
|---|---|
| CAUTION | Never use anything other than kerosene to clean the caliper buttons or you may damage the rubber bellow material, resulting in premature failure. |

# 8.3. Inspect Buttons for Damage or Wear

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-003 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 week |
| **Duration (time period):** | 10 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

1. Split the scanner heads and inspect the caliper buttons for signs of wear.
2. If you are experiencing measurement issues and significant wear is present, replace the barrel assembly (See Remove Caliper Barrel) and see if the measurement instability goes away.

# 8.4. Inspect Caliper Retraction

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-004 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Operator |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 week |
| **Duration (time period):** | 10 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |

| | Part Number | Quantity | Lead Time |
|---|---|---|---|
| **Required Parts:** | | | |
| **Required Tools:** | | | |

1. During standardize and when the caliper is not actuated, ensure that both upper and lower caliper arms fully retract into the caliper barrel.

   If not, this can be due to a number of reasons:

   - Bellows Failure (See Inspect Bellows)
   - A dirty vacuum pump (See Clean Vacuum Pump) that prevents the arm from fully retracting into the barrel assembly.
   - Plugged air-vent (See Clean Air Vent) that prevents the Venturi from working properly and prevents the arm from fully retracting into the barrel assembly.
   - Low air pressure (See Check Air Pressure)

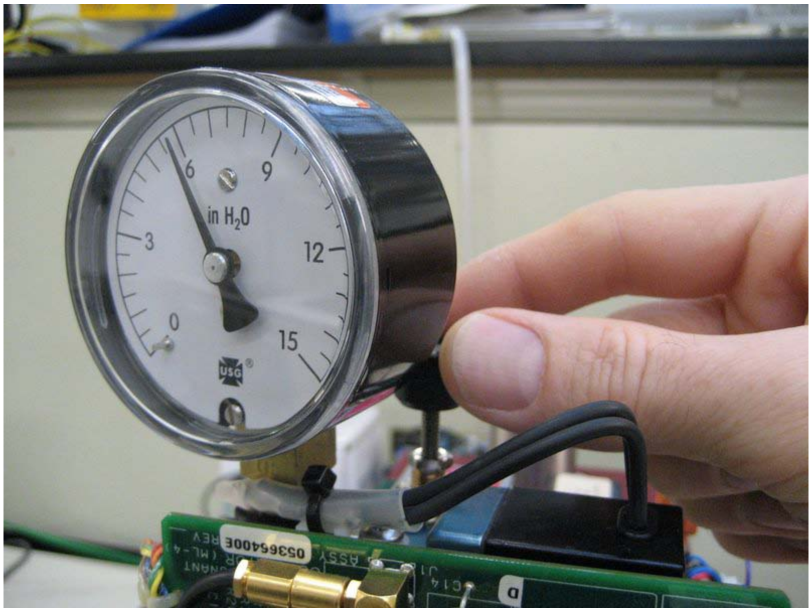
# 8.5. Check Button Alignment

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-005 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Medium | **Cautions:** | |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 month |
| **Duration (time period):** | 10 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Allan Keys | | |

1. Using the sensor diagnostic frames of the system, set up for a Caliper **SAMPLE**.

2. Press the **SAMPLE** button.

3. Check that the actuation pressure on the upper dial gauge still reads the desired value.

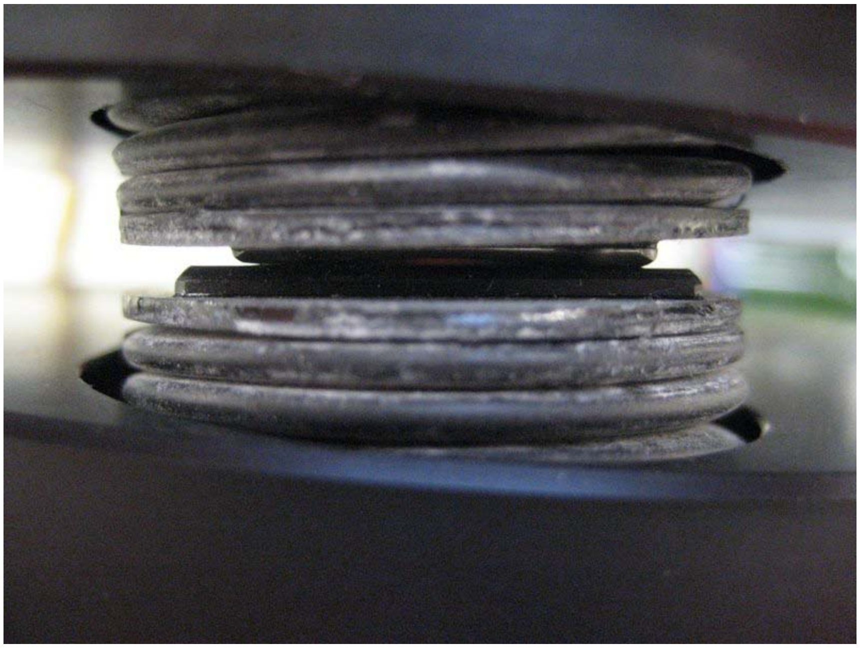


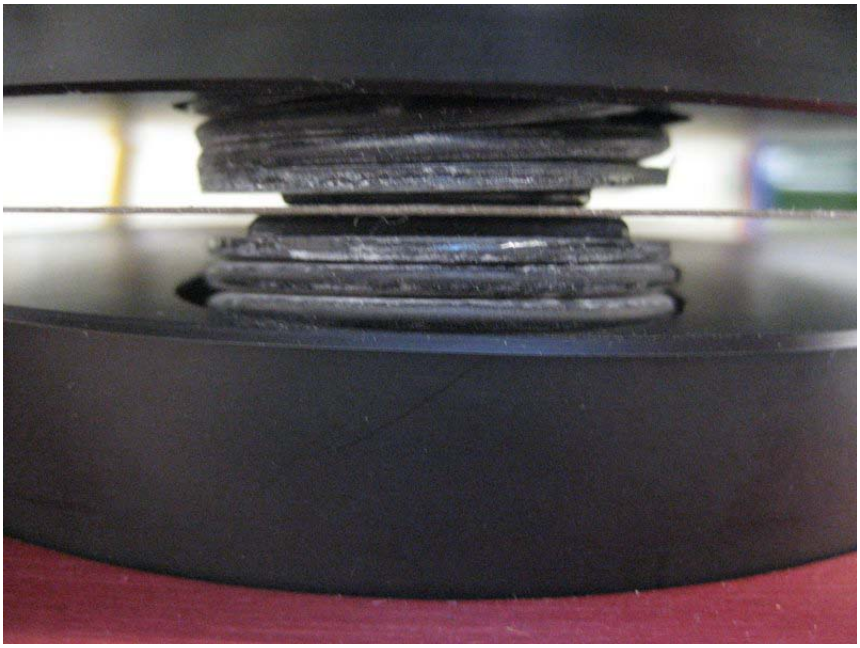

4. Check that the sensing elements meet squarely in the middle of the gap.

5. Visually inspect the sensor elements. Ensure the elements are aligned directly on top of one another. If not, loosen the four mounting screws that fasten the caliper assembly to the sensor plate and rotate the upper sensor assembly until they are properly aligned.

   The bellows may angle a bit in order to ensure the elements are aligned properly. Once paper is in the gap, the bellows align themselves accordingly.

   Lateral misalignment of the buttons by more than a millimeter or two can result in caliper profiles that are highly sensitive to scanner misalignment.





6. In rare cases when the misalignment is severe and/or scanner re-alignment is not possible, it may be necessary to re-position the Mylar arms at their pivot point by de-clamping the arm and opening up the two mounting holes. Re-position the arm accordingly to correct for misalignment. This is only possible in the case of Unifoil caliper sensor barrel assemblies.

7. When alignment is complete, re-tighten securing screws on the upper caliper sensor.

8. Using a sheet of stiff material, again press the **SAMPLE** button with the sheet inserted. While raising and lowering the sheet, observe that for every movement of the upper bellows, the lower bellows extend or retract and follow the movement.

9. Adjust the air pressure to increase or decrease pressure as required. Ideally when on sheet, both buttons should touch the sheet, but without sufficient pressure to score it.

ATTENTION

It is crucial that the nuts be tightened on the regulators after the pressure has been set to prevent the pressure from drifting or becoming unstable.

# 8.6. Clean Air Vent

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-006 | **Applicable Models:** | All |
| **Type of procedure:** | Maintain | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 1 month |
| **Duration (time period):** | 30 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |

| | Part Number | Quantity | Lead Time |
|---|---|---|---|
| | | | |
| **Required Tools:** | Wire (type up to judgment of technician)<br>High pressure air | | |

1. Check the air vent on the upper and lower barrels to ensure they are not plugged with process material.

   If plugged, air will not exhaust properly and could compromise the retraction of the caliper arm.

2. Try to clear the hole by using a stiff wire. If that is not sufficient, remove the caliper barrel (See Remove Caliper Barrel) and use a wire and high pressure air to clear this hole of debris.

# 8.7. Clean Vacuum Pump

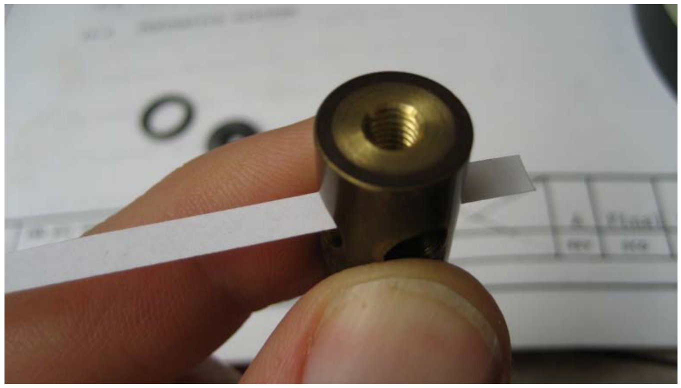
| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-007 | **Applicable Models:** | All |
| **Type of procedure:** | Maintain | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | 6 months |
| **Duration (time period):** | 1 hour | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | Remove Caliper Barrel | | |
| **Post Procedures:** | | | |

| | Part Number | Quantity | Lead Time |
|---|---|---|---|
| **Required Parts:** | | | |
| **Required Tools:** | Small flat screw driver<br>Piece of copy paper<br>Scissors | | |

1. Remove the upper/lower barrel assembly.
2. The pump is located in the middle of the assembly as shown. There is a locking ring that needs to be removed first.

3. Once the locking ring is removed, there is a black washer and a rubber seal that can be popped out using a screw driver. The vacuum assembly can subsequently be removed. Be sure to remember the orientation of the vacuum when it is removed for proper re-install.

4. Clean the vacuum assembly with a piece of regular copy paper pulled through the narrow opening of the pump. If hard build-up is present, it may be necessary to soak it in a warm soapy solution to get clean.



5. Re-install the pump into the sensor following the reverse steps. Make sure you install the vacuum tube in the same orientation as it was removed.

# 8.8. Check Air Pressure

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-008 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

Low air pressure can have a negative effect on sensor retraction since the vacuum produced by the vacuum pump depends entirely on line pressure.

The air for the caliper sensor is fed down the power track. The pressure in this hose must be 40 psi to assure proper sensor actuation and retraction. Typically the air is supplied through a regulator/filter unit located near the scanner.

1. Check the line-pressure on the regulator gauge near the scanner. Ensure it is set to a level equal to or above 40PSI.

2. Long hose lengths can lead to pressure drops that also can adversely affect sensor operation. Confirm that 40PSI is reaching the inlet air line for the caliper sensor.

3. Sharing the caliper air in the head with other uses can lead to pressure problems. Ensure that air-splitting has not caused caliper air pressure to go below 40PSI.

# 8.9. Diagnose Electrical Issues

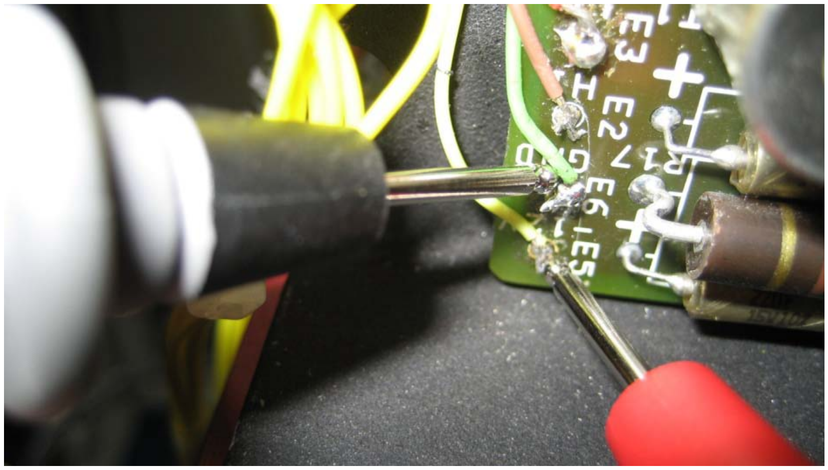
| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-009 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | Electric Shock |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 30 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Multimeter with probes<br>Oscilloscope with Frequency Measurement | | |

1. Check that all electrical connector are correctly placed and securely fastened.

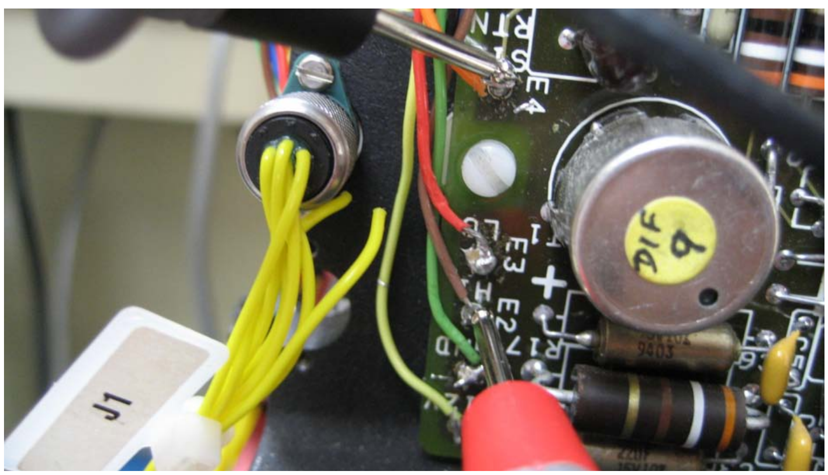
2. Make sure that the W1 jumper is installed on the EDAQ boards corresponding to the caliper sensor.

   For additional information about EDAQ replacement and troubleshooting, refer to Experion MX MSS and EDAQ Data Acquisition manual 6510020381.

3. Check -12V DC power to the caliper oscillator board (test points are labeled on the PCB, see graphic).



4. Measure output signal from caliper (HI and SIG RTN, see graphic). With the sensor fully retracted, the waveform should a reasonably clean square wave with a frequency of 200 kHz nominally. Excessive noise or distortion (ringing) may cause false triggering or missed counts.



5. With the sensor extended and buttons touching, the waveform should be a reasonably clean square wave with a frequency of 50 kHz nominally for bare ferrite sensors; a significantly higher frequency for a sapphire-coated lower button.

6. The frequency stability of the sensor can be verified by running successive references and checking the S parameter stability. S is the ratio of time-zero open counts to open counts at last standardize. This number must be stable to within 0.3% or better, but may differ slightly from 1.000 if the oscillator PCB has been changed.

7. In case of erratic S values, the typical cause is either an unstable oscillator PCB or damaged Litz wire (See Diagnose Litz Wire Failure) in the upper element. The latter problem is generally observable in the caliper signal on a scope when the upper arm is moved about manually.

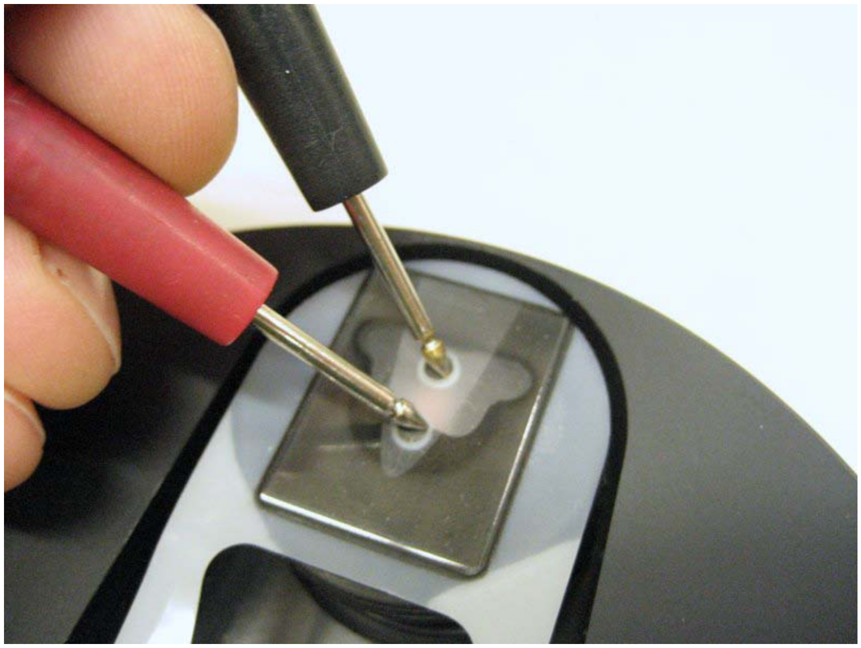
# 8.10. Diagnose U-Core Cracking

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-010 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Multimeter with probes | | |

The contacting caliper has a maximum ambient temperature of 100 deg C when the gauge is located within a temperature-controlled sensor enclosure. High temperature could cause the U-core in the upper button to crack, which usually manifests itself as a sloping profile seen when coming on-sheet after a sheet break.

The U-core surfaces must be very clean in order for a reliable resistance measurement to be made.

1. Suspected cracks in the U-core can normally be verified by splitting the heads and measuring the resistance between the ends of the two round pole pieces of the upper arm's U-core. The ferrite material is slightly conductive and in the absence of microfractures the resistance between the poles should be less than about 15 K-ohm, as measured with moderate but not excessive pressure on the poles with the ohmmeter probes (Pressing too hard with the probes can tend to force the crack together and make the resistance look lower than it truly is).



2. A resistance higher than 15 K-ohm (in particular, infinite resistance) indicates damage to the U-core, requiring replacement of the upper barrel.

# 8.11. Minimize Edge Effects

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-011 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

Insufficient actuation pressure, particularly on fast-moving sheets or on sheets with excessive flutter or edge curl can cause measurement errors.

1. Open the upper scanner head and while the sensor is actuated increase the actuation pressure. Ensure the buttons are properly centered at the new actuation pressure.
2. Test the sensor to see if the edge effects subside. If not, continue to increase the actuation pressure accordingly. Be sure not to exceed 10" H20 for soft bellow assemblies, and 12" H20 for hard-bellow assemblies.

**CAUTION** Increasing the actuation pressure can lead to sheet tearing in some situations.

3. If actuation pressure cannot compensate for edge effects, contact TAC for additional advice on mechanically stabilizing the edge of the sheet.

# 8.12. Minimize Measurement Spikes

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-012 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

Measurement spikes can occur at some sites if the sensor elements are bounced out of contact with the sheet by a major wrinkle or other sheet upset. These may be infrequent and very brief occurrences, but may take a long time to filter out of the filtered profile - a small bounce of 1 mil or 25 microns is a huge effect compared to the 1 - 2 micron true thickness variability. Until the spike filters away, it can cause problems in CD control.

1. To help prevent this kind of measurement problem, it is wise to enter limits on the accepted caliper reading. Even fairly wide limits -- 15 microns on either side of nominal - can prevent spikes from occurring, without risk of suppressing good readings.

2. Make sure that the W1 jumper is installed on the EDAQ boards corresponding to the caliper sensor.

3. In extreme cases, the use of external sheet stabilizers may also be used to reduce sheet movement and greatly reduce the chances of spike conditions arising. Sheet stabilizers are particularly useful for light sensor actuation pressures. Contact TAC for more information.

4. Sheet static can also cause changes in caliper readings. Consider using a grounded caliper assembly and/or installing static eliminators if you suspect static is a problem.

# 8.13. Minimize High Caliper Readings

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-013 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | Average | **Cautions:** | None |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

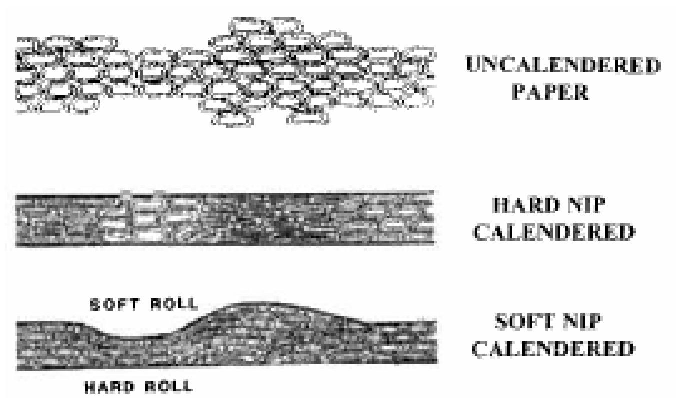
Soft-nip calendaring can be a problem for accurate caliper measurement. High basis weight areas in a sheet pass through a soft-nip calendar without being crushed and become visible as thickness variations (as opposed to hard-nip calendaring where basis weight variations also become density variations – see graphic after step 2).

High frequency changes in thickness can result in the caliper flying over the peaks of a soft-nip calendered sheet resulting in high readings. The amount of flying will depend on local basis weight variations.

The lab typically reads lower than the field caliper in these instances because the actuation pressure of a lab caliper gauge is much higher than what is done on-sheet.

1. Try increasing the actuation pressure of the caliper sensor to overcome this effect.

2. Add an offset into the caliper measurement to correct mean offset errors.




# 8.14. Prevent Button Cracking

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-014 | **Applicable Models:** | All |
| **Type of procedure:** | Maintain | **Expertise Level:** | Control Engineer |
| **Priority Level:** | High | **Cautions:** | None |
| **Availability Required:** | Sensor Offline | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |

| | | | |
|---|---|---|---|
| **Duration (time period):** | 15 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | | | |

In almost all cases, cracking of the lower ferrite button is due to thermal shock. The caliper sensor heats up to sheet temperature and is then cooled down by room temperature kerosene. If you have this configuration, there are a few options.

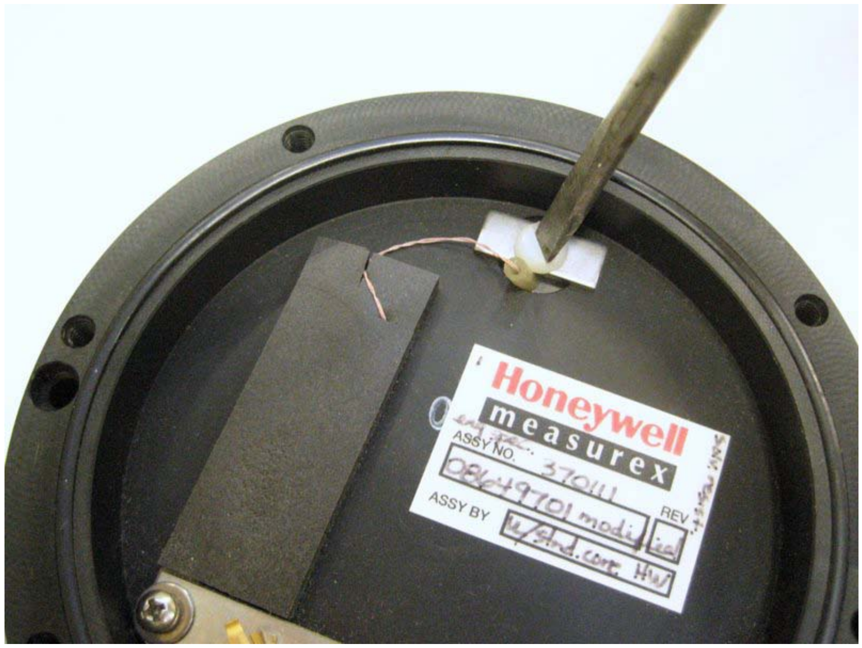
1. Add a delay between when the caliper comes off sheet and when the cleaning process begins. 30 to 60 seconds is normally sufficient.
2. In some instances, it may be necessary to heat the cleaning solution to reduce the thermal shock on the ceramic ferrite. Kerosene has a very low flash point and cannot be heated. Instead, use Safety-Kleen Premium Gold Solvent. It has a flash point of 140° F.

# 8.15. Diagnose Litz Wire Failure

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-015 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 45 minutes | **# of People Required:** | 1 |
| **Prerequisite Procedures:** | Remove Caliper Barrel | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Phillips screw-driver | | |

Occasionally the Litz wire that connects the U-core in the upper arm to the electrical terminals in the barrel which feed the oscillator PCB become damaged due to stripping of insulation, mishandling, or breakage. This can lead to caliper errors or catastrophic failure.

1. Remove the barrel from the upper assembly (See Remove Caliper Barrel).
2. Carefully remove the retainer ring that fastens the bellow to the barrel. Then remove the retainer ring from the bellow, being careful not to kink or damage the Litz wire in the process.


Honeywell
measurex
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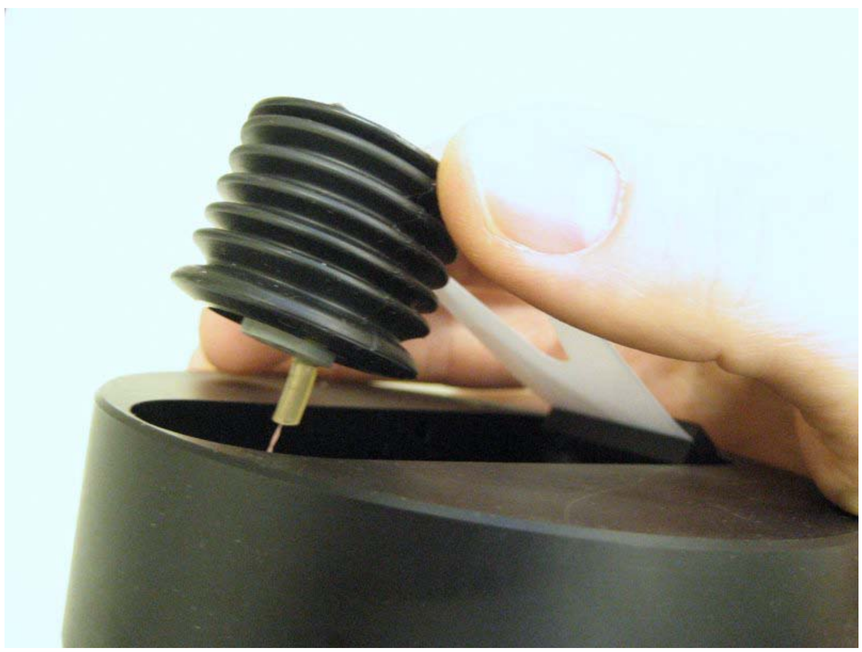


3. Inspect the litz wire inside the barrel from the point it connects to the U-core inside the bellow to the other end that connects to the terminal mounted inside the barrel. Look for signs of breakage or stripping of insulation.

4. If damage or wear is found, replace the barrel assembly accordingly.

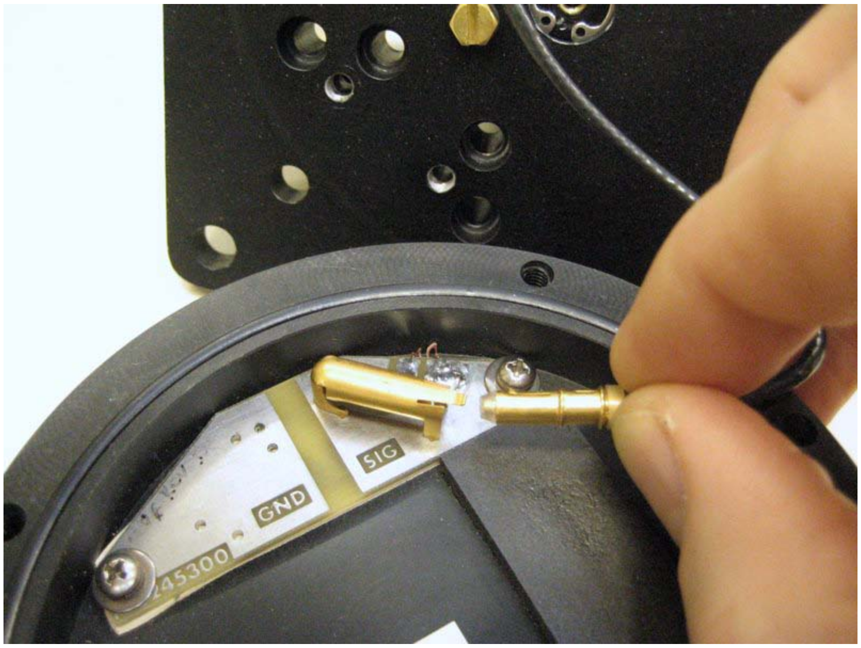
# 8.16. Remove Caliper Barrel

| | | | |
|---|---|---|---|
| **Activity Number:** | Q4290-61-ACT-016 | **Applicable Models:** | All |
| **Type of procedure:** | Inspect | **Expertise Level:** | Technician |
| **Priority Level:** | High | **Cautions:** | |
| **Availability Required:** | Scanner Offsheet | **Reminder Lead Time:** | |
| **Overdue Grace Period:** | | **Frequency (time period):** | |
| **Duration (time period):** | 30 minutes | **# of People Required:** | 1 |

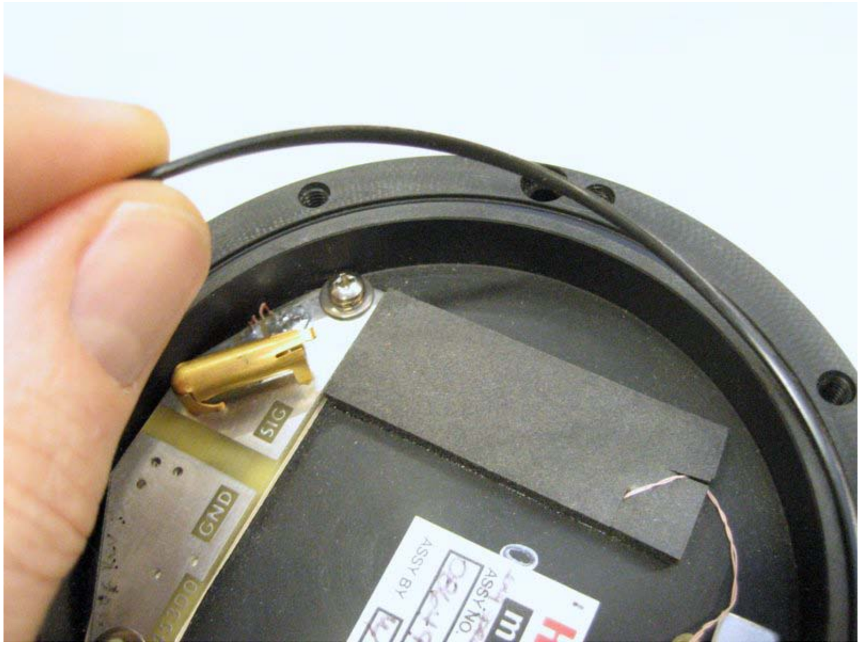
| | | | |
|---|---|---|---|
| **Prerequisite Procedures:** | | | |
| **Post Procedures:** | | | |
| | Part Number | Quantity | Lead Time |
| **Required Parts:** | | | |
| **Required Tools:** | Allen Keys<br>Phillips Screwdriver | | |

1. Remove the four bolts that hold the barrel assembly to the actuator chassis.

2. Disconnect the barrel's electrical connector (upper barrel only).




3. Replace with a new barrel, ensuring that the O-ring is properly seated around the circumference of the barrel.



# 9. Troubleshooting

In this chapter, possible issues with the Caliper Measurement Sensor are divided into two sections:

- Alarm-based – troubleshooting steps to be taken in response to a specific alarm generated in the Experion MX system.
- Non-alarm based – troubleshooting steps that may not be related to a specific alarm in the Experion MX system.

## 9.1. Alarm based troubleshooting

Depending on your system's configuration, your Experion MX system may only display some of these alarms.

### 9.1.1. Now Value Too High

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Caliper reading exceeds the user-defined upper limit (Caliper UL)** | Physical effects caused by the paper | (solutions are in descending order of probability)<br><br>Minimize Measurement Spikes |
| | | Minimize Edge Effects |
| | | Minimize High Caliper Readings |
| | Build-up of dirt on buttons | Clean Buttons |
| | Failure of a component | Inspect Bellows |

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| | | Check Button Alignment |
| | | Inspect Buttons for Damage or Wear |
| | | Prevent Button Cracking |

## 9.1.2. Now Value Too Low

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Caliper readings are below the user-defined lower limit (Caliper LL).** | Electrical Issue | Diagnose Electrical Issues |

## 9.1.3. S Corrector Factor Too Low

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Ratio of open counts to those at time-zero is above the user-defined limit (S ULimit)** | Electrical Issue | Diagnose Electrical Issues |

## 9.1.4. S Corrector Factor Too High

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Ratio of open counts to those at time-zero is below the user-defined limit (S LLimit)** | Electrical Issue | Diagnose Electrical Issues |

### 9.1.5. Crud Too High

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Crud has exceeded the user-defined upper limit (Crud Limit)** | Build-up of dirt on buttons | Clean Buttons |

### 9.1.6. Crud drift Too High

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Rate of change of crud between successive standardizes exceeds the user-defined upper limit (Delta Crud Limit)** | Build-up of dirt on buttons | Clean Buttons |

### 9.1.7. Bad Input

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Bad input error** | This error is generated when the frequency signal from the caliper sensor is outside of expected range (no frequency signal or signal above 250 kHz). | Diagnose Electrical Issues |

## 9.2. Non-alarm based troubleshooting

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Bellows Failure** | Bellows Has Failed | Inspect Bellows |
| | Lack of External Air Pressure | Check Air Pressure |
| | Dirty Vacuum Pump | Clean Vacuum Pump |
| | Plugged Air-Vent | Clean Air Vent |
| | Improper Cleaning | Clean Buttons |
| | Edge Effects | Minimize Edge Effects |

| Symptom | Possible Cause(s) | Solution (Tasks) |
|---|---|---|
| **Upper or lower arm fails to actuate properly** | Low air pressure | Check Air Pressure |
| | Dirty Vacuum Pump | Clean Vacuum Pump |
| | Plugged Air Vent | Clean Air Vent |
| | Electrical Issue | Diagnose Electrical Issues |
| **Sensor counts appear to be incorrect** | Bad Oscillator PCB | Diagnose Electrical Issues |
| **Bad Caliper Profile** | Button Alignment | Check Button Alignment |
| | Dirt Build-up on the buttons | Clean Buttons |
| | Scanner Misalignment | Check Button Alignment |
| | Damaged or Worn Buttons | Inspect Buttons for Damage or Wear |
| | Excessive Sheet Movement | Minimize Edge Effects |
| | Exceeding Operating Temperature | Diagnose U-Core Cracking |
| | Insufficient Actuation Pressure | Minimize Edge Effects |
| | Electrical Issues | Diagnose Electrical Issues |
| | Spikes in Profile | Minimize Measurement Spikes |
| | Soft-Nip Calendering | Minimize High Caliper Readings |
| | Litz Wire Fatigue | Diagnose Litz Wire Failure |
| **Button Cracks** | Thermal Shock | Prevent Button Cracking |
| **Sheet Tearing** | High Actuation Pressure | Minimize Edge Effects |
| | Wrong Caliper Type | Contact TAC |
| | Softer Lead-in | Contact TAC |

# 10. Storage, Transportation, End of Life

## 10.1. Storage and transportation environment

In order to maintain integrity of sensor components, storage and transportation of all equipment must be within these parameters:

| Duration of Storage | Acceptable Temperature Range | Acceptable Humidity Range |
|---|---|---|
| Short Term<br>(less than one week) | -20°C to 45°C | 20-90% non-condensing |
| Long Term | -10°C to 40°C | 20-90% non-condensing |

## 10.2. Disposal

Honeywell supports the environmentally conscious disposal of its products when they reach end of life or when components are replaced.

All equipment should be reused, recycled or disposed of in accordance with local environmental requirements or guidelines.

This product may be returned to the Honeywell manufacturing location, and it will be disposed using environmental friendly methods. Contact the factory for further details and instructions.

Except where identified within this section, the scanner does not contain hazardous or restricted materials.

Guidelines for disposal of equipment by Honeywell or the customer for scanner-specific materials are:

### 10.2.1. Solid materials

- Remove all non-metallic parts (except plastic) from the sensor and dispose through the local refuse system. Recycle plastic parts.
- Wire and cabling should be removed and recycled; the copper may have value as scrap.
- Electrical and electronic components (for example, solder, circuit boards, batteries, and oil-filled capacitors) should be recycled or handled as special waste to prevent them from being put in a landfill, as there is potential for lead and other metals leaching into the ground and water.
- Metals should be recycled, and in many cases have value as scrap.

### 10.2.2. Disposal of radioactive sources

- Contact Radiological operations and they will advise and facilitate safe disposal.

## 10.3. Storing radioactive sources

If a sensor containing a radioactive source has to be stored for a period of time before it can be mounted on the scanner, it must be placed in an area to which access is controlled by licensed personnel. This generally means that the sensor head must be stored in a locked room or cabinet. If such storage will be for a period of weeks or months, arrangements often can be made to have Honeywell store the sensor. Contact Honeywell Radiological Operations. The main contact numbers for Radiological Operations are

First level of support:

- The Americas, Asia Pacific and India are supported directly by Phoenix at 602-313-3330.
- Europe, Middle East and Africa are supported by Waterford at + 353 (0) 51 372 151.

Second level of support (world-wide) is Phoenix at 602-313-3330. Phoenix also has a toll-free number for the U.S. and Canada at 866-811-0312.

WARNING

While in storage, a shipping shield must be bolted to each sensor head containing a radioactive source.

# 11. Glossary

| | |
|---|---|
| **Actuator** | Mechanical or electronic device that performs the control action in a control loop. |
| **ASD** | **Automatic Shutdown** |
| **Back Side** | See **Drive Side**. |
| **Cable End** | Location of the electronics and/or the entry point for communications and power on the scanner. |
| **Cable end** | Formed steel channel welded to the upper and lower box beams at the cable end. |
| **CD** | **Cross Direction** |
| | Used to refer to those properties of a process measurement or control device that are determined by its position along a line that runs across the paper machine. The Cross Direction is transverse to the MD (Machine Direction) that relates to a position along the length of the paper machine. |
| **O-frame** | The O-shaped metal support for the sensor head. |
| **Code**<br>**Code Name** | See **Recipe**. Alternately, another name for alloy. |
| **Experion MX** | A Quality Control System. |
| **Distant End** | The end of the scanner opposite the Cable End. |
| **Drive Side (DS)** | The side of the paper machine where the main motor drives are located. Cabling is routed from this end. Also called **Back Side**. |

| | |
|---|---|
| **DSR** | **Data Storage and Retrieval**<br>A mechanism provided in RAE for storing recipe- or grade-dependent data, such as tuning, calibration and setup values, and retrieving them when a recipe is loaded. The recipe- or grade-dependent data are saved to a database known as the Recipes database. |
| **Front Side** | See **Tending Side**. |
| **Gauge** | Sheet thickness |
| **MD** | **Machine Direction**<br>The direction in which paper travels down the paper machine. |
| **MIS** | **Management Information System**<br>A mechanism provided in RAE to accumulate and manipulate production data, and to generate reports for mill wide management. |
| **QCS** | **Quality Control System**<br>A computer system that manages the quality of the product produced. |
| **RAE** | **Real-Time Application Environment**<br>The system software used by the QCS to manage data exchange between applications. |
| **Recipe** | A list of pulp chemicals, additives, and dyes blended together to make a particular grade of paper. |
| **RTDR** | **Real-Time Data Repository**<br>The database managed by RAE to store system data and data for individual applications. |
| **Sensor Set** | The term used in the Sensor Maintenance displays to describe a set of sensors working together on a scanner to perform one measurement. |
| **Setpoint (SP)** | Target value (desired value). Setpoints are defined process values that can be modified by entering new values through the monitor, loading grade data, and changing a supervisory target. |

**Target** A screen area that is available for the user to make a selection or to enter data (RMPCT displays).

or

A numeric value that specifies a desired product quality.

**Target Profile** The desired absolute CD profile in CD bin resolution a sheet property should be controlled to.

**Tending Side (TS)** The side of the paper machine where the operator has unobstructed access. Also called **Front Side**.

**VIO** **Virtual Input/Output**

# A. Caliper Types

## A.1. Round button

The round-button caliper is the oldest version of this sensor and was released in the 1980s (see Figure A-1). It is identified by a round button attached to a metal arm (or ski). The U-core is always oriented in the machine direction (MD).

**Figure A-1 Upper Round-Button Caliper**

When ordering this caliper assembly, there are several options available.

## A.1.1. Bellow Type

Several different materials for rubber bellow exist.

**NITRILE** is the standard rubber material for contacting caliper. It works in the majority of applications. Nitrile bellows are offered in both soft and hard versions.

**EPDM** is made of a slightly softer rubber than the current Nitrile material. EPDM bellows are recommended for mills that notice their current bellows getting hard and/or brittle in certain instances, eventually leading to cracking and/or the creation of holes. EPDM bellows are offered in both soft and hard versions and can operate up to a temperature of 120 deg C.

**HNBR** is a new material that has a greater resistance to chemical exposure compared to EPDM or the Nitrile material. The rubber is slightly stiffer than the current bellow. HBNR bellows are only offered in the soft version. Expect a soft HNBR bellow to behave like a HARD bellow made from the current Nitrile material.

## A.1.2. Ferrite or Ferrite/Sapphire

In cases of high abrasive wear, it is possible to construct the lower ferrite button with a protective covering. The Q4293-54 and Q4293-55 have 0.02" of sapphire on top, Q4293-58 and Q4293-59 have 0.01" of sapphire on top. While the covering can greatly reduce abrasive damage, it also reduces the measurement resolution (by about a factor of 6 at 3 mils product thickness (when 0.01" of sapphire is used), in comparison to bare ferrite.

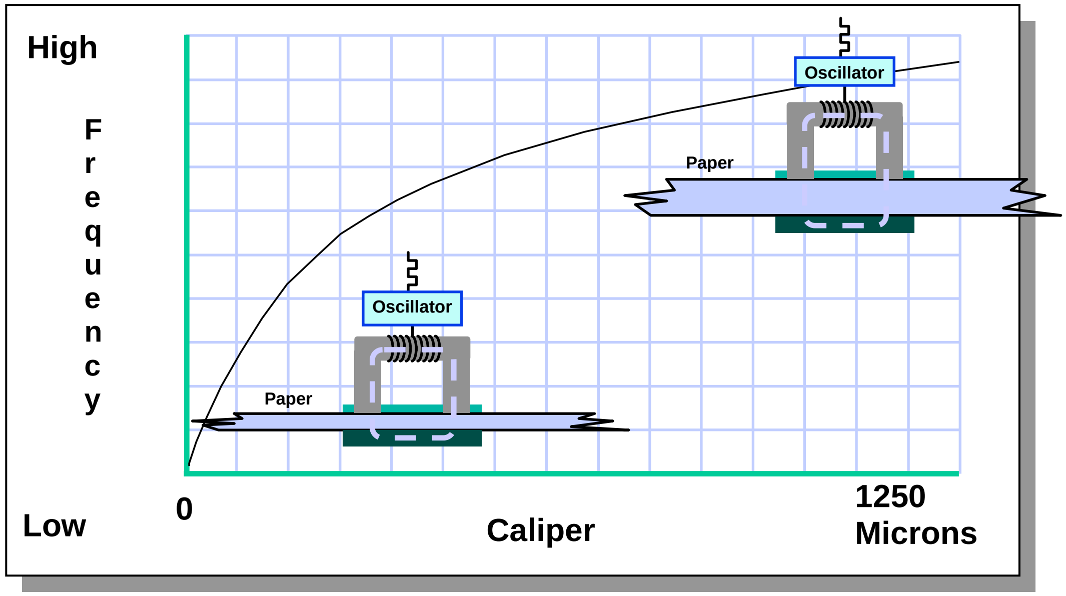



**Figure A-2 Caliper Sensitivity versus Thickness**

# A.1.3. Protector ring

In some variations of the round-button caliper there is a protector ring on the arm assembly that helps shield the bellows from situations where the paper may come in contact and be damaged due to sheet curl or other perturbations.

**Figure A-3 Round-button lower caliper barrel with protector ring**

## A.1.4. Fixed upper

In a small subset of applications you may prefer a fixed upper assembly in which there is no arm or bellow (Figure A-4). This type of configuration is normally applied to heavy board recycled products. If you order a Model Q4293-58 sensor, the upper button is fixed rather than actuated and the lower arm can be actuated at much higher pressures than for the standard sensor as it contains a higher pressure regulator and a high pressure gauge. Large actuation pressure is used to self clean the buttons.

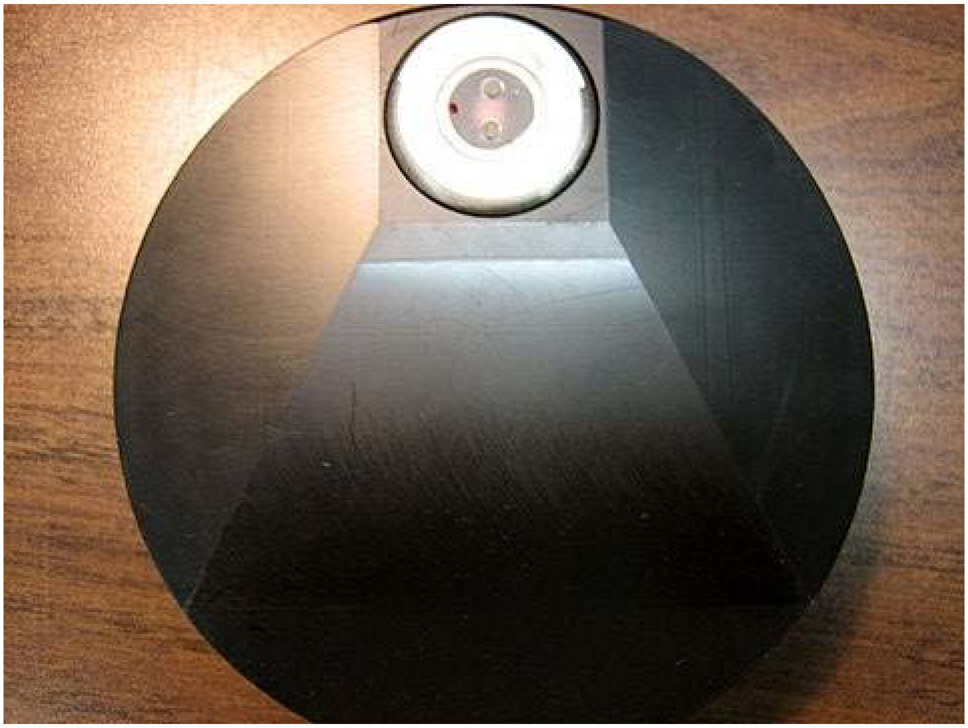


**Figure A-4 Fixed round-button barrel assembly (upper)**

# A.2. Unifoil

The caliper sensors in the Unifoil family are similar in most respects to the round-button caliper sensor, differing chiefly in the shape of the contacting buttons and the construction of the arms.

Whereas the contacting buttons of earlier caliper sensors are round, the Unifoil buttons are more rectangular or wedge-shaped, so as to minimize the possibility of sheet damage.

The upper Unifoil button has an aerodynamic groove machined into its downstream portion to reduce the flying effect of boundary layer air carried along by the sheet. Whereas earlier round-button caliper arms were made of stainless steel, the arms which hold the contacting Unifoil buttons in place are constructed of light, flexible, and resilient mylar.

The pulse train output of the Unifoil sensors is identical to previous caliper sensors, as are the calibration equations, computer algorithms, and software frames used by the operator. The physical footprint of the sensors is also unchanged, allowing a Unifoil caliper barrel to serve as a direct replacement to earlier round-button designs.

**Figure A-5 Unifoil Caliper Barrel (Upper)**

When ordering this caliper assembly, there are several options available.

## A.2.1. Bellow Type

The options for bellow type are the same as for the round-button caliper. See Section A.1.1.

## A.2.2. Ferrite or Ferrite/Sapphire

In cases of high abrasive wear, it is possible to construct the lower ferrite button with a protective covering of 0.010" thick sapphire. The Q4290-63, Q4290-64, Q4290-67, and Q4290-68 sensors have this sapphire protection. While the covering can greatly reduce abrasive damage, it also reduces the measurement resolution (by about a factor of 6 at 3 mils product thickness, in comparison to a bare ferrite with a CD U-core upper button) and can somewhat increase the measurement sensitivity to relative xy movement of the heads as they scan.

## A.2.3. MD or CD U-core orientation

Models Q4290-61 through Q4290-64 utilize an upper button in which the U-core is oriented in the cross direction (CD). The Q4290-65 through Q4290-68 utilize an upper button in which the U-core is oriented in the machine direction (MD), inside the aerodynamic groove. In the latter case, the pole pieces are slightly recessed so as to be flush with the surface of the groove -- about 0.005" or so. The recessed pole pieces lead to a reduction in measurement resolution (by about a factor of 3 at 3 mils product thickness, assuming a bare lower ferrite) but the fact that the pole pieces no longer reach the sheet results in a smoother button surface. This can reduce the chances of both buildup and sheet damage.

- CD U-core orientation has the highest sensitivity for caliper measurement. It is also slightly more sensitive to XY misalignment (due to the poles being close to the edge of the lower button) and slightly more susceptible to buildup and sheet damage due to the exposed pole pieces.

- MD U-core orientation have the poles recessed inside the aerodynamic groove of the button. This reduces measurement sensitivity by a factor of three, but is less sensitive to XY misalignment, buildup, and sheet damage.

In most case, CD U-core orientation is preferred, due to its higher sensitivity.

# A.3. Released specials

There are a number of released caliper specials that have been developed to address unique field issues.

## A.3.1. Grounded Upper Caliper Barrel (Unifoil)

The grounded upper caliper barrel is used for applications where static at the sheet is affecting the caliper measurement. A precursor to using this gauge is to implement proper static drain wires up sheet from the scanner. If these static drains do not eliminate the caliper measurement issue, then a grounded caliper barrel may help.

The grounded barrel attaches a Litz wire from the U-core electrical windings to a small spring loaded stainless steel ball that is located on the outer circumference of the barrel (see Figure A-6). This ball makes contact with the scanner sheet guide and provides a grounding path for the U-core.

ATTENTION

Shave off the anodization on the sheet guide where the ball plunger comes in contact. Anodization acts as an electrical insulator and the grounding will not work.

**Figure A-6 Grounded Caliper Barrel with spring loaded ball bearing (upper)**

## A.3.2. Diamonex Coated Lower Ferrite Button (Unifoil)

For applications where extreme buildup is an issue, a Diamonex-coated lower button assembly is available (upper buttons are always sapphire). This coating is only several microns thick. While it offers a lower coefficient of friction and a slightly higher hardness rating compared to sapphire, it will not last nearly as long when measuring abrasive product. Figure A-7 illustrates the relative hardness of bare ferrite, sapphire, and Diamonex.

- Diamonex-coated assemblies are ideal for non-abrasive products where buildup is an issue.
- Both hard and soft bellow options are available.

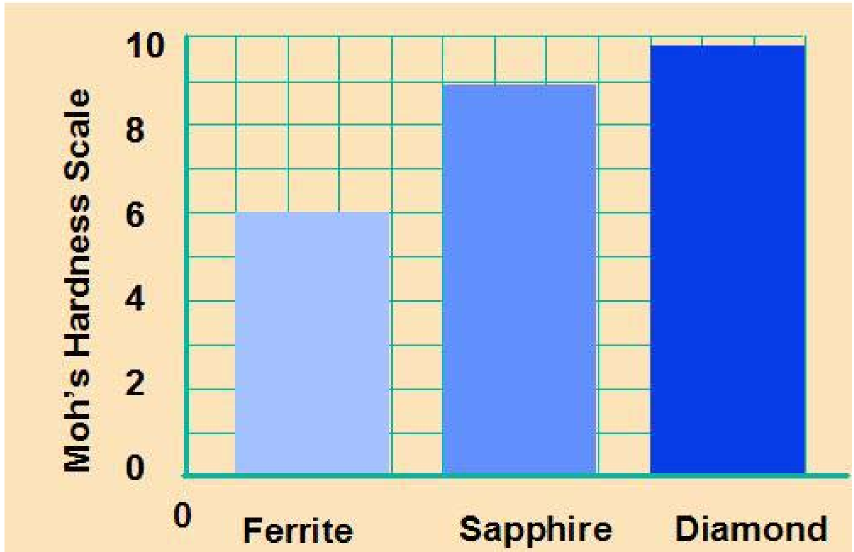



**Figure A-7 Hardness of Ferrite, Sapphire, and Diamonex**

## A.3.3. Aluminum Oxide (Unifoil)

Aluminum oxide is the same composition as sapphire which accounts for its high hardness, wear resistance, and chemical resistance. It also boasts a very smooth surface which has proven to be better than sapphire in certain applications where wear or build-up is an issue. It is the same thickness (0.010”) as the sapphire version of the caliper arm and so the level of sensitivity reduction is equivalent. It is used on the lower ferrite button as a substitute for sapphire.

## A.3.4. Tunnel Caliper (Round Button)

The tunnel caliper has a very light touch and is designed for delicate sheets. It is a round-button caliper with oversized button and soft lead-in, along with a plastic interface between the arm and the bellow (see Figure A-8, item 9) that has an aerodynamic tunnel to provide stability. The disadvantage is that in some instances the caliper is so light it gives erroneous readings. This is not a good option other than for exceptional circumstances. The plastic tunnel interface is available in both the upper and lower arm assemblies.

To further lessen the impact onsheet you have the option of a U-core assembly in which the poles are flush with the sapphire surface, or to have the U-core recessed 0.010" (sapphire covers the U-core poles) that provides a uniform and smooth sapphire surface on the upper button to minimize sheet damage and dirt build up. In most cases, a recessed version of this assembly is recommended.

Hard bellow is the only option for this special.

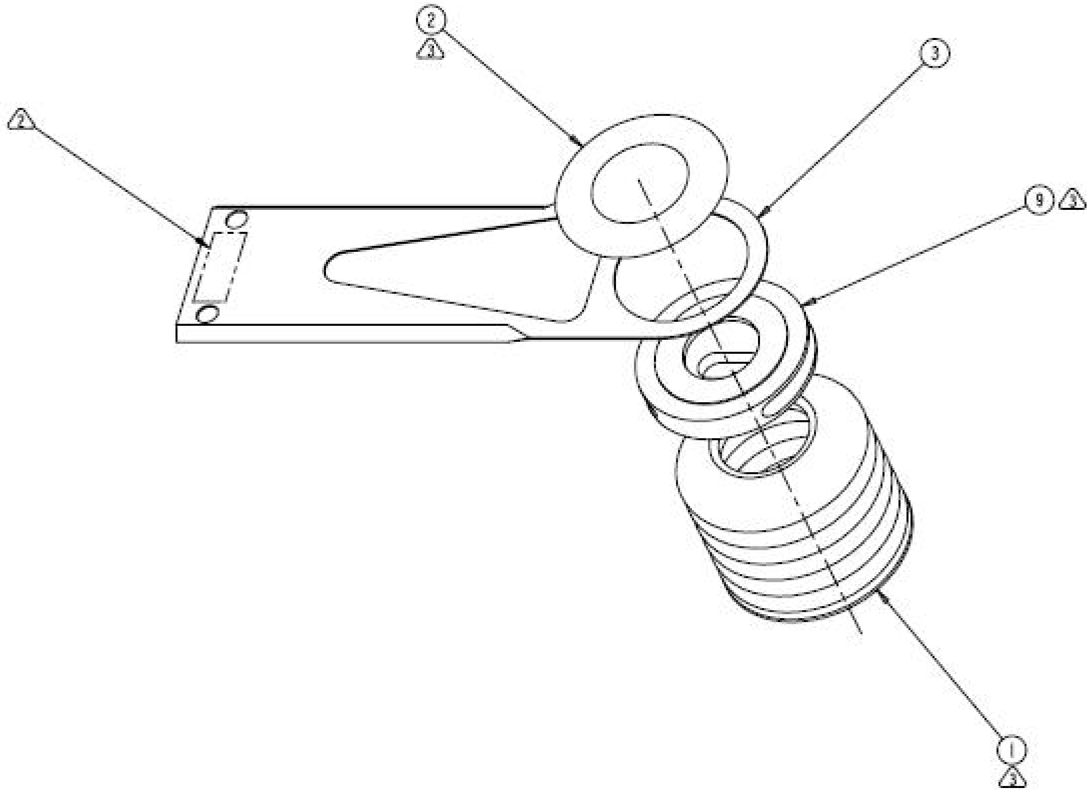



**Figure A-8 Arm assembly for a tunnel caliper**

# A.3.5. Fastback Caliper (Modified Round-Button)

The fastback caliper is used to minimize buildup on the sensor surface and is designed to operate at high pressures on recycled Kraft product. It has a smaller button area and modified shape that aids in the self cleaning of the buttons, especially when dirt tails begin to build upstream of the caliper button.

Both recessed and flush U-core versions are available (same option as the Tunnel caliper). This can only be used with hard bellows and the recessed U-core option is almost always preferred. Figure A-9 illustrates the specially-designed button shape for this assembly.

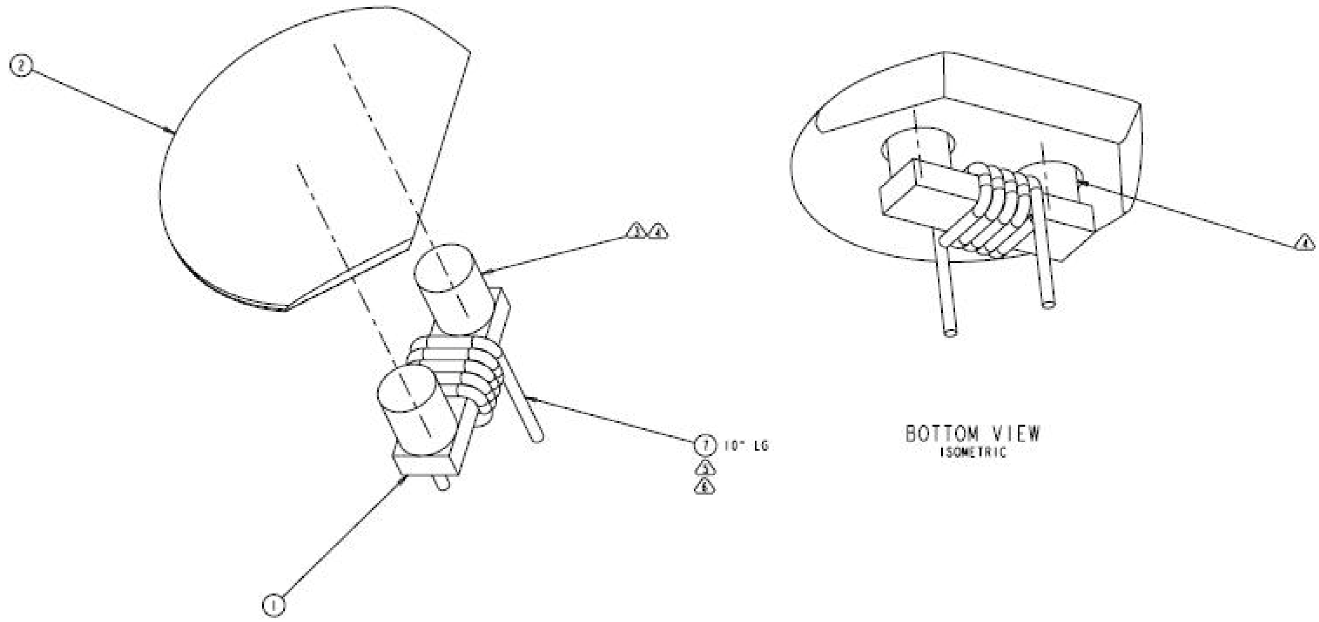



**Figure A-9 Fastback caliper button design**

# A.4. Applications

## A.4.1. General Purpose

The Q4293-60 sensor is optimized for responsiveness and high resolution . The Q4293-60 has been successfully used in a very wide range of applications from newsprint to fine paper to board. If the sheet is not overly fragile and does not present a high risk of buildup or abrasion, the Q4293-60 is the sensor of choice among all the caliper sensors.

If abrasion is an issue, the more rugged Q4293-59 may be preferable as it uses a sapphire/ferrite lower button and hard bellows.

## A.4.2. High Pressure

For recycled products of sufficient strength (typically 5 mil or thicker kraft products), the high pressure sensor Q4293-58 is recommended over the Q4293-59 because it can often provide an improved level of self-cleaning.

The Q4293-58 high pressure sensor is designed to provide high-precision, reliable caliper measurement on recycled products whose strength will permit the measurement buttons to contact the sheet at relatively high pressure (> 1 psi). The high pressure assists in self-cleaning the contacting buttons.

The Q4293-58 is similar in most respects to earlier versions of the caliper sensor, differing chiefly in the nature of the actuation mechanics and the pressure at which the sensor is operated. All other caliper sensors have contacting buttons that are actuated from both sides of the sheet, whereas for the high pressure caliper only the lower button is actuated. The upper button for the Q4293-58 is fixed on a dome protruding to the center of the gap. Actuation pressures for other caliper sensors are typically below 10 inches of water (0.36 psi) whereas the high pressure caliper is typically run at > 1 psi in order to take advantage of the self-cleaning action.

The contacting buttons of the Q4293-58 are identical to those of the Q4293-59 round-button sensor, with the lower ferrite having a 10-mil protective coating of sapphire. The button holder for the fixed upper button has a special shape which assists in resisting buildup from recycle products.

## A.4.3. Delicate Sheet

For very light or delicate sheets, the Unifoil sensors Q4290-61 through Q4290-68 are preferred. The Unifoil sensors are more gentle to the sheet than the Q4293-60 or Q4293-59 sensors, but the Unifoil sensors have a larger contacting footprint and are also somewhat more fragile in operation.

As of this writing, the Unifoil sensor with by far the largest field population is the Q4290-61 (CD U-core, soft bellows, no sapphire protection of lower ferrite). It provides the optimum in measurement resolution and its soft bellows provides the most delicate response at low actuation pressures. In the absence of other information, the Q4290-61 is the best choice for most delicate sheet applications. However, over the years experience has been gained with other members of the Unifoil family in varied situations and the choice of another member of the Unifoil family can reasonably be made if the application of interest is nearly identical to one for which a successful track record exists with another member.

Examples:

Sites with high abrasion would be well advised to use sapphire-protected lower buttons. The sacrifices with sapphire are in measurement resolution -- which is rarely an issue in practice -- and in a somewhat increased sensitivity to relative x-y movement of the heads.

For sites where experience has shown that actuation pressures of  greater than 6 - to 8 inches is best, the hard bellows versions can show less tendency to tilt when offsheet for static calibration or dirt correction. They are also more rugged than the soft bellows. The hard bellows are somewhat heavier and stiffer, however, and will show slightly more inertia.

Several newsprint sites have reported a slightly improved performance with the MD U-core Unifoil in cases where corrugation effects are a problem. Also, some sites have reported slightly improved resistance to buildup and to sheet damage with this configuration. Again, the sacrifice is in somewhat decreased measurement resolution, especially in situations where the lower ferrite is sapphire-protected.

# B. Part Numbers

## B.1. Round-Button Caliper

| Q Model # | Legacy # | Description | Upper Caliper Assy | Lower Caliper Assy | Upper Barrel | Lower Barrel | Upper Button | Lower Button |
|---|---|---|---|---|---|---|---|---|
| Q4293-52 | 092213-02 | General Purpose<br>- Hard Bellows<br>- No Sapphire (lower) | 08388901 | 08389001 | 08505102 | 08505103 | 08346800 | 08345400 |
| Q4293-54 | 092213-04 | General Purpose<br>- Hard Bellows<br>- 0.02" Sapphire (lower) | 08388901 | 08436700 | 08505102 | 08505105 | 08346800 | 08435700 |
| Q4293-55 | 092213-05 | - Hard Bellows<br>- 0.02" Sapphire (lower)<br>- Protect Ring (upper / lower) | 08436400 | 08436500 | 08505107 | 08505106 | 08435400 | 08435500 |
| Q4293-58 | 092213-08 | High Pressure Caliper<br>- Fixed Upper<br>- Protect ring (lower)<br>- Hard Bellows (lower)<br>- 0.01" Sapphire (lower) | 08500301 | 08650800 | 08500501 | 08543100 | 08500601 | 08543200 |
| Q4293-59 | 092213-09 | General Purpose<br>- Protect Ring (upper / lower)<br>- Hard Bellows (upper / lower)<br>- 0.01" Sapphire (lower) | 08542600 | 08543000 | 08542800 | 08543100 | 08542900 | 08543200 |
| Q4293-60 | 092213-10 | General Purpose<br>- Soft Bellows (upper / lower)<br>- No Sapphire (lower) | 08542601 | 08389000 | 08505100 | 08505101 | 08346800 | 08345400 |

Note: The part numbers in the columns labeled Upper and Lower caliper will include all the actuation, electronics, air regulators, and mounting chassis for that upper or lower assembly. To order the entire sensor (both upper and lower) you would use the "Sensor" part number Q42XX-XX.
Note: When ordering the lower or upper round button assemblies, you don't receive the metal arm. You need to order an entire barrel assembly to get this.

# B.2. Unifoil Caliper

| Q Model # | Legacy # | Description | Upper Caliper Assy | Lower Caliper Assy | Upper Barrel | Lower Barrel | Upper Arm | Lower Arm |
|---|---|---|---|---|---|---|---|---|
| Q4290-61 | 092213-11 | General Purpose<br>- Soft Bellows (upper / lower)<br>- No Sapphire (lower)<br>- CD U-Core | 08542602 | 08543001 | 08713500 | 08713200 | 08713700 | 08713100 |
| Q4290-62 | 092213-12 | General Purpose<br>- Hard Bellows (upper / lower)<br>- No Sapphire (lower)<br>- CD U-Core | 08542603 | 08543004 | 08713501 | 08713201 | 08713701 | 08713101 |
| Q4290-63 | 092213-13 | General Purpose<br>- Soft Bellows (upper / lower)<br>- 0.01” sapphire (lower)<br>- CD U-Core | 08542602 | 08543003 | 08713500 | 08713202 | 08713700 | 08713102 |
| Q4290-64 | 092213-14 | General Purpose<br>- Hard Bellows (upper / lower)<br>- 0.01” sapphire (lower)<br>- CD U-Core | 08542603 | 08543002 | 08713501 | 08713203 | 08713701 | 08713103 |
| Q4290-65 | 092213-15 | General Purpose<br>- Soft Bellows (upper / lower)<br>- No sapphire (lower)<br>- MD U-Core | 08649900 | 08543001 | 08713600 | 08713200 | 08713800 | 08713100 |
| Q4290-66 | 092213-16 | General Purpose<br>- Hard Bellows (upper / lower)<br>- No sapphire (lower)<br>- MD U-Core | 08649901 | 08543004 | 08713601 | 08713201 | 08713801 | 08713101 |
| Q4290-67 | 092213-17 | General Purpose<br>- Soft Bellows (upper / lower)<br>- 0.01” sapphire (lower)<br>- MD U-Core | 08649900 | 08543003 | 08713600 | 08713202 | 08713800 | 08713102 |
| Q4290-68 | 092213-18 | General Purpose<br>- Hard Bellows (upper / lower)<br>- 0.01” sapphire (lower)<br>- MD U-Core | 08649901 | 08543002 | 08713601 | 08713203 | 08713801 | 08713103 |
| Q4290-70 | 092213-20 | General purpose caliper actuator pair. | - | - | - | - | - | - |

# B.3. Released Specials

| Sensor | Description | Upper Barrel | Lower Barrel | Upper Arm | Lower Arm | Application |
|---|---|---|---|---|---|---|
| Unifoil | Grounded Upper Barrel<br>- CD U-Core<br>- Soft Bellows | 08713502 | | 08737200 | | Static Issues |
| Unifoil | Grounded Upper Barrel<br>- CD U-Core<br>- Hard Bellows | 08713503 | | 08737201 | | Static Issues |
| Unifoil | Grounded Upper Barrel<br>- MD U-Core<br>- Soft bellows | 08713602 | | 08737300 | | Static Issues |
| Unifoil | Grounded Upper Barrel<br>- MD U-Core<br>- Hard Bellows | 08713603 | | 08737301 | | Static Issues |
| Round Button | Grounded Upper Barrel<br>U-Core Flush<br>Soft Bellows | 08759000 | | 08758900 | | Static Issues |
| Round Button | Grounded Upper Barrel<br>U-Core Flush<br>Hard Bellows | 08759001 | | 08758901 | | Static Issues |
| Round Button | Grounded Upper Barrel<br>U-Core Recessed<br>Soft Bellows | 08759002 | | 08758902 | | Static Issues |
| Round Button | Grounded Upper Barrel<br>U-Core Recessed<br>Hard Bellows | 08759003 | | 08758903 | | Static Issues |
| | | | | | | |
| Unifoil | Diamonex Coated Lwr<br>- Soft Bellows | | 08713204 | | 08713104 | Extreme Buildup<br>Non Abrasive Sheet |
| Unifoil | Diamonex Coated Lwr<br>- Hard Bellows | | 08713205 | | 08713105 | Extreme Buildup<br>Non Abrasive Sheet |
| | | | | | | |
| Unifoil | 0.10” Aluminum Oxide / Ferrite Lower, Soft Bellows<br>(like 08713102) | | | | 6581800177 | High Abrasion Resistance, Low Friction/Buildup |
| Unifoil | 0.10” Aluminum Oxide / Ferrite Lower, Hard Bellows<br>(like 08713103) | | | | 6581800178 | High Abrasion Resistance, Low Friction/Buildup |
| | | | | | | |
| Round Button | Fixed Lower<br>- No Sapphire | | 08741101 | | 08741001 | - Reduction in tearing (when used with upper tunnel caliper).<br>- Normal |

| Sensor | Description | Upper Barrel | Lower Barrel | Upper Arm | Lower Arm | Application |
|---|---|---|---|---|---|---|
| | | | | | | Conifguration |
| Round Button | Fixed Lower<br>- 0.01" Sapphire | | 08741100 | | 08741000 | - Reduction in tearing (when used with upper tunnel caliper).<br>- Rare Configuration |
| | | | | | | |
| Round Button | Tunnel Caliper<br>- Hard Bellows<br>- No Sapphire (Lower)<br>- U-Core Recessed | 08738800 | 08738600 | 08738700 | 08738500 | - Light Touch<br>- Delicate Sheet<br>- Normal Configuration |
| Round Button | Tunnel Caliper<br>- Hard Bellows<br>- No Sapphire (Lower)<br>- U-Core Flush | 08738801 | | 08738701 | | - Light Touch<br>- Delicate Sheet<br>- Rare Configuration |
| | | | | | | |
| Modified Round | Fastback Caliper<br>- Hard Bellows<br>- 0.01" sapphire (lower)<br>- U-Core Recessed | 08740900 | 08740500 | 08740800 | 08740300 | - Recycled Kraft<br>- Normal Configuration |
| Modified Round | Fastback Caliper<br>- Hard Bellows<br>- No Sapphire (lower)<br>- U-Core Flush | 08740901 | 08740501 | 08740801 | 08740301 | - Dirt Tails, Build Up<br>- Recycled Kraft<br>- Normal configuration |
| | | | | | | |
| Unifoil | - 08713502 upper barrel with soft HNBR<br>- 08737200 upper arm with soft HNBR | 6581800125 | | 6581800109 | | Bellow Failures |
| Unifoil | - 08713502 upper barrel with soft EPDM<br>- 08737200 upper arm with soft EPDM | 6581800124 | | 6581800120 | | Bellow Failures |
| Unifoil | 08713102 lower arm with soft HNBR bellow | | | | 6581800110 | Bellow Failures |
| Unifoil | 08713102 lower arm with soft EPDM bellow | | | | 6581800122 | Bellow Failures |
| Unifoil | 08713104 lower arm with soft HNBR bellow | | | | 6581800119 | Bellow Failures |
| Unifoil | 08713104 lower arm with soft EPDM bellow | | | | 6581800121 | Bellow Failures |
| Unifoil | - 08713602 upper barrel with soft HNBR<br>- 08737300 upper arm with soft HNBR | 6581800111 | | 6581800112 | | Bellow Failures |
| Unifoil | - 08713602 upper barrel with soft EPDM<br>- 08737300 upper arm with soft EPDM | 6581800115 | | 6581800116 | | Bellow Failures |

| Sensor | Description | Upper Barrel | Lower Barrel | Upper Arm | Lower Arm | Application |
|---|---|---|---|---|---|---|
| Unifoil | - 08713500 upper barrel with soft HNBR<br>- 08713700 upper arm with soft HNBR | 6581800113 | | 6581800114 | | Bellow Failures |
| Unifoil | - 08713500 upper barrel with soft EPDM<br>- 08713700 upper arm with soft EPDM | 6581800117 | | 6581800118 | | Bellow Failures |
| Unifoil | - 08713601 upper barrel with hard EPDM<br>- 08713801 upper arm with hard EPDM | 6581800126 | | 6581800123 | | Bellow Failures |
| Unifoil | - 08713100 lower arm with soft HNBR | | | | 6581800131 | Bellow Failures |
| Unifoil | - 08713100 lower arm with soft EPDM | | | | 6581800132 | Bellow Failures |
| Unifoil | - 08737201 GND Upper Hard EPDM | | | 6581800179 | | |
| Unifoil | - 08713103 Lower with Hard EPDM | | | | 6581800180 | |

# B.4. Spare Parts

| Part Name | Part Number | Description |
|---|---|---|
| Oscillator PCB | 05366400 | Oscillator PBC for the upper caliper assembly |
| Solenoid Valve | 22000052 | Located on the the caliper chassis and used for directing air between actuation and retraction mechanisms. |
| Pressure Regulator | 07388000 | Pressure Regulator (0-5 PSI) |
| Pressure Regulator Gasket | 00309500 | Sealing the pressure regulator stem to the caliper chassis |
| Vacuum Pump | 61000195 | Venture vaccum pump centered in the middle of the caliper chassis |
| O-Ring (4.5”) | 00285800 | O-Ring for sealing chassis to scanner head |
| O-Ring (3.75”) | 25000082 | O-Ring for sealing caliper barrel to caliper chassis |
| Pneumatic Plug | 61000231 |  |
| #10-32 Cap Socket Screw | 28110039 | For mounting caliper chassis to scanner head |
| Flat Washer | 28310001 | For mounting caliper chassis to scanner head |
| Lock Washer | 28310004 | For mounting caliper chassis to scanner head |
| #8-32 x 0.75 Screw | 28108032 | For mounting caliper barrel to caliper chassis. |
| Shoulder Washer | 28308011 | For mounting caliper barrel to caliper chassis. |
| Lock Washer | 28308002 | For mounting caliper barrel to caliper chassis. |
| Flat Washer | 28308001 | For mounting caliper barrel to caliper chassis. |
| Pressure Gauge | 61000289 | Gauge for measuring air pressure during caliper actuation |
| 4-40x0.37 Nylon Screws | 28104054 | For attaching upper caliper OSC PCB to actuator assembly |
| 1/4” Flat Washers | 28316003 | For attaching upper caliper OSC PCB to actuator assembly |
| #8 Insulating Shoulder Washers | 28308011 | For attaching upper caliper OSC PCB to actuator assembly |
| Solenoid Control Cable Assembly | 08639700 | One of two cables attached to upper caliper assembly |
| Oscillator PCB Cable Assembly (Experion MX) | 08639801 | For attaching the Oscillator PCB in the upper caliper assembly |
| Oscillator PCB Cable Assembly (4000 Series) | 08639800 | For attaching the Oscillator PCB in the upper caliper assembly |
| Solenoid Control Cable | 08639700 | Cable attached to the lower caliper assembly |