Basis Weight Measurement

System Manual

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Basis Weight Measurement

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Introduction

The purpose of this manual is to provide an introduction to the operation, installation, calibration, and maintenance of the Experion Basis Weight Measurement.

This version of the manual covers the Basis Weight Measurement for Source 6 (Sx 6), Source 9 (Sx 9), and Source 12 (Sx 12) model numbers:

- Q2201-72 (Sx 6)
- Q2201-73 (Sx 6)
- Q4201-62 (Sx 9)
- Q4201-63 (Sx 9)
- Q4201-64 (Sx 9)
- Q4202-50 (Sx 12)

Audience

This manual is intended for use by engineers or process engineers 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 sixteen chapters and an appendix.

Chapter 1, **System Overview**, describes Basis Weight Measurement and its system components.

Chapter 2, **Radiation Safety and Interlocks**, describes the safety components of Basis Weight Measurement.

Chapter 3, **EDAQ**, describes the principles and operation of the Ethernet Data Acquisition (EDAQ) board.

Chapter 4, **Installation**, describes the installation and set up tasks for the sensor.

Chapter 5, **Topography Procedures**, describes the topography procedure required for the Q4201-10 model Source 9 sensor.

Chapter 6, **Model Q4201-XX Operations and Calibration Constants**, describes typical calibration and provides correction constants for the Source 9 sensors.

Chapter 7, **Model Q4202-50 Operations and Calibration Constants**, describes typical calibration and provides correction constants for the Source 12 sensor.

Chapter 8, **Model Q2201-XX Operations and Calibration Constants**, describes typical calibration and provides correction constants for the Source 6 sensor.

Chapter 9, **Static Calibration**, describes calibration and verification procedures.

Chapter 10, **Basis Weight Calibration Details**, describes the various operations available to the nuclear sensor, and corrections that can be applied to the raw reading.

Chapter 11, **Air Gap Sensors**, describes the operation and maintenance of the air gap sensors.

Chapter 12, **Preventive Maintenance**, describes a schedule for recommended ongoing maintenance tasks.

Chapter 13, **Tasks**, describes procedures for maintenance, diagnostic, and troubleshooting tasks.

Chapter 14, **Troubleshooting**, describes symptoms, alarms, possible causes, and links to associated diagnostic or troubleshooting tasks.

Chapter 15, **Storage, Transportation, End of Life**, describes methods for storing, transporting and disposing of sensor components.

Chapter 16, **Glossary**, describes the terms and acronyms used in this manual.

Appendix A, **Part Numbers**, lists the part numbers for basis weight model assemblies and their components

Related Reading

The following documents contain related reading material.

Honeywell Part Number	Document Title / Description
6510020381	*Experion MX MSS and EDAQ Data Acquisition System Manual*
6510020197	*Radiation Safety Manual For Honeywell Customers*

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. 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. 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: **`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. System Overview

This chapter provides an overview of the operation of Basis Weight Measurement in the Q4000 scanner.

1.1. Sensor models and nomenclature

The are several types of weight sensors because each one is optimized for a particular type of product, a particular basis weight, and ash range.

Table 1-1 shows the Basis weight sensors currently released, and their range of applicability.

Table 1-1 Basis Weight Measurement Ranges

	Pm147 4201-10	Kr85 4201-62	Kr85 4201-63	Kr85 4201-64	Pm-147 4202-50	Sr90 2201-72	Sr90 2201-73
Basis Weight Range: **g/m^2 (lbs/3000 ft^2)**	2–200 (1.2–120)	140–1200 (85–730)	8–1200 (5–730)	20–1000 (12–610)	2-250 (1.2 -140)	80-7200 (49–4425)	170–3500 (85–2150)
Sheet Ash Range	Any	< 5%	2–20%	> 20%	Any	Small	Medium
Head Gap	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)	19 mm (0.75 in)

Ash refers to inorganic additives, or fillers, with higher atomic numbers than the hydrocarbons in paper and plastics. Commonly used fillers are TiO_2, clay, talc, and $CaCO_3$.

With the introduction of Experion MX a new set of model numbers were allocated for the sensor assemblies (see Table 1-2).

Table 1-2 Model Numbers

Experion MX Model Number	Da Vinci/MXProLine Model Number
Q4201-62	094201-12
Q4201-63	094201-13
Q4201-64	094201-14
To be determined	094201-10
Q4202-50	094202-0X
Q2201-72	092201-22
Q2201-73	092201-23

The Q2201-XX series are *Source 6* (Sx-6), which refers to the development series number.

Similarly, the Q4201-XX series are the Source 9 (Sx 9).

The Q4202-XX series sensors are the Source 12 (Sx 12).

1.2. General Principles of Basis Weight Measurement

This chapter covers the physical principles of operation of basis weight sensors that use beta emitting sources.

Beta particles are electrons that are emitted from atomic nuclei during nuclear decay. Once they have left the nucleus they may be thought of as an electron beam as found in the cathode ray tube used in older model televisions or computer monitors. Beta particles are not of a single energy but are emitted at a continuum of energies up to a maximum value. This maximum value is dependent on the type of capsule used. The more energetic the beta energy, the more penetrating it is and can therefore be used for heavier products.

The most commonly used capsules, in order of increasing maximum energy, are Promethium-147 (Pm-147), Krypton-85 (Kr-85), and Strontium-90 (Sr-90), where the number signifies the particular isotope used. The emitted beta particles may be scattered from the sheet, may be absorbed by the sheet, or may lose energy in the sheet. The betas that make it through the sheet and into the receiver enter an ionization chamber. This is a detector with a small current (approximately 1 nanoampere) output proportional to:

(the average energy of the betas) × (number of betas per second)

The current from the ion chamber goes through a short lead to a detector amplifier with an output that is an analog voltage on the order of 1–8 V. This signal is sent to an electronic circuit and is read by a computer that averages the signal for some prescribed time interval. Then, using stored algorithms, the software converts the average signal to a calculated basis weight of the product.

The basic physical principle used in the basis weight sensor is: As the basis weight of the sheet increases, the signal at the ionization chamber decreases in a prescribed manner.

A principal advantage of using beta emitters as sources for basis weight sensors is that beta particles are absorbed nearly uniformly by all substances: The absorption is dependent on the basis weight and not on color, texture, state of matter, or other factors. However, the air in between the source capsule and the ionization chamber, as well as any debris that may accumulate on the windows of the heads, will absorb beta particles just like the product being measured. Therefore, several correctors need to be applied in order to maintain the required accuracy of the sensor.

The correctors account for:

- debris (dirt) build-up on the heads
- changes in air density due to air temperature changes
- changes in the height of the air column due to changes in head separation (Z)
- any difference in absorption properties between the Mylar® calibration standard and the customer product (known as the KCM)
- any sensitivity of the sensor due to head misalignment in the machine direction or cross direction (profile correction)

- any change in the product in-between the area that the sensor measures the product and the area where the sample is taken for dynamic correlation, referred to as the Dynamic Offset Basis Weight (BWDO).

  An example of BWDO would be if the sheet were under tension during the manufacturing process but was allowed to relax after taking a sheet as a dynamic sample. If the sheet stretched online, a dynamic offset would be added to account for this fact.

Another very important attribute of basis weight sensors is that because the nuclear decay process is statistical, the sensor reading always has some random noise component. This may be reduced by either increasing the beta ray flux, or by averaging the signal for longer time periods

Increasing the flux is one of the main goals of the beta gauge designer. The sensor measurement always contains a random noise level that may only be reduced for a given set of hardware by increasing the amount of time that the signal is averaged. For example, whenever the sensor stability specification is given it is always given for some prescribed integration (averaging) time interval.

Sensor stability improves by the square root of the number of particles emitted, which in turn implies that it depends on the square root of the integration time (assuming all the noise comes from nuclear statistics, rather than air density changes or other factors). For example, the sensor will be about twice as stable when integrating for four seconds as when integrating for one second. This noise is present in all measurements made by the basis weight sensor, including standardization, reference, sample, and onsheet measurements.

The same random noise calculation also applies to source half-life. Because a single half-life period implies half the radioactive material is remaining, the source will now produce half the number of particles in a given period. This means the noise will increase by only the square root of 2 (~1.41) after one half-life.

Random error is commonly expressed using a concept known as *sigma*. Sigma is a property of a group of numbers, and is computed by means of a standard algorithm. For a randomly varying quantity (such as the measured basis weight of a sample, or the flag-to-air (F/A) ratio), 68% of the numbers (results of the measurements) lie within ± 1 sigma of the mean, 95% lie within ± 2 sigma of the mean, 99.5% of the numbers lie within ± 3 sigma of the mean, and so on. Sigma can be defined as a measure of how tightly grouped, or repeatable, the group of numbers is.

1.3. Basis Weight Correctors

There are two general approaches to handling external influences on the sensor:

- modify the hardware to minimize the effect of the external influence on the sensor
- measure the quantity doing the influencing and make a correction in software

Both approaches, individually and in combination, are used:

- ash in the sheet is an example of modifying the hardware
- air temperature is an example of measuring the quantity
- X-Y head alignment sensitivity is an example of both approaches being used

1.3.1. Ash

Basis weight sensors using beta ray attenuation are inherently sensitive to higher atomic number additives (ash). This sensitivity may be reduced significantly by the design of the compensator. However, reducing this sensitivity in general has other effects on the sensor such as changing the usable basis weight range and sensor repeatability so that the sensor family has a model which is optimized for the parameters of a particular product.

Sensitivity to ash is commonly expressed as the percentage of measured basis weight change for a 1% change in ash loading.

The ideal sensor would have a sensitivity to ash of 0/% change in ash. Ash would have absorption characteristics exactly like that of paper (no change from paper). Insensitivity to ash is a key attribute of the sensor in order to have a single grade group for all products. There is no correction made in software for ash.

1.3.1.1. Ash-insensitive Models

The different models of the gauge have different ash sensitivities. There is an inherent trade off between the highest measurable basis weight range, the gauge repeatability, and the ash insensitivity. For that reason, high-ash insensitive models (such as Q4201-64) should be selected only if the variation in ash between grades is large. Ash sensitivity is a complex function of the type of ash and the basis weight that is measured-there is no single figure describing the measurement error obtained when, for example, changing the amount of ash from 5% to 10%. Ash insensitivity is controlled by the type of compensator, usually a plastic disk or honeycomb structure, located in front of the basis weight receiver ion chamber.

1.3.2. Dirt

Dirt, as used here, means any change in mass between the source and receiver from one standardization to the next. For example:

- debris on the source or receiver window
- change in air density due to air temperature or pressure changes
- change in window mass due to window replacement

Changes in air temperature in between standardizations (onsheet) are handled by means of the air temperature correction, not the dirt correction. Updating the air counts will make a linear dirt correction, but this still leaves non-linear dirt effects, which can be quite large. Non-linear dirt effects are handled by a Honeywell patented dirt correction technique.

A quantity called DFRAC (dirt fraction) is computed at each standardize or reference and depends on:

- F/Alast (last flag-to-air measurement)
- T0FA (flag-to-air at scanner maintenance or installation)
- T0CF (change in F/A ratio when known dirt is inserted)

The first quantity is the F/A ratio at the last standardize. The T0FA is the F/A value obtained at calibration (when the scanner was presumably clean). The T0CF value is the change in F/A expected when the amount of dirt in the gap equals that of the dirt Mylar inserted during the dirty calibration (see Chapter 8).

DFRAC determines whether the clean calibration curve is used (DFRAC = 0) or the dirty calibration curve (DFRAC = 1) or some fraction thereof (0 < DFRAC < 1). The best way to understand DFRAC is through an example (see Table 1-3).

Table 1-3 DFRAC

If	Then
If F/Alast = T0FA	then DFRAC = 0.0
If F/Alast = (T0FA + T0CF)	then DFRAC = 1.0

ATTENTION

Note that T0FA + T0CF = F/Adirty and that T0FA = F/Aclean.

1.3.3. Air Temperature

Beta particles are absorbed by the air just as they are by the web, so that as the basis weight of the air between the source and receiver changes, the beta absorption will change also. An amount of 25.4 mm (1 in) of air at standard temperature and pressure has a basis weight of 32 g/m^2.

Air density effects due to air temperature changes are one of the principal sources of potential error in the basis weight sensor, particularly for lighter weight sheets, so this is a very important correction. According to the *Perfect Gas Law*, the change in basis weight of an air column is proportional to:

[1/Tinitial - 1/Tfinal]

where temperature is expressed in K = °C + 273.

The air temperature correction for each air column is expressed as:

AGAn * [1/TStdz - 1/TNow]

where AGAn is a calibration constant (1800 g/m^2 K for half of the standard 0.4-inch gap).

It is necessary to measure the air temperature in each zone between the source and receiver where the air temperature may change in order to make a correction. The air temperature corrections for each zone are added together to give the total correction, which is an additive correction with units of grams per square meter (g/m^2). The AGAn values for each sensor type are specified in Chapters 6 and 7, and are entered with the calibration constants. In terms of measured weight, Prometheum and Krypton gauges are equally sensitive to temperature changes.

The Q4000 version of the Sr-90 gauge (the Q2201-XX) does not come equipped with air gap sensors.

1.3.4. Z-Head Displacement

The principal reason for sensitivity to head displacement in the Z-direction is because the height, and therefore the basis weight, of the air column between the heads changes as the heads move relative to one another. The strategy for dealing with this is very similar to that for air temperature changes: measure Z using a Z-sensor, and compute changes in Z from standardize and make a real time correction. The Z-correction is an additive correction with the units of grams per square meter (g/m^2). The calibration constant that is entered at calibration is referred to as CFZ, expressed in m^2/g.

1.3.5. X-Y Head Displacement

Basis weight sensors are inherently sensitive to relative head displacements in the X-Y directions (cross direction/machine direction). The compensator reduces this sensitivity significantly; however, there may be some residual sensitivity. To correct for any remaining sensitivity use the profile correction. The profile correction is an additive correction with units of g/m^2, calculated for each bin of the profile, with separate correctors for forward and reverse scanner motion.

1.3.6. Sheet Passline Variations

Basis weight sensors are inherently sensitive to relative sheet displacements in the Z-direction, commonly known as passline sensitivity or flutter sensitivity. The compensator greatly reduces this sensitivity. Different models of basis weight sensors have different residual sensitivities to flutter. For a given model of basis weight sensor the sensitivity to passline is often somewhat basis-weight dependent. There is no software correction for sheet passline changes. Passline on a sensor is minimized by careful design of the compensator. See Section 1.3.2.

1.3.7. KCM

Although beta particles are relatively insensitive to anything other than the basis weight of the sheet, there may be slight differences in beta absorption between the calibration standard and the customer product. During calibration a quantity called KCM is determined for each grade of product.

KCM determines the offset of the customer product (paper, plastic, and so on) calibration relative to the calibration standard (Mylar). For nearly all systems all grades have the same KCM and one grade group.

1.3.8. Dynamic Offset

The BWDO is provided to allow a grade dependent offset. The offset is only used onsheet (not at sample) and is meant to account for effects such as moisture flashoff and sheet stretch, effects where the basis weight of the sheet at the scanner is physically different from that as measured at the mill lab.

Do not change BWDO just because a dynamic check does not agree with a measurement, but use it as a last option when it is clear that the sensor and all corrections are reading properly.

1.4. Differences between sources 6, 9, and 12

Table 1-4 summarizes hardware differences between Sources 6, 9, and 12. This table is provided primarily for those already familiar with earlier Honeywell basis weight sensors.

Table 1-4 Differences between Source 6, Source 9, Source12

	Source 6	Source 9	Source 12
Radionuclides	Kr-85, Sr-90, Am-241, (Pm-147 obsolete)	Kr-85, Pm-147	Pm-147 only
Source Capsule/ Beam Spot	Round disk	Round disk	Rectangular line
Flags	1	1	2
Shutter Actuator	Electric solenoid	Pneumatic capsule rotator	Linear pneumatic
Flag Actuator	Electric solenoid	Electric solenoid	Linear pneumatic
Air Supply (head internal)	None	1 line for shutter (1/4 inch OD) 45 ± 5 psi	1 line for shutter, flags (1/4 inch OD) 45 ± 5 psi 2 for air curtain :1 Sx , 1 Rx. (1/2 inch OD)
Green light switches (Sense shutter closed)	1	2	2
Temperatures Measured	Sx air column	Sx air column Upper and lower air gap (External to head)	Sx air column Head temperatures (Sx and Rx)
Temperature Algorithms	Various non linear thermisters	Various non linear thermisters	1 linear algorithm 100* Volts = Degrees C
Source Window	3.46 inch diameter	3.46 inch diameter	4.75 inch diameter
Receiver Window	3.46 inch diameter	4.75 inch diameter	4.75 inch diameter
Interlocks	Rx assembly position switch	Rx assembly position switch	Rx assembly position switch

1.5. Model Q4201-XX Sensor

1.5.1. Basis Weight Source

The principal changes to the basis weight sensor from the older Source-6 design are in the source body. The source capsule rotates to one of two positions–either shutter open (capsule inserted) or shutter closed (capsule retracted).

Figure 1-1 is a sketch of the source body with the principal components labeled. The purpose of this design is to bring the capsule closer to the detector and sheet that provide more efficient optics as well as minimize the amount of air between the source and the receiver.

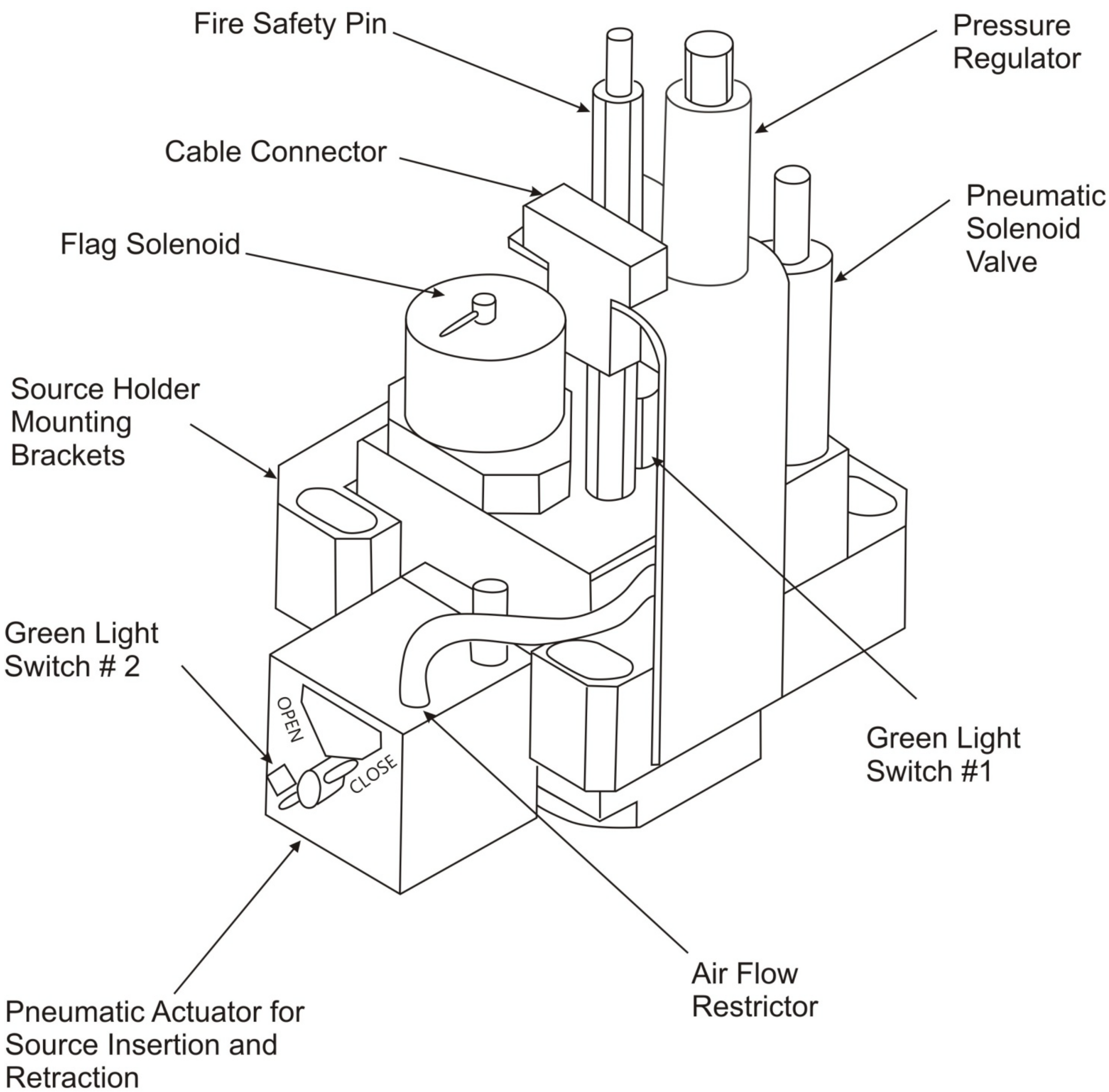


Figure 1-1 Sx 9 Source Components

Another change is to use a pneumatic rotary actuator to move the capsule instead of an electrical solenoid. The pneumatic rotary actuator does not produce any heat, so there is no warm-up time associated with source body heating. In this document, the phrase *opening and closing of the shutter* refers to the rotation of the source body to face the sheet.

When the rotary actuator has power applied (air pressure of at least 40 psi is needed to overcome an internal spring), it inserts the capsule. The position of the capsule can be seen by looking at the position of the pin relative to the labels on the rotary actuator.

When air pressure is removed, a spring in the rotary actuator returns the capsule to the retracted position. A very small orifice at the inlet of the rotary actuator reduces the flow rate so that the capsule and wheel (the rotating capsule mount) rotate slowly (insertion time of 4.5 s) so that the capsule comes to a soft landing at its stops in both positions.

Source air column temperature is measured by having the measuring device protrude from the body, therefore measuring the air temperature directly rather than measuring the body temperature.

Several features have been kept from the traditional Da Vinci/MXProLine Honeywell source body, including the flag (internal standard), the flag electrical solenoid, and the fire safety pin (see Figure 1-2). When the fire safety pin is activated, it pushes on the rotating capsule mount and forces the capsule to go to the closed (retracted) position. In addition, there are now two green light switches that are used to indicate the position of the source capsules that are electrically in-series.

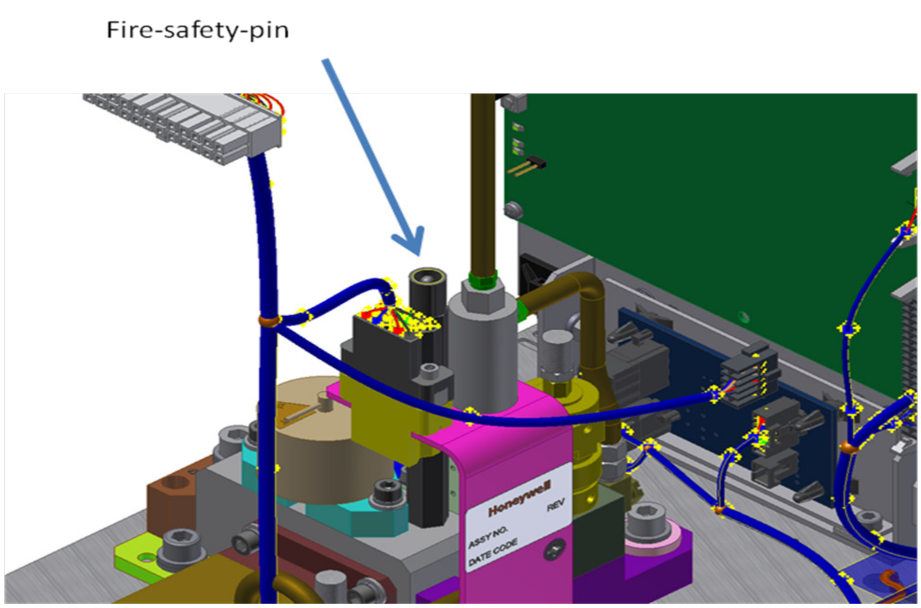


Figure 1-2 Q4201-XX Basis weight source showing location of the safety pin

Because a pneumatic rotary actuator is being used to drive the rotating source capsule, there is a pneumatic circuit. The pneumatic rotary actuator uses 45 psi ± 5 psi very clean air at a very low flow rate.

In general, the source and receiver are aligned geometrically (center lines co-linear). For some models, it is important to align the source and receiver by optimizing the receiver output (see Chapter 4). This procedure is called *topography*. Topography is always done in the plant before shipping for those models that require it.

If a source body needs to be removed for some reason, always ensure that the metal stops (X- and Y-directions; see Chapter 4) are in place and secure, and that the source is up against them so that the source can be replaced at the exact same position.

1.5.2. Basis Weight Receiver

The principal components of the basis weight receiver are:

- The ionization chamber that detects the beta radiation. Different types of ion chambers are used for different sensors although they all have the same size and power requirements. When exchanging ion chambers, be very careful to replace the old one with exactly the same type (same part number).

- The compensator mounted in front of the ion chamber (toward the source) gives the sensor many of its important properties. The purpose of the compensator is to reduce the sensitivity to additives (ash) and sheet passline (flutter). The compensator also affects the sensor range and stability. The orientation of the compensator, both rotational and front/back, is very important.

- The electronics, which provide power at the proper voltages, provide test points, and convert the current from the ion chamber into a voltage that is read and averaged by the system electronics.

The detector amplifier card uses a 20 or a 100 MΩ resistor. The gain is changed by soldering jumpers although a new amplifier with a rotary switch is expected to be introduced in the future. See the schematic for the particular board used for gains and their jumper connections.

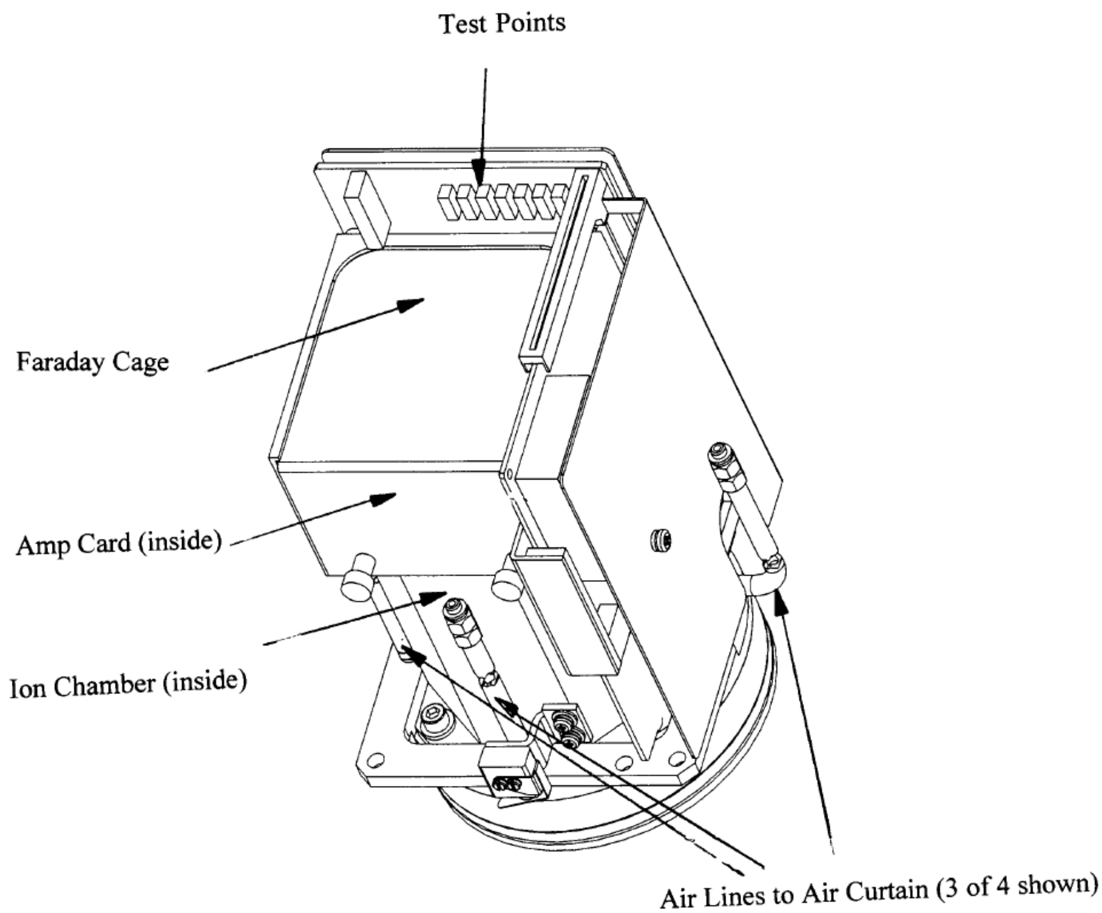


Figure 1-3 Q4202-50 Receiver

1.5.2.1. Receiver head

The receiver head contains the receiver assembly, a backplane, and a manifold for the air curtain.

1.5.2.2. Receiver assembly

The receiver assembly used in Source 12 is the same as the Close Geometry Receiver assembly used in Promethium Source 9 basis weight sensors. This receiver has the following tests points. The board with these test points is sometimes referred to as the *Nevada* board because its shape is similar to that of the U.S. state of Nevada.

Table 1-5 Sx 9 and Sx 12 Receiver Assembly Backplane Test points

Tests Points Receiver Assembly Backplane (Nevada board)	
TP #	**Label**
1	RTN
2	+24
3	RCVR RTN
4	+12
5	-12
6	-350
7	BW (Basis weight signal)
8	T1 (Not Used)
9	T2 (Not Used)

1.5.3. Electrical and Pneumatic Requirements

The sensor electricals run off 24 V DC. Because a pneumatic rotary actuator is being used to drive the rotating source capsule, there is a pneumatic circuit. The pneumatic rotary actuator requires 45 psi ± 5 psi very clean air. There is only a small amount of flow each time the source capsule is rotated.

1.6. Model Q4202-50 Sensor

A new source body is the most prominent feature of the Q4202 (Source 12) Basis Weight sensor. The receiver is based upon the Close Geometry Receiver used in Source 9. The source body holds a Promethium 147 radioisotope capsule configured as an elongated line source, with the long axis aligned in the machine direction. The source body is designed specifically for the characteristics of Promethium, and is not appropriate for higher energy or gamma emitting radioisotopes such as Krypton-85 or Strontium-90.

A normally closed stainless steel shutter provides radiation protection. That is, the shutter is forced closed by a spring unless the linear pneumatic actuator over powers the spring to the open the shutter. The loss of either power or pneumatic (air) pressure will cause the spring to close the shutter. An orifice in the air line slows the action of the shutter to insure repeatable positioning and long life. All mechanical parts involved in shielding the radioactive capsule or connecting those shielding parts together are made from stainless steel for resistance to melting in case of fire. If the temperature exceeds a preset value a fire safety pin will activate, causing the shutter to close until the mechanism has been disassembled.

The shutter, while several times thicker than needed to stop the radiation from Pm, is much thinner than required for an isotope such as Krypton-85, allowing the source capsule to be located very close to the source head window. This minimizes the air gap and optimizes the geometry for delivering large numbers of beta particles to the receiver, ensuring an accurate, highly repeatable measurement.

1.6.1. Basis Weight Flags

Source 12 has the normal Honeywell flag, called Flag1. Periodically, the sensor goes offsheet and measures the signal with just this Flag1 in the beam. This measurement is called *reference* or *standardize*. By comparing the current Flag1 reading to the reading at calibration, the sensor measures the dirt build up. A dirt correction is based on this standardize flag reading (this method will attribute to dirt a change anything that has changed since last standardize, not just dirt build up on the windows).

Source 12 has a second flag assembly. Both flags are activated by linear pneumatic actuators identical to the shutter's. The flags lie in separate planes both directly opposite the thick shutter. Because they are in separate planes, both flags can be inserted into the beam path simultaneously. In addition to the normal Honeywell three point standardization, this allows two point verification. These two points are Flag2 and Flag1 + Flag2.

Source 12 software supports this new standardization in the following way: three point standardization provides the usual correction factors, which are then applied to evaluate the weights of Flag2 and Flag1 + Flag2. The combination of Flag1 and Flag2 is called Flag12 (flag one two). The weights of the flags should be constants since corrections have been applied for temperature, Z, dirt, new background, and air readings. The readout of the weights constitutes a true quality indicator that can be tracked over time. Differences in the weight readings from the weights at calibration time are Flag2 error and Flag12 error.

In order to maintain a consistent evaluation for the of Flag2 and Flag12 weights, there is a dedicated set of calibration coefficients used exclusively for flag weight calculations. They are FA0 - FA7 and FD0 - FD7. FAs are for the clean calibration curve, while FDs are for the dirty curve. They are established at the factory using polyester samples, and are themselves made of polyester (Mylar), Flag1 being nominally .001 inch (.025 mm or Å32 gsm) and Flag2 .0005 inch (.013 mm or Å16 gsm), making the combination .0015 inch (.038 mm or Å48 gsm). However, these exact values are not very important, as the concern is any change in the flag weights, not their absolute values.

Calculating the weights of Flag2 and Flag12 is fundamentally different from the common but sometimes misleading practice of calculating the weight of the single flag (as in Source 6 and Source 9). Calculating the weight of the single flag is not as independent as measuring at another weight. This is because the dirt correction is based on the single flag ratio just as is the weight of the single flag. At this ratio, the nature of the dirt correction tends to compensate exactly, whether or not the correction is appropriate. Using a second flag, at a different weight and ratio, there is both statistical and systematic independence. Flag2 and Flag12 errors are much better quality indicators than the old style flag weight, and also far better than common attempts to use the F/A (Flag to Air) ratio as a quality indicator. F/A ratio is, by design, the basis of a corrector, and expected to change, much as the air gap temperatures will.

To allow for influences that can affect the sensor's reading in ways not corrected by the usual means, which would cause the flag weights (Flag2 and Flag12) to vary from their original values, the Source 12 software allows for a correction to be applied to subsequent on-line measurements. Designated as the Source 12 corrector, it can be calculated in four different ways to allow for maximum flexibility in real-world situations. The Source 12 corrector was coded to be as general as possible, so that the optimum algorithm could be easily implemented on site, based on experience. It also allows that different sites may have different influences requiring different approaches.

The default situation is to set the corrector to zero. The corrector can be determined from the error in the flag weights in either percentage terms or in absolute weight units (g/m^2), with arbitrary weighting of the two verification samples. This allows for correction of influences that are percentage or weight based. Finally, the corrector can be a function of weight, determined by a slope and intercept from the errors of the two samples, and this can be either percentage or weight based.

ATTENTION

> Currently the flag2 and flag12 results are used for diagnosis and performance monitoring only.

An understanding of the major hardware components and their functions is necessary for proper maintenance. The Source 12 Basis Weight Sensor hardware and its heads consists of:

- Source holder assembly containing the radioactive Promethium source capsule.
- Source head containing source holder, backplane, and source air curtain.

- Receiver assembly containing detector, amplifier, and integral air curtain.
- Receiver head containing receiver assembly (with integral air curtain) and backplane.

1.6.2. Source

Figure 1-4 is a view of the Source 12 Source Holder assembly. Major features are identified: aperture, shutter, source air column temperature measuring device, mechanical shutter indicator arm, mounting tabs, Source 12 Radiation Interlock PCB, fire safety pin, and blue cover. Underneath the blue aluminum cover are the air cylinders and solenoid actuators for the shutter and both flags as well, orifice restrictors , and plumbing hoses. Although some parts below this cover are field serviceable, *call Honeywell ACS Global Radiological Operations before removing this cover*. There are no field serviceable parts under the stainless steel side plates.

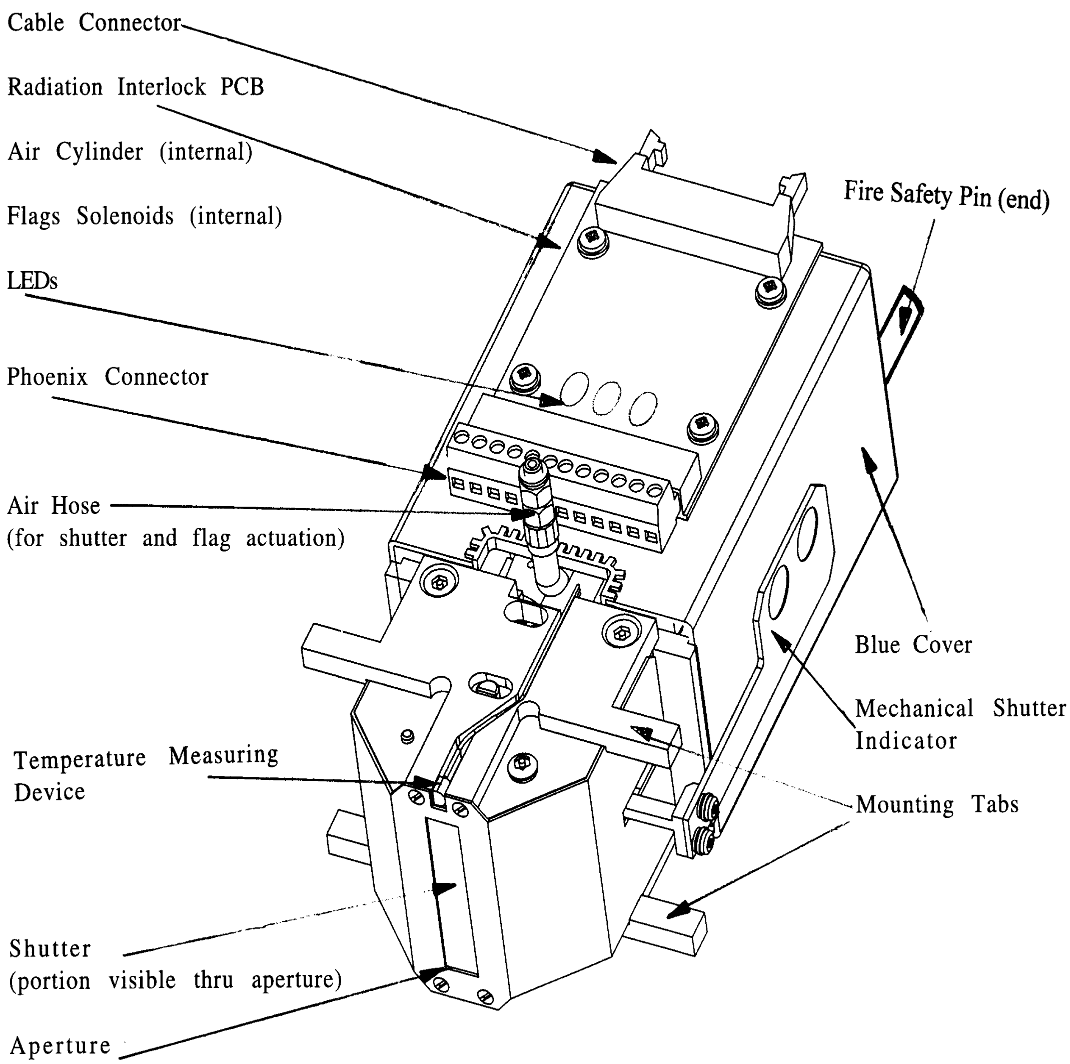


Figure 1-4 Major Features of Q4202-50 Source Holder Assembly

The mechanical shutter indicator is shown in the closed position. The second flag closest to the sheet.

The Source 12 Basis Weight Sensor hardware are described in the next subsections.

1.6.2.1. Aperture and shutter

An important safety feature of the shutter mechanism requires the presence of both air pressure and electrical power to open. If either air pressure or electrical power is lost while open, the shutter will close.

The shutter opens by a chain of events: electrical, pneumatic, and finally mechanical. First, the computer closes a switch, sometimes referred to as making a contact output closure. This signal is sent to the head, through the source backplane and Source 12 radiation interlock board to the shutter solenoid. The energized solenoid then opens allowing pressurized air into the shutter air cylinder. When inflated, this air cylinder pulls on the shutter, which rotates open. Unless so pressurized, the shutter is closed by the air cylinder's internal spring. This spring is an important shutter safety mechanism, forcing the shutter closed if electrical power or air pressure is lost.

Through the source capsule's rectangular window passes the beam of beta particles. The aperture is a rectangular hole in a stainless steel cover. This is close to the stationary source capsule and covers the capsule window and lower portions of two sides. When commanded to open, the shutter rotates away from its normal resting position between the aperture and the source capsule. This allows the beta particles out through the open aperture.

1.6.2.2. Side plates with mounting tabs

On two sides of the aperture cover are the side plates. These are attached with tamper resistant screws to prevent disassembly. As the source capsule holder is inside, it would pose a potential radiation safety hazard were these plates removed. Four rectangular stainless steel extend outward from the source holder assembly. These are sized 6 x 8 mm (1/4 x 5/16 in) extending out about 19 mm (3/4 in) from the source holder. These are the mounting tabs where the source body is clamped to the head, or safety cap. Three mounting blocks are used to hold the source holder in place.

1.6.2.3. Mechanical shutter arm

This arm indicates when the shutter is open or closed. It is also possible to open and close the shutter manually by this arm. When this arm is in its normal non-energized state, the position closest to the sheet, the shutter is closed. When away from the sheet, the shutter is open. Green and red sheet dots are on the indicator.

1.6.2.4. Temperature measuring device

Temperature measurement is simplified in Source 12 compared to Source 6 and Source 9. Source 12 has five temperature measurements : Source column, Source backplane, Source air curtain, Receiver air curtain, and Receiver backplane. All Source 12 temperatures are measured by a direct readout temperature device. The voltage output of this device is linear with temperature. To convert to degrees Centigrade multiply the signal output voltage by 100 (For example, 220 mV is 22 C). This device looks very much like a transistor, having three pins extending out of a small plastic bead.

There is a separate maintenance procedure for replacement of the source air column temperature measurement device. Replacing this device requires removing the source body holder, and working close to the capsule. The assembly for easier field replacement contains the temperature device and three wires attached.

WARNING

Only personnel qualified under radiation safety license and with clearance from Honeywell ACS Global Radiological Operations are allowed to replace the temperature measuring device on the source body assembly (Source air column measurement).

1.6.2.5. Fire safety pin

The fire safety pin prevents accidental opening of the shutter after a fire. The design is much like previous fire safety pins. The actual pin has a new part number, but its working principles are the same as in the earlier version, solder holds a compressed spring. In case of high temperature from a fire, the solder melts releasing the spring that forces a pin down to close the shutter.

There is a separate maintenance procedure for replacement of the fire safety pin.

WARNING

Only personnel qualified under radiation safety license and with clearance from Honeywell ACS Global Radiological Operations are allowed to replace the fire safety pin.

1.6.2.6. Q4202-50 termination PCB

The board mounts on the Source 12 source assembly. It provides termination to the solenoids, green light switches and for the source air column temperature measurement device (and generates the required +15 V). Beside these functions, the board's primary function is to provide additional radiation interlock as described below.

Radiation interlock

The shutter and the flags are on adjacent curved planes. In theory, if the shutter were closed and the flag or flags actuated, they could push open the shutter permitting radiation to escape. The board prevents either flag air valve from receiving +24V when the shutter is not activated; lessening the chance of this fault condition. Note that overall radiation safety is provided by a combination of the algorithm running on the controller data acquisition board (see Chapter 2) and associated radiation interlock board.

Versions

There are two versions of the board -00 and -01; the difference is for the various radiation warning lamps employed. The -00 version requires low current to operate the shutter and is used with such scanners such as the 2080-00 (those with LED radiation warning lights), the 4080 and Q4000-80 scanner. The -01 version is designed to be placed in series with four incandescent red rad lamps such as the ones found in the 2040-XX and 2106-XX (those with incandescent radiation warning lights).

LEDs

A red LED illuminates when the shutter air valve receives power and amber LEDs are illuminated when the flag air valves receive power. These are clearly labeled **SHTR** (shutter), **FLAG1**, and **FLAG2**.

Fuse

A pico fuse, labeled **F2**, is in series with the shutter signal and a spare fuse is provided on the board. This spare is labeled **F1 SPARE**. These fuses are inserted and not soldered.

1.6.2.7. Regulator

Although the regulator is mechanically attached to the manifold for the air curtain, the air curtain and shutter pneumatic lines are separate. The regulator is on the air line to the shutter solenoid. It prevents a high pressure surge on the supply air line from reaching the air cylinder.

1.6.2.8. Manifold and hoses

There are several hoses to supply steady air flow. These hoses must not to be kinked or twisted so as to block the air flow. The large air hose supplies the air curtain manifold with a ample flow of air. The manifold distributes the air evenly to the four smaller hoses which go to the air curtain. To help ensure equal flow, these four hoses are of equal length. Swivel fittings on the manifold allows the fittings and hoses to rotate when assembling.

1.6.3. Receiver assembly

The receiver assembly for the Sx 12 is the same as that of the Sx 9. See Section 1.5.2.

1.7. Model Q2201_XX Sensor

The Q2201-XX (Sx6) sensor is the oldest sensor design supported by the Q4000 scanner and it is only used with Strontium-90 (^{90}Sr) as the isotope for heavy sheet applications.

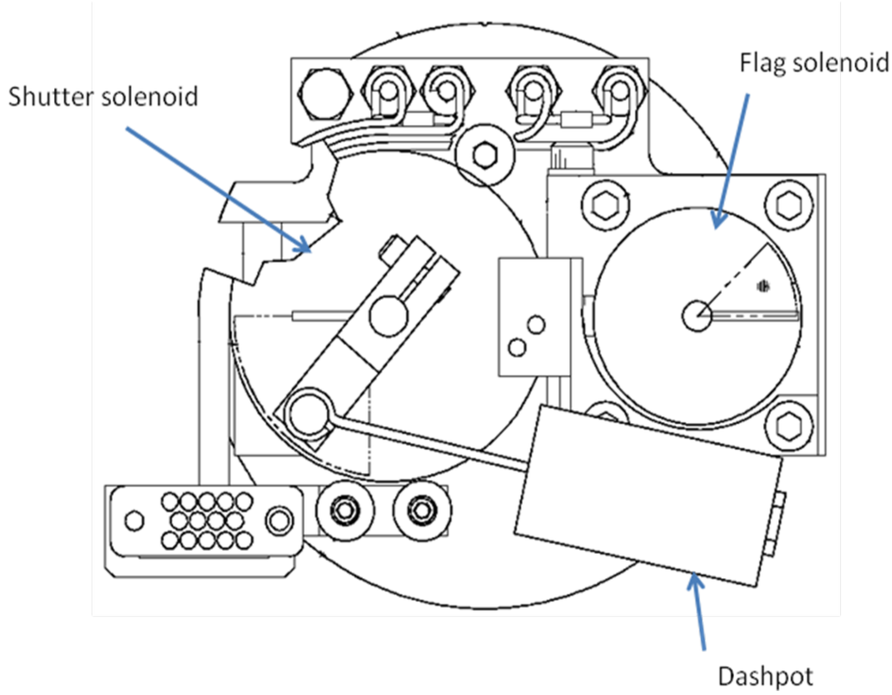


Figure 1-5 Top view of the Source 6 Assembly, showing two solenoids and dashpot

The sheet is exposed to the beam by rotating a tungsten shutter out of the way. Both the shutter and flag are driven by electrical solenoids. The solenoids require 11 V to open and 5 V to remain open. In the Q4000 scanner, a separate 24 V to 12 V converter is required when this sensor is called out.

The impedance of the shutter solenoid is roughly 7 Ω, resulting in 20 W of power dissipated. The flag solenoid, however, uses only 2 W in the closed state.

A thermistor in the source monitors the temperature and is connected to thermistor temperature channel 1 (of 4), connector J3 on the EDAQ (slow analog input).

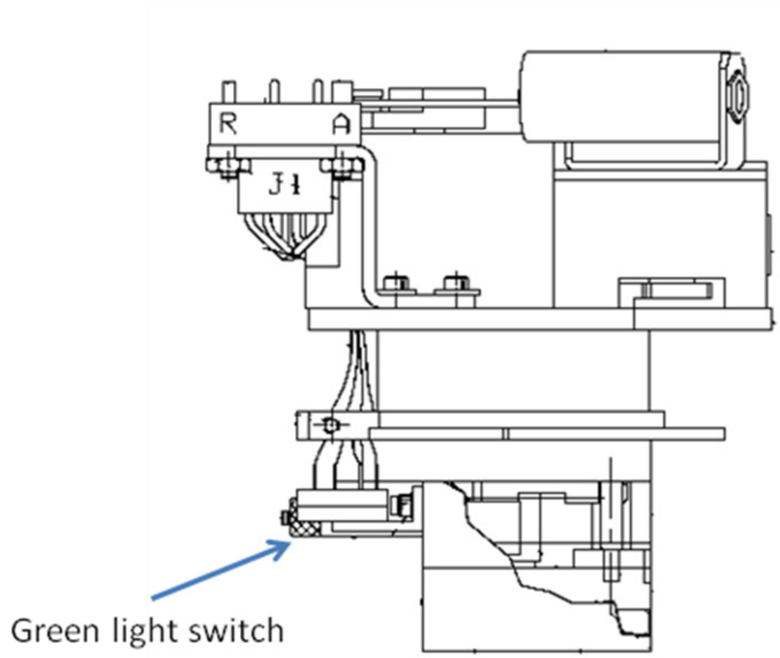


Figure 1-6 Side view of Source 6 Assembly

Field personnel are allowed to order and replace the following parts:

- flag solenoid
- thermal safety bolt
- temperature sensor
- diodes
- micro-switch
- dashpot

For all other items, contact Radiological Operations.

Figure 1-6 and Figure 1-7 show the locations of the thermal safety bolt and the green light switch. On Figure 1-7, the transportation safety bolt is shown mounted for storage to the left of the sensor

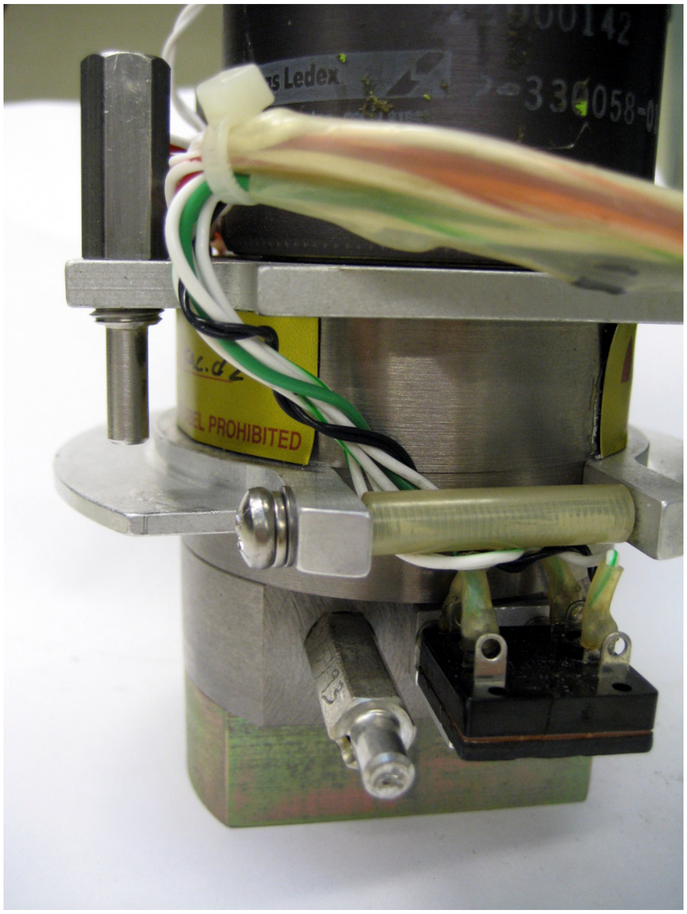


Figure 1-7 Source 6 assembly showing the thermal bolt and the green light shutter switch

The Source 6 receiver is similar to that of the Source 9 and Source 12.

It consists of four boards:

Part number	Function
05410000	HV inverter, -350 VDC
05404600	Reciever power supply and thermistor
05323500	Back plane
05277501	Detector amplifier

The receiver backplane contains test points for these signals:

Table 1-6 Test points for Nevada Board

Test Points Receiver Assembly Backplane (Nevada board)	
TP #	**Label**
1	+24 V DC
2	+24 V DC RTN
3	RCVR RTN
4	BW Signal Out
5	+12 V
6	-12 V
7	-350 VDC (Ion Ch)
8	Same as TP2
9	Same as TP3

Since the Sx6 is only used with the high-penetrating Sr-90 isotope and intended for heavy sheet or wet end applications, air temperature corrections are not implemented in the Q4000 scanner series. There is no air gap sensor included in this sensor assembly.

1.8. Heads and Scanners

Basis weight sensors are used with a variety of heads and scanners.

The purpose of the heads is to shield the sensor as much as possible from the environment, and to keep the sensor at a constant operating temperature. All systems provide head temperatures read at reference and/or standardize, and can be consulted if problems occur.

The purpose of the scanner is to move the heads back and forth across the sheet while maintaining constant X-Y (cross direction/machine direction), and Z-head relationship. Radiation lights are mounted on the scanner to provide information about the condition of the radioactive source.

The Experion MX scanner head is substantially different from those on previous scanner models. In this head, all the electrical and signal wiring to the source and receiver terminate in the head. Source and receiver are part of a module containing the air gap sensor and an analog-to-digital processing board called the Ethernet Data Acquisition (EDAQ) board. The EDAQ performs all signal conversions, drives the digital output signals, and passes the data back to the Measurement Sub System (MSS) through the Ethernet.

The only analog signal routed through the scanner is the green light radiation interlock signal. As in previous scanners, it passes through all shutters in a scanner system and is terminated at the endbell operator panel, a human/machine interface (HMI). See Chapter 3 for more information on the EDAQ board and EDAQ software.

1.9. Signal Inputs and Outputs

There is one output from the basis weight sensor: the basis weight voltage signal from the detector amp. Each head has an air gap temperature and an air column temperature that are used for corrections, for a total of three measurements.

The Z-sensor has one output and is used for corrections also. The head temperature that was measured by basis weight sensor on some head models is now measured by each EDAQ board. An average of all EDAQ boards is reported to the Experion MX system.

The only inputs to the sensor are the digital logic signals to insert the flag and the radioactive capsule (shutter).

1.10. Q4201-XX Performance Specifications

Table 1-7 summarizes the specification for the various sensors, excluding Source 6 models.

Table 1-7 Specifications for the different basis weight gauge models

	Pm^{147} 4201-10	KR^{85} Q4201-62	KR^{85} Q4201-63	KR^{85} Q4201-64
Basis Weight Range	1–200 g/m^2	140–1200 g/m^2	8–1200 g/m^2	20–1000 g/m^2
Sheet Gap	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)	10 mm (0.4 in)
Sheet Ash Range	Any	< 5%	2–20%	> 20%
Repeatability on Mylar, (2 sigma, 16 s integration). The greater of:	± 0.05% or 0.01 g/m^2	± 0.05% or 0.02 g/m^2	± 0.05% or 0.03 g/m^2	± 0.05% or 0.05 g/m^2
Static Accuracy (2 sigma on Mylar, 16 s integration). The greater of:	± 0.25% or 0.02 g/m^2	± 0.25%	± 0.25%	± 0.25%
Dynamic Correlation, 2 sigma, by Roll Check Method	± 0.25%	± 0.25%	± 0.25%	± 0.25%

	Pm^{147} 4201-10	KR^{85} Q4201-62	KR^{85} Q4201-63	KR^{85} Q4201-64
Measurement Spot Diameter	15 mm (0.6 in)	15 mm (0.6 in)	15 mm (0.6 in)	15 mm (0.6 in)
Sensor Response Time (analog signal, to see 63% of step change)	1 ms	1 ms	1 ms	1 ms

2. Radiation Safety and Interlocks

This chapter describes the safety components of the Basis Weight Measurement in the Experion MX, EDAQ-based Q4000-80 scanner. This chapter does not apply to the Da Vinci 4000 or 4022 scanner series. The information applies to sensor series Source 6, Source 9, and Source 12.

2.1. Radiation Safety

WARNING

Under no circumstances place any part of the body in the gap.

The basis weight sensor produces hazardous radiation. Anyone working with this sensor must have participated in radiation safety training, be familiar with radiation safety practices, and carry a radiation badge.

Consult *Honeywell Radiation Safety Manual* for more information.

The radiation safety system for a Q4000 scanner consists of a number of redundant hardware and software systems.

The main user indicators are the red and the green light systems that are present on all scanners. The general rule is:

- **Green ON** indicates that all radiation shutters on a scanner are in the **CLOSED** state. It is safe to split the heads and work in the sensor gap area.

- **Red ON** means that the command to open the shutters was given by the controlling hardware. It does not necessarily mean that the shutters actually opened (see Section 2.2); when the red light is **OFF**, it does not mean that the shutters are closed.

This chapter briefly summarizes the differences in implementation from previous scanners.

2.2. Green Light Circuit

The green light circuit (see Figure 2-1) remains essentially unchanged. It is hardwired through the entire scanner. The green light circuit is a loop that starts with + 24 V at the endbell, passes through the green light LEDs in the **HMI/UPI** panels, the upper and lower head shutter switches, and finally to ground.

The only changes involve sensing the current and voltage at three points in order to identify where a failure has occurred (burned out light bulbs or failed circuits in the upper or lower head). The head split clutch is controlled by a hard-wired key switch. The clutch can only be activated if there is current in the green light circuit. There is no software interaction involved.

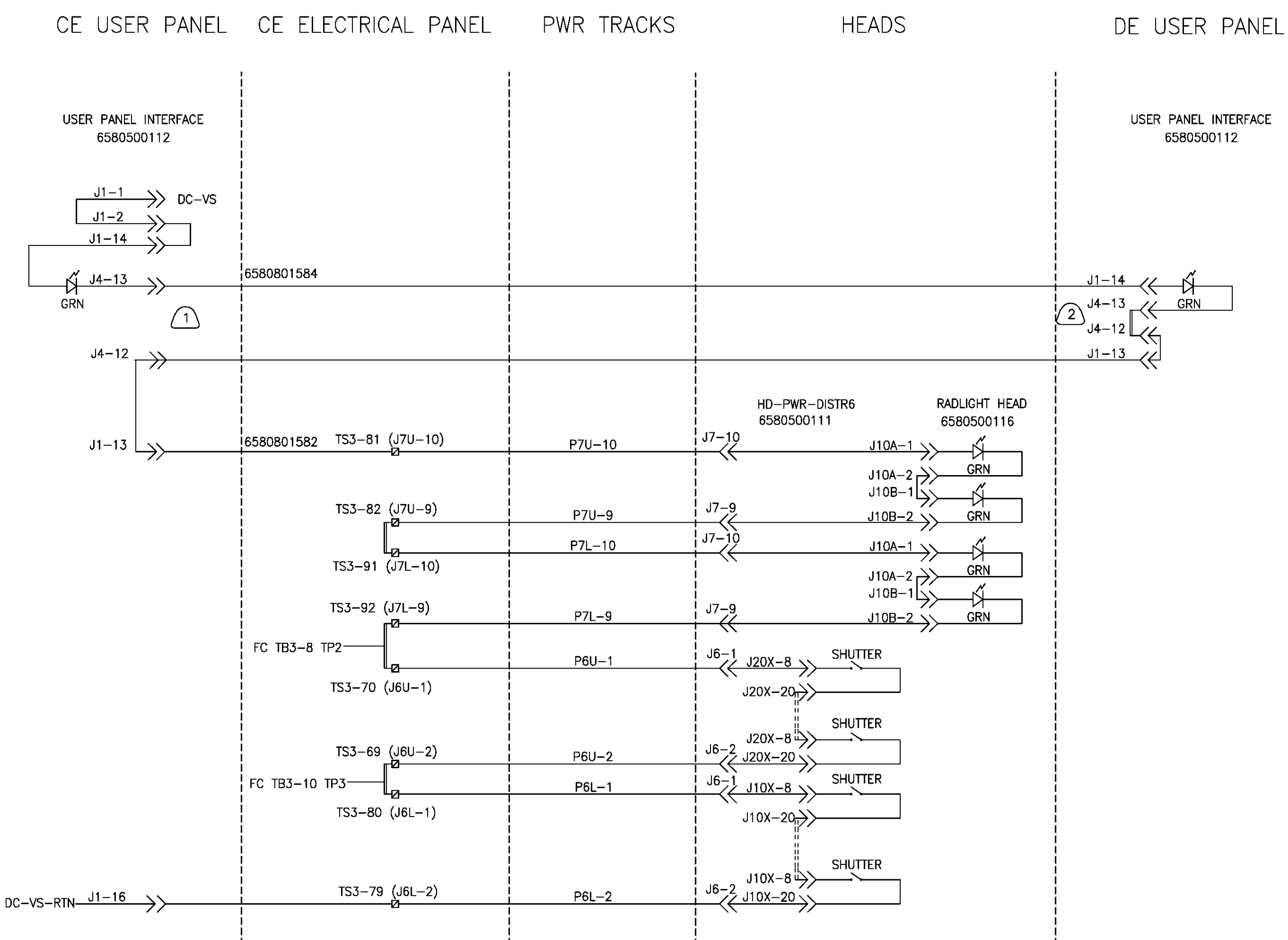


Figure 2-1 Green Light Circuit Schematic

2.3. Red Light Circuit

In the Q4000 scanner all red light-related signals are handled through the Ethernet Data Acquisition (EDAQ) boards attached to each sensor. The decision to allow shutter open commands is made on the basis weight source EDAQ CPU board based on information receiver over the Ethernet. Examples of such information is a relevant switch (sensor-in-place, or head-in-place), or condition of the lights (red light lit up), which might come from the alley EDAQ or the Frame Controller EDAQ

The sensor EDAQ controlling the radiation source subscribes to the status of these switches or lights. If feedback from the respective EDAQ is not received within a short time-out period, the gauge controlling EDAQ will block a subsequent shutter open command, or, if the shutter is already open, the EDAQ will close the shutter and disable the shutter drive logic. For example, when the signal is not received, any of the following three actions will happen:

- the EDAQ will not relay a shutter command if a shutter command is sent
- the EDAQ will close the shutter if the shutter was open
- the EDAQ will turn off power to the gauge if the gauge had power (applicable to ash, not basis weight gauges)

The feedback signals are monitored constantly for as long as the shutter is open– the gauge EDAQ needs to get continuous information on the state of switches and lights to keep the shutter open. If communication fails with any of the devices that supply this information, the shutter is closed or power is removed.

The X-ray and nuclear gauges are not powered directly, but through a separate hardware interlock circuit. This is in order to handle fatal software problems or board lock-up. The interlock board expects a regular, < 500-ms period digital signal from the controlling EDAQ. If that fails to arrive, the + 24 V to the gauge is disconnected.

In order to maintain the shutter open signal to the nuclear sensor, the gauge source controlling EDAQ requires the following conditions (all of the following also apply to the X-ray gauges):

- the red light be lit (active feedback from a light sensor)
- the receiver-in-place switch is closed

- the head-in-place switch is closed
- the receiver signal strength corresponds to the state of the shutter:

  HIGH when the shutter is commanded open

  LOW after it is commanded shut
- the interlock board receives a regular watchdog signal from the controlling EDAQ

The time out for any of these conditions is 500 ms or less, meaning that a shutter will be closed within 500 ms of any of the conditions failing.

New to the Q4000 Scanner is a **Nuclear Gauge enable** button, located at the end bells. This button will disable any command from being executed by the EDAQ board. It operates similarly to the amber light for the X-ray sensor.

Figure 2-2 shows the schematic for the controlling EDAQ, the power interlock board 6580500109, and the shutter command line for the nuclear gauges. The EDAQ only sends the keep-alive signal when interlock conditions are met. The board then supplies the + 24 V to the shutter.

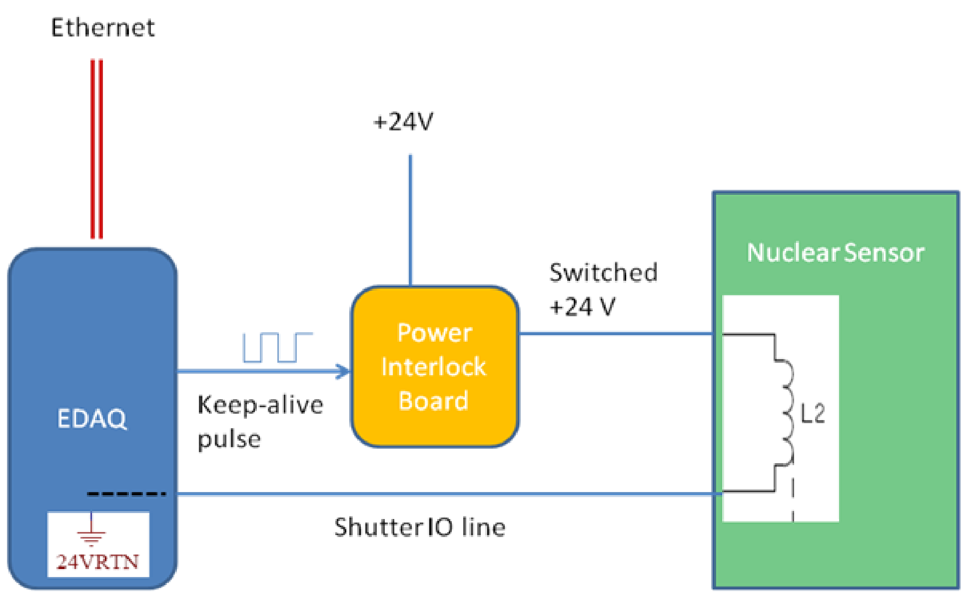


Figure 2-2 EDAQ, Power Interlock Board, and Shutter Command Line Schematic

For the Q2201-XX only, the Switched +24V shown in Figure 2 2 is routed through a 24 to 12V converter to the shutter solenoid.

3. EDAQ

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

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

The board is based on an ARM CPU running the Linux™ operating system and a Field-Programmable Gate Array (FPGA) that controls real-time data acquisition.

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://www.honeywell.com/ps/thirdpartylicenses* or found on the Experion MX distribution media under *C:\Program Files\Honeywell\Experion MX\MSS\SenLan\Images\GPL*.

The EDAQ board contains a large number of input/output (I/O) systems, including:

- analog inputs (16 inputs of 12 bits @ 4 kHz and 8 inputs of 10 bits @ 1 Hz)
- analog outputs (2 @ 12 bits)
- digital inputs (16 @ 24 V logic)
- digital output (16 @ 24 V logic)
- frequency input (400 Hz to 500 kHz)
- Three serial ports
- USB (presently unused)
- 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 Measurement Sub System (MSS) by Ethernet.

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

This chapter gives a brief overview of the EDAQ board and some of the diagnostic information. More detail is provided in *Experion MX MSS EDAQ Data Acquisition System Manual* (p/n 6510020381).

3.1. Physical Layout

Figure 3-1 and Figure 3-2 show the EDAQ PCBA 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 (FC) expansion board.

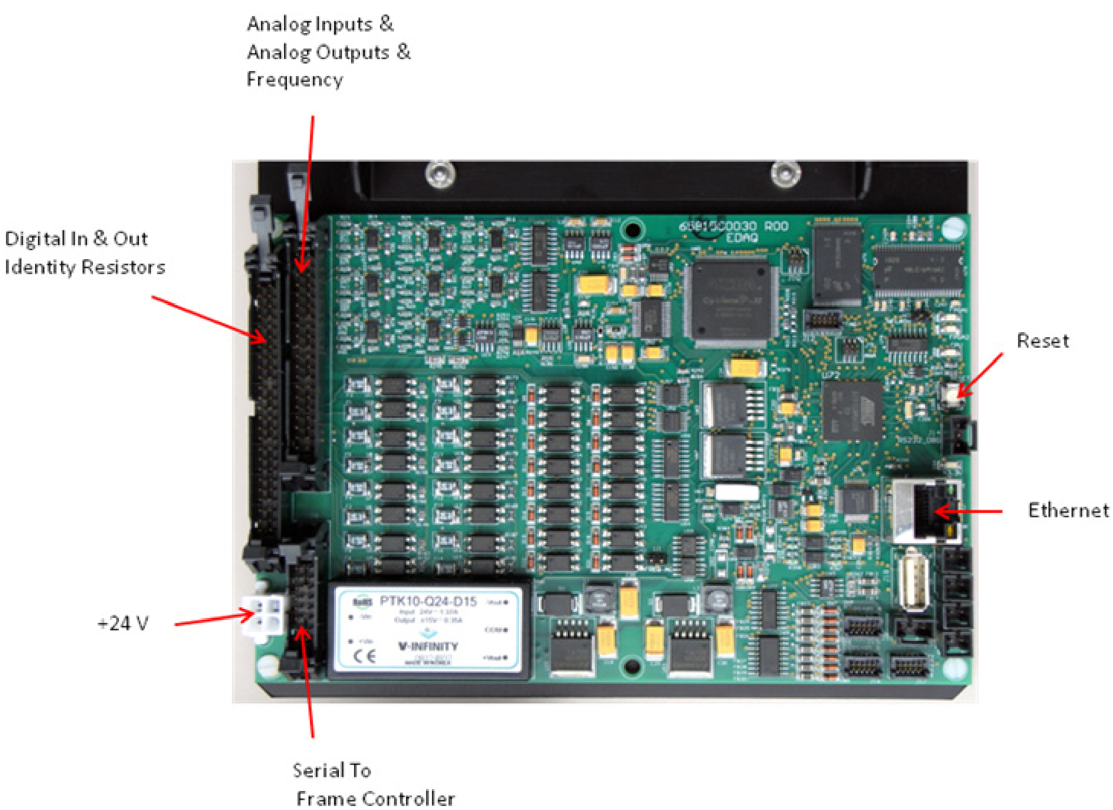


Figure 3-1 EDAQ Board

J1 is the large 50-pin connector on the far left. J2 is the smaller 40-pin connector. J8 on the lower left is used for the FC only.

To the right are the Ethernet port, some diagnostic LEDs, serial connections, and temperature inputs. There are no test points for use in the field. A serial debug port is available (115200 kb/s, 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.

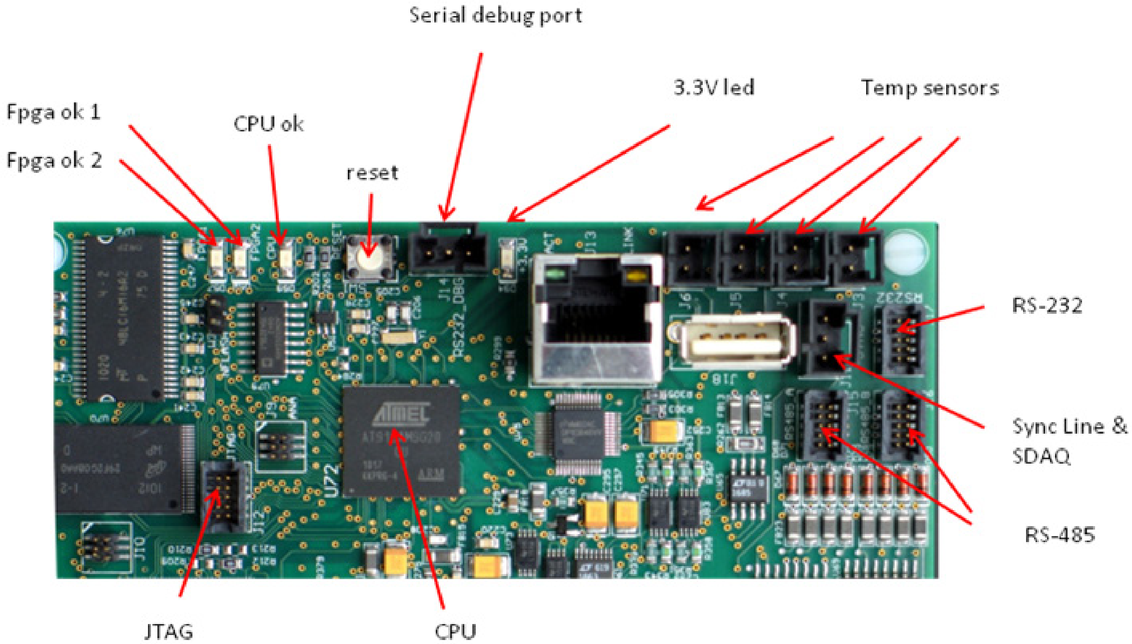


Figure 3-2 EDAQ Board: Ports and Diagnostic LEDs

3.2. Hardware Status Information

There are four diagnostic LEDs on the EDAQ (see Figure 3-2).

- The *3.3 V LED*. When lit, this indicates that all power supplies on the 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 + 24 V input.

- The *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.

- The *Fpga ok 1* (not used at present).
- The *Fpga ok 2*. This LED will blink if the FPGA is loaded and running code.

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

3.3. 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 real-time application environment (RAE) station.

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.

3.4. EDAQ Sensor Identification and IP Addressing

Assuming the firmware revision (flash code) is the same, all EDAQs are identical. EDAQs can be freely interchanged between sensors and the scanner endbell and even between scanner series.

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 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 your scanner manual to troubleshoot if the EDAQ does not identify itself properly (or 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 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 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.

3.5. Obtain EDAQ Status Information – Experion MX Platform

An overall status page is available from a RAE station under the **MSS Setup Diagnostics** tab. Select the **MSS Summary** page.

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

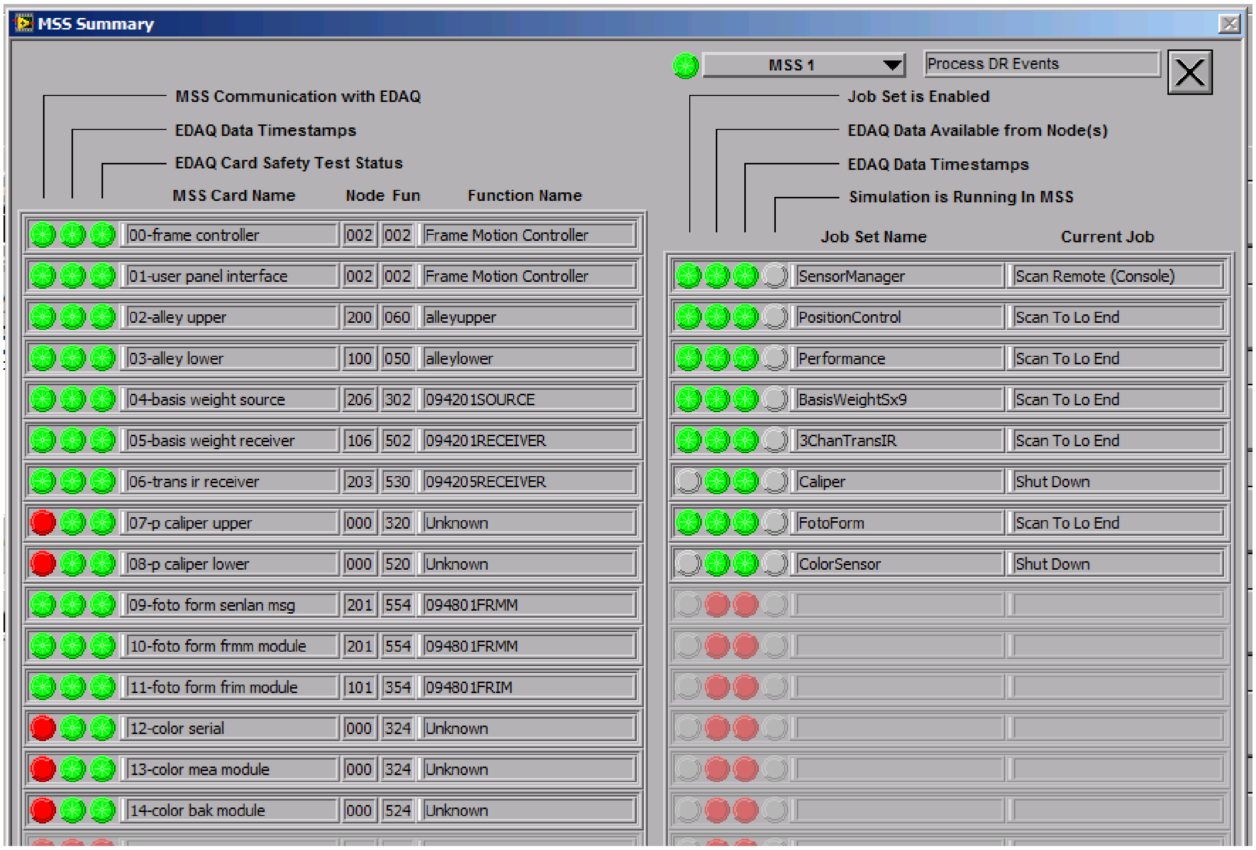


Figure 3-3 MSS Summary

Table 3-1 MSS Summary Display Status Indicators and Descriptions

Column	Description
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 Test 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, for example, *07-caliper upper* in Figure 3-3.

3.6. MSS and EDAQ Web Pages

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 appropriate 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 first MSS on the system)

Figure 3-4 shows the main MSS Web page (**PHP MSS Page**).

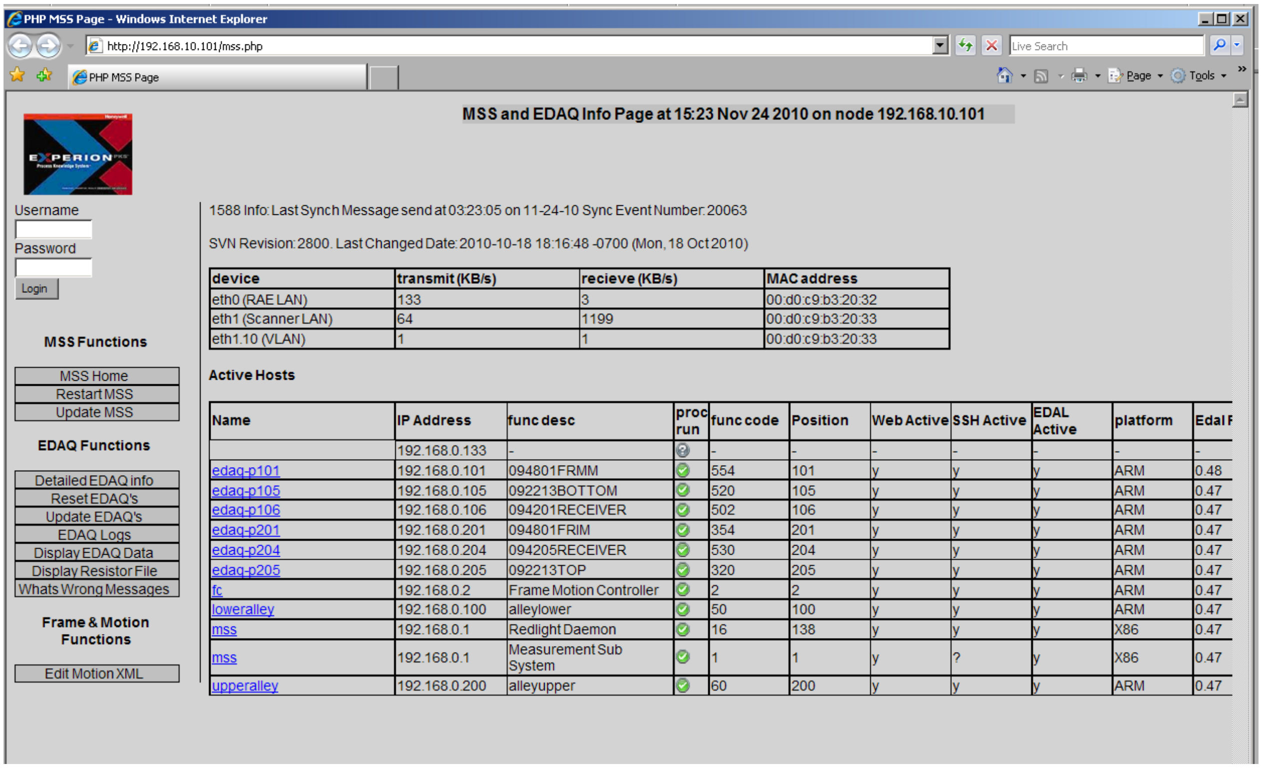


Figure 3-4 PHP MSS Page

The left panel shows a column of options divided into:

- **MSS Functions**
- **EDAQ Functions**
- **Frame and Motion Functions**

Enter the username (**`admin`**) and password (**`hmxresult`**) 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 labeled **eth1** (scanner LAN) typically shows it receiving a few MBs. The MAC addresses of the MSS are also shown–the **eth0** address is the one 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 and 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 calls 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 3-5) shows a number of technical details that are not discussed in this document. Important columns include **Process load** (usually less than 0.5), **local time** (matches MSS time clock shown at top) and **Offset From MSS (µs)** (less than 50 µS a few minutes after start up).

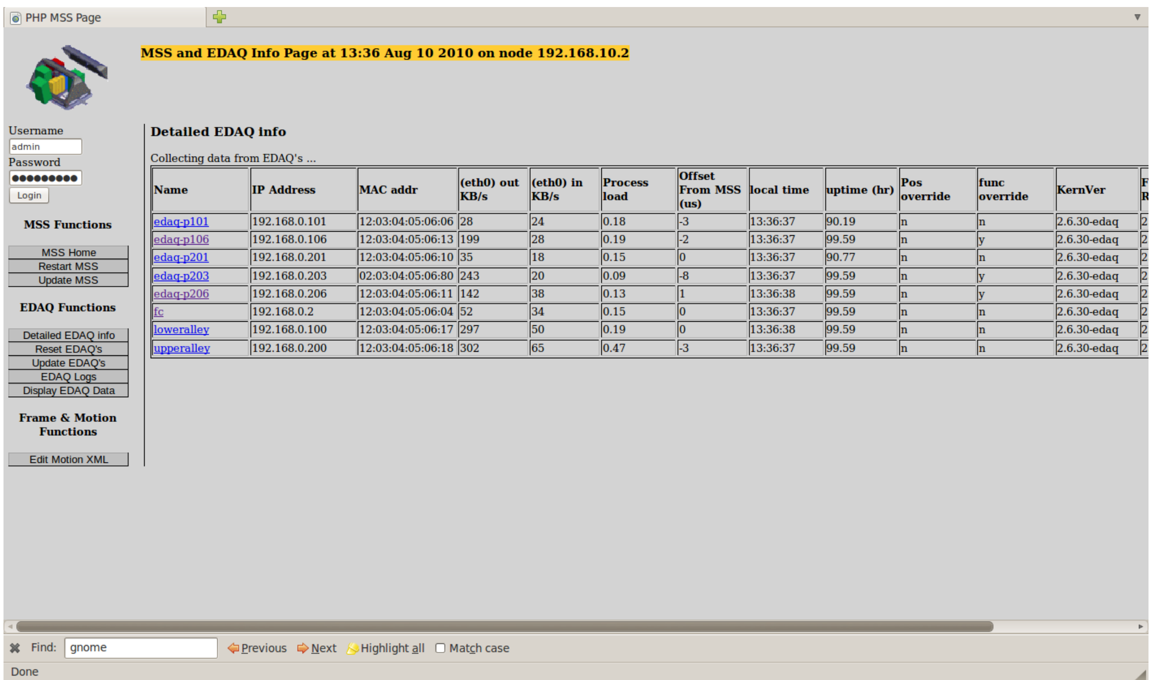


Figure 3-5 Detailed EDAQ Information: Partial Display

3.7. Other Diagnostic Tools

The proper operation of the basis weight gauge and the EDAQ can also verified using the following tools:

1. EDAQ/MSS log files: The EDAQ writes all BW shutter open/close and other significant I/O operations to a log that is stored on the MSS.

These log files can be viewed and downloaded from the MSS main web page. It is possible to view several weeks of shutter movement.

In addition, when an interlock error occurs, the EDAQ dumps a large amount of BW signal data leading up to the fault to the log file for analysis.

2. The EDAQ Scope Tool: A Windows/Linux platform executable program is available from Engineering which allows direct access to all the EDAQ raw signals in parallel to the Experion MX system obtaining those data. Data can be plotted, save and analyzed.

4. Installation

This chapter describes the installation of the Basis Weight measurement in the Q4000-80 platform heads. The procedures here apply to the Source 6, Source 9 and Source 12 sensors.

4.1. Mechanical Installation and Removal

It is convention to install the source in the top head and the receiver in the bottom head, but this can be reversed at will without affecting the measurement. Configuration is automatic, because the Ethernet Data Acquisition (EDAQ) board recognizes the new position of the source/receiver pair and passes the information on to the Measurement Sub System (MSS) and the real-time application environment (RAE).

To remove the entire module:

1. Split the heads (the green lights must be on and the head key split in the *on* position).
2. Locate the two cover screws on the sheet guide side of the basis weight platform and remove them.
3. Using a hex screw driver, loosen the screws buried inside the plate.
4. Remove the end bar (which holds in all the sensor modules on that side of the head) , see Figure 4-1.
5. Slide the basis weight module out.

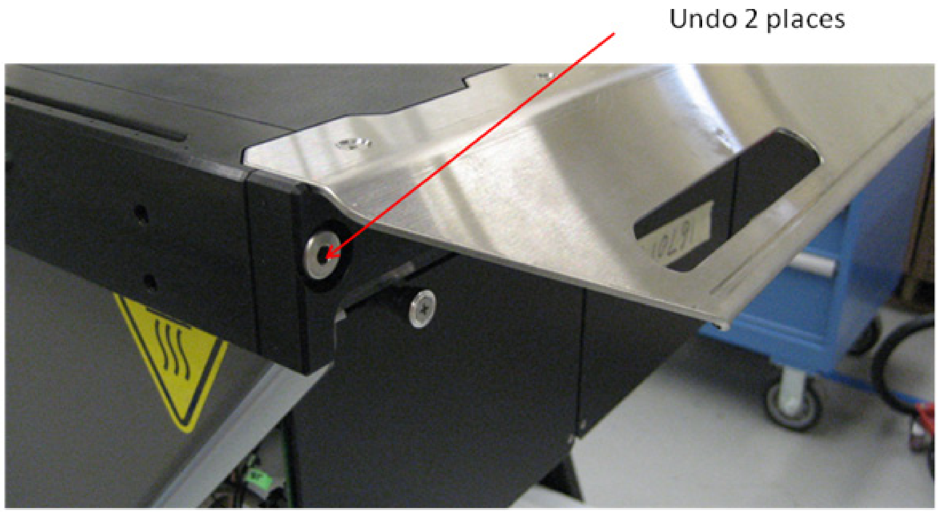


Figure 4-1 Removing end bar below sheet wings

When the source module is inserted, only the air line, Ethernet cable, and the head power distribution cable have to be connected. The mounting hardware of the sensor to the chassis (platform) uses imperial standard hardware, whereas all the other Q4000-80 bolts and nuts are metric.

4.2. Q4201-XX Platform Installation Images

The source air gap sensor is not shown, but it is shown for the receiver side. The usual orientation with the source at top is shown on the right in Figure 4-2, but this is not required for operation.

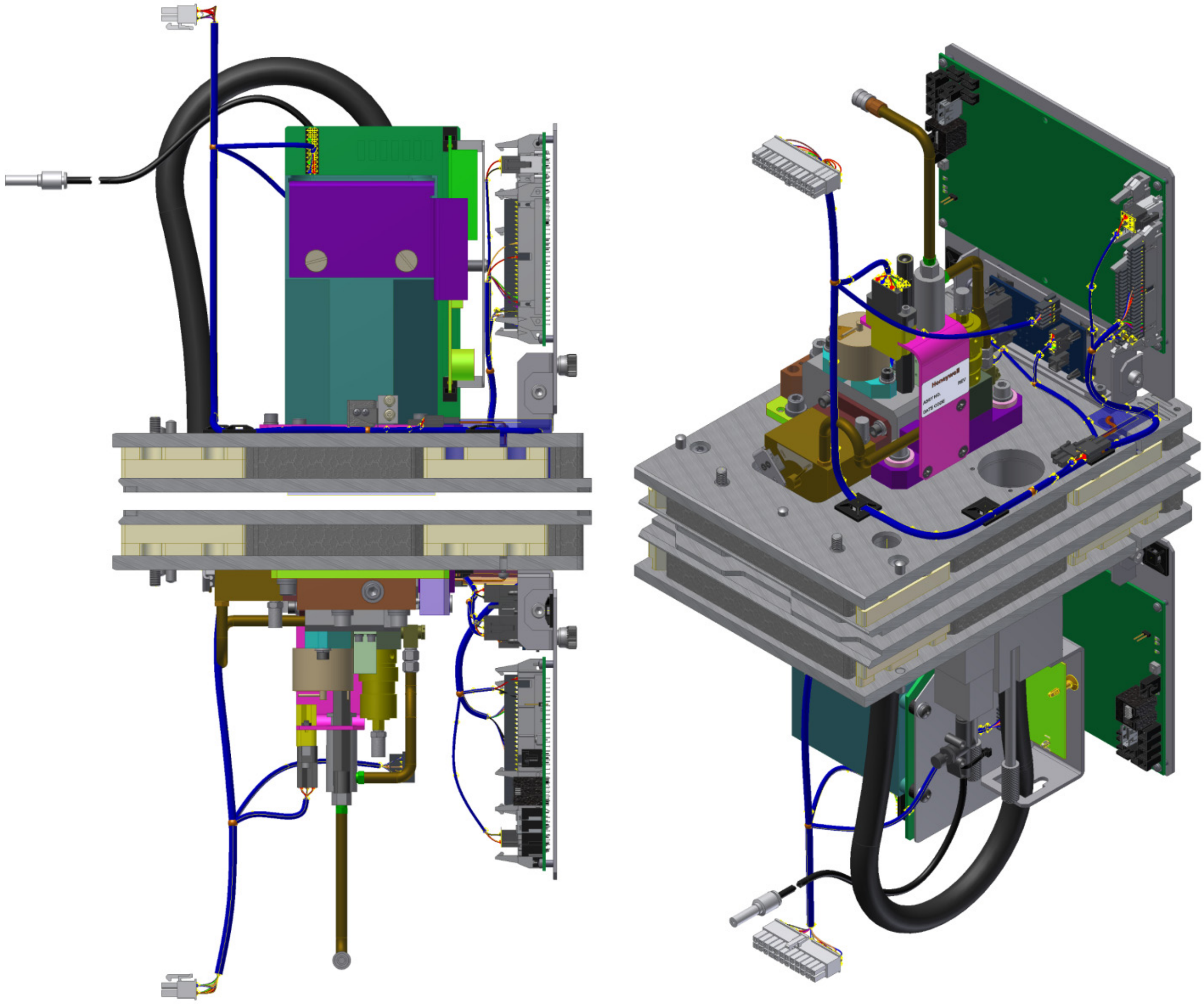


Figure 4-2 Source and Receiver modules (Q4201-XX) shown)

The source window assembly and the receiver window assembly for the Sx9 gauge are identical to that of the Sx 12 and are shown in the next section.

4.3. Q4202-50 Platform Installation Images

The next images show the installation of the Sx12 source and receiver on the Q4000 platform. Figure 4-3 and Figure 4-4 show the EDAQ (large PCB) and the radiation safety interlock board (small PCB) to the left of the sensor body. In the source images, the air gap sensor is not shown.

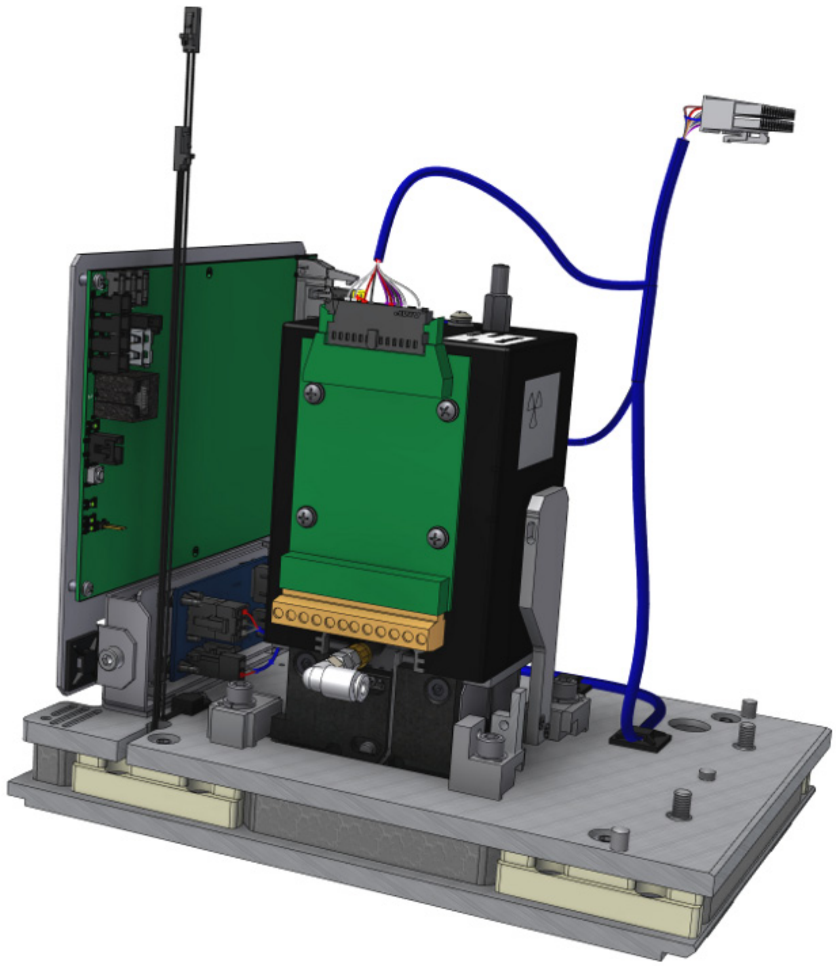


Figure 4-3 Q4202-50 Source Body installed on the Q4000 platform

In Figure 4-3, the EDAQ is to the left. The termination PCB is mounted on the source body. Also shown is the shutter lever arm (to the right of the source body) and the thermal safety pin (top).

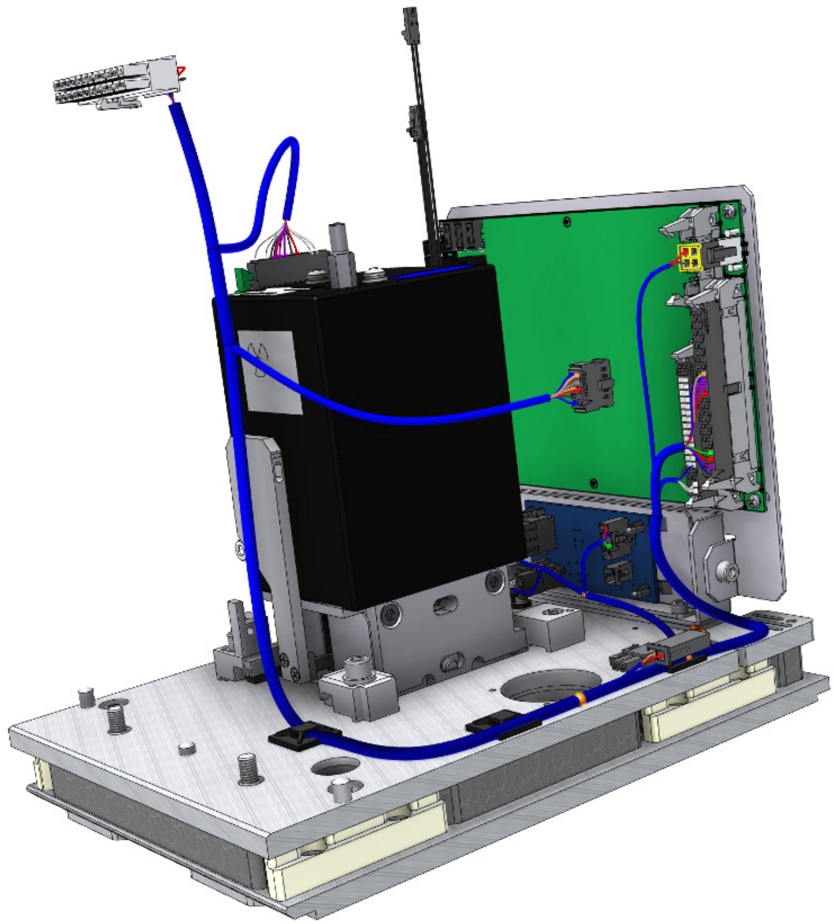


Figure 4-4 Q4202-50 Source (air gap sensor not shown)

Figure 4-5 and Figure 4-6 provide details on the mounting hardware and the window assembly.

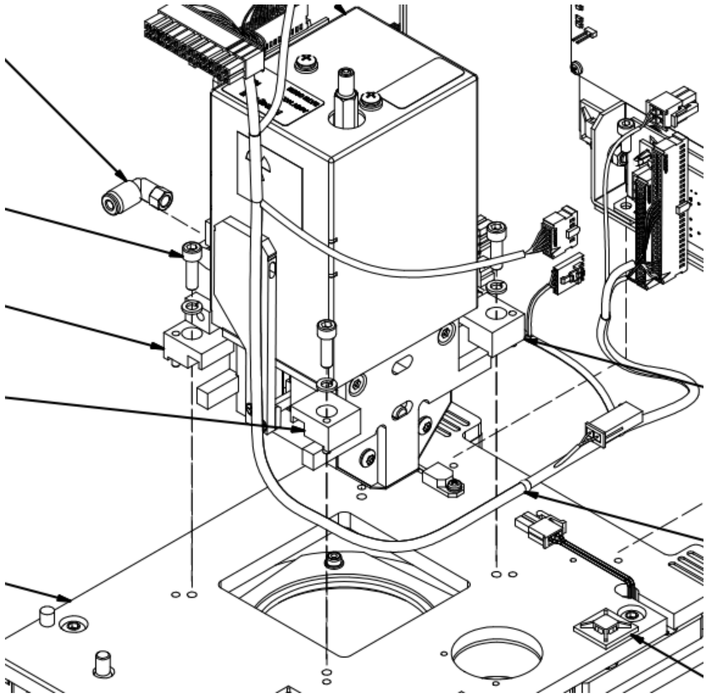


Figure 4-5 Source detail, showing the mounting hardware

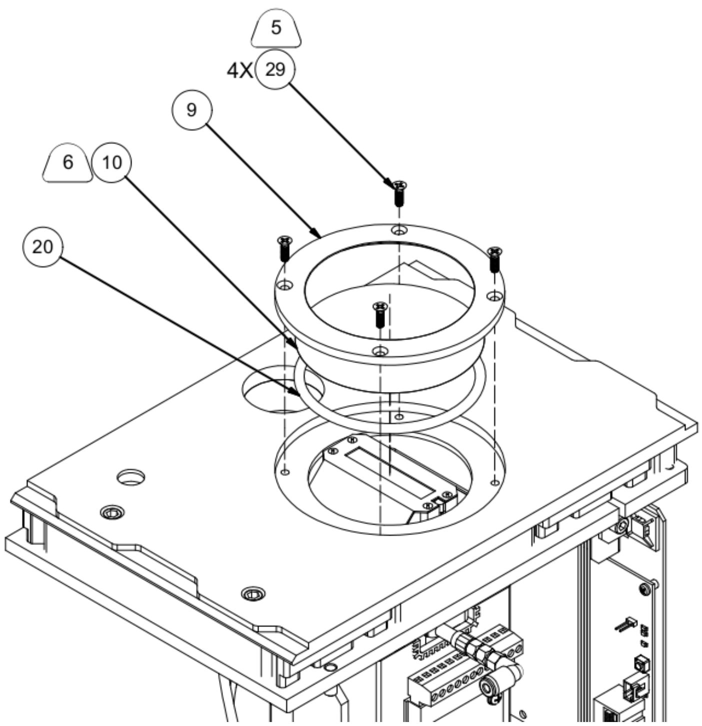


Figure 4-6 Source platform showing window ring assembly details

Figure 4-7 shows the receiver unit on the installation platform. The air gap sensor is shown beside the receiver. The combined harness takes both the basis weight signal and the air gap signals to the local EDAQ board.

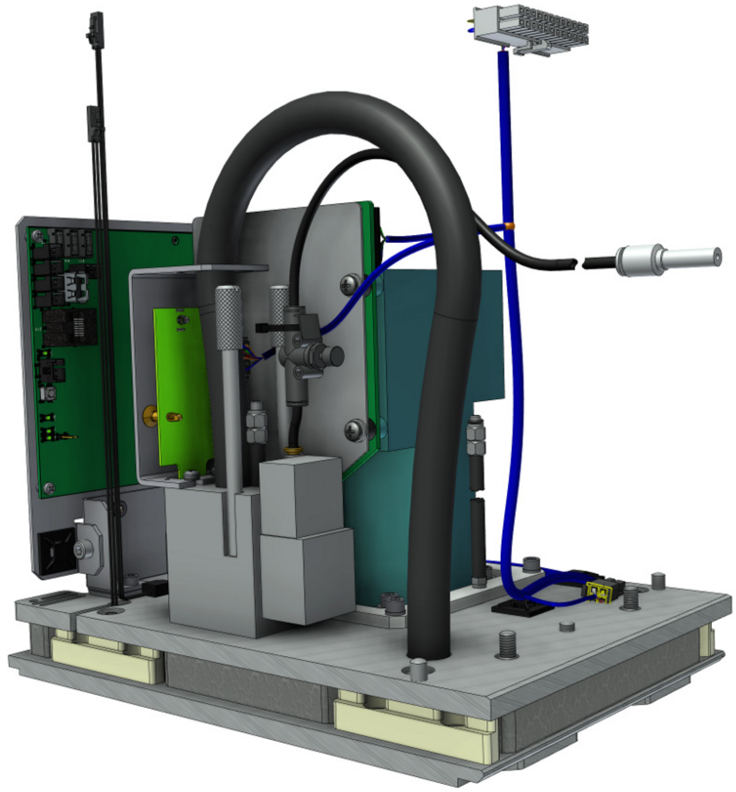


Figure 4-7 Q4202-50 Receiver Assembly showing the air gap sensor (front)

Figure 4-8 shows the details of the window assembly on the receiver. The window is part of the assembly, unlike the receiver where there window is screwed onto the platform plate. The location of the sealing o-ring (labeled as part number 21 on the figure) should be lubricated with conductive grease to ensure a path to ground for the aluminized-Mylar window.

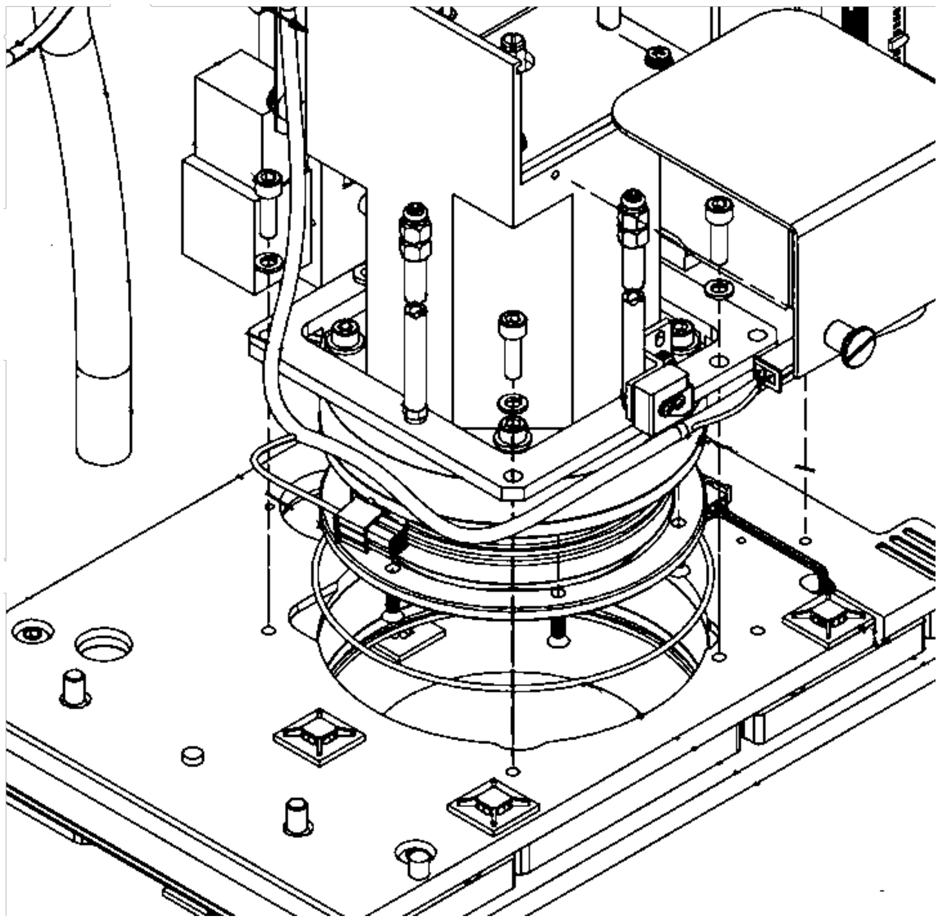


Figure 4-8 Detail of the Receiver Window Assembly

4.4. Model Q2201-XX Sensor Installation Images

Figure 4-9 shows both the source and receiver platform. You can decide the actual orientation in the head (as for all nuclear gauges, but it is recommend the source be in the upper head). Removal of either module is as for the Sx9 and Sx12 described in previous sections.

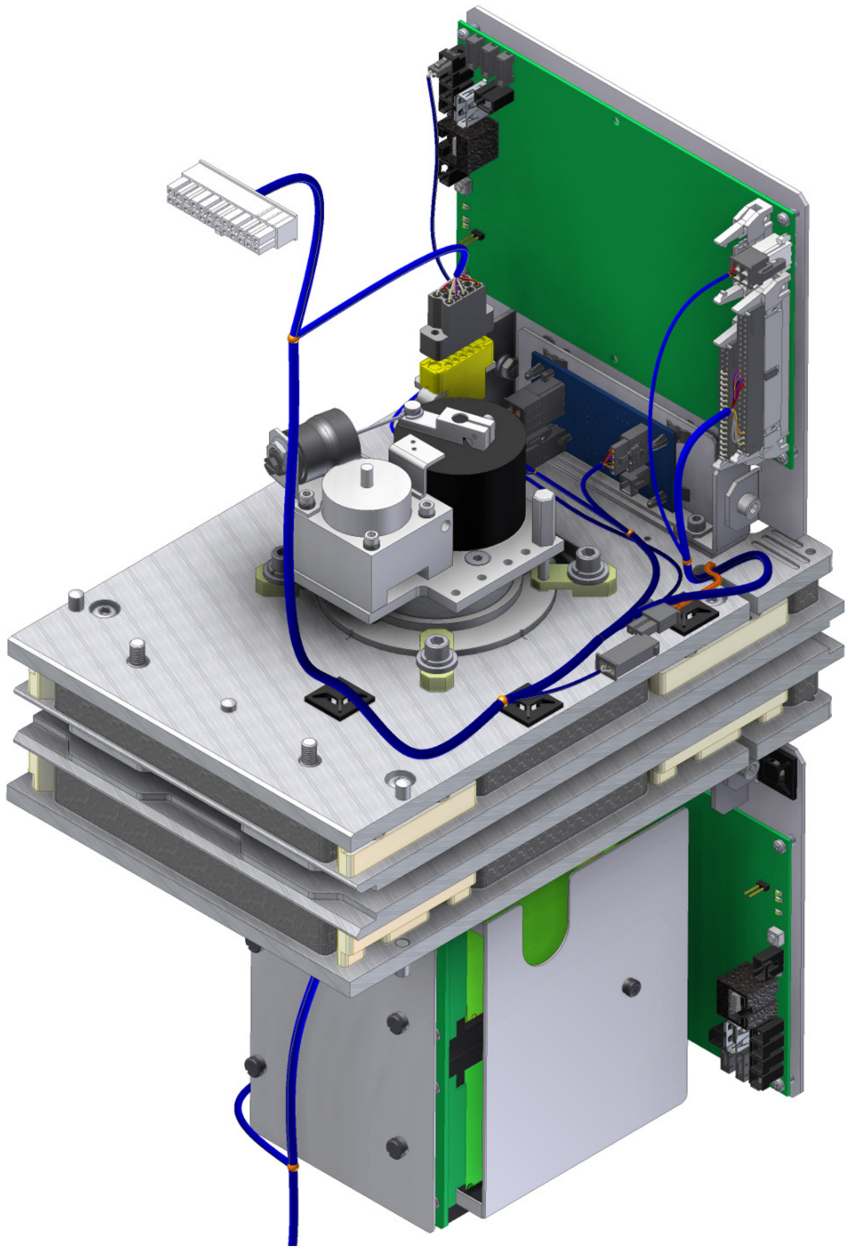


Figure 4-9 Q2201-XX sensor modules

In Figure 4-9, the source, interlock board and source EDAQ are on top. Not shown is the wiring leading to the external 24 V to 12 V power converter. Note the lack of air gap sensors.

In addition to the hardware depicted here, there is a Phoenix Contact 24 V to 12 V converter, required to drive the solenoids. It is mounted on a DIN rail near the head support columns.

When the safety requirements are met, the interlock safety board provides the +24 V to converter, which then directly provides the +12 V to the shutter solenoid. The ground return is connected to the EDAQ digital input.

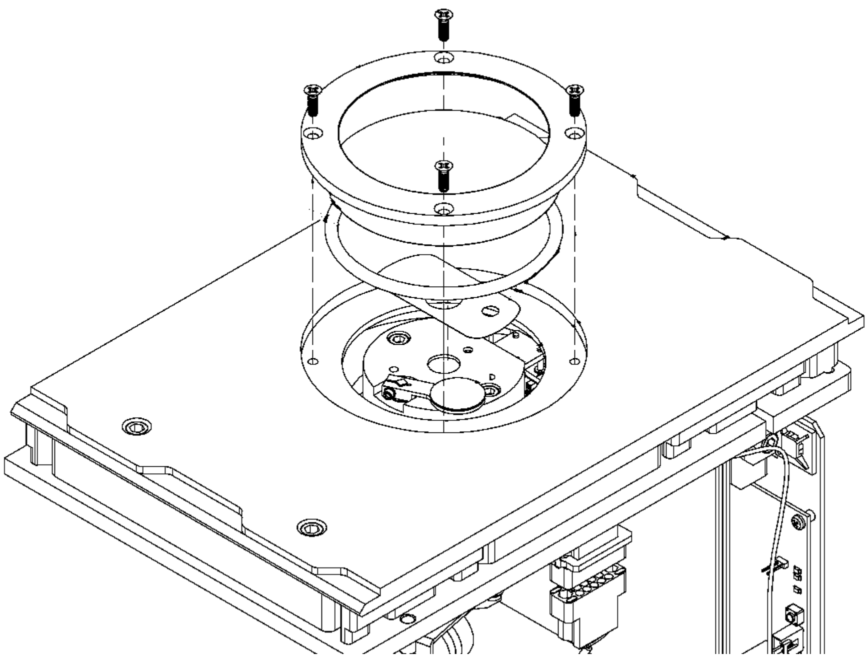


Figure 4-10 Sheet guide side of the platform, showing window mountings

Note that in Figure 4-10, the two screws on the left have to be removed and the screw below them loosened prior to sliding the platform out.

Figure 4-10 shows the detail of the window in the sheetguide. The window may be replaced as part of a normal maintenance procedure.

5. Topography Procedures

The purpose of this procedure is to position the source body in the optimum position (plateau center) with respect to the detector.

Only the Pm-147 isotope versions of the Basis Weight sensors (Q4201-10) require the topography procedure.

5.1. Model Q4201-10 Topography Procedure

5.1.1. Data Collection Maximum Travel

Center the source body using the pin alignment tool and the stop, and set the dials to read zero. This position will be the mechanical center position of the source body.

Start with machine direction:

1. Take a reference with the sensor at the mechanical center position.
2. Move the source body towards the front (start edge) until the dial reads 2.03 mm (0.08 in) from the center.
3. Take readings every 0.50 mm (0.02 in) as the source body travels along the machine direction, between ± 2.03 mm (0.08 in) from the center position determined above. Record the readings on a data sheet (plotting of data is required). The point at the opposite edge of the start edge must be read twice before heading back to the start edge.
4. When you return to the start edge, you have two readings per position. Examine the readings closely. If the readings vary randomly, repeat the test. If they are close or vary in a systematic way (see Figure 5-6 and Figure 5-7), then average the sample ratios for each position.

Make a plot of the average ratios, Y-axis against position X-axis. Connect the points to determine the curve.

5. Move the source body back to the mechanical center position. Lock-in the current direction (machine direction or cross direction).

Proceed with cross direction by repeating Steps 1–5, but move the source body across from left to right and back to determine the cross direction curve.

The following figures (Figure 5-1, Figure 5-2, Figure 5-3, Figure 5-4, Figure 5-5) show the mounting of the Sx9 models in detail, and indicate which bolts must be loosened or remain tight during the topography procedure.

Figure 5-1 shows the cross direction and the machine direction.

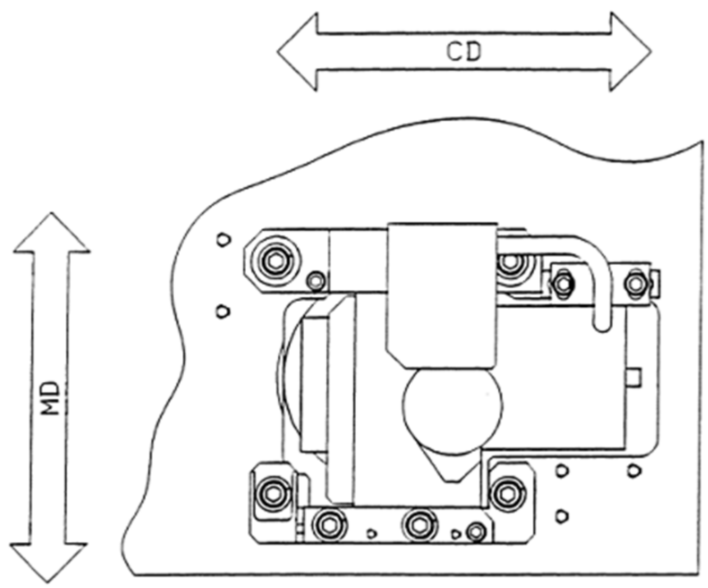
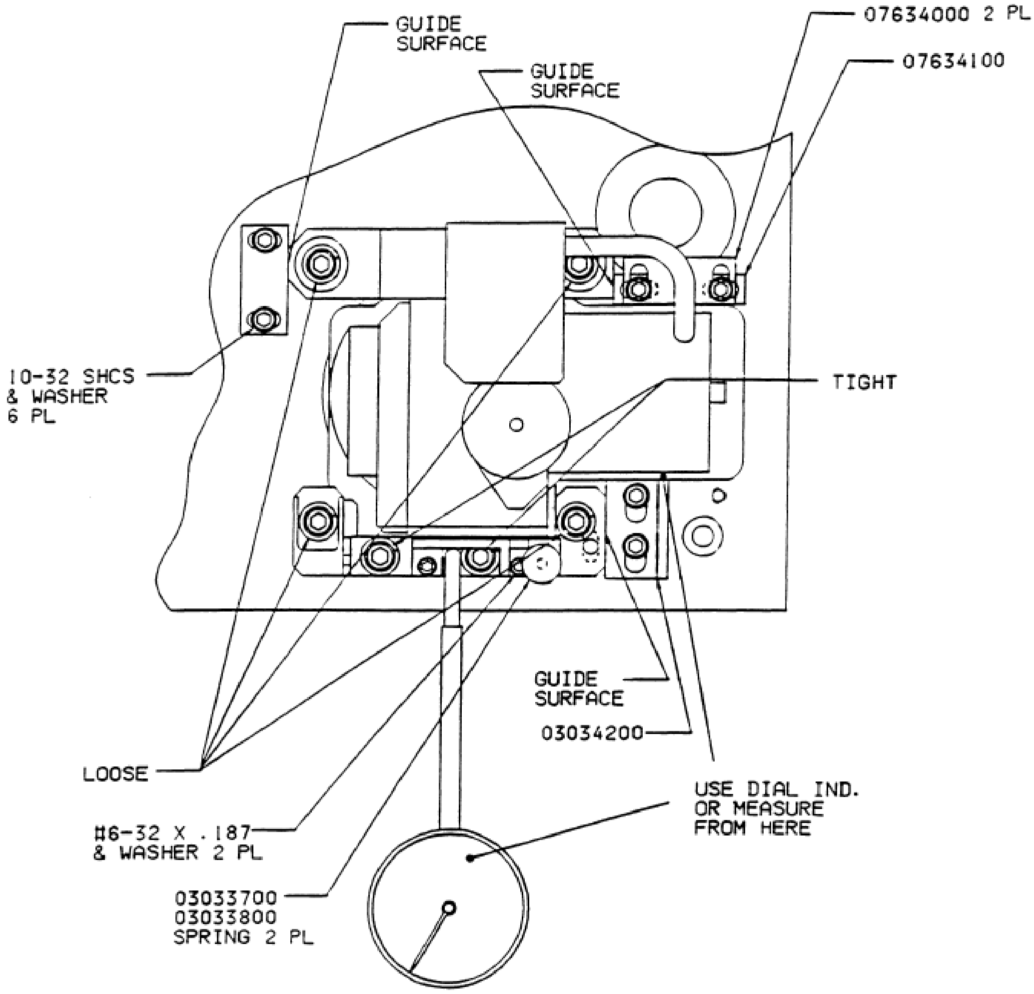


Figure 5-1 Topography Directions

Figure 5-2 shows all the mounting bolts that are loosened for the topography procedure.



NOTES:

1. VERIFY SENSOR STABILITY BEFORE STARTING. CHECK FOR DRIFT DURING TOPOGRAPHY READINGS BY READING BOTH ALONG THE AXIS AND BACK AGAIN. IF READINGS ARE ERRATIC. REPEAT. IF THEY SHOW A SMALL REGULAR DRIFT. AVERAGES MAY BE USED FOR EACH POINT.
2. START WITH MD. CD CENTERED. MOVE SOURCE TO MD POSITION NEAREST EDGE OF HEAD. TAKE READING OF AIR COUNTS THERE AND AT .020 INCH (0.50 MM) INCREMENTS AS THE BODY IS MOVED ALONG THE MD AXIS AND BACK AGAIN. LOCK THE BODY IN POSITION AT THE CENTER OF PLATEAU. NOW DO THE CD AXIS. IF CD PLATEAU IS NOT AT THE CENTER REPEAT MD PROCESS. REPEAT CD AND MD UNTIL A COMMON PLATEAU IS FOUND. LOCK BOTH AXES AS SHOWN. RECORD READINGS.

Figure 5-2 Mounting Bolts

Figure 5-3 shows the bolts that need to be loose and/or tight prior to moving the sensor in the cross direction.

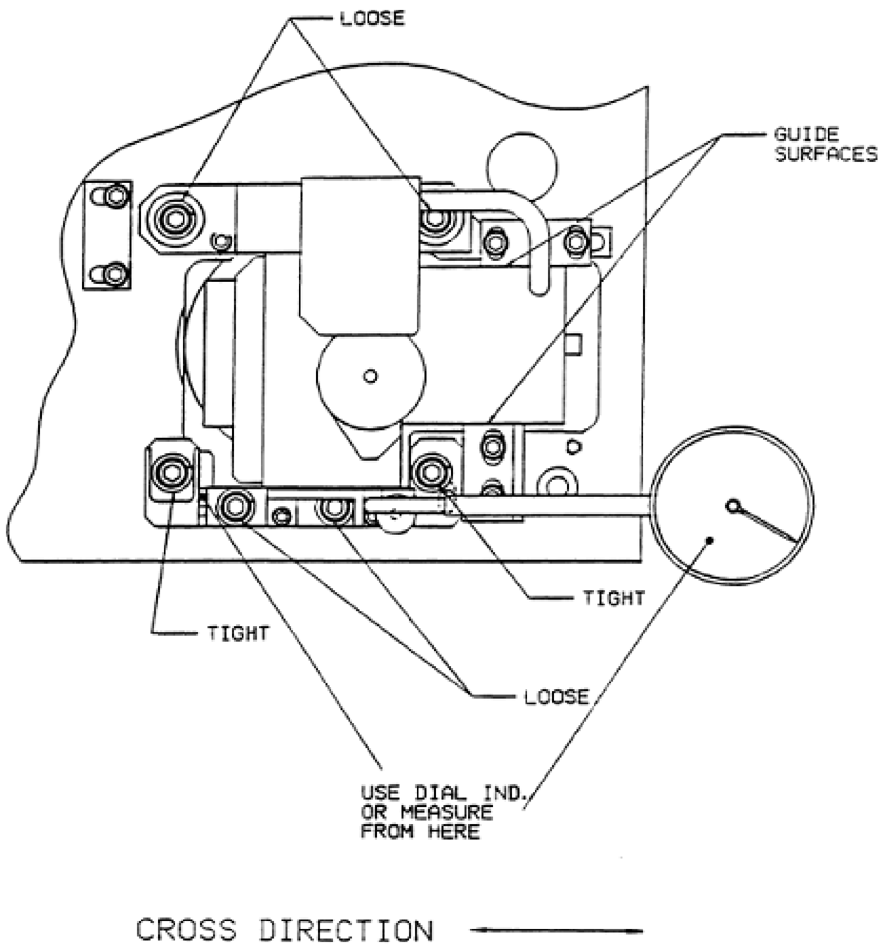


Figure 5-3 Cross Direction Travel Bolts

Figure 5-4 shows the mounting bolt that must be kept tight when removing the sensor from the base mounting plate.

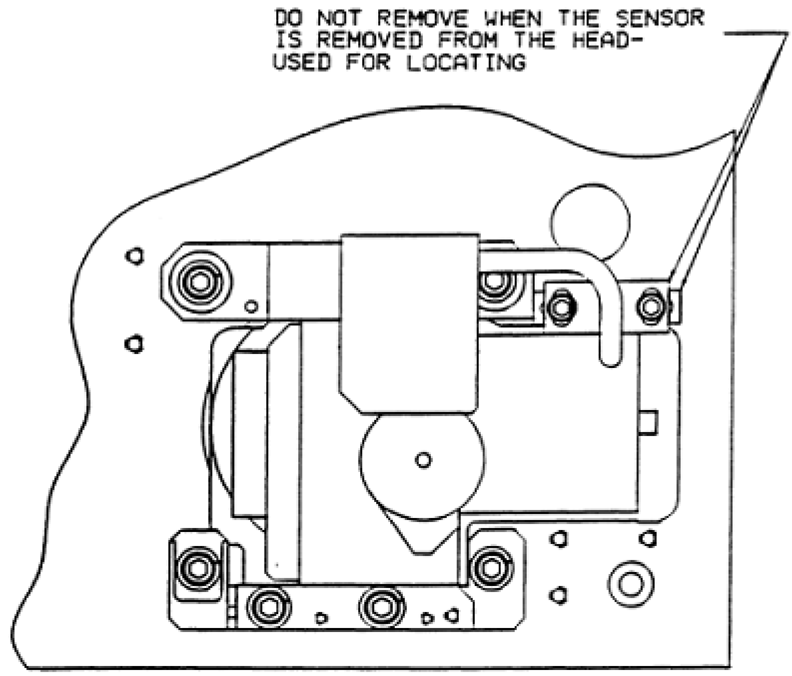


Figure 5-4 Bolt to tighten after completion of the procedure

For the most of the models, topography is not required. For these sensors, a stop is threaded in the source body that inserts into the base plates. Figure 5-5 shows the thread stops inserted for those Source 9 models that do not require topography.

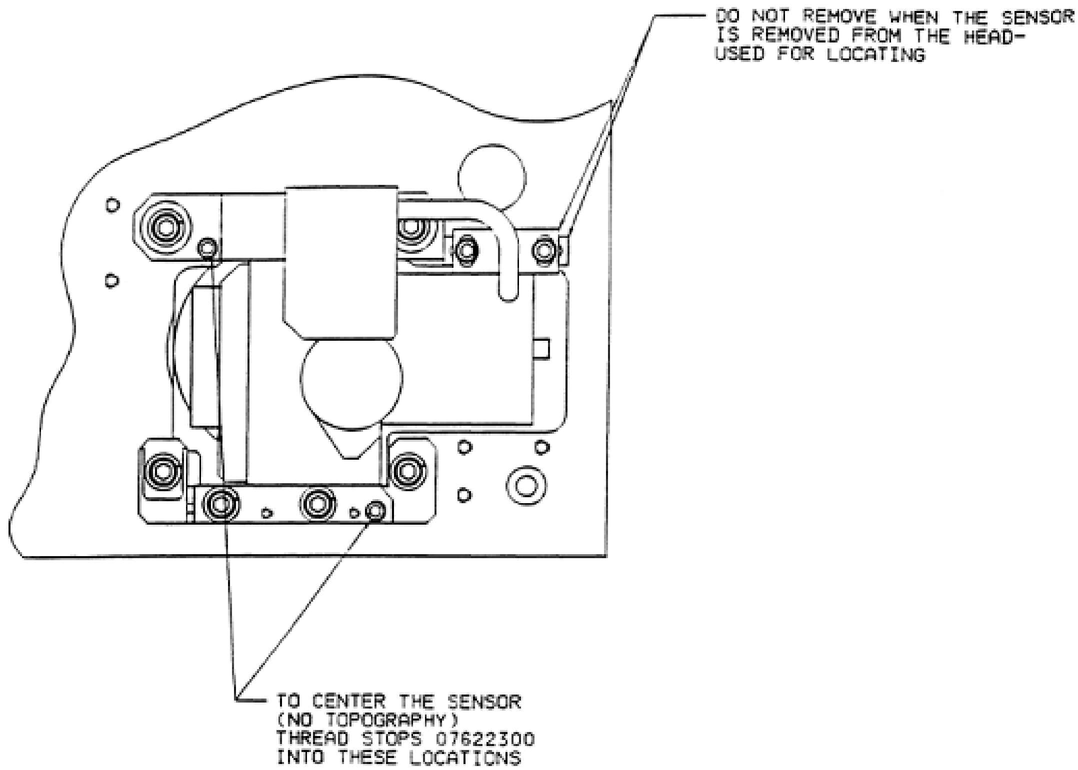


Figure 5-5 Thread Stops

5.1.2. Data Analysis

This section describes how to determine the optimum machine direction and cross direction positions.

5.1.2.1. Data Analysis: Part 1

Figure 5-6 through Figure 5-10 show the initial data collected for the topography of Q4201-10 production system on the floor.

Graphs *I-A* and *I-B* (see Figure 5-6 and Figure 5-7) are included to emphasize the need to take the readings in both directions of travel so that an average can be calculated. If the opposite edge is not read twice an average will not be available for that position.

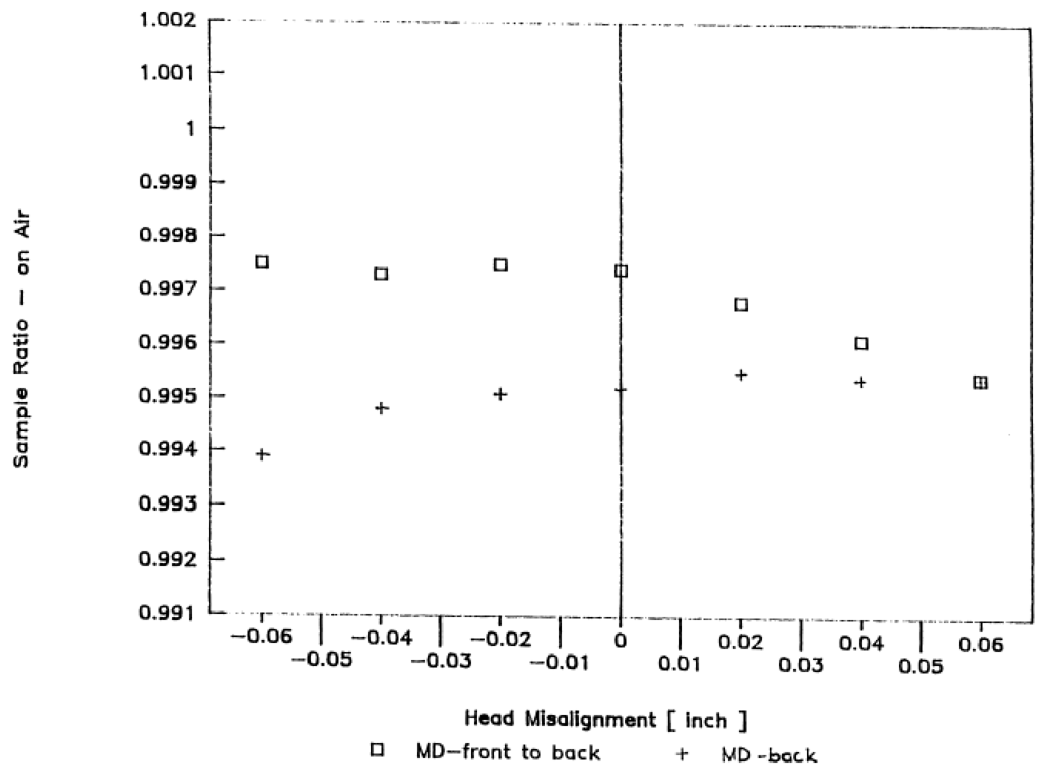


Figure 5-6 Graph I-A

Graph *I-C* (see Figure 5-8) is used to determine whether the procedure is complete or not.

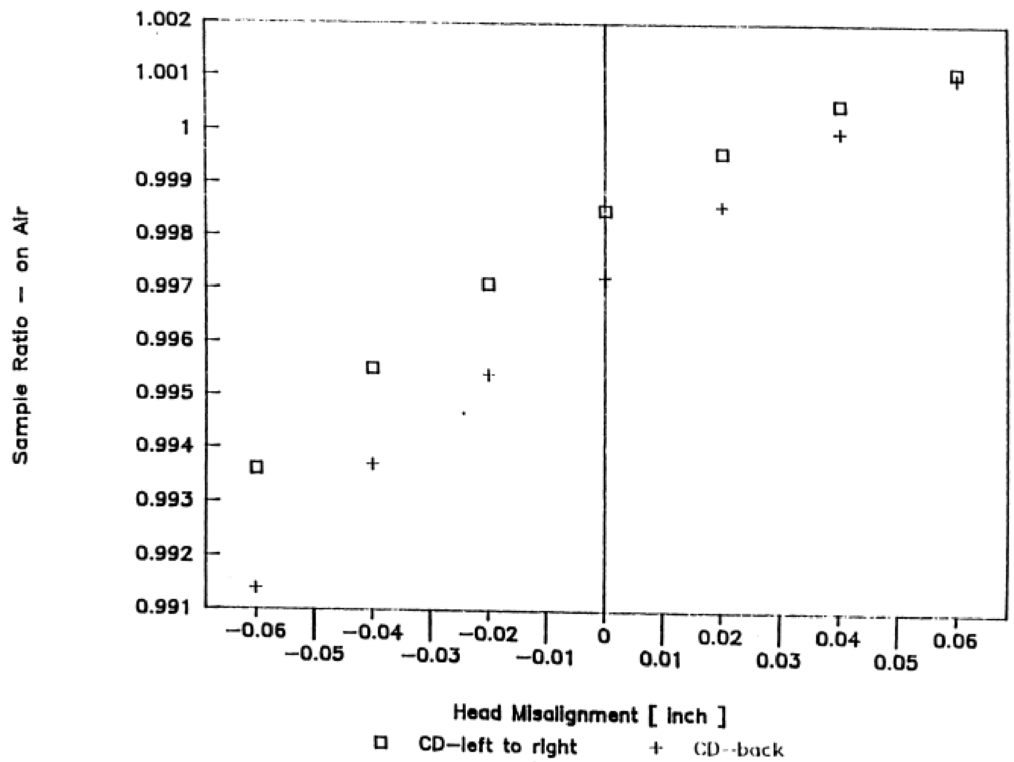


Figure 5-7 Graph I-B

The optimum position requirements for the source body:

- must be a plateau of sensor ratio that is at least 2 mm (0.08 in) wide
- the difference between the highest sample ratio and the lowest sample ratio within this distance in the curve must be less than or equal to 0.0010

In Graph *I-C* (see Figure 5-8), the machine direction average curve zero-position meets the requirements. The cross direction average curve zero-position does not. Therefore, topography is not yet done. Both machine direction and cross direction must meet the requirements in order to finish topography.

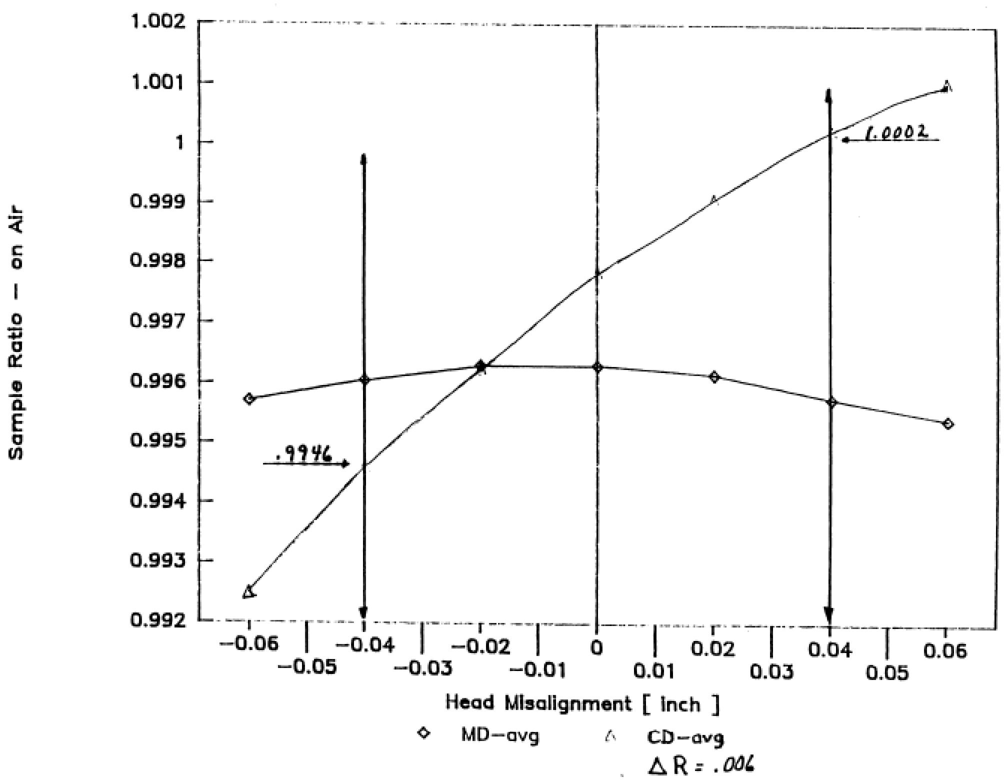


Figure 5-8 Graph I-C

5.1.2.2. Data Analysis: Part 2

The compensator has three available positions. It is already on the first, so rotate it to a second position and repeat the procedure. If the second position is not successful, rotate the compensator to the third position, and try again.

If after trying all three positions you were not able to get the optimum machine direction and cross direction positions, return your present compensator.

Graph *II* (see Figure 5-9) corresponds to sample readings taken with the compensator on the third position. If we look at the cross direction average curve, the zero-position now meets the requirements, but the machine direction average curve does not.

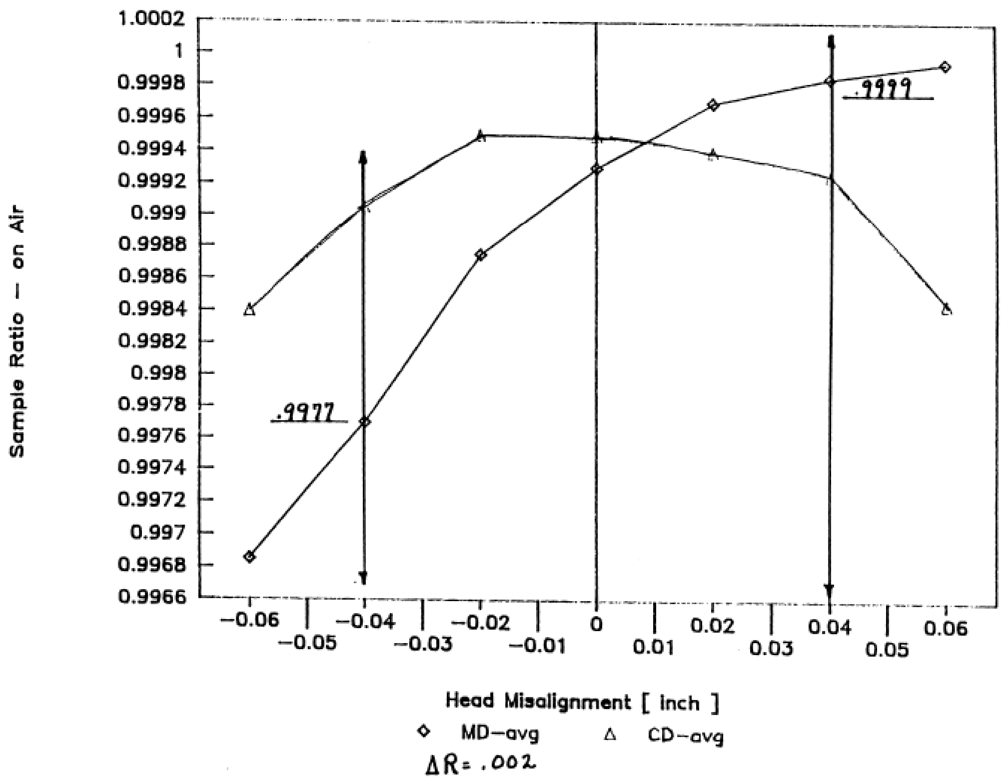


Figure 5-9 Graph II

Examine the machine direction average curve. If the zero-position is moved to the 0.02 inch location the new center point will satisfy the requirements. Do not move it any further. The requirement stated above that the optimum machine direction position have 1 mm (0.04 inches) at either side. Lock the machine direction travel and repeat the cross direction travel to make sure that it is still good.

Graph *III* (see Figure 5-10) shows the new cross direction average curve meets the requirements. For this particular system, topography is now finished.

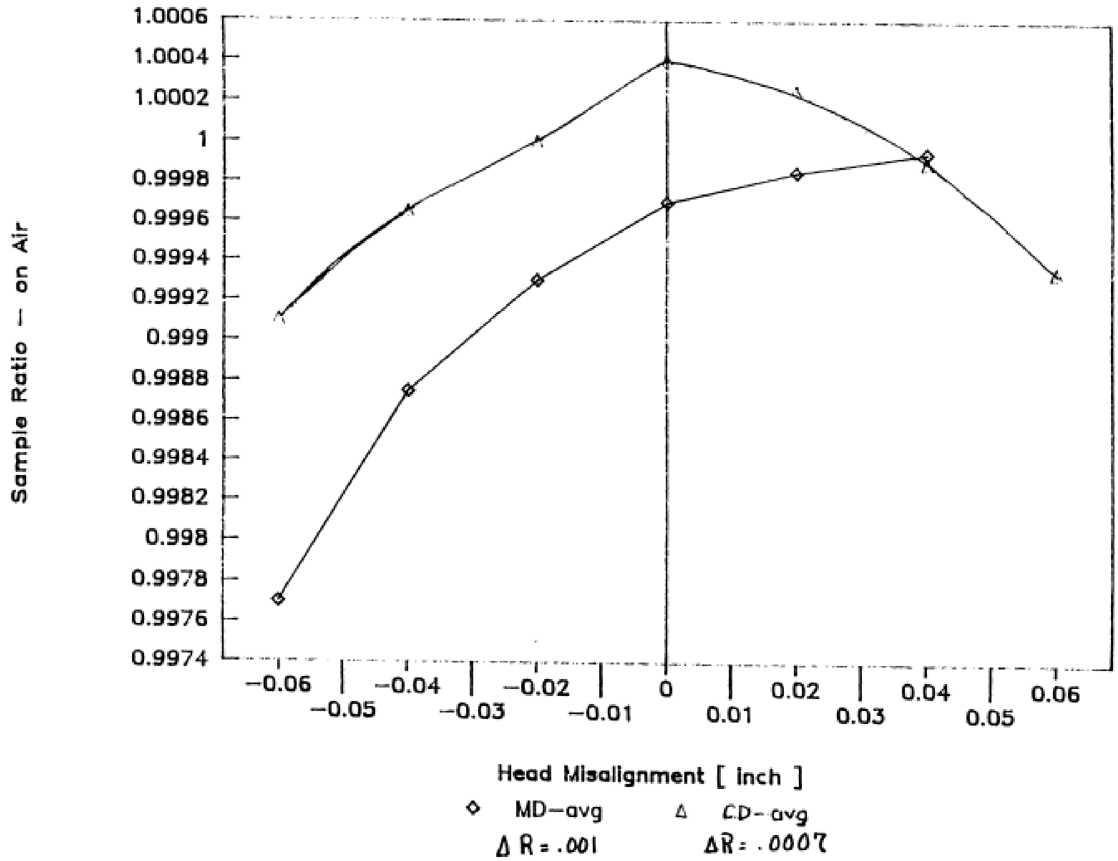


Figure 5-10 Graph III

Table 5-1 is a sample work spreadsheet for recording the change in sensor ratio versus the position of the source.

Table 5-1 Sensor Ratio Versus the Position of the Source

Readings	Point	Position inch	Sample Ratio (printout)	Average at Point
1	4(start edge)	.08		
2	3	.06		
3	2	.04		
4	1	.02		
5	0 (center)	0		
6	-1	-.02		
7	-2	-.04		
8	-3	-.06		
9	-4 (other edge)	-.08		
10	-4 (read it again and go back)	-.08		
11	-3	-.06		
12	-2	-.04		
13	-1	-.02		
14	0 (center)	0		
15	1	.02		
16	2	.04		
17	3	.06		

5.2. Model Q4202-50 Topography Procedure

5.2.1. Introduction

This procedure describes how to perform and document topography on the Source 12 basis weight sensor prior to offline calibration. The object is to maintain a difference in sample ratio of less than 0.0040 within 0.040in of the nominal mounting.

At the time of writing, the source 12 topography fixture is still under design and the source has to be moved manually.

Topography must be performed prior to sensor calibration and results of sample data must be plotted and included with the customer's integration checklist.

Before installing the top head in the calibration fixture, remove the Kapton window assembly form the basis weight receiver and verify that the compensator is aligned correctly.

Reject the receiver if the compensator is not parallel to machine direction.

5.2.2. Fixture Setup and Alignment Steps

1. Secure the topography fixture to the head so that the plunger is just less than fully extended when the source body is all the way to the left

2. Locate the point where the voltage reading is the lowest.

3. With the topography fixture and source body in place, read the voltage on the receiver back-plane TP7 (**BW Signal Out**) to TP3 (**RCVR RTN**) with the shutter open. Move the source body from far left to far right (in the CD direction).

4. The voltage reading should go from high to low and back to high as the source body moves from left to right (actual voltage change will be approximately 0.2 volts between high and low).

   If this is not the case, check that the topography fixture is not keeping the source from moving fully to the right.

5. Position the source body where the lowest voltage reading is found. Adjust the dial indicator on the topography fixture to read zero at this position.

5.2.3. Sample Screen Setup

Using RAE, set the system to Maintenance Mode and open the Advance screen for the Nuclear Sensor Processor. Using the **Add Sample** button, add seven samples to the verification screen. Set up is:

Measurement Units:

Y axis = Ratio

X Axis = Lab wt

Scaling = Automatic

Sample Data Values for Lab Weight:

Sample 1:	.06
Sample 2:	.04
Sample 3:	.02
Sample 4:	.00
Sample 5:	-.02
Sample 6:	-.04
Sample 7:	-.06

1. Perform a reference.
2. Move the source body to the left until the dial indicator reads 0.06 in from the zero position.
3. Take sample readings on air every .02 in as the source body travels from -0.06 to +0.06 in with respect to the zero position. This gives seven data points.
4. Graph the ratio (y-axis) against the position of the source body (x-axis) in 0.02 inch increments. Graph should resemble a parabola as in Figure 5-12.

5.2.4. Check Specfications

The difference between the highest sample ratio and the lowest sample ratio within +/- 0.04 in of the zero position must be less than or equal to 0.0040. If not, reposition the source body to correspond with the lowest point on the graph and repeat steps 1 through 4 from Section 5.2.3.

Topography is complete (no MD topography is required). **Save / Copy / Print the graph and sample printouts for inclusion in the white books.**

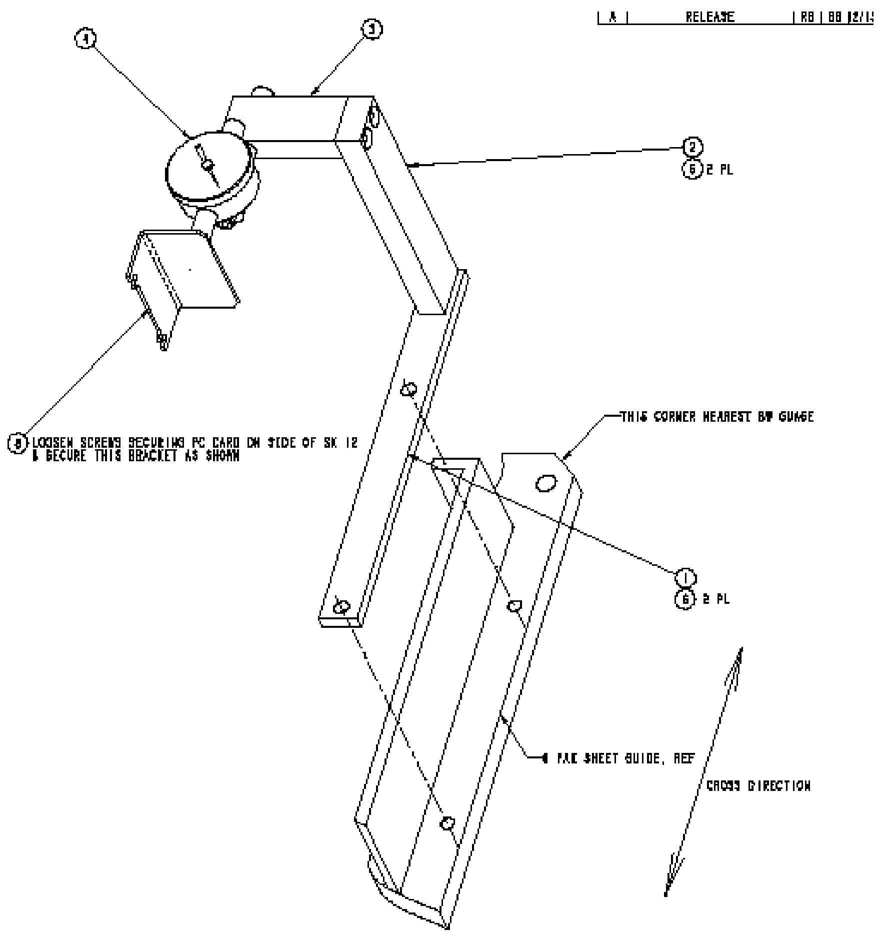


Figure 5-11 Topography Fixture for Q4202-50

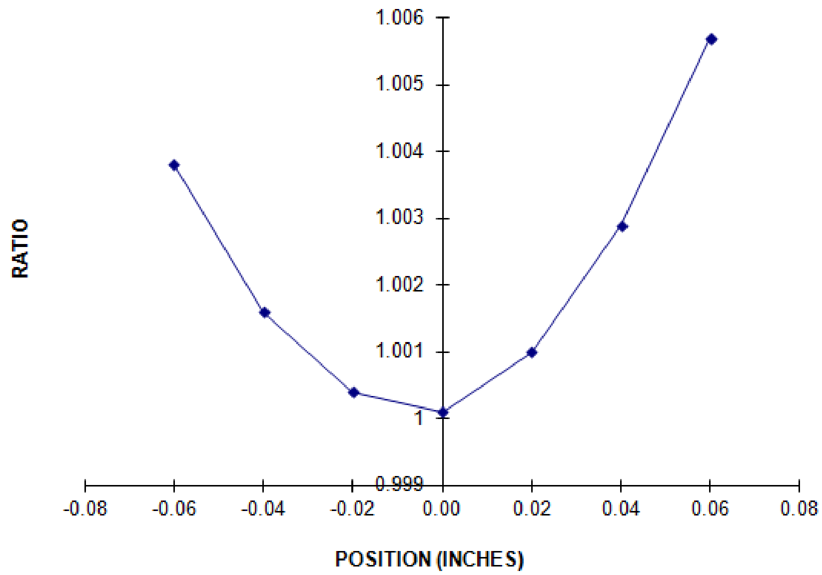


Figure 5-12 Topography that meets the specification

In **Figure 5-12**, the difference between the highest sample ratio and the lowest sample ratio within +/-.04 of zero position of the source body is less that .0040.

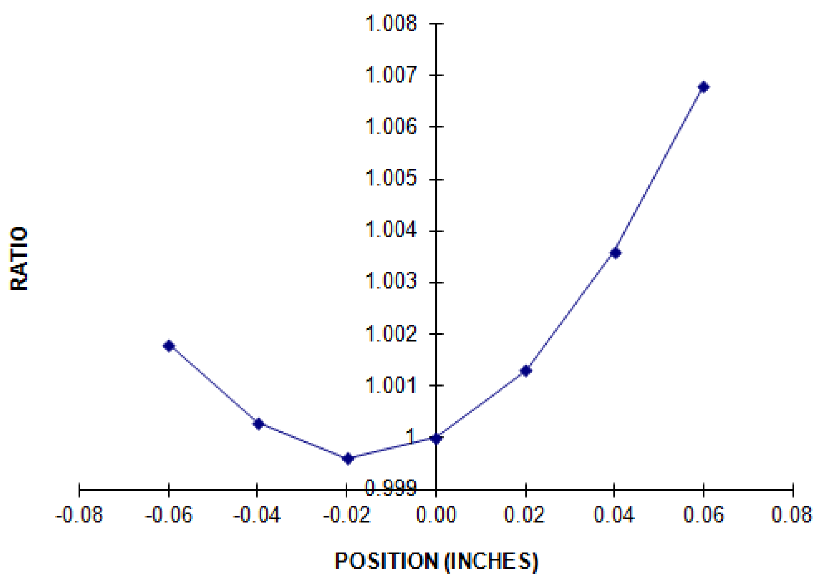


Figure 5-13 Topography that needs to be redone

In Figure 5-13, the source body should be repositioned to the -.02 position, the topography fixture dial indicator set to zero, and steps 1 through 4 from Section 5.2.3 repeated.

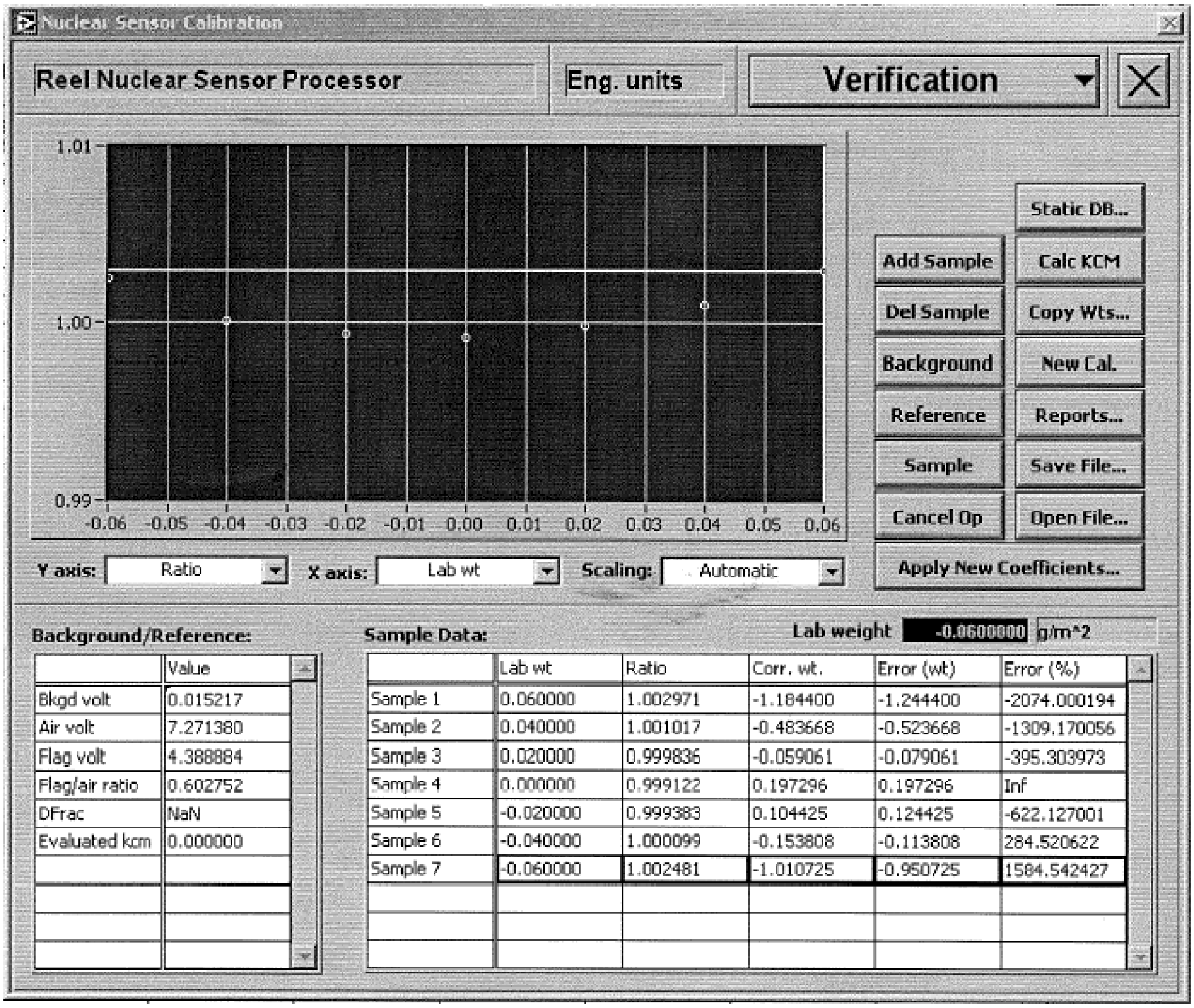


Figure 5-14 Typical RAE calibration screen used during topography test

Include a screen capture of your version of the image in Figure 5-14 in the Sensors section of the Customer's QCS Whitebook.

6. Model Q4201-XX Operations and Calibration System Constants

6.1. Overview

This chapter provides values for typical calibration and correction constants for all the Basis Weight Measurement Q4201-XX (Source 9) models.

6.2. Checkout and Calibration

The section provides the specifications needed for the checkout and calibration of each basis weight sensor. These include values determined at calibration (calibration constants), database values that vary by sensor model (for example, AGAs), and performance values for each model number.

All values are typical and nominal except for flag-to-air (F/A) stability that also includes the investigational limit. If the investigational limit is exceeded, examine the various values and compare them to their typical values.

6.2.1. Stability Notes

The values for stability specifications were determined using sets of 30 references, taken sequentially, with no additional interval between readings. They pertain to conditions of thermal equilibrium in the heads and constant gap temperature.

The typical values are from 12 or more sets of 30 references each. The investigational limit value is approximately 35% higher and represents the largest value usually obtained in a single set of 30 references. If data is taken before thermal equilibrium, the stability values may be several times greater–more so for air counts, less so for F/A ratios.

At the same time F/A and air counts stability are tested, background stability must be checked as follows:

> If while adjusting the background (offset) voltage the meter readings indicate an oscillation or drift of more than ± 1 mV (0.001 V), you should stop and determine if the cause of this drift is a grounding, ion chamber, or detector amp problem.

Table 6-1 provides conversion constants between common basis weight units.

Table 6-1 Conversion Constants

Customer Units	Unit Conversion Factor
g/m^2	1.0
$lb/3,300\ ft^2$	0.6759
$lb/3,000\ ft^2$	0.6145
$lb/1,000\ ft^2$	0.2048
$lb/yard^2$	0.001843
$oz/yard^2$	0.02949

6.3. Q4201-10 Pm-147 0.4-inch Gap

Range	2–200 g/m^2
Ash range	1–20%
Hardware set-up	Gain = 19 on low gain detector amp (100 MΩ) Gap = 0.4 in
Topography required	Yes (see Chapter 5)

6.3.1. Sensor Constants

Nominal source strength	=	700 ABU
Typical background	=	15 mV
Typical air volts	=	8.0 V (from 6–9 V)
TOFA for 0.001 in Mylar® flag	=	0.55 ± 0.03
TOCF for 0.0005 in Mylar dirt	=	-0.0089 ± 0.001

6.3.2. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical 1 sigma air counts (= 1-sigma / average air counts*100)%	=	0.013%
Typical 1 sigma F/A ratio	=	0.00009
Investigational limit 1 sigma F/A	=	0.00012

6.3.3. Typical Values of Constants Determined During Mylar Calibration (range 8–170 g/m^2)

Clean	**Dirty (using 0.0005 inches Mylar dirt)**
BA0= -2 ± 0.6	BD0= 0.03 ± 0.5
BA1 = -60.0 ± 2.7	BD1 = 1.21 ± 2.1
BA2 = -3.7 ± 1.7	BD2 = -0.50 ± 0.8
BA3 = -0.20 ± 0.5	BD3 = -0.18 ± 0.1

6.3.4. Grade Dependent Constants

BWDO	=	0.0
KCM	=	1.00–1.05 (tissue typically near 1.05, newsprint near 1.015)

6.3.5. Accuracy Specifications

Calibration fit accuracy	± 0.02 g/m^2 between 2–8 g/m^2
	± 0.25% between 8–200 g/m^2
Static Mylar verification accuracy (Mylar dirt for verification 0.00025 in = 8 g/m^2)	± 0.10 g/m^2 between 2–25 g/m^2
	± 0.40% between 25–200 g/m^2

6.3.6. Constants Supplied by Sensor Development Department

For a Gap of 10.2 mm (0.4 in)

AGAU	=	1,800 (g/m^2) (K)
AGAL	=	1,800 (g/m^2) (K)
AGAR	=	3,500 (g/m^2) (K)
AGAS	=	4,300 (g/m^2) (K)
CFZ	=	12 g/m^2 with Z-sensor
CFZ	=	0.0 g/m^2 with no Z-sensor
CFZS	=	0.0
KCM2	=	0.0

6.4. Q4201-10 Pm-147 0.4-inch and 0.2-inch Gap

Range	4–200 g/m^2
Ash range	1–20%
Hardware set-up	Gain = approximately 2.4 on low gain detector amp (100 MΩ) Gap = 0.4 in and 0.2 in Flag = 0.001 in Mylar
Topography required	Yes (see Chapter 5)

6.4.1. Sensor Constants

Nominal source strength	=	700 ABU
Typical background	=	15 mV
Typical air volts	=	7.0 V (set gain for 6–9 V)
TOFA	=	0.57 ± 0.02
TOCF for 0.0005 in Mylar dirt	=	-0.0075 ± 0.001

6.4.2. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical F/A ratio 1 sigma	=	0.00006
Investigational limit F/A 1 sigma (test bench)	=	0.0001
Investigational limit F/A 1 sigma (system)	=	0.00012

Additional diagnostic data:

- typical background 1 sigma = 0.02 mV (or 0.14%)
- typical air counts 1 sigma = 0.010% on test bench (defined as 1-sigma / average air counts*100%)

6.4.3. Typical Values of Constants Determined During Mylar Calibration (range 8–153 g/m^2)

Clean	Dirty (using 0.0005 inches Mylar dirt)
BAO = -0.11	BDO = 0.02
BA1 = -60.0	BDI = 1.2
BA2 = -3.4	BD2 = -0.5
BA3 = -0.25	BD3 = -0.2

6.4.4. Grade Dependent Constants

BWDO	=	0
KCM	=	1.00–1.05 (tissue typically near 1.05, newsprint near 1.015)

6.4.5. Accuracy Specifications

Calibration fit accuracy	± 0.02 g/m^2 all weight below 8 g/m^2
	2σ of residuals < 0.25% for all weights above 8 g/m^2
Static Mylar verification accuracy (Mylar dirt for verification = 0.00025 in) all points within:	± 0.10 g/m^2 from 2–25 g/m^2
	± 0.40% from 25–200 g/m^2

6.4.6. Constants Supplied by Sensor Development Department

For a Gap of 10.2 mm (0.4 in)

AGAU = 1,800 (g/m^2) (K)
AGAL = 1,800 (g/m^2) (K)
AGAR = 0.0 (g/m^2) (K)
AGAS = 4,300 (g/m^2) (K)
CFZ = 16 g/m^2 with Z-sensor
CFZ = 0.0 g/m^2 with no Z-sensor
CFZS = 0.0
KCM2 = 0.0

For a Gap of 5.1 mm (0.2 in)

AGAU = 900 (g/m^2) (K)
AGAL = 900 (g/m^2) (K)
AGAR = 0.0 (g/m^2) (K)
AGAS = 4,300 (g/m^2) (K)
CFZ = 8 g/m^2 with Z-sensor
CFZ = 0.0 g/m^2 with no Z-sensor
CFZS = 0.0
KCM2 = 0.0

6.5. Q4201-62 Kr 0.4-inch and 0.2-inch Gap

Range	140–1200 g/m^2
Ash range	< 2%
Hardware set-up	Gain = approximately 0.24 on low gain detector amp (20 MΩ) Gap = 0.4 in and 0.2 in Flag = 0.01 in Mylar
Topography required	No

6.5.1. Sensor Constants

Typical background	=	15 mV
Typical air volts	=	7.0 V (set gain for 6–9 V)
TOFA	=	0.40 ± 0.03
TOCF for 0.001 in Mylar dirt	=	-0.004 ± 0.002

6.5.2. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical F/A ratio 1 sigma	=	0.00004
Investigational limit F/A 1 sigma (test bench)	=	0.00006
Investigational limit F/A 1 sigma (system)	=	0.00009

Additional diagnostic data:

- typical background 1 sigma = 0.02 mV (or 0.14%)
- typical air counts 1 sigma = 0.01% on test bench (defined as 1-sigma / average air counts*100%)

6.5.3. Typical Values of Constants Determined During Mylar Calibration (range 8–153 g/m^2)

Clean	Dirty (using 0.001 in Mylar dirt)
BAO = -0.2	BDO = 0.6
BA1 = -415.0	BDI = 6.0
BA2 = -37.0	BD2 = 0.4
BA3 = -2.0	BD3 = -0.3

6.5.4. Grade Dependent Constants

BWDO = 0
KCM = 0.98–1.0

6.5.5. Accuracy Specifications

Calibration fit accuracy	2σ of residuals < 0.025% from 140–1100 g/m^2
Static Mylar verification accuracy (Mylar dirt for verification = 0.0005 in) all points within:	± 0.40% from 140–1100 g/m^2

6.5.6. Constants Supplied by Sensor Development Department

For a Gap of 10.2 mm (0.4 in)

AGAU = 1,800 (g/m^2) (K)
AGAL = 1,800 (g/m^2) (K)
AGAR = 0.0 (g/m^2) (K)
AGAS = 4,300 (g/m^2) (K)
CFZ = 40 g/m^2 with Z-sensor
CFZ = 0.0 g/m^2 with no Z-sensor
CFZS = 0.0
KCM2 = 0.0

For a Gap of 5.1 mm (0.2 in)

AGAU	=	900 (g/m^2) (K)
AGAL	=	900 (g/m^2) (K)
AGAR	=	0.0 (g/m^2) (K)
AGAS	=	4,300 (g/m^2) (K)
CFZ	=	20 g/m^2 with Z-sensor
CFZ	=	0.0 g/m^2 with no Z-sensor
CFZS	=	0.0
KCM2	=	0.0

6.6. Q4201-63 Kr 0.4-inch and 0.2-inch Gap

Range	8–1200 g/m^2
Ash range	< 20%
Hardware set-up	Gain = approximately 0.48 on low gain detector amp (20 MΩ) Gap = 0.4 in and 0.2 in Flag = 0.002 in Mylar
Topography required	No

6.6.1. Sensor Constants

Typical background	=	15 mV
Typical air volts	=	7.0 V (set gain for 6–9 V)
TOFA	=	0.81 ± 0.01
TOCF for 0.001 in Mylar dirt	=	-0.0021 ± 0.001

6.6.2. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical F/A ratio 1 sigma	=	0.00004
Investigational limit F/A 1 sigma (test bench)	=	0.00008
Investigational limit F/A 1 sigma (system)	=	0.0001

Additional diagnostic data:

- typical background 1 sigma = 0.02 mV (or 0.14%)
- typical air counts 1 sigma = 0.01% on test bench (defined as 1-sigma / average air counts*100%)

6.6.3. Typical Values of Constants Determined During Mylar Calibration (range 32–770 g/m^2)

Clean	Dirty (using 0.001 in Mylar dirt)
BAO = -0.12	BDO = -0.2
BA1 = -360.0	BDI = 6.0
BA2 = -36.4	BD2 = 1.3
BA3 = -3.0	BD3 = 0.2

6.6.4. Grade Dependent Constants

BWDO = 0
KCM = 0.98–1.0

6.6.5. Accuracy Specifications

Calibration fit accuracy	2σ of residuals < 0.25% from 8–1200 g/m^2
Static Mylar verification accuracy (Mylar dirt for verification = 0.0005 in) all points within:	± 0.10 g/m^2 from 7.5–25 g/m^2
	± 0.40% from 25–1200 g/m^2

6.6.6. Constants Supplied by Sensor Development Department

For a Gap of 10.2 mm (0.4 in)

AGAU = 1,800 (g/m^2) (K)
AGAL = 1,800 (g/m^2) (K)

For a Gap of 10.2 mm (0.4 in)

AGAR	=	0.0 (g/m^2) (K)
AGAS	=	4,300 (g/m^2) (K)
CFZ	=	36 g/m^2 with Z-sensor
CFZ	=	0.0 g/m^2 with no Z-sensor
CFZS	=	0.0
KCM2	=	0.0

For a Gap of 5.1 mm (0.2 in)

AGAU	=	900 (g/m^2) (K)
AGAL	=	900 (g/m^2) (K)
AGAR	=	0.0 (g/m^2) (K)
AGAS	=	4,300 (g/m^2) (K)
CFZ	=	18 g/m^2 with Z-sensor
CFZ	=	0.0 g/m^2 with no Z-sensor
CFZS	=	0.0
KCM2	=	0.0

6.7. Q4201-64 Kr 0.4-inch and 0.2-inch Gap

Range	20–1000 g/m^2
Ash range	$>$ 20%
Hardware set-up	Gain = approximately 2.4 on low gain detector amp (100 MΩ) Gap = 0.4 in and 0.2 in Flag = 0.002 in Mylar
Topography required	No

6.7.1. Sensor Constants

Normal source strength	=	40
Typical background	=	15 mV
Typical air volts	=	8.0 V (set gain for 6–9 V)
TOFA	=	0.77 ± 0.01
TOCF for 0.001 in Mylar dirt	=	-0.0035 ± 0.001

6.7.2. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical F/A ratio 1 sigma	=	0.00008
Investigational limit F/A 1 sigma (test bench)	=	0.00012
Investigational limit F/A 1 sigma (system)	=	0.00016

Additional diagnostic data:

- typical background 1 sigma = 0.02 mV (or 0.14%)
- typical air counts 1 sigma = 0.007% on test bench (1-sigma + average air counts)*100

6.7.3. Typical Values of Constants Determined During Mylar Calibration (range 32–770 g/m^2)

Clean	Dirty (using 0.001 in Mylar dirt)
BAO = -0.22	BDO = -0.23
BA1 = -380.0	BDI = 5.0
BA2 = -26.8	BD2 = 0.0
BA3 = -3.3	BD3 = -0.3

6.7.4. Grade Dependent Constants

BWDO	=	0
KCM	=	1.09–1.11

6.7.5. Accuracy Specifications

Calibration fit accuracy	2σ of residuals < 0.25% from 20–1000 g/m^2
Static Mylar verification accuracy (Mylar dirt for verification = 0.0005 in) all points within:	± 0.40% from 20–1000 g/m^2

6.7.6. Constants Supplied by Sensor Development Department

For a Gap of 10.2 mm (0.4 in)

AGAU = 1,800 (g/m^2) (K)
AGAL = 1,800 (g/m^2) (K)
AGAR = 0.0 (g/m^2) (K)
AGAS = 4,300 (g/m^2) (K)
CFZ = 13–200 g/m^2 with Z-sensor
CFZ = 20 g/m^2 from 200–400 g/m^2 with Z-sensor
CFZS = 30 g/m^2 from 400–600g/m^2 with Z-sensor
CFZ = 40 g/m^2 above 600 g/m^2 with Z-sensor
CFZ = 0.0 g/m^2 with no Z-sensor
CFZS = 0.0
KCM2 = 0.0

For a Gap of 5.1 mm (0.2 in)

AGAU = 900 (g/m^2) (K)
AGAL = 900 (g/m^2) (K)
AGAR = 0.0 (g/m^2) (K)
AGAS = 4,300 (g/m^2) (K)
CFZ = 6.5–200 g/m^2 with Z sensor
CFZ = 10 g/m^2 with no Z-sensor
CFZS = 15 g/m^2 from 400–600g/m^2 with Z-sensor
CFZ = 20 g/m^2 above 600 g/m^2 with Z-sensor
CFZ = 0.0 g/m^2 with no Z-sensor
CFZS = 0.0
KCM2 = 0.0

7. Model Q4202-50 Operations and Calibration System Constants

7.1. Checkout and Calibration

The section provides the specifications needed for the checkout and calibration of each basis weight sensor. These include values determined at calibration (calibration constants), database values that vary by sensor model (for example, AGAs), and performance values for each model number.

All values are typical and nominal except for flag-to-air (F/A) stability that also includes the investigational limit. If the investigational limit is exceeded, examine the various values and compare them to their typical values.

7.1.1. Stability Notes

The values for stability specifications were determined using sets of 30 references, taken sequentially, with no additional interval between readings. They pertain to conditions of thermal equilibrium in the heads and constant gap temperature.

The typical values are from 12 or more sets of 30 references each. The investigational limit value is approximately 35% higher and represents the largest value usually obtained in a single set of 30 references. If data is taken before thermal equilibrium, the stability values may be several times greater–more so for air counts, less so for F/A ratios.

At the same time F/A and air counts stability are tested, background stability must be checked.

If while adjusting the background (offset) voltage the meter readings indicate an oscillation or drift of more than ± 1 mV (0.001 V), stop and determine if the cause of this drift is a grounding, ion chamber, or detector amp problem.

Table 7-1 provides conversion constants between common basis weight units.

Table 7-1 Conversion Constants

Customer Units	Unit Conversion Factor
g/m^2	1.0
$lb/3,300\ ft^2$	0.6759
$lb/3,000\ ft^2$	0.6145
$lb/1,000\ ft^2$	0.2048
$lb/yard^2$	0.001843
$oz/yard^2$	0.02949

7.2. Typical Values of Constants Determined during Mylar Calibration

Table 7-2 gives the typical nominal calibration coefficients when a single curve fits the entire weight range, 0-250 gsm. Coefficients vary for other weight ranges, particularly with higher low ends.

Table 7-2 Typical Calibration Curve Coefficients

Clean	Dirty
	(using .0005 inch Mylar Dirt)
BA0 ≅ 0	BD0 ≅ 0
BA1 ≅ - 60	BD1 ≅ 2 ±1
BA2 ≅ 0	BD2 ≅ 0±5
BA3 ≅ 0	BD3 ≅ 0
BA4 ≅ 0	BD4 ≅ 0
BA5 ≅ 0	BD5 ≅ 0
BA6 ≅ 0	BD6 ≅ 0

7.3. Grade Dependent Constants

BWDO = 0
KCM = 1.00 - 1.05 (tissue near 1.05, newsprint near 1.015)
KCM varies with chemical and physical makeup of customer product.

7.4. Accuracy Specifications

Calibration fit accuracy	± .02 gsm for all points below 8 gsm
Static Mylar verification accuracy for all points (Mylar dirt for verification = .000025 inch, ¼ mil, Mylar dirt for building curve = .0005 inch, ½ mil) must be within:	± 0.10 gsm from 0 - 25 gsm ± 0.40 % from 25 - 250 gsm

7.5. Constants Supplied by Sensor Development Department

Table 7-3 provides the corrector constants for a gap of 0.4 inches (10.2 mm):

Table 7-3 Corrector Constants

Constant	Value	Definition
AGAU	1,800 gsm / K	Upper Air Gap Temp Corrector
AGAL	1,800 gsm / K	Lower Air Gap Temp Corrector
AGAR	0 gsm / K	Rx Air Gap Temp Corrector
AGAS	4950 gsm / K (does not change with changes in gap)	Sx Air Gap Temp Corrector
CFZ	(with Z sensor) 14.5 gsm Normal or ratio algorithm (default)	Z-correction coefficient on-sheet (normal or default CFZ)
CFZ	(with Z sensor) 14.5 gsm/mm absolute difference algorithm [1]	Z-correction coefficient on-sheet (use this when you know you are using absolute difference algorithm)
CFZS	0.0	Z-correction coefficient standardize
KCM2	0.0	used for Mylar curve to customer product curve transformation

[1] Normal or default (ratio) algorithm: Zcorrection=CFZ·(Zred-Znow)/Zref + CFZS
Alternative (absolute) algorithm: Zcorrection= CFZ·(Zref-Znow) + CFZS

Except for the AGAS these constants scale linearly. For example, doubling the gap would require the doubling of all of the values in Table 7-3.

8. Model Q2201-XX Operations and Calibration System Constants

8.1. Q2201-72 (heavy product and wet end applications)

Range	80-7200 g/m^2
Ash range	< 2% or constant by grade
Hardware set-up	Gain = approximately 0.24 on low gain detector amp (20 MΩ) Gap = 0.4 Flag = 28 mil Mylar
Topography required	No

8.1.1. Typical Values of Constants Determined during Mylar Calibration

Table 8-1 gives the typical nominal calibration coefficients when a single curve fits the entire weight range, 70-3270 gsm. Coefficients vary for other weight ranges, particularly with higher low ends.

Table 8-1 Typical Calibration Curve Coefficients

Clean	**Dirty**
	(using .0005 inch Mylar Dirt)
BA0 $\cong$ -5	BD0 $\cong$ 0
BA1 $\cong$ -740	BD1 $\cong$ -50

Clean	Dirty
	(using .0005 inch Mylar Dirt)
BA2 ≅ 590	BD2 ≅ -10
BA3 ≅ 170	BD3 ≅ 0

8.1.2. Grade Dependent Constants

BWDO = 0
KCM = Depends on application but expect to be between 0.97 and 1.02

8.1.3. Accuracy Specifications

Calibration fit accuracy	± 0.30 gsm for all points below 120 gsm ± 0.25 % between 120 – 7200 gsm
Static Mylar verification accuracy for all points (Mylar dirt for verification = 0 .0005 inch):	± 0.50 gsm below 120 gsm ± 0.40 % from 120 - 7200 gsm

8.1.4. Constants Supplied by Sensor Development Department

Table 8-2 provides the corrector constants for a gap of 0.4 inches (10.2 mm):

Table 8-2 Corrector Constants

Constant	Value	Definition
AGAU	0 gsm/K	Upper Air Gap Temp Corrector – not used in the Q4000
AGAL	0 gsm/K	Lower Air Gap Temp Corrector –not used in the Q4000
AGAR	0 gsm / K	Rx Air column Temp Corrector
AGAS	6500 gsm/K	Sx Air column Temp Corrector
CFZ	(with Z sensor) 16 gsm Normal or ratio algorithm (default)	Z-correction coefficient on-sheet (normal or default CFZ)
CFZS	0.0	Z-correction coefficient standardize

Constant	Value	Definition
KCM2	0.0	used for Mylar curve to customer product curve transformation

8.1.5. Sensor Constants

Typical background	=	15 mV
Typical air volts	=	7.0 V (set gain for 6–9 V)
TOFA	=	0.41 ± 0.03
TOCF for 0.001 in Mylar dirt	=	0.0075 ± 0.002

8.1.6. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical 1 sigma F/A ratio	=	0.00007
Investigational limit 1 sigma F/A	=	0.00011

8.2. Q2201-73 (wire calender)

Range	170-3500 g/m^2
Ash range	Medium
Hardware set-up	Gap = 0.75 Flag = 28 mil Mylar
Topography required	No

8.2.1. Typical Values of Constants Determined during Mylar Calibration

Table 8-3 gives the typical nominal calibration coefficients when a single curve fits the entire weight range, 175-2125 gsm. Coefficients vary for other weight ranges, particularly with higher low ends.

Table 8-3 Typical Calibration Curve Coefficients 175- 2125 gsm

Clean	Dirty
	(using .0005 inch Mylar Dirt)
BA0 ≅ 0	BD0 ≅ -10
BA1 ≅ -1535	BD1 ≅ -1500
BA2 ≅ -175	BD2 ≅ -155
BA3 ≅ 45	BD3 ≅ -40

Table 8-4 Typical Calibration Curve Coefficients 2125- 3550 gsm

Clean	Dirty
	(using .0005 inch Mylar Dirt)
BA0 ≅ -675	BD0 ≅ -935
BA1 ≅ -2520	BD1 ≅ -3380
BA2 ≅ -975	BD2 ≅ -1345
BA3 ≅ -295	BD3 ≅ -295

8.2.2. Grade Dependent Constants

BWDO = 0
KCM = Depends on application but expect to be between 0.97 and 1.02

8.2.3. Accuracy Specifications

Calibration fit accuracy	± 0.25 % between 170 – 3500 gsm
Static Mylar verification accuracy for all points (Mylar dirt for verification = .0005 Mylar)	± 0.40 % 170 - 2500 gsm ± 0.50 % 2500 – 3000 gsm ± 0.60 % 3000 - 3500 gsm

8.2.4. Constants Supplied by Sensor Development Department

Table 8-5 provides the corrector constants for a gap of 0.4 inches (10.2 mm):

Table 8-5 Corrector Constants

Constant	Value	Definition
AGAU	0 gsm/K	Upper Air Gap Temp Corrector – not used in the Q4000
AGAL	0 gsm/K	Lower Air Gap Temp Corrector –not used in the Q4000
AGAR	6500 gsm / K	Rx Air column Temp Corrector
AGAS	0 gsm/K	Sx Air column Temp Corrector
CFZ	(with Z sensor) 30 gsm Normal or ratio algorithm (default)	Z-correction coefficient on-sheet (normal or default CFZ)
CFZS	0.0	Z-correction coefficient standardize
KCM2	0.0	used for Mylar curve to customer product curve transformation

8.2.5. Sensor Constants

Typical background	=	15 mV
Typical air volts	=	7.0 V (set gain for 6–9 V)
TOFA	=	0.47 ± 0.03
TOCF for 0.005 in Mylar dirt	=	-0.007 ± 0.010

8.2.6. Stability Specifications

Sigmas and averages are for 30 consecutive references at a 16 second integration time. Waiting interval between references = zero.

Typical 1 sigma F/A ratio	=	0.00010
Investigational limit 1 sigma F/A	=	0.00014

9. Static Calibration

The calibration of the sensor can only be achieved once the sensor is known to be stable. The sensor is calibrated, both clean and dirty, using Mylar® samples.

This data is fit using a UniCal proprietary fit routine. The calibration constants are entered and the sensor is then verified, both clean and with approximately half the dirt used during the generation of the dirty curve.

Customer samples are read in the sensor and a factor, called KCM, is used as a multiplicative factor from the Mylar calibration curve. The KCM represents the small difference in absorption properties of the customer product relative to the base Mylar curve. Transfer samples are set up to maintain long term sensor accuracy.

This chapter is organized into four sections:

- general calibration instructions
- calibration interface and how to use it
- calibration procedures
- verification procedures.

9.1. General Calibration Instructions

9.1.1. Conversion Constants

Table 9-1 provides conversion constants between common basis weight units.

Table 9-1 Conversion Constants

Customer Units	Unit Conversion Factor
g/m^2	1.0
$lb/3{,}300\ ft^2$	0.6759
$lb/3{,}000\ ft^2$	0.6145
$lb/1{,}000\ ft^2$	0.2048
$lb/yard^2$	0.001843
$oz/yard^2$	0.02949

For example, $1 g/m^2$ is $0.6145 lbs/3000\ ft^2$.

9.1.2. Required Tools

- Mylar sample set including simulated dirt for calibration and verification
- sensor calibration constants from original calibration
- 11.43-cm (4.5-in) and 17.78-cm (7-in) dies
- customer samples
- sample paddle for appropriate head
- lab balance

For an 11.43-cm (4.5-in) sample the conversion factor is:

(weight in grams) × (97.458) =sheet basis weight in g/m^2

For a 17.78-mm (7.0-in) sample the conversion factor is:

(weight in grams) × (40.276) = sheet basis weight in g/m^2

Details on using the paddle and the fixture (see Figure 9-1) can be found in your scanner system manual.

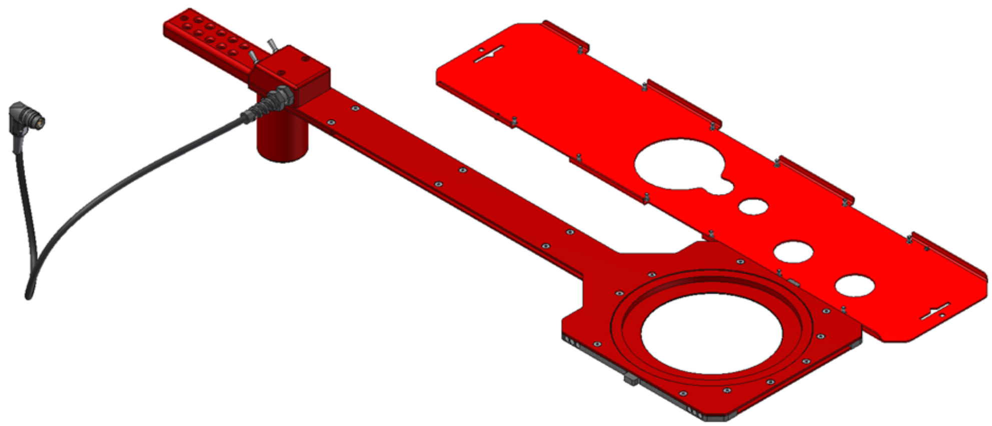


Figure 9-1 Sample Paddle and Alignment Fixture

9.1.3. Pre-calibration Sensor Checks

1. Check that topography has been done in the factory. This is required for the Pm-147 isotope version of the Source 9 and always for the Source 12.

2. Verify that the sensor meets the flag-to-air (F/A) stability standards as listed in calibration package. When doing an F/A stability, make sure that the heads are thermally stabilized and the integration time for reference/standardize is set to 16 seconds.

   References should be done in groups of 30, and a 1 sigma for the F/A can be computed for each group of 30. It is a good idea to do at least two groups of 30 to verify that the sensor has reached a stable condition. The stability test can be done through the **Sensor Maintenance** display by choosing maintenance mode.

3. For optimum stability it is suggested that you:

   a. Close up heads.

   b. Disable sheetguide heaters.

   c. Provide air to the source, but not to air temperature sensors or air wipe.

d. Establish thermal equilibrium (takes approximately 2 hours).

4. Check sample paddle interference: without a sample in the paddle, sample should give sensor ratios of 1.0000 ± 0.0010 or better.

5. Ensure that the integration times for references and samples are 16 seconds, and if possible do a screen copy to document these integration times.

9.1.4. Mylar Calibration Procedures

1. Determine the customer basis weight range.

2. A Mylar sample set has been put together with at least one, and preferably two, samples lighter and heavier than the customer's lightest and heaviest samples.

   The set should contain at least 10 samples. More samples are needed if the calibration is to be over a wide range (see Step 6). The samples have been carefully weighed and their basis weights recorded.

   A Mylar dirt simulation sample for calibration, and a dirt simulation sample for verification, which is typically about one half the basis weight of the dirt simulation sample for calibration, are also needed.

   Six transfer samples spanning the weight range should also have been prepared. Transfer samples are individual samples of varying weight (rather than thin samples to be stacked).

3. Once the sensor has passed the pre-calibration checks, do a background and reference and read each sample. Rotate and stir the samples to ensure uniform illumination of the sample by the beam.

   Drift Check: Read an air sample (empty paddle, 16 seconds) at the beginning of the calibration. Read another air sample at the end of the calibration, or every 10 samples if additional samples are required. If the drift exceeds the following limits, do another reference and repeat the preceding samples:

   sensor ratio drift limit Kr85 sensors: ± 0.0005

   sensor ratio drift limit Pm-147 sensors: ± 0.0010

   sensor ratio drift limit Sr90 sensors: ± 0.0005

4. Put the appropriate dirt simulation (see Chapter 9) sample in the paddle, do a reference (with the dirt), and read each sample (with the dirt). At this point each sample has an associated clean and dirty ratio. Again, read a dirty air sample (empty paddle except for the dirt) at the beginning and end of the calibration to check for drift.

5. Fit the clean and dirty data to determine the UniCal fit coefficients.

6. See Chapter 9 for the fit goodness in the accuracy specification section, or allow the calibration department to check when doing the fit. If the fit is not as good as listed and the weight range is large, try breaking the fit into two fit segments. There should be at least eight points per range.

7. Compare the fit coefficients with those in Chapter 6,7 or 8, or with the original fit. The coefficients should be generally similar. If the weight range is similar and the same number of coefficients are chosen, the fit coefficients should be very close to those given, particularly BA1 and T0CF ([dirty F/A] - [clean F/A]).

9.1.5. Mylar Verification Procedures

1. Do a clean reference and then read at least six of the samples throughout the range. Chapters 6, 7 and 8 list the applicable verification accuracies and these are listed in the calibration package shipped with each system.

2. Using half the amount of dirt as was used in the original calibration, do a dirty reference and then read the same samples with the dirt in place. The calibration package from the original calibration lists the applicable verification accuracies.

9.1.6. Mylar Transfer Samples

The Mylar transfer samples are intended to be long-term repeatability samples used as part of a regular sensor preventative maintenance program. After calibration has been verified on Mylar standards, determine the basis weights of the Mylar transfer samples as follows:

1. Do a clean reference.

2. Read transfer samples clean.

3. Do a dirty reference.

4. Read transfer samples dirty.

5. Average the clean and dirty basis weights for each sample. This average becomes the Lab Basis Weight for each transfer sample and is marked on the sample.

6. Compare the average basis weight to the basis weight clean and the basis weight dirty. Basis weight clean and basis weight dirty should verify to average basis weight within the accuracy specifications given in Chapter 6, 7 or 8.

9.1.7. Customer Product Procedures

The purpose of reading the customer product is to determine the offset of the sensor response for the customer product relative to the calibration standard, Mylar. This offset is expressed as a multiplicative quantity called KCM.

In general, all grades will have the same KCM values even though the software allows the possibility for each grade to have its own KCM. The two known reasons why KCM may differ from one grade to the next are:

- Additives such as barium sulfate. Because barium has an atomic number of 56, the sensor reads these samples as heavier than they really are thus giving a KCM value lower than ash-free paper.

- Formation in the paper may cause non-linear averaging of the weights. This will cause the KCM value to read high. This should not be confused with formation effects showing up as random noise when sampling, due to the fact that the sample is not completely uniformly illuminated by the beam no matter how carefully the sample paddle is designed.

Random effects from non-uniformity are best handled by reading several samples from each grade and averaging all the KCM values and then using this average for the grade. A general rule is to average the KCM values of various grades if no sample has a KCM more than 0.0075 from the average.

1. Prepare the customer samples by dieing-out one or more seven-inch disks for each sample.

2. Make sure the sensor has verified clean and dirty on Mylar.

3. Do a clean reference.

4. Read one or more samples of each grade.

5. Die-out 11.43-cm (4.5-in) center of each sample read. This is done because the sample paddle only allows the center 11.43 cm (4.5 in) of the sample to be illuminated by the beam.

6. Weigh each 11.43-cm (4.5-in) sample and calculate the basis weight (g/m^2 or customer units using the unit conversion factors (UCF) shown in Table 9-1: multiple grams by 97.46).

7. Calculate KCM.

9.2. Using the Calibration Interface

Perform all the general maintenance procedures in this section using the **Sensor Maintenance** display.

Have a laptop computer at the scanner during the calibration process so that you can see the results of each of the samples. The laptop can be connected to a port on the Ethernet switch in the endbell. A local IP address is provided through DHCP. You can then remote-desktop to the real-time application environment (RAE) server by any number of methods such as VNC, PCAnywhere, RDP, Windows Remote Desktop, and others. The IP address of the server as seen by the Measurement Sub System- (MSS) RAE network should be used to connect to the server.

9.2.1. Verify Sensor Stability

Before starting to perform any further maintenance procedure, always ensure that the sensor is in a working condition by verifying its stability. Generally, this procedure involves requesting multiple references. The statistics, such as the average and the standard deviation (sigma), of the readings should be reasonably within the tolerance limit set forth by the sensor's manual.

Usually, if the statistical numbers do not fall into specification, there may be some hardware or environment issues associated with the sensor. Stop and resolve the problem before going any further.

1. In maintenance mode, request at least one background operation before requesting references.

2. Set up to request a set or multiple sets of 30 references using the method described in the scanner documentation. The results of more than one set of operations usually give a more reliable view of the stability of the sensor.

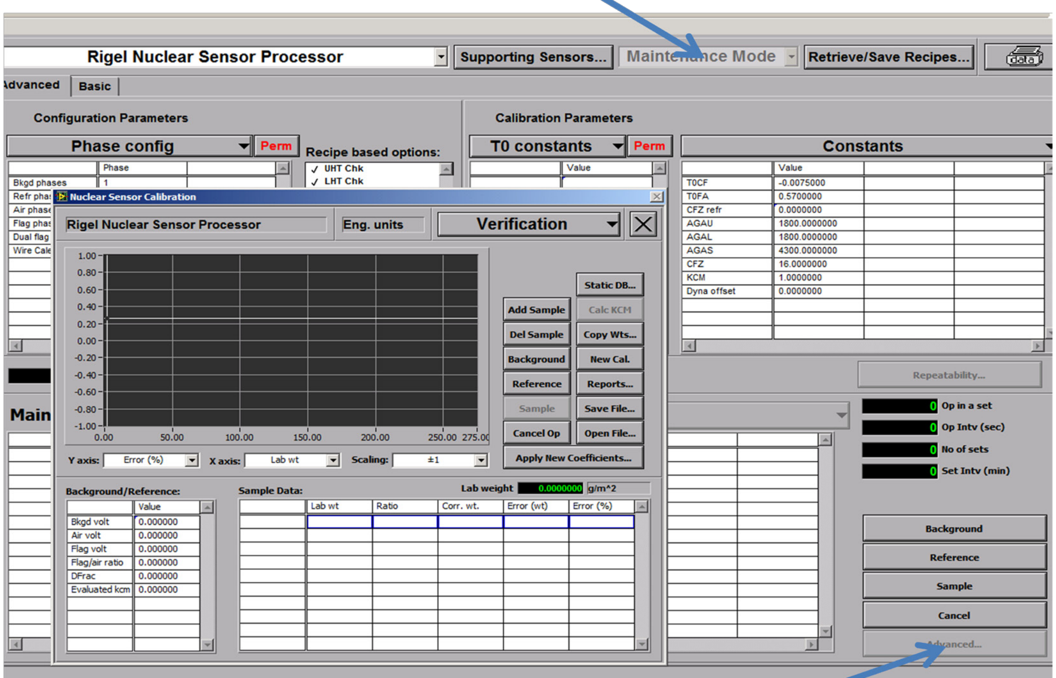
3. Compare the resulting statistics against the specification in Chapter 6 or Chapter 7.

4. If within specification, go ahead to the next maintenance procedure. Otherwise, troubleshoot the sensor to find out what caused the problem reading.

9.2.2. Calibration

Advanced maintenance procedures are performed on the display called up by the **Advanced maintenance selector** while RAE is in maintenance mode.

1. Switch to maintenance mode, load grade



2. Choose 'advanced..'

Figure 9-2 Basis weight sensor calibration screen

Finish the calibration procedure, or more generally, the advanced procedure, of a processor before engaging in the calibration procedure of another processor of the same sensor type, because the common interface maintains only one copy of working memory for the calibration of a sensor type. By selecting a processor other than the one you are currently calibrating, for example, nuclear sensor on scanner 2 while the calibration of the nuclear sensor on scanner 1 is underway, acts as a request to the common interface server to prepare the memory for a brand new procedure. As a result, the memory gets re-initialized.

If pre-empting the calibration of one processor with the calibration of another is necessary, click **Save File** to save the calibration data into a file before the switching. Retrieve it later by clicking **Open File**.

9.2.3. Nuclear Sensor Advanced Display

The advanced display for the nuclear sensors is called **Nuclear Sensor Calibration** (see Figure 9-3).

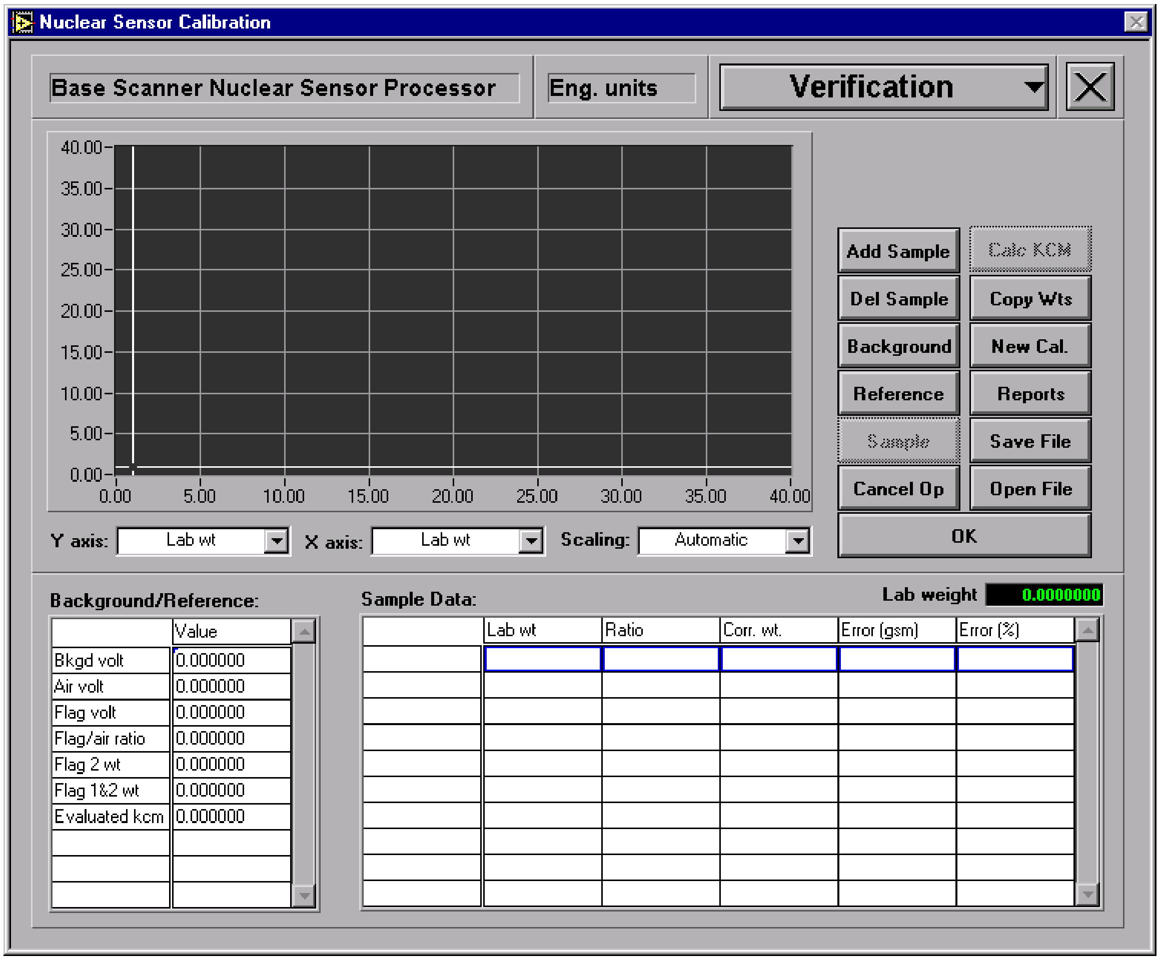


Figure 9-3 Nuclear Sensor Calibration Display

The upper part of the display shows which nuclear sensor in the system is under maintenance and what system of units, either the engineering units or the customer units, is being used. These two settings are inherited from the **Sensor Maintenance** display and can only be changed from there.

9.2.4. Available Modes

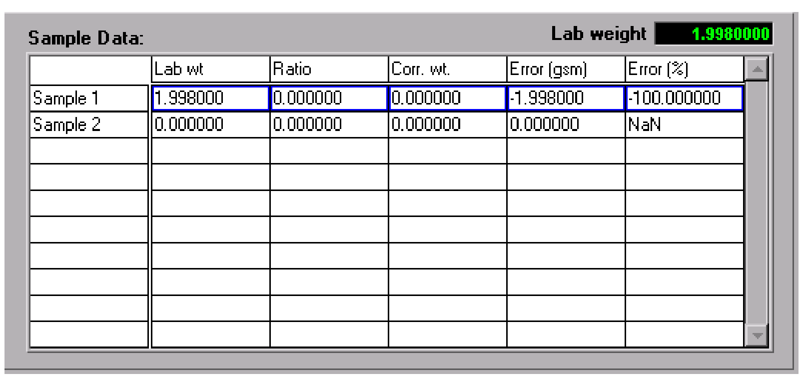
The calibration window has three operation modes, accessible through the top right-hand drop-down menu:

- **Verification**–used to verify a previously obtained calibration and/or determine the multiplicative correction factor, KCM, which accounts for the material difference between individual customer product and the standard material used in calibration.
- **Clean Calibration**–used by the calibration procedure to hold results on the standard clean samples.
- **Dirty Calibration**–used by the calibration procedure to hold results on the standard dirty samples (clean samples plus a dirt simulation sample).

9.2.5. Add a Sample

To add a sample in any mode, click **Add Sample**. If there are already samples in the **Sample Data:** table, the new entry will be added immediately after the highlighted sample.

A new sample entry will be added to the **Sample Data:** table at the bottom of the advanced window. By default, the new sample entry has a lab weight of 0.000000. To modify, highlight the new sample entry and change the value in the **Lab wt** numeric control text box.


Sample Data: Lab weight 1.9980000

	Lab wt	Ratio	Corr. wt.	Error (gsm)	Error (%)
Sample 1	1.998000	0.000000	0.000000	-1.998000	-100.000000
Sample 2	0.000000	0.000000	0.000000	0.000000	NaN

Figure 9-4 Lower Portion of the Nuclear Sensor Calibration Display

9.2.6. Delete a Sample

To delete a sample from the **Sample Data:** table of a mode, that is, **Verification**, **Clean Calibration**, or **Dirty Calibration**, highlight the sample by clicking on the row and click **Del Sample**.

9.2.7. Copy Sample Weights

It is possible to save the time of re-entering all the weights for a different mode, if they turn out to be identical, by copying them from one mode to the other. To copy sampling weights:

1. Click **Copy Wts** (you are prompted to select the source).
2. Select the desired mode from which to copy.
3. Click **OK** to accept the choice.

9.2.8. Start a New Calibration/Verification

To start a new calibration/verification, click **New Cal**.

9.2.9. Open and Save a Calibration/Verification File

At any time during the calibration/verification procedure, you can save the data into a file by clicking **Save File**. The path for nuclear sensor is defaulted to *%MXRoot%HMX\Database\Calibration Data\Nuclear* and requires entering a name.

9.3. Calibration Procedures

Start from a blank working space. The calibration page will be blank the first time the **Advanced** display is called up. If not, click **New Cal.**, or load a previous file.

9.3.1. Clean Calibration

1. Select **Clean Calibration** mode.
2. Ensure that you click to clear the **Curve Fit** check box.

3. Click **Background** to request a background operation (nothing in the gap). The result shows up in the **Background/Reference** table at the lower leftmost corner of the display.

4. Click **Reference** to request a reference operation without anything in the sensor gap. The result also shows up in the **Background/Reference** table. This is the clean reference and the result will be included in the time-zero constant calculation, should the calibration be adopted.

5. Add entries for weights in the standard set. Modify lab weight fields. The sensor is now ready to shoot clean samples.

6. Select the first entry in the **Sample Data:** table.

7. Place the corresponding standard sample in the paddle, insert it into the sensor gap, and request the sample operation either from the RAE display or from the sample paddle switch.

8. When the operation is done, the result will be read and incorporated into the **Sample Data:** table. The highlighted row automatically shifts down to the next entry.

9. Stack the second sample on top of the first one to make up the lab weight entered for the second entry.

10. Stir and request the sample operation again.

11. Repeat Steps 8–10 for the third entry, the fourth entry, and so on until all the standard weights are measured.

12. There is now data for the clean calibration.

13. Save the data to a file at this time as a safety measure.

9.3.2. Dirty Calibration

1. Take out all the samples from paddle.

2. Select **Dirty Calibration** mode.

3. Place the dirt simulation sample in the paddle, insert it to the sensor gap, and perform a reference on it. This is your dirty reference and the result will be used in the time-zero constant calculation.

4. Click **Copy Wts** to copy the lab weights of the standard set from **Clean Calibration** mode. The sensor is now ready to shoot dirty samples.

5. Highlight the first entry in the **Sample Data:** table, stack the sample that corresponds to the weight entered in this entry on top of the dirt simulation sample, stir it, and perform a sample operation.

6. Stack the second sample on top of the first one and the dirt simulation sample, and perform a sample operation for the second entry. Continue stacking and performing sample operations for each of the rest entries until all of them are done.

7. There is now data for the dirty calibration. Save the data again. To avoid a circular overwrite problem, save the data to the same file created for the clean calibration procedure.

9.3.3. Fit Clean and Dirty Curves

Figure 9-5 shows typical results for a clean Mylar calibration.

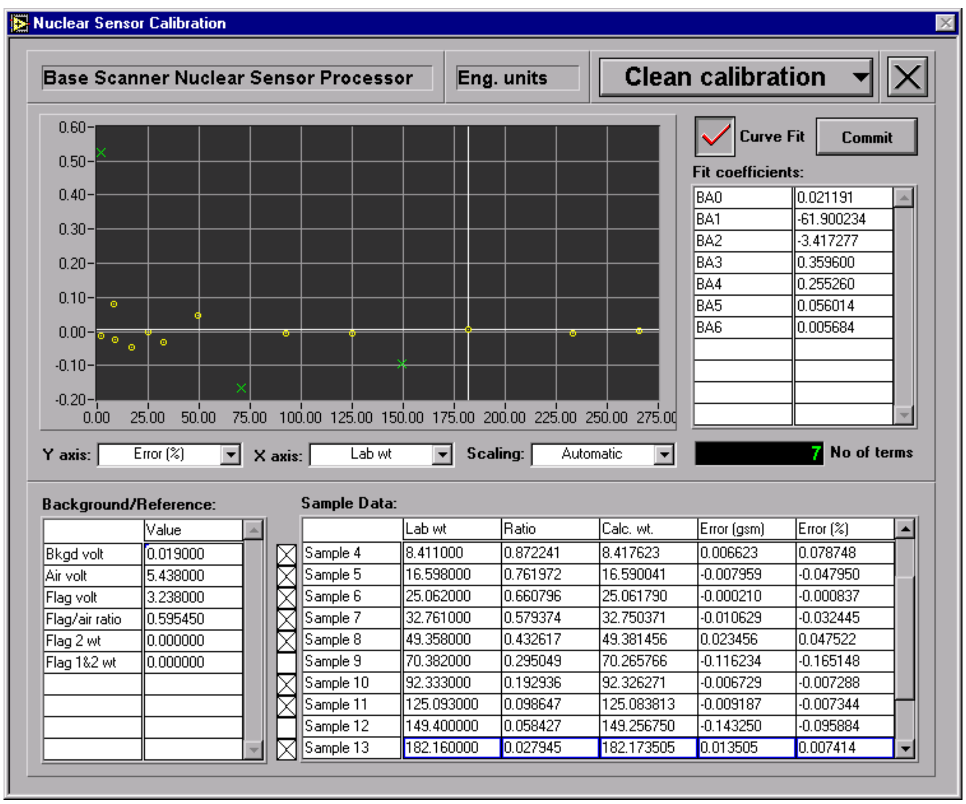


Figure 9-5 Clean Calibration Screen After the Curve Fit

1. Select **Clean Calibration** mode.

2. Select the **Curve Fit** check box to fit the clean sample result.

3. The calibration results can be plotted on the graph with virtually any combination of variables. Select a view (for example, **Error (%) vs. Lab weights**, or **Calculated weights vs. Lab weights**), that is the most informative in determining the goodness of the fit.

4. Adjust the number of terms (polynomial orders) used in the curve (**No of terms** text box). Outliers can be identified by looking at the graph and clicking to clear the check box next to the appropriate sample and refitting the data. Click **Commit** to commit the changes. Take care not to over-fit the curve by selecting too many terms. A general rule is that the number of samples should always be greater or equal to two-times the number of terms used (# of samples ≥ 2 * # of polynomial terms in use).

5. Repeat Step 4 for the **Dirty Calibration** mode. Remember to have the obtained clean and dirty curves working correctly for a nuclear sensor. The number of terms must be the same. Once the number of terms is decided in the **Clean Calibration** mode, do not change it in the **Dirty Calibration** mode. However, if revising (if revising is necessary), go back to **Clean Calibration** mode to fit the curve with the new term number again.

9.3.4. Activate the New Calibration

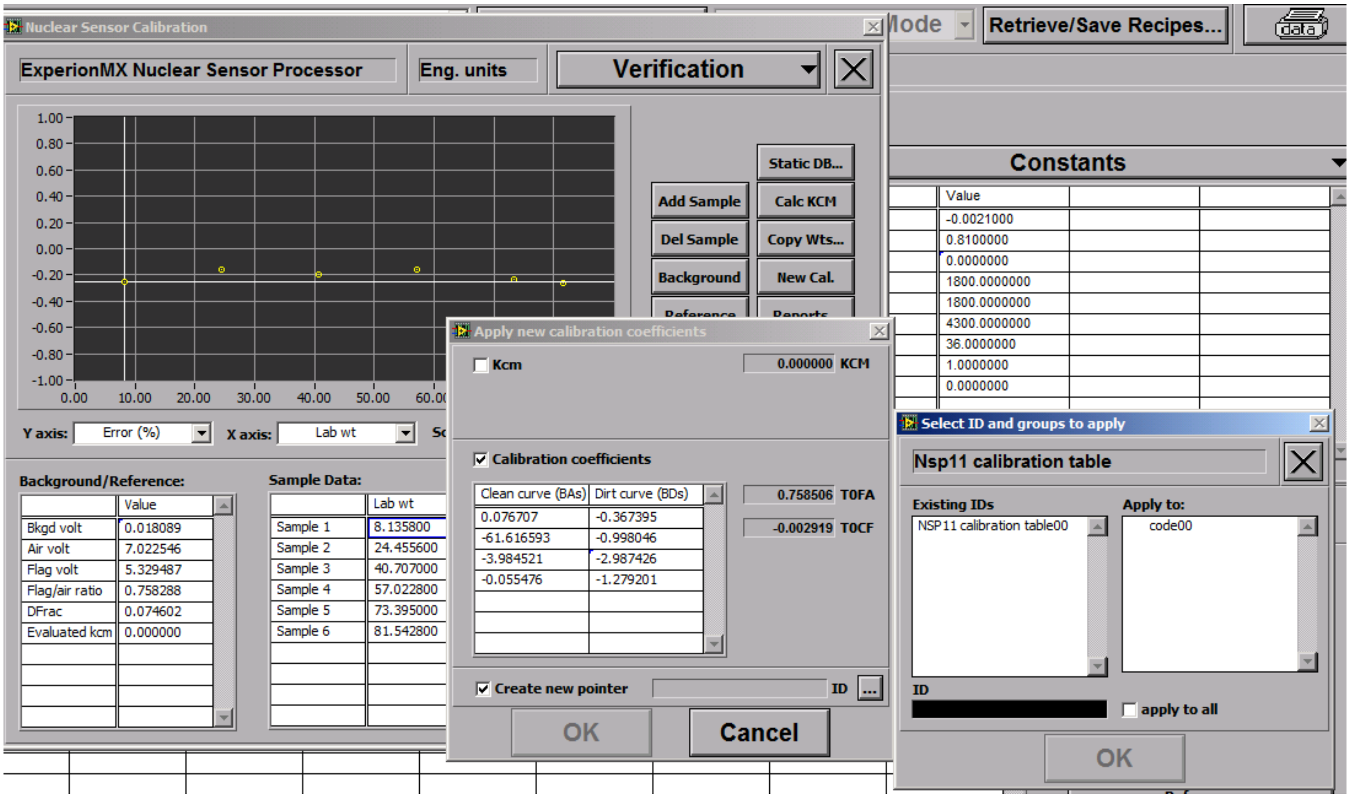


Figure 9-6 Applying New Calibration Coefficients

To permanently add the calibration coefficients into the recipe database:

1. Click **Apply New Coefficients**.
2. Select the **Create new pointer** check box and specify a recipe pointer ID for the set of nuclear sensor coefficient just obtained.
3. Click the browse option (**...**) to the right of **ID** (see Figure 9-6) to browse existing IDs and see what production code applies.
4. A new or old pointer can be associated with a system recipe later on using the **Recipe Maintenance** display.

The **Calibration coefficients** portion includes the **Clean curve (BAs)** and the **Dirt curve (BDs)** (calculated from both the clean and dirty curve), as well as the time-zero constants. For a dual-flag nuclear sensor, you can elect to use the current set of calibration coefficients as the one used to calculate the flag weights. Click **OK** to update.

To have the system use the new coefficient in this maintenance mode only, do not select the **Create new pointer** check box, but click **OK** on the **Apply new calibration coefficients** display (see Figure 9-6).

9.4. Verification Procedures

9.4.1. Clean Verification

1. Ensure that the new calibration coefficients are used by the GSP.
2. In the **Advanced** display, select the **Verification** mode.
3. Request a background operation.
4. Request a reference operation with nothing in the gap.
5. Request a sample operation with nothing in the gap. Verify that the ratio returned is virtually equivalent to 1.
6. Add entries for weights from the standard set. This can be the full set or just a subset of it.
7. Highlight the first entry in the **Sample Data:** table.
8. Place the corresponding standard sample in the paddle, insert it into the sensor gap, stir it, and request a sample as you do during the calibration procedure.
9. When the operation is done, verify that the measured result is within the tolerance limit set forth by the sensor manual. Usually, for a nuclear sensor with integration time of 16 seconds, the error should not exceed ± 0.1 g/m^2, or the percentage error should not exceed ± 0.4%.
10. Repeat Steps 7–9 for the second entry, the third entry, and so on, and stack the samples as done during calibration procedures until all the verification weights are measured and verified.

9.4.1.1. Dirt Correction Verification

1. Select the **Verification** mode.

2. Insert a dirt simulation sample, usually of half of the weight of the dirt simulation sample that is used in Subsection 9.3.2, in the sensor gap. Request a reference operation.

3. Ensure that the dirt correction option for the sensor is turned on (on the **Sensor Maintenance** display).

4. Add entries for weights from the standard set. This can be the full set or just a subset of it, and is not necessary to be the same as those used in clean verification; however, they are often the same because it is much simpler to prepare.

5. Leave the dirt simulation sample in the paddle, highlight the first entry in the **Sample Data:** table, stack the corresponding standard sample on top of it, stir, and request a sample operation.

6. Verify that the measured result is within the tolerance limit when the operation is done. This is to see whether the dirt correction is accurate and effective enough to correct the effect of the dirt simulation sample on the samples.

7. Repeat Steps 5 and 6 for the rest of the entries until all the weights are measured and verified.

9.4.2. KCM Determination

1. Prepare at least five samples of a customer product to determine the KCM value.

2. Measure the basis weight of these samples in the lab, or use samples with weights that are already known.

3. On the **Sensor Maintenance** display, retrieve the recipe for that product through the Retrieve/Save Recipes button dialog.

4. If the weights of these samples are known in customer units, go to the **Unit Setup** of the **Measurement Setup** tab and set up the system customer unit for basis weight to the proper one. Check **In Customer Unit?** on the **Sensor Maintenance** display to ensure that lab weights can be entered in customer unit.

5. In the verification mode of the **Advanced** display, add entries to the **Sample Data:** table for the product samples. Modify the lab weights. If **In Customer Unit?** on the **Sensor Maintenance** display is selected, these weights should be entered in whatever unit is set up; otherwise, they should be in g/m^2.

6. Request a reference operation without anything inserted in the sensor gap.

7. Request sample operation for each of the product samples until all of them are done.

8. Click **Calc KCM** to have the KCM value automatically calculated. This routine takes into account the effect of the previous KCM if the KCM correction was enabled during the execution of sample operations. The resulting value is shown in the lower left of the **Background/Reference** table and is directly applicable to the system.

9. Click **OK** to call up the confirmation dialog. The **KCM** option is automatically selected if there is one available to update to the system.

10. Click **OK** to confirm the update.

11. Unlike the calibration coefficients, selecting the **Create new pointer** option of the confirmation dialog has no effect on the KCM value. Use the **Retrieve/Save Recipes** dialog to store this value into recipe.

9.4.3. Calibration/KCM Reports

To export the calibration and KCM results from the **Advanced** display to a set of standard format printed reports, click **Reports** and then select the reports to print.

10. Basis Weight Calculation Details

This chapter details the various operations available to the nuclear sensor, and corrections that can be applied to the raw reading. A good understanding of these correctors is required for optimal correlation to customer measurements.

10.1. Sensor Operations

10.1.1. Background

A *background* is scheduled periodically, typically every eight hours. It is taken by reading the basis weight signal after shutter closed (retracting the capsule). The counts are stored and subtracted from air, flag, sample, and onsheet readings.

10.1.2. Reference and Standardize

A *reference* is manually requested. A *standardize* is scheduled periodically during the scanning process. Typical standardization times are 20 min intervals although it should be done more frequently if there are environmental changes.

A reference is done to one sensor at a time, while a standardize is done to all sensors at the same time. Otherwise, these functions are identical. The reference/standardize is done in two phases:

- an air phase and either
  - one flag phases (Sx 6 and Sx 9) or
  - three flag phases (Sx 12)

After completion of the second phase the flag-to-air (F/A) ratio is computed by:

F/A = (Flag_In – Background)/(Air phase – Background)

After this, a quantity used to compute the dirt correction, referred to as the *dirt fraction* (DFRAC), is computed. During reference/standardize the temperatures are read and averaged as well as the Z-value and stored as *standardize values*.

10.2. Online Basis Weight Calculation and Corrections

The principal measurement comes from the transmission ratio which to first approximation is related to the basis weight of the product by:

$R = e^{-\mu W}$

where W is the basis weight and μ is the absorption coefficient

This is known as *Beer's Law*. In practice a more accurate, and more complicated, algorithm is used that uses weighted higher order terms to smoothly represent the data.

In order to make the measurement more accurate under scanning conditions, several different correctors are applied. All of the correctors except for the customer product correction (KCM) have basis weight units (g/m^2, sometimes written as *gsm*) and are additive correctors. This feature makes it possible to understand them from a physical basis and to be aware of relative magnitudes of the correctors.

All calculations are always done in the *International System of Units* (SI units) (grams, meters, Kelvin, and so on) and then converted to any selected customer units for display. A unit conversion factor (UCF) is used to convert basis weight from g/m^2 to customer units.

The correctors are described in this document. The following notation is used:

Sx	=	Source
Rx	=	Receiver
Stdz	=	Reading at last standardize or reference
Now	=	Now reading (onsheet, while scanning)
U and Up	=	Upper
L and Low	=	Lower
Time-0	=	The time at which the Mylar® calibration is done and T0FA and T0CF are determined
R	=	Sensor Ratio: Onsheet sensor voltage minus background divided by the air volts minus background

BWUC (uncorrected basis weight)–the basis weight of a sample with the same absorption properties as Mylar at the measured ratio. The exact algorithm is proprietary but involves the ratio (R) and BA0, BA1, BA2, and BA3 (and possibly higher terms). The algorithm fits the data very well over a wide range of basis weights; however, it is sometimes necessary to split the calibration fit into two ranges, lighter and heavier.

BWDRT (dirt correction)–the dirt correction accounts for any change in mass between the source capsule and the ion chamber that is not product-related from one standardize to the next, for example, debris build-up on the sensor heads or change in air density.

The DFRAC is computed during standardization. The DFRAC is multiplied by the (dirty-clean) curve computed at the now-ratio to form an additive dirt correction in g/m^2. The DFRAC can best be understood by noting if the F/A value at the last standardize is the same as T0FA then DFRAC = 0, if it is the same as the dirty F/A (= T0FA + T0CF) at calibration then DFRAC = 1.0.

BWKC (KCM correction basis weight)–the KCM correction accounts for the fact that there may be slight differences in the absorption properties of the customer product compared to the calibration standard (Mylar). It is determined by reading customer samples and noting the fractional offset relative to the Mylar calibration. The algorithm is:

BWcustomer product = KCM*BWmylar.

so that (KCM-1)*100 = % offset of paper relative to Mylar

A KCM of 0.996 means that this grade of paper has an offset of 0.4% relative to Mylar. Typically KCM is between 0.99 and 1.02 (<± 2% offset from Mylar). KCM is grade-dependent, but for nearly all systems it has the same value for all grades.

BWZ (Z-correction basis weight)–the Z-correction accounts for the possibility that the scanner may change shape in the Z-direction so that the height of the air gap and thus the basis weight of the air between the heads can change dynamically. The Z-correction then adds a correction to account for changes in the basis weight of the air between the heads. The algorithm is:

BWZ= CFZ*[(Znow-Zstdz)/Zstdz]

BWTEMP (temperature correction basis weight)–the temperature correction accounts for any air density changes due to temperature changes in any of the (three or four) zones between the source capsule and the ion chamber entrance window. The zones in between the heads are known as *air gaps*, the zones inside the heads are known as *air columns*. Most models of the basis weight sensors have three correction zones, not four, because the receiver air column thermistor is not present due to the fact that the ion chamber is so close to the source window. The AGA coefficients (see Chapter 6) are the calibration constants for the temperature correction. *Tup, stdz*, for example, is the upper air gap temperature as measured at the last standardize. For the algorithm, see Table 10-1.

Table 10-1 AGA Coefficients

BWTEMP =			
AGAU*[(1/Tupr,stdz)	-	(1/Tupr,now)]	+
AGAL*[(1/Tlow,stdz)	-	(1/Tlow,now)]	+
AGAS*[(1/TSx,stdz)	-	(1/TSx,now)]	+
AGAR*[(1/TRx,stdz)	-	(1/TRx,now)]	

BWDO (dynamic offset basis weight)–the dynamic offset correction is only applied dynamically and is meant to account for sheet stretch, flashoff, and so on. That is, actual physical changes in the basis weight of the sheet between the point of measurement and the dynamic laboratory weight measurement. It should not be used without a good reason, and not without checking for other sources of basis weight error. BWDO is an additive correction with units of g/m^2 and does not depend on any calibration constants.

BWPC (profile correction basis weight)–the profile correction accounts for any sensitivity of the sensor to changes in the machine direction and cross direction head alignment. It is bi-directional, that is, two arrays are stored:

- left-to-right
- right-to-left

BWPC is generated by scanning on a sample. It is an additive correction with units of g/m^2 and does not depend on any calibration constants.

The algorithms that are used during the static sampling process and when scanning are:

BW-sample	=	BWUC+BWDIRT+BWTEMP+BWKC
BW-scanning	=	BWUC+BWDIRT+BWTEMP+BWKC+BWZ+BWPC+BWDO

10.3. Calibration Constant Description

Name	**Description**
BA0, BA1, BA2, BA3	Clean Mylar fit coefficients (can have more, depending on the order chosen)
BD0, BD1, BD2, BD3	(Dirty-clean) Mylar fit coefficients
T0FA	Time-zero clean F/A ratio, determined at Mylar calibration
T0CF	Time-zero (dirty F/A-clean F/A) ratio, determined at Mylar calibration
AGAS, AGAR	Source and receiver air column temperature correction coefficients (internal to head)
AGAU, AGAL	Upper and lower air gap temperature correction coefficients (external to head)
CFZ	Z-correction coefficient
CFZS	CFZS = 0 always (because it is not currently used)
KCM	Grade dependent multiplicative factor to account for offset between Mylar and customer product
KCM2	Always set = 0 (because it is not currently used)
BWDO	Dynamic offset to account for sheet stretch, flash-off, and so on
UCF	Converts g/m^2 to customer basis weight units for display and printouts

10.4. Sensor Maintenance Display

The *sensor status display* contains all the raw values–intermediate calculated values as well as final calculated values for the uncorrected basis weight as well as all the corrections.

The use of the sensor status frame as a diagnostic instrument cannot be over-emphasized. Whenever there are problems with the basis weight sensor, consult the sensor status frame.

10.5. Printouts

Summary information is printed at background, reference/standardize, and sample. These printouts contain valuable information about the sensor and are also useful as diagnostics.

10.6. Daily Sensor Report

Although the details vary from one software version to the next, most systems have a daily sensor report that contains summary information about the sensors covering the previous 24 hours.

10.7. Sensor Checks

Although the sensor, along with the entire system, has been checked at the factory before shipment, it is good practice to thoroughly check out the sensor during installation. Save inspection records and start using the preventative maintenance schedule (see Chapter 11).

10.7.1. Stability

Verify sensor F/A stability using numbers from initial calibration as guide to performance.

10.7.2. Mylar Verification

Samples must be checked clean and dirty but it is probably not necessary to verify all samples. Three or four from the customer product range should be sufficient, but always read them clean and dirty. This is a good time to begin a transfer sample procedure. See Subsection 8.1.6.

10.7.3. Air Temperature Correction Details

There are three aspects to the air temperature correction:

- an accurately calibrated temperature sensor

- a way to assure that the air that the temperature sensor measures is representative of the air temperature where the radiation beam is
- the basis weight correction in software

Checking the accuracy of the temperature sensor under static conditions is straightforward. A thermocouple or similar probe can be used to check the accuracy of the measurement under static conditions. Ensuring that the temperature sensor is actually sampling air from the space where the beam exists is mainly a function of the design; however, the primary action that can be taken once the design is completed is to be sure that there is a large air flow through the air wipe and air gap temperature sensor.

ATTENTION

A very important and often overlooked point: Check if there is any suspicion that the air temperature is not behaving properly.

Checking the air temperature correction of the system under dynamic conditions is extremely difficult to do even in the lab under the best of conditions and with equipment specially designed for this type of experiment. In nearly all circumstances it is better to use the AGA numbers that are provided at calibration than to try to derive new, better, AGA numbers.

CAUTION

Under no circumstances should blowing a heat gun in the gap be used to check the numbers, because the possibility of experimental error is so large. Using a heat gun induces thermal gradients within the gap and assures that the air temperature where the beta beam is will be different from the air temperature at the air gap temperature sensor.

If you need to verify the AGA numbers, check the accuracy of the air gap temperature sensors under static conditions, and check to be sure that there is a very strong flow of air through the air wipe and air gap temperature sensor.

If the AGA numbers still need to improve, compare the basis weight dynamic (lab test) profile error versus the air gap temperature sensor profile. If there is consistently a basis weight dynamic profile error that is the same shape as the air gap temperature sensor profile (a *smile* in both cases), then the correction applied is too large (cold air is more dense, so the subtracted basis weight should be higher where there air gap profile shows a dip. If this dip also exist in the basis weight profile, then the correction might be too large). Reduce AGAU and AGAL on the **Sensor Maintenance** screen. Model Q2201-XX does not use air gap sensors on the Q4000 scanner.

10.7.4. Z-Correction Details

The Z-correction refers to the fact that as the heads separate from one another the basis weight of the air in between the heads changes, which then appears to be a change in the sample basis weight unless a correction is made.

There are two parts to the Z-correction:

- accurate measurement of Z, the distance between the heads
- actual correction to the measured basis weight done in software

The Z-correction may be verified by reading a Mylar sample at a basis weight near that of a typical product at various Z-values, at differing head separations. This procedure involves changing the Z-dimension between the heads, which can be accomplished by either putting shims under the wheels of the top head or by loosening the top head and letting it rest against shims placed on the bottom head.

The advantage of resting the top head on shims on the bottom head is that the Z-sensor calibration can be verified at the same time if the shim thicknesses are accurately known.

Take care so that no metal blocks the Z-sensor, for example, from the sample ring.

It may be convenient to use cardboard sample rings for this test. Typically four or five points can be read, for example 8, 9, 10, 11, and 12 mm (for a sensor that has a nominal 10 mm gap).

The percent difference from the gap center basis weight, for both the uncorrected and the Z-sensor corrected basis weight of the sample, can be plotted on the Y-axis versus Z-displacement on the X-axis. If done properly, this curve should be smooth.

The Z-correction should make the corrected basis weight nearly insensitive to Z-head displacements, or in other words the curve for the Z-sensor corrected basis weight should be flat. The algorithm used for the Z-correction is:

BWZ = CFZ * [(Znow-Zstdz)/Zstdz]

So that if the correction is too large or small, CFZ can be changed by the appropriate amount. Regard changes of more than approximately 25% from the nominal CFZ as very suspicious.

10.7.5. KCM Correction

Check the KCM correction by reading customer samples. One or two samples should be sufficient to ensure everything is working properly.

10.7.6. Profile Correction

Getting an accurate profile correction can be difficult due to the fact that it must be done when the sheet is not in the gap. However, some scanners may change shape depending on the temperature conditions, so that when the heat source (the sheet) is not present the scanner may assume a different shape than when the sheet is present and heating the scanner.

Generate the profile correction arrays as fast as possible in order that the scanner not change shape too much, but if too little time is spent on each slice there will be too much statistical noise.

Typically, two to four seconds dwell time (that is the total time spent in the zone for all the scans) per correction zone is about right. Each system should be considered individually. The thermal stability of the scanner and the general thermal conditions will dictate the appropriated well time to use.

The profile correction should be generated on a sample, *not* the flag. The reason for this is that the flag, due to its position very near the source capsule, behaves in a different manner than a sample in the gap when the heads move relative to one another. It is true that a profile correction can be generated on the flag and will verify, but it is not the correction that will make a sheet in the gap center have a flat profile.

The profile correction is stored in two bi-directional arrays:

- left to right
- right to left

To generate a good profile correction:

1. Ensure that the Z-sensor is enabled.
2. Build the profile correction array with the scanner in thermal conditions as close to realistic as possible.
3. For basis weight measurement sensors, set the number of scans so that two to four seconds of data are accumulated per correction zone for each direction. If the scanner is very thermally stable, longer periods can be used, if it is unstable, shorter periods must be used.
4. Place a Mylar sample at the light-weight end of the calibration range in the gap in such a way that it does not impinge on the Z-sensor and allows air flow over and under the sample.
5. Generate the profile correction arrays (**L-to-R** and **R-to-L**).
6. Typical corrections are at most a few tenths of a gram per square meter (for example, ± 0.1 g/m^2 and ± 0.2 g/m^2) and smoothly varying. Numbers over 0.5 g/m^2 could indicate a scanner alignment or scanner track issue.
7. Put a Mylar sample with a weight that is also at the light-weight end of the calibration, set the filter factor to 0.1 or 0.2 and scan on the sample. Check the flatness of the measured sample.

10.7.7. Dynamic Offset

The dynamic offset correction is done through the additive constant BWDO. This constant should be set to zero until it can be proven beyond doubt that all other aspects of the sensor are working correctly. When lab measurements consistently show higher or lower data than the scanner, use the difference as BWDO. Again, the purpose of the dynamic offset is to account for effects that change the basis weight of the sheet between the point of the measurement and the lab. Sheet stretch and moisture flashoff are the two primary examples.

10.8. Dynamic Verification

The dynamic verification is the most important check by which the sensor performance is judged. Dynamic verification techniques vary from industry to industry and even from mill to mill. This section outlines general techniques that can be followed or adapted to the particular situation found.

There are two general dynamic verification techniques:

- roll check
- die out samples from end of roll

Other informal techniques, such as grab samples, are only valid to a few percent and should be avoided since they generally lead to invalid conclusions about the sensor performance. If the sensor performance is going to be judged, the technique used must be accurate and based on a valid technique.

10.8.1. Roll Check

In the roll check method, the reel total weight is obtained from a scale, and the total length, for example, from a tachometer, and the width from either the Honeywell system or an actual measurement of the trim to obtain the average basis weight for the entire reel. That is compared to the Honeywell reel average basis weight.

This can be a very accurate technique since it averages the entire roll; however no information is retained about profile accuracy. An accurate scale and accurate methods for measuring roll length and width are required.

10.8.2. Die Out Samples from End of Roll

In this technique samples are died out across the sheet and compared to average profile readings at end of reel, or filtered scan average basis weight at end of reel. Although very time consuming, it potentially yields more information, because it checks the profile accuracy.

1. Choose several positions across sheet where the basis weight profile is flat, and provide a template to allow repeatable locations of these positions.

2. Ensure that the slice number is accurately known.

3. At reel turn-up, automatically print the basis weight profile on a slice by slice basis as well as the profile display.

4. Ensure that there have not been any machine direction upsets during this period.

5. Prepare sealable containers, such as Ziploc® bags (marked with slice numbers), to put samples into.

6. Slab off about 20–30 wraps at the end of a reel Use the template to mark positions of slices and die out as many samples deep as possible using a sharp die. As the paper gets heavier, it becomes more difficult to die out more samples but the test will be more accurate the more samples that can be died out.

7. Place the samples in the marked containers. Quickly discard the top and bottom sample or two to avoid moisture conditioning problems.

8. When all samples have been gathered, take the containers to the lab and weigh. Be very careful to not let the samples condition (change moisture content). Either the samples plus the containers can be weighed and then the container weight subtracted, or the only samples can be weighed. The samples must be counted and the average basis weight per sample computed.

9. At this point the average basis weight at the end of the reel can be computed for the slices that were checked and then compared with slice averages for the end of the reel, or the samples can used to calculate an end of reel scan average basis weight.

11. Air Gap Sensor

In the Experion MX Q4000 series scanner, the air gap sensors are an integral part of the Source 9 and the Source 12 Basis Weight sensors platform. The sensor is not called out the Source 6 due to the heavy weight range. This chapter provides details on their operation and maintenance.

11.1. Description

The air gap temperature (AGT) sensor is an integral part of the Honeywell basis weight measurement system. It improves the accuracy of the measurement by compensating for the changes in air density due to changes in temperature. In the Experion MX scanner the AGT sensor is mounted on the same platform as the basis weight sensor. It is controlled, and its signals are digitized using the basis weight source/receiver Ethernet Data Acquisition (EDAQ) board.

The dynamic response of the AGT sensor is very important. Consider the not unusual system that scans at 16 inches per second for cross direction control purposes, with 6-inch control zones, the frequency response required is at least 5 Hz.

The thermistor used in the AGT sensor has a nominal time constant of 1 second or 0.16 Hz nominal cut-off frequency. That is far slower than the minimum 5 Hz required for cross direction control. To improve the frequency response of the sensor, a *predictor* circuit was designed. The new AGT sensor is tuned to obtain maximum frequency response from the thermistor while minimizing the noise sensitivity.

11.1.1. Frequency Response Performance

Tests were performed on the AGT sensor with the predictor printed circuit board (PCB) and compared to the sensor without the predictor. Tests were done with an air switch that alternately applied hot and cold air to the sensor. With the air switch, the sensor could be tested up to a frequency of 70 Hz. Figure 11-1 shows the frequency response of the sensor with and without the predictor circuit.

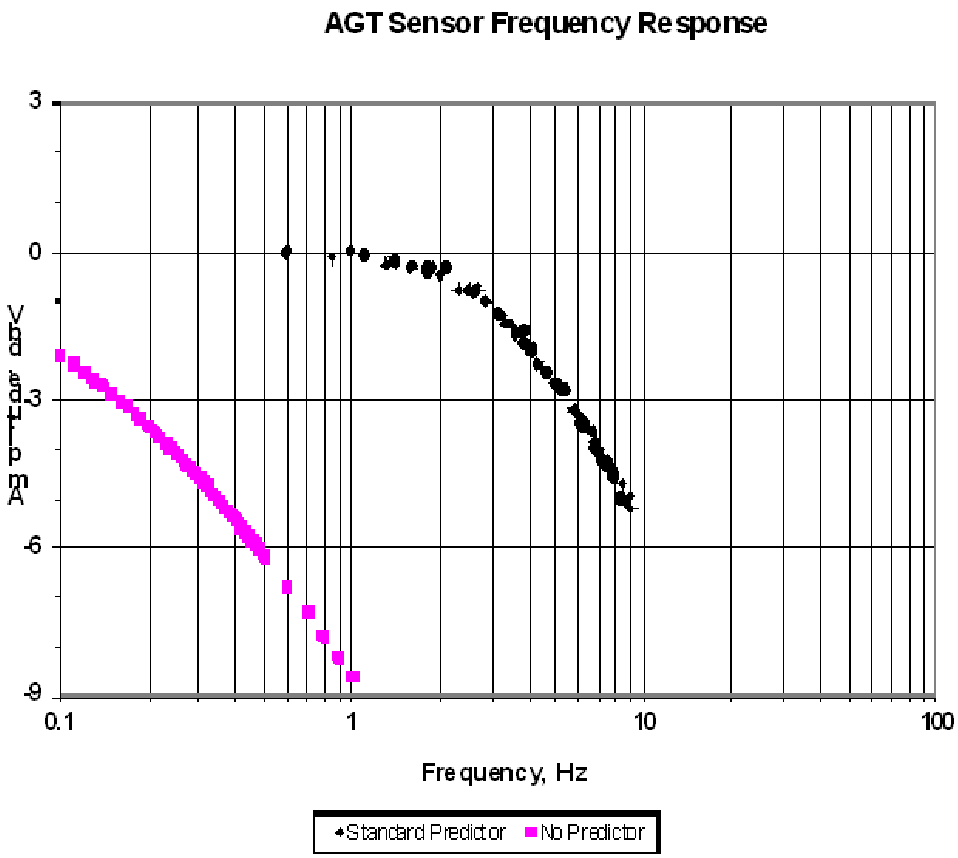


Figure 11-1 AGT Sensor Frequency Response

11.1.2. Accuracy

To test the accuracy of the AGT sensor, a thermocouple was placed next to the AGT sensor thermistor and heated air was applied. The results show that the AGT sensor and the thermocouple agree within ± 1.73 °C (2-sigma) (35.11 °F).

11.2. Sensor Specifications

One AGT sensor is used in each source and receiver assemblies. Air is pulled from the gap between heads past a thermistor by an air amplifier device. The air temperature is used to correct the basis weight sensor readings for changes in air density due to temperature changes.

The Absolute accuracy is ± 1.75 °C (2-sigma).

The high frequency response speed cut-off is 5 Hz, or equivalent 1 pole time constant is 32 ms.

Power requirements are:

- ± 12 V @ 20 mA each
- + 24 V @ 100 mA

Air requirement is 40 psi at the sensor at a flow rate of at least 50 cfh.

11.3. Adjustments

Adjust air pressure at the sensor to 40 psi. At this pressure the airflow will be about 50 cfh.

The only electronic adjustment required is offset:

1. Turn off the sheetguide and air wipe heaters.
2. Track the temperature readings of both sensors on a system trend plot.
3. Place a thermocouple gauge or similar temperature measuring instrument at the openings of the AGT sensors in the gap between heads.
4. After enough time for the readings on the sensors to stabilize, compare the AGT sensor readings to the thermocouple.
5. Adjust R1 on the PCB until the AGT sensor readings agree with the thermocouple to ± 1.5 °C.

11.4. Maintenance and Repair

The AGT sensor has a self cleaning feature. An air solenoid reverses the airflow to dislodge any debris that gets stuck in the air intake opening (also known as the *sneezer*). Inspect the air intake visually periodically to verify cleanliness.

Split the heads, look at the intake openings, and remove any debris stuck in the opening, taking care not to damage the thermistor.

Verify the operation of the solenoid by manually exercising the contact output from the scanner maintenance frame and feeling the airflow from the intake.

11.5. Failure Symptoms

Basis Weight Accuracy–failure of the AGT sensor often shows up as poor basis weight sensor accuracy, because the air gap temperature is used to correct the basis weight readings. When investigating basis weight accuracy issues, verify the performance of the AGT sensor.

Flat Profile–a normal air gap temperature profile is hotter in the middle of the sheet and cooler on the edges. A completely flat temperature profile indicates a sensor failure. If in doubt, perform the functional test described in Section 11.6. If the sensor fails the functional test:

- Inspect the thermistor for damage by splitting the heads and looking into the intake opening. The thermistor is about one quarter-inch into the opening. It should be a smooth round bead. If it looks damaged replace it. The offset will need adjusting as described in Section 11.3.

- Inspect the PCB. If the PCB is bad, it is easily replaced. The only adjustment required is the offset as described in Section 11.3.

Abnormal Profile–if the temperature profile is not completely flat, but does not look normal:

- Check air pressure at the sensor, which should be 40 psi. If low, check air filters, air hoses, and connections for clogs or leaks.

- Check for dirt build-up. In very dusty environments it may help to increase the sneezing action. Normally the sneeze is set for three sneezes each time the head scans offsheet. The number of sneezes can be increased in the software.

Erratic Profile–if the profile is changing often, with peaks and/or dips in different locations on each scan, static discharge could be the problem. This version of the AGT sensor is much less sensitive to static than earlier versions, but very high static could affect the sensor.

Static Chains–work with the mill personnel to add static eliminator chains or similar devices on the sheet.

11.6. Functional Test

When an AGT sensor is suspected to have failed, a quick functional test can be performed:

1. Put the heads at single point offsheet.
2. Put the AGT sensor readings on a trend plot.
3. Turn off the sheetguide and air wipe heaters.
4. Observe the temperature drop on the trend plot. A drop of approximately 20 °C (68 °F) is typical.

   Optional: For a more quantitative test, place a thermocouple sensor at the air intakes and compare its readings to the AGT sensor (exact agreement between thermocouple and AGT sensor is not expected because temperature gradients are quite large during cooling). Use the thermocouple to verify that the temperature is changing and the AGT sensor is responding to the change.
5. Turn the sheetguide and air wipe heaters back on before scanning again.

12. Preventive Maintenance

Preventive maintenance, when performed on a periodic basis, can prevent many failures and can catch minor problems before they become major ones.

12.1. Preventive Maintenance Schedule

Table 12-1 Preventive Maintenance Internal Checklist

Procedure	Daily	Weekly	Months		Years			Task Details
			1	>	1	3	5	
Inspect Head Gap		X						Section 13.1
Verify Transfer Samples				2 m				Section 13.3
Verify Gauge Stability			X					Section 13.4
Apply Conductive Grease				2 m				Section 13.5
Check Receiver Voltages				2 m				Section 13.6

13. Tasks

The following tools will be helpful to have to perform many maintenance tasks:

- digital volt meter (to at least three decimal places, for example, 1.999)
- metric and imperial hex drivers with ball ends–all Experion MX scanner bolts are metric, but sensor bolts are imperial sizes
- computer with spreadsheet and graphics programs (not required, but very helpful)
- calibration sample set
- sample paddle
- transfer sample set

13.1. Inspect Head Gap

Activity Number:	Q4201-62-ACT-001	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Operator
Priority Level:	Average	**Cautions:**	Radiation
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	0
Overdue Grace Period:		**Frequency (time period):**	1 week
Duration (time period):	10 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time

Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:	Digital multimeter for grounding check		

Visual inspection of windows (be sure there are no tears and that aluminized side is facing out toward the gap). The actual frequency that this needs to be done is site dependent, so adjust accordingly. Also check window conductivity to ground plane.

When trouble shooting basis weight alarms related to low open safe volts or interlock faults, check whether the gap is clear and that the top and bottom heads are aligned.

13.2. Air Gap Temperature Sensor Cleaning

Activity Number:	Q4201-62-ACT-002	**Applicable Models:**	Q4201, Q4202
Type of procedure:	Inspect	**Expertise Level:**	Operator
Priority Level:	Average	**Cautions:**	Radiation
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	0
Overdue Grace Period:		**Frequency (time period):**	1 week
Duration (time period):	10 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:			

This procedure does not apply to the Model Q2201-XX sensor.

The air gap temperature (AGT) sensor has a self cleaning feature. An air solenoid reverses the airflow to dislodge any debris that gets stuck in the air intake opening (also known as the *sneezer*). Inspect the air intake visually periodically to verify cleanliness.

Split the heads, look at the intake openings, and remove any debris stuck in the opening, taking care not to damage the thermistor.

Verify the operation of the solenoid by manually exercising the contact output from the MSS diagnostic display, I/O point monitor and feeling the airflow from the intake.

13.3. Verify Transfer Samples

Activity Number:	Q4201-62-ACT-003	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	Radiation
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	1 week
Overdue Grace Period:		**Frequency (time period):**	2 months
Duration (time period):	60 min	**# of People Required:**	1
Prerequisite Procedures:	Verify Stability	**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Mylar transfer set	Quantity	Lead Time
Required Tools:	Digital multimeter for grounding check		

Read transfer samples using sample paddle. Do both clean and dirty readings to check calibration and dirt correction. Plot percent deviation from nominal for each sample as a function of time. See Chapter 6 for details.

13.4. Verify Stability

Activity Number:	Q4201-62-ACT-004	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	1 week

Overdue Grace Period:		**Frequency (time period):**	1 month
Duration (time period):	30 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

See Subsection 6.2.1. for detailed instructions.

See Chapter 6 or Chapter 7 for expected values.

13.5. Apply Conductive Grease

In the course of scanning, the Kapton® window on the basis weight sensor builds up a static charge. The static charge must be drained to prevent erroneous signals in the receiver when the static is discharged by arcing.

The grounding of the receiver window is accomplished by connecting the window portion of the receiver assembly to the sheet guide assembly through a conductive o-ring.

A silver-filled conductive grease is applied to the o-ring to improve the continuity between the o-ring, receiver, and sheetguide, and to ease the insertion of the receiver into the sheetguide.

Activity Number:	Q4201-62-ACT-005	**Applicable Models:**	Q4201, Q4202
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	1 week
Overdue Grace Period:		**Frequency (time period):**	2 months
Duration (time period):	30 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	

	Part Number	Quantity	Lead Time
Required Parts:	Conductive grease p/n 16000332 O-ring (p/n 00285800)		
		Quantity	Lead Time
Required Tools:	Allen keys, screws drivers, tools to remove receiver/source windows from platform		

This procedure does not apply to the Model Q2201-XX sensor.

1. Verify conductivity between the window and the sheet guide using a multi-meter. If this is over 100 Ω follow Steps 2 and 3.

2. Split the heads and remove the sensor assembly as described in Chapter 4. Remove the window rings from the sheet guide side. Apply a coating of conductive grease to the entire o-ring before installing the o-ring in the sheetguide groove. Use enough grease to hold the o-ring in the groove and to provide adequate lubrication for inserting the receiver assembly. Do not use any other lubricant (for example, vacuum grease), with the conductive grease. Replace o-ring if any other lubricant has been applied to it.

3. Re-apply grease if receiver is removed and o-ring looks dry or has an insufficient amount of grease to insure good continuity and easy insertion of receiver.

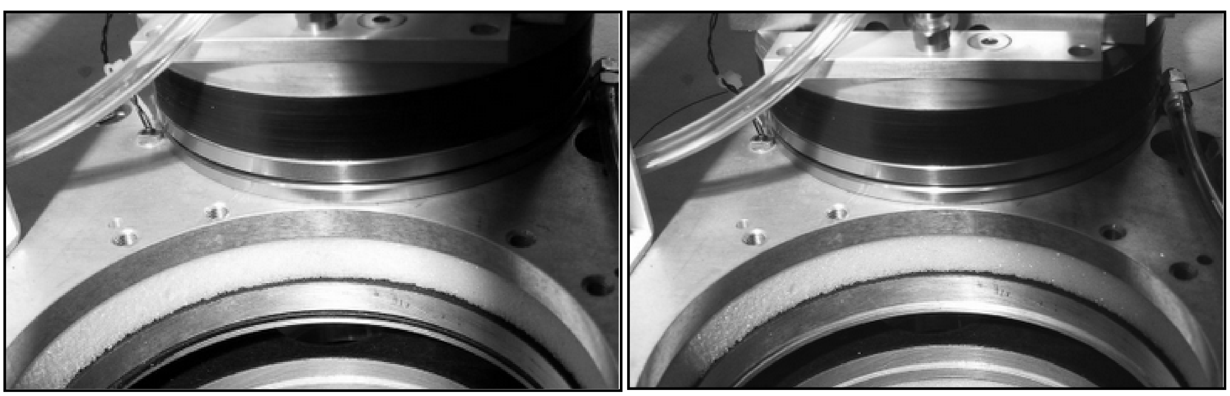


Figure 13-1 Receiver Side: Receiver Module Removed

In Figure 13-1, the left figure shows the o-ring before removal; the right figure, after removal. This procedure is particularly important for proper readings of the Sx12 due to the lower mean Beta energy.

13.6. Check Receiver Voltages

For stable operation the basis weight receiver requires that the correct voltages are generated on the back plane board. The following procedure uses the test points available to verify the + 24 V, ± 12 V, and -350 V ion chamber voltage.

Activity Number:	Q4201-62-ACT-006	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	Electric Shock
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	1 week
Overdue Grace Period:		**Frequency (time period):**	2 month
Duration (time period):	30 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

Measure the test points on the receiver backplane PCB and verify against tolerances as shown in Table 13-1. This table applies to both the Sx9 and Sx12 receiver.

Table 13-1 Source 9 and Source 12 Receiver Backplane Test Point, Description and Expected Values

Test Point	Function	Expected	Tolerance (± unless otherwise indicated)
TP1	RTN	n/a	n/a
TP2	+ 24 V DC	24 V	0.3 V
TP3	RTN internal	n/a	n/a
TP4	+12 V DC amplifier	12 V wrt TP3	0.1 V
TP5	-12 V DC amplifier	-12 wrt TP3	0.1 V
TP6	-350 V ion chamber	-350 V wrt TP3	Should be between 330–350 V
TP7	Basis weight out signal	0.015 V	0.005 V
TP8	TEMP 1	1.0 V DC at room temp	n/a
TP9	TEMP 2	1.0 V DC if used, otherwise 11	n/a

Table 13-2 Source 6 Receiver Backplane Test Point, Description and Expected Values

Test Point	Function	Expected	Tolerance (± unless otherwise indicated)
TP1	+24 V DC	+24	0.3 V
TP2	+24 V DC RTN		
TP3	RCVR RTN		
TP4	BW Signal Out	0.015 V	0.005 V
TP5	+12 V	12	0.1 V
TP6	-12 V	-12	0.1 V
TP7	-350 VDC (Ion Ch)	-350 V	20 V
TP8	Same as TP2		
TP9	Same as TP3		

13.7. Basis Weight Receiver Amplifier Checks

The basis weight receiver has a very high gain current-to-voltage amplifier. It is sensitive to static. When failed, the most common characteristic is that the Ethernet Data Acquisition (EDAQ) ADC is railed at + 10 V, generating a high basis weight alarm or closed high voltage alarm.

Activity Number:	Q4201-62-ACT-007	**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):	60 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

Typical operational air volts from the receiver should be in the range 6–9 V. The Krypton source decays with a half-life of about 11 years, it is recommended that the amplifier gain be increased (strapped) every five years to compensate for the signal levels. The Promethium sources decay with a half life of 2.6 years and those amplifiers should be strapped every if possible.

The newer amplifier version has a rotary switch to adjust gain. The older version requires soldering together the gain select post as described in Table 13-3.

Table 13-3 Gain Adjustment for the 052775XX amplifier

20 MΩ	100 MΩ	500 MΩ	Jumpers
(-02 version)	(-01 version)	(00-version)	
0.04	0.20	1.0	E2 + E3
0.08	0.40	2.0	E2 + E5 and E3 + E4
0.12	0.60	3.0	E2 + E5 and E3 + E4 and E8 + E9
0.17	0.86	4.3	E2 + E5 and E3 + E4 and E5 + E7 and E8 + E9
0.22	1.10	5.5	E2 + E4
0.24	1.20	6.0	E2 + E4 and E5 + E7
0.28	1.40	7.0	E2 + E4 and E8 + E9
0.32	1.58	7.9	E2 + E4 and E5 + E7 and E8 + E9
0.37	1.84	9.2	E2 + E4 and E6 + E9
0.40	2.00	10.0	E2 + E4 and E5 + E9
0.44	2.20	11.0	E2 + E4 + E6
0.48	2.40	12.0	E2 + E4 + E7
0.56	2.80	14.0	E2 + E4 + E5 and E7 + E8
0.64	3.20	16.0	E2 + E4 + E5 and E6 + E8
0.76	3.80	19.0	E2 + E4 + E8
0.96	4.80	24.0	E2 + E4 + E6 and E8 + E9
1.40	7.00	35.0	E2 + E5 + E7 and E8 + E9
1.80	9.02	46.0	E2 + E4 + E5 and E7 + E8 + E9
2.00	10.02	51.0	E2 + E5 and E7+E8 + E9

With the shutter closed, the amplifier should read a voltage near zero. It should be adjusted to 15 mV ± 5 mV using the trim pot on the PCB. If the signal is still near 10 V, the main OpAmp is broken and the board needs to be replaced.

1. Remove the amplifier shielding cover.
2. Remove the four mounting screws.
3. Remove the ion chamber signal cable.

4. Note the existing gain settings.
5. Modify the new amplifier to have the same jumpers or rotary dial position.
6. Use rubber gloves or a grounding strap while replacing the amplifier to avoid static discharge.

13.8. Replace Basis Weight Receiver Ion Chamber

The basis weight receiver ion chamber usually has a life time of several years; however, failure of the welding joint or punctures of the thin steel window can cause component failure. This often shows up as poor repeatability and lower signal amplitude.

Activity Number:	Q4201-62-ACT-008	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Honeywell Expert
Priority Level:	Average	**Cautions:**	Electric Shock
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	60 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

The removal of the ion chamber is somewhat involved and should only be performed if all other causes of issues have been ruled out.

WARNING

The ion chamber shell is connected to a low-current -350 V source. Ensure that the sensor is disconnected from power before attempting to remove it.

Removing the ion chamber requires removing both the amplifier and the receiver window. Ensure that the ion chamber replacement is covered with a heat shrink sleeve to prevent issues with condensation.

After completing the replacement, enter the system into Maintenance Mode for that particular scanner.

1. On the **Sensor Maintenance** display, select **Nuclear Sensor Processor**.
2. Shoot three References to check the basis weight voltage. Ensure that it is below 8.5 volts. If it is not, re-strap the preamp to use a lower gain setting.
3. If this a Q4202-50, perform the topography procedure for source. See Chapter 5.
4. After the topography procedure is complete, shoot verification samples to confirm calibration.

   If samples are off by more than 0.3% or more from previous verification, perform a full re-calibration on the system (clean and dirty). Apply new calibration coefficients and T0FA.
5. Ensure that after re-calibration is done that the T0FA set to the average from 30 references. At this time the DFRAC should be around 0.00 – if not at 0.00, redo the T0FA.

13.9. Verify Shutter Operation

This section describes possible issues with the shutter not closing on command or not opening on time.

Activity Number:	Q4201-62-ACT-009	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	Radiation
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	10 min	**# of People Required:**	2

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

13.9.1. Shutter not closing

There are two independent fault conditions that can occur if the shutter does not close when the digital output is cleared. First, the green light circuit, which connects + 24 V through the green lights through the shutter switches to a ground at the scanner HMI panel, will not turn on.

ATTENTION

When a Q4237-XX ash gauge is present, the green light will not turn on until the ash gauge is enabled and powered. The green light circuit does not involve any EDAQ control.

Secondly, the real-time application environment (RAE) system will alarm that the receiver voltage is high but the shutter was commanded closed (red lights are off).

WARNING

Beyond the visual inspection described here, field personnel are not allowed to repair a stuck shutter. Honeywell ACS Global Radiological Operations must be called in this event.

Remove power to the EDAQ or disconnect the sensor harness cable from the head power distribution board, to ensure that all the digital outputs are low.

If the actuator closed when the power was removed, the problem is likely a faulty safety interlock board (the small PCB mounted next to the EDAQ). It is unlikely to be a faulty EDAQ digital output because both the digital out for the shutter *and* the watchdog pulse are required to activate the shutter.

Moreover, if the EDAQ digital output is shorted on, the feedback signal from the interlock boards is now inconsistent with the request from the EDAQ to close the shutter and this is reported by the software to the RAE system.

With the shutter command off, the shutter indicator should be in the **Close** position (see Figure 13-2 for the Sx9 and Figure 13-3 for the Sx12).

For the Sx 9 and Sx 6 only, try to manually try to rotate the actuator to the closed position. If the shutter can be closed manually, but does not close automatically, contact Honeywell ACS Global Radiological Operations. Do not attempt to replace shutter mechanism or investigate the cause of failure. Field service is not permitted to replace the shutter solenoid.

13.9.2. Shutter not opening

Some of the reasons are similar to the shutter not opening above, such as a failed EDAQ Digital Output. It is also possible (especially on the Sx 6) that the fire-safety pin has released or partially released. Check if rod is still attached to housing by solder. If there is any indication it has, contact Honeywell ACS Global Radiological Operations.

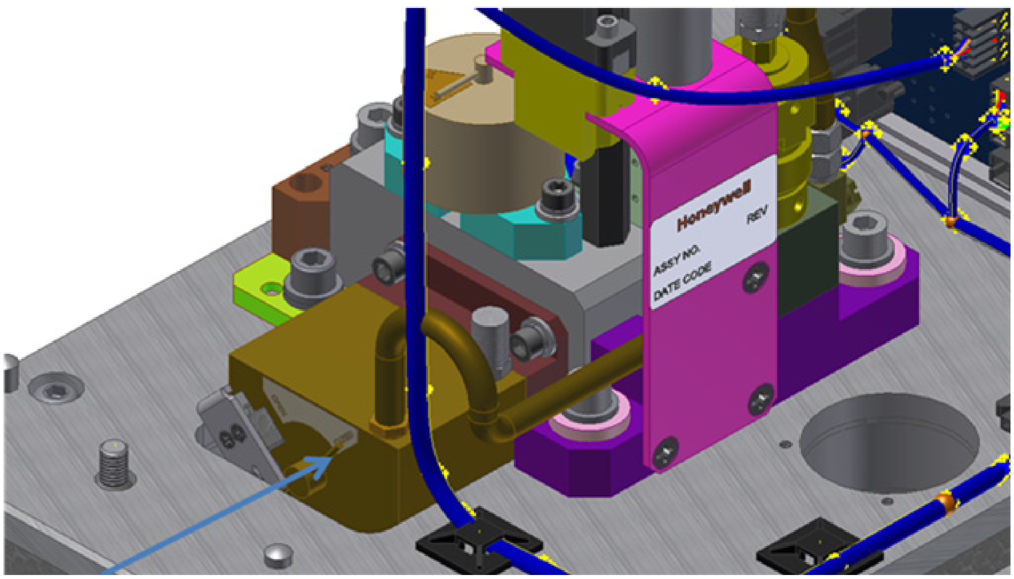


Figure 13-2 Q4201-XX source with shutter lever indicator in closed position

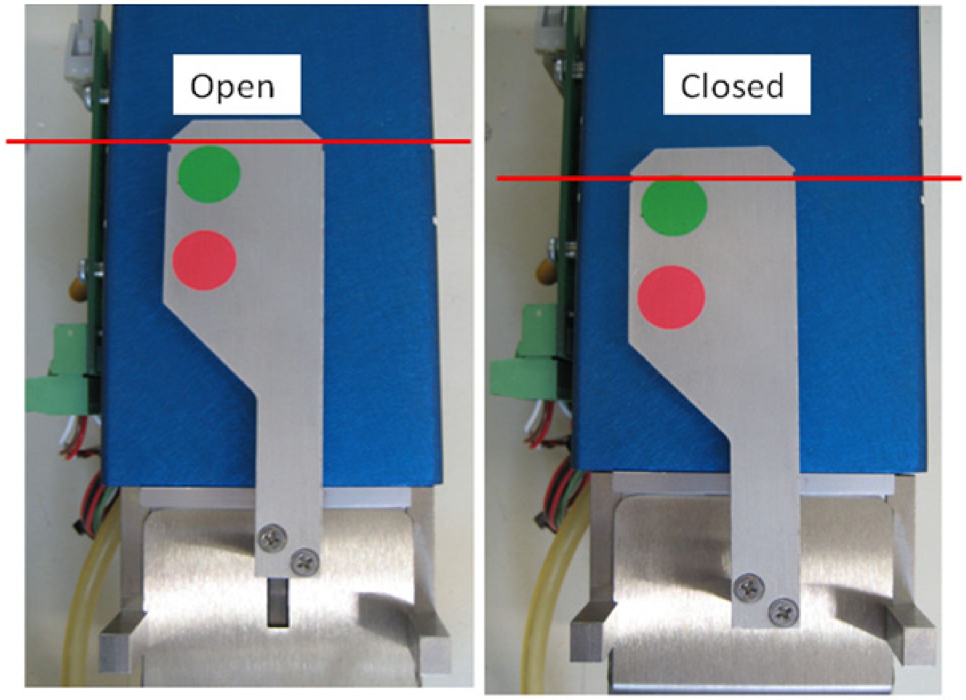


Figure 13-3 Q4202-50 open (left) and shutter closed (right)

Note the white markings on the right side of the source housing in Figure 13-3, which indicate which position is open or closed.

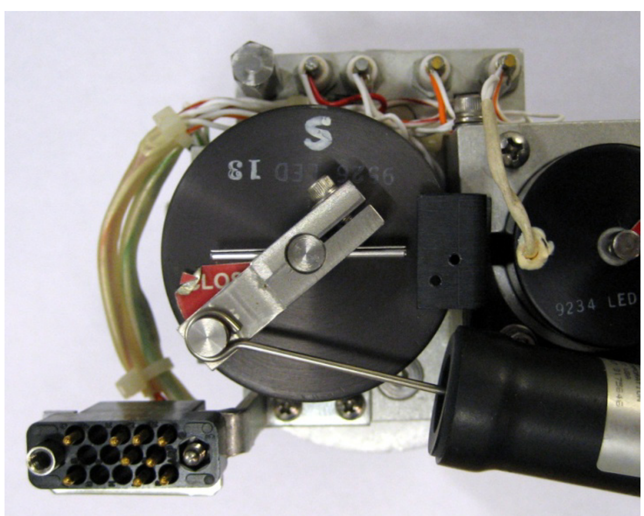


Figure 13-4 Source 6 with the shutter solenoid in the close position

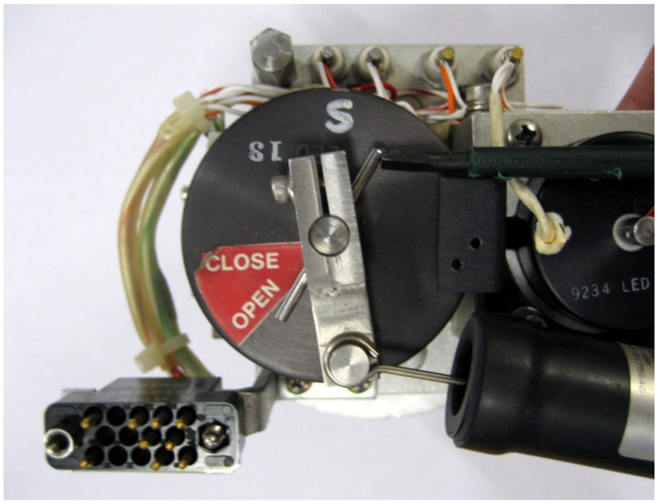


Figure 13-5 Source 6 solenoid with the shutter in the open position

Field service is not permitted to replace the shutter solenoid. Contact Radiological Operations.

13.9.3. Shutter not opening, or opening slowly

A low open safe volts alarm can be the result of the shutter not opening when requested. Basis weight stability tests failure or drifting flag to air ratios can be a result of the shutter opening too slowly. One of the common reasons is low or no air pressure at the sensor (for Source 9 and Source 12) Check whether the input pressure to the scanner is at least 50 psi. Disconnect the quick release tubes at the sensor and verify that air is coming out.

For the Source 6, a slow shutter opening could be due to a failing solenoid or the failure of the 24 V to 12 V converter. The voltage can be measured and checked on the converter unit. Field service is not permitted to replace the shutter solenoid. Contact Radiological Operations.

The EDAQ stores and writes to a log files the receiver signals prior to a safety fault. These can be analyzed by Honeywell Engineering to check for slow moving shutters.

Check whether the shutter is attempting to move when the command is given:

1. Navigate to the Measurement Sub System (MSS) **Setup Diagnostic** tab.
2. Click **IO Point Monitor** and choose the basis weight source from the drop-down menu listing all EDAQs.

3. Select **Digital Outputs** and turn on the first output. Watch the shutter indicator (see Figure 13-1). If the heads are aligned and the receiver is in place, you may attempt to move the shutter manually and verify the shutter movement is smooth. If not, Honeywell ACS Global Radiological Operations must be called. Do not attempt to diagnose.

13.10. Replace EDAQ

In case of a suspect EDAQ hardware failure (such as a shutter not opening when requested, resulting in an interlock alarm) the EDAQ should be replaced.

Activity Number:	Q4201-62-ACT-010	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner Offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	20 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:	Loop-back harness, p/n 6580801773		
		Quantity	Lead Time
Required Tools:			

For details of EDAQ replacement and programming, refer to *Experion MX MSS and EDAQ Data Acquisition System Manual*. The following four steps should be performed:

1. From the MSS main web page or the **MSS Summary** page on the RAE system (under **MSS Setup Diagnostics**) note down the position (node) and function number for this EDAQ. For example, a basis weight source may have function code 302 and might be in position 201–206 in the upper head.

2. Replace the EDAQ with a spare.

3. Check whether the new EDAQ reports with the expected position (node) and function numbers in the main MSS web page. If not, refer to *Experion MX MSS and EDAQ Data Acquisition System Manual* for information on how to correct the assignment.

4. Upgrade the EDAQ to the software revision present on the other EDAQs. Refer to *Experion MX MSS and EDAQ Data Acquisition System Manual* for details.

The removed EDAQ may be self-tested to verify whether it is functional or not. A loop-back harness is required for this operation. The self-test can be performed from any PC connected to the EDAQ. For details, refer to *Experion MX MSS and EDAQ Data Acquisition System Manual*.

13.11. Verify Wiring

This task is a generic placeholder for electrical failures.

Activity Number:	Q4201-62-ACT-011	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:		**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	30 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

The part numbers listed in Table 13-4 might be useful. The schematics can be requested from Honeywell Engineering.

Table 13-4 Part Numbers for Q4201-XX Electrical Wiring

Part Number	Description
6580801552	Sx9 source harness, Experion MX
6580801553	Sx9 receiver harness, Experion MX
6580500109	BW/X-ray Interlock board (at source)

Table 13-5 Part Number for the Q4202-50 Electrical Wiring

Part Number	Description
6580801676	Sx12 source harness, Experion MX
6580801686	Sx12 receiver harness, Experion MX
6580500109	BW/X-ray Interlock board (at source)

Table 13-6 Part Number for Q2201-XX Electrical Wiring

Part Number	Description
6580801726	Sx6 source harness, Experion MX
6580801727	Sx6 receiver harness, Experion MX
6580500109	BW/X-ray Interlock board (at source)

13.12. Replace Interlock Board

Low open safe or interlock board alarms may be due to a failure of the interlock board used in the MX Experion scanner.

Activity Number:	Q4201-62-ACT-012	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	20 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time

Required Parts:			
		Quantity	Lead Time
Required Tools:			

Each radiation gauge in the Experion MX scanner has its own interlock board that is mounted with the source next to the EDAQ board. Unlike the 4000 series scanners, there are no radiation interlock circuits in the scanner endbell or elsewhere.

The interlock board provides + 24 V to the basis weight shutter actuator as long as it receives a periodic (faster than 2 Hz) digital output signal from the EDAQ. This periodic signal is driven by the same EDAQ process that controls the shutter. In the case of a program error or electronic failure that halts these transitions, the interlock board will remove the + 24 V supply.

The shutter will therefore open only if two conditions are satisfied:

1. The EDAQ digital input grounds the return from the basis weight actuator.
2. There is + 24 V supplied to the actuator by the interlock board

In addition, the interlock board returns a digital input signal to the EDAQ to signal that the + 24 V is being supplied. The EDAQ raises an alarm if this signal is inconsistent with the requested shutter state.

The interlock board can be easily replaced by removing the four screws and inserting a spare. There is no configuration.

13.13. Enable Sensor on the Human/Machine Interface Panel

In the Q4000 Experion MX scanner series, all radiation sensors must be explicitly enabled at the scanner human/machine interface (HMI) panel.

Activity Number:	Q4201-62-ACT-013	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None

Availability Required:		**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	1 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:			

A `Reset MSS to Clear Safety Fault` command from the RAE server disables the radiation sensors (this may be configurable in future software releases). This ensures that remote commands cannot open the shutter while maintenance activities are performed at the scanner.

Ensure that the sensor is enabled:

1. Turn the key switch to the **ON** position.
2. Press the **BW** button on the **HMI/UPI** panels at either end of the scanner.
3. The amber light turns on and stays on.

If the amber light does not stay on, a What's Wrong message generates and passes to the RAE system. These are visible in the **MSS Diagnostic** tab under **MSS Summary Page** or the I/O point monitor. Refer to your scanner system manual.

13.14. Inspect Air Gap Sensor

In the Q4000 scanner the air gap sensors for the Source 9 and the Source 12 have been integrated in the module for the basis weight source and receiver. Unlike the previous scanner generation, the signal digitization is done by the same EDAQ module that handles the basis weight signals.

Activity Number:	Q4201-62-ACT-014	**Applicable Models:**	Q4201, Q4202
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):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:			

The MSS **Setup Diagnostic** tab **IO point monitor** screen for the basis weight source or receiver can be used to check if the air gap sensor signal is digitized as expected. A quick check of the sensitivity can be done by turning on and off the air wipe heaters and watching the voltage response on the IO point monitor.

A *Bad Input* alarm usually means there is no valid voltage input from the sensor to the EDAQ card. The signal has usually railed at -10 V or +10 V. A common cause is failure of the air gap sensor PCB.

Temperature alarms can indicate a poorly adjusted air gap sensor PCB. This offset is normally trimmed at the factory but it should be verified in the field. See Chapter 10, Sections 10.3 and 10.4 for further details.

13.15. Inspect Source Column Temperature Sensor

The source column temperature measurement is intended to correct for changing of the air density in the volume between the radioactive capsule and the Mylar® window. Source 6 temperature is measured using a 100 KΩ thermistor. The signal is digitized by the EDAQ thermistor inputs and converted to degrees C on the EDAQ.

Source 9 measurement is performed using an integrated circuit temperature chip that produces a voltage proportional to temperature in Fahrenheit.

In Source 12 a similar chip is used that produces a voltage proportional to the temperature in Celsius.

Activity Number:	Q4201-62-ACT-015	**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):	1 hour	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:	voltmeter		

Q2201-XX (Sx 6) Models:

The thermistor is connected between pins P and R on the Sx 6. It arrives on J3 on the EDAQ, the first thermistor input.

The signal is converted to degrees Celsius on the EDAQ and so the MSS Setup Page IO Point Monitor shows the value in Celsius when selecting the sensor analog input display.

Q4201-XX (Sx 9) Models:

The LM34 chip used in the Sx 9 requires a +12 V supply. This voltage should be present between pins B and E on the Sx9 connector (see source wiring diagram p/n 6580801552). The output, a voltage between 0.0 V and 10 V corresponding to 10 mV per degree Fahrenheit on pin D (ground is pin E). If that voltage is correct, check harness and presence of the signal on J1 pin 1 and 2 on the EDAQ. See Chapter 3, Figure 3-1, also refer to *Experion MX MSS and EDAQ Data Acquisition System Manual* for looking at EDAQ digitized signals, or check the MSS IO point monitor for the basis weight sensor from the **MSS Setup Diagnostic** tab on the RAE server.

Q4202-50 (Sx 12) Model:

For the Source 12, the required +15 V voltage is generated on the PCB using a zener diode and is present on point TB2-9 and TB2-10 (GND). The LM35 chip produces a voltage of 10 mV/deg C.

WARNING

Only personnel qualified under radiation safety license and with clearance from Honeywell ACS Global Radiological Operations are allowed to replace the temperature measuring device on the source body assembly (Source air column measurement).

13.16. Inspect Z-sensor

The Z-sensor is used to measure the instantaneous gap size. In the Q4000 series sensors it is powered from and connected to the upper alley EDAQ.

Activity Number:	Q4201-62-ACT-016	**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):	20 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:			

The Z-sensor is connected to analogue inputs channel 11 (pins 21 and 22 on EDAQ connector J1). It requires + 24 V between pins 1 and 3 on the connector going to the Z-sensor (P14) on drawing 6580801548.

13.17. Replace Compensator

The compensator is used both the reduce passline effects and to reduce ash sensitivity. The thin compensator on the Q4202-50 (Sx12) is easily damaged. This usually results in shifted F/A data or spikes in the basis weight profile.

Activity Number:	Q4201-62-ACT-017	**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):	60 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:	Screw drivers, Allen keys		

Remove the sensor from the head. The compensator is accessed by removing the receiver assembly from the platform and then removing the window assembly.

For the Source 6 and Source 9, the compensator depends on the model number:

Table 13-7 Source 6 Compensator Part Numbers

Sensor	Compensator
092201-72	08434100 (honeycomb)
092201-73	08353503 (plastic)

Table 13-8 Source 9 Compensator Part Numbers

Sensor	Compensator
094201-10	08638801
094201-62	08630800
094201-63	08639300
094201-64	08639400

For the Source 12, replace with 658180001, which is made from Kapton, not the transparent Mylar. Make sure the orientation is exactly as before – the compensator must be aligned with the MD direction, that is, should match the long line profile of the Sx 12 source

After completing the replacement, enter the system into Maintenance Mode for that particular scanner.

1. On the sensor Maintenance screen, select **Nuclear Sensor Processor**.
2. Shoot three References to check the BW Voltage. Ensure that it is below 8.5volts, if not re-strap the preamp to use a lower gain setting.
3. If this is a Q4202-50 (Sx 12), perform the topography procedure for source. See Chapter 5.
4. After the topography procedure is complete (if required), shoot verification samples to confirm calibration.

   If samples are off by more than 0.3% or more from previous verification, perform a full re-calibration on the system (clean and dirty). Apply new calibration coefficients and T0FA.
5. Ensure that after re-calibration is done that the T0FA set to the average from 30 references. At this time the DFRAC should be around 0.00 – if not at 0.00 redo the T0FA.

13.18. Inspect and Replace Source Flags

A flag may break due to old age, exposure to chemicals in the environment or due to repeated motion against the flag stop in Q4202-50 (Sx12). Radiation damage is usually not an issue for the flag.

A cracked or broken flag will show an increase in flag voltage and an increase in flag to air ration but no change in air volts or background volts.

Activity Number:	Q4201-62-ACT-018	**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):	60 minutes	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
	Part Number	Quantity	Lead Time
Required Tools:	Screw drivers, Allen keys		

Q4201-XX (Sx 9) has only one flag. It can be inspected by splitting the heads and removing the window ring assembly. To replace it:

1. Remove the Sx 9 body from the Q4000-80 platform (sensor base).
2. Remove the fire safety pin and insert the transportation pin.
3. After replacing the flag, rotate the flag solenoid by hand to make sure the flag does not stick against the surface of the sensor.

Q4202-50 (Sx12) has a flag 1 and flag 2 assembly. To replace them:

1. Insert the transportation safety pin and remove the source from the sensor base.
2. Remove the four screws holding the aluminum cover plate onto the nose of the sensor. See Figure 13-7.

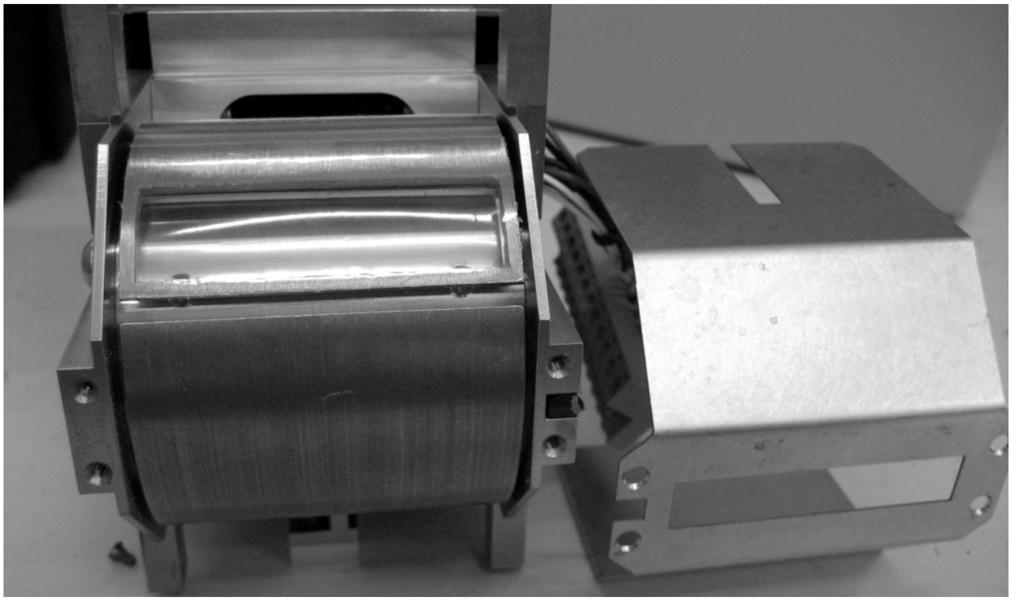


Figure 13-6 Source 12 with the Nose Cover Removed

3. Remove the three screws holding in the second flag. See Figure 13-8.

4. Remove flag holder and remove the screws for Flag 1. See Figure 13-8.

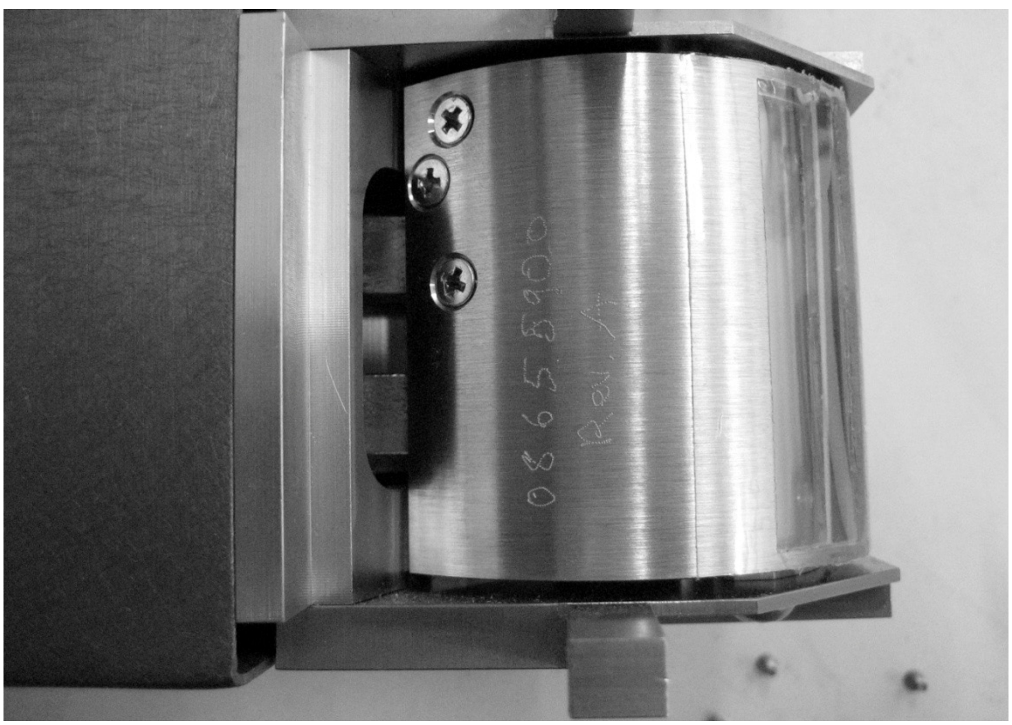


Figure 13-7 Source 12 showing the 3 Screws holding Flag 2

Figure 13-8 Source 12 with Flag 2 Removed showing Mounting Screws for Flag 1

5. After replacing either one of the flags, check the F/A ratios by doing 30 F/A references.

6. Reset the T0FA value with the average of these samples.

Q2201-XX (Sx6) has one flag, ash, shown on Figure 13-10. To replace, use a hex key to unscrew the flag holder. When replacing, make sure the flag can freely rotate over the surface of the source.

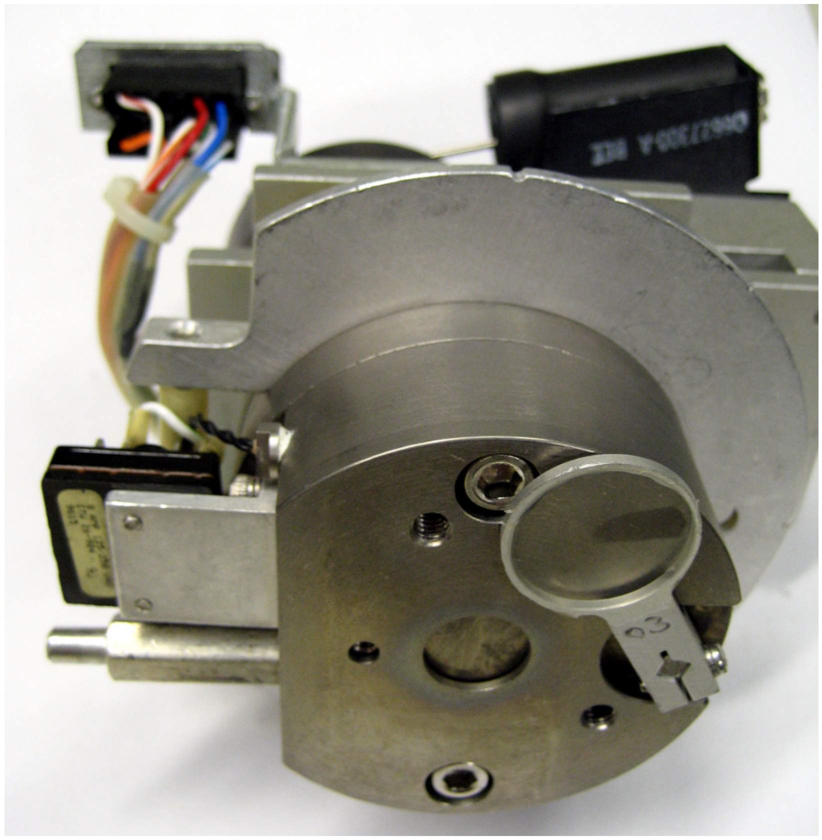


Figure 13-9 Sx6 Flag

14. Troubleshooting

This chapter covers possible issues with the basis weight sensor. It is divided into two sections:

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

14.1. Alarm Based Troubleshooting

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

14.1.1. Receiver (Rx) Sensor Not in Place

Symptom	Possible Cause(s)	Solution (Tasks)
Micro-switch between nuclear receiver body and platform is not closed as expected	Receiver module not screwed in place	
	EDAQ digital input failure	Replace EDAQ

14.1.2. Interlock Board

Symptom	Possible Cause(s)	Solution (Tasks)
Nuclear Interlock board did not feed back the + 24 V power-on signal to the EDAQ as expected	Interlock board failure	Replace Interlock Board
	EDAQ digital input failure	Replace EDAQ
	Harness failure	Verify Wiring

14.1.3. No BW Signal

Symptom	Possible Cause(s)	Solution (Tasks)
BW signal below background voltage (usually 15 mV)	EDAQ receiver harness not plugged into EDAQ	Check Receiver Voltages
	No ± 12 V power generated on receiver	Check Receiver Voltages
	Amplifier not installed	Basis Weight Receiver Amplifier Checks

14.1.4. BW Signal High

Symptom	Possible Cause(s)	Solution (Tasks)
BW receiver signal above maximum allowed voltage (usually near 10 V)	Amplifier OpAmp broken	Basis Weight Receiver Amplifier Checks
	Amplifier gain set to high	Basis Weight Receiver Amplifier Checks

14.1.5. High Closed Safe Volts

Symptom	Possible Cause(s)	Solution (Tasks)
Shutter was closed or requested to close but receiver signal higher than expected	Receiver amplifier failed	Basis Weight Receiver Amplifier Checks
	Shutter did not close	Verify Shutter Operation

14.1.6. Low Open Safe Volts

Symptom	Possible Cause(s)	Solution (Tasks)
Shutter was open or requested to open but the receiver voltage was below threshold	Shutter did not open due to EDAQ hardware failure	Replace EDAQ
	Shutter did not open due to interlock board failure	Replace Interlock Board

Symptom	Possible Cause(s)	Solution (Tasks)
	Receiver module not functioning	Check Receiver Voltages
	Shutter did not open due to mechanical issues (air, power)	Verify Shutter Operation
	Thick material in the gap	Inspect Head Gap
	Source and receiver are not aligned	Inspect Head Gap
	Fire safety pin has mistakenly activated (Source 12 only)	Verify Shutter Operation
	Orifice at inlet of pneumatic actuator in source is plugged (Source 12 only)	Contact Honeywell ACS Global Radiological Operations

14.1.7. Sensor Not Enabled

Symptom	Possible Cause(s)	Solution (Tasks)
Sensor is enabled in RAE but not at the scanner HMI panel (amber light is off)	MSS or frame controller reboot or clear safety fault disabled the sensor and it was not re-enabled before requesting scanning operations	Enable Sensor on the Human/Machine Interface Panel on scanner

14.1.8. Flag to Air Shift Out of Limits

Symptom	Possible Cause(s)	Solution (Tasks)
Flag to Air ratio (F/A) drift from the time-zero value exceeds the limit	Excessive dirt on the sensor	Inspect Head Gap
	Broken flag	Inspect and replace source flags
	Bad ion chamber	Replace Basis Weight Receiver Ion Chamber
	Low air pressure	Verify Shutter Operation

A careful analysis of the *Standardize Report* will confirm whether the shift is due to changes in air volts, changes in flag volts, or both. If both vary, the cause is likely to be the ion chamber or low air pressure. If only the flag value changes, the flag is likely broken.

14.1.9. Dual Flag Shift Out of Limits (Q4202-50 only)

Symptom	Possible Cause(s)	Solution (Tasks)
The 2nd Flag weight drift from the time-zero value exceeds the limit	Excessive dirt on the sensor	Inspect Head Gap
	Broken flag	Inspect and replace source flags
	Bad ion chamber	Replace Basis Weight Receiver Ion Chamber
	Low air pressure	Verify Shutter Operation

A careful analysis of the *Standardize Report* will confirm whether the shift is due to changes in air volts, changes in flag volts, or both. If both vary, the cause is likely to be the ion chamber or low air pressure. If only this flag value changes, but the first flag ratios are within specification than the flag is likely broken.

14.1.10. Source Air Gap Bad Input

Symptom	Possible Cause(s)	Solution (Tasks)
Signal from sensor is outside acceptable range for the RAE processor	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.11. Source Air Gap Temperature Below Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is below the minimum limit	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.12. Source Air Gap Temperature Above Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is above the maximum limit	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.13. Source Air Gap Temperature Drifting

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which has drifted too far from the standardize value	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.14. Receiver Air Gap Sensor Bad Input

Symptom	Possible Cause(s)	Solution (Tasks)
Signal from sensor is outside acceptable range for the RAE processor.	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.15. Receiver Air Gap Temperature Below Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is below the minimum limit	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.16. Receiver Air Gap Temperature Above Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is above the maximum limit	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.17. Receiver Air Gap Temperature Drifting

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which has drifted too far from the standardize value	Disconnected air gap sensor, broken air gap sensor PCB	Inspect Air Gap Sensor

14.1.18. Source Column Temperate Below Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is above the minimum limit	Disconnected or broken temperature sensor	Inspect Source Column Temperature Sensor

14.1.19. Source Column Temperate Above Limit

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which is below the minimum limit	Disconnected or broken temperature sensor	Inspect Source Column Temperature Sensor

14.1.20. Source Column Temperature Drifting

Symptom	Possible Cause(s)	Solution (Tasks)
Temperature processor computes a temperature from input data which has drifted too far from the standardize value	Disconnected or broken temperature sensor	Inspect Source Column Temperature Sensor

14.1.21. Sensor Processor Bad Input

Symptom	Possible Cause(s)	Solution (Tasks)
Sensor input data required for processor is not within valid range	Bad analog signal from basis weight receiver	Check Receiver Voltages

14.1.22. Sensor Processor Bad Intergauge Input

Symptom	Possible Cause(s)	Solution (Tasks)
Data received from other sensor processor is not within a valid range	No valid result for a basis weight corrector, such a the z-sensor or air gap sensor	Inspect Air Gap Sensor
		Inspect Z-sensor

14.1.23. Net Flag Voltage Negative

Symptom	Possible Cause(s)	Solution (Tasks)
The voltage read with the shutter open and flag in was less than background (shutter closed) voltage	Shutter did not open	Replace Interlock Board
	Bad background voltage	Replace EDAQ
		Check Receiver Voltages
		Basis Weight Receiver Amplifier Checks

14.1.24. Net Air Voltage Negative

Symptom	Possible Cause(s)	Solution (Tasks)
The voltage read with the shutter open was less than background (shutter closed) voltage	Shutter did not open	Replace Interlock Board
	Bad background voltage	Replace EDAQ
		Check Receiver Voltages
		Basis Weight Receiver Amplifier Checks

14.2. Q2201-XX Non-alarm based troubleshooting: Sensor Failure Modes

The receiver assembly of the Source 6 is similar but not identical to that of the Source 9 and Source 12, however, the same troubleshooting applies. See Section 14.3.2. For a description of the diagnostic test points, see Chapter 1 or Table 13-2.

The most common failure mode of the Source 6 source is the firing of the thermal safety nut, resulting in the shutter not opening.

A second issue in recent years is failure of the Flag-to-Air ratio stability. This is due to increased manufacturer tolerances on the flag solenoid shaft.

Parts orderable by the field can be found in Appendix A.

14.3. Q4201-XX Non alarm based Troubleshooting: Sensor Failure Modes

14.3.1. Source Components

Component	Function	Power Requirements	Test Points	Failure Modes
Pressure regulator (internal to source body, there is also an external regulator)	Regulates pressure to 45 ± 5psi	> 40 psi	Put pressure gauge on inlet and outlet	Output pressure can fluctuate if line pressure from external regulator is set below internal regulator setpoint
Pneumatic solenoid valve	Switches air to drive pneumatic rotary actuator to open position (a spring moves it to closed position)	24 V DC opens valve 0.0 V DC closes valve	Two pins for input voltage. Can measure output pressure with gauge on manifold. Measure resistance at pins (should be hundreds of ohms).	Coil can open circuit

Component	Function	Power Requirements	Test Points	Failure Modes
Pneumatic rotary actuator	Supplies torque to rotate capsule to open position when pressure applied, internal spring applies torque to rotate capsule to closed position when pressure off	> 35 psi	Roll pin and labels indicate position	May stick
				May not receive enough pressure
Air flow restrictor	Small orifice to reduce flow so that capsule does not slam into stops	None	Visual inspection of hole–wet finger can be used to see if there is flow	May clog
Wheel stops (internal)	Provide surface to stop capsule in both Open and Closed positions	NA	None	May wear
				May become dirty
				Unscrew
Flag/flag solenoid	Rotate flag (internal standard) into inserted or retracted positions	20–26 V DC	Visual inspection using position indicator pin and labels	Flag may tear
				Flag may become bent and jam
				Solenoid can overheat and jam
Fire safety pin	Forces capsule to retract in event of high temperature condition	Activated by temperatures exceeding 260 °C (500 °F)	Visually see if rod is still attached to housing by solder. Try to move actuator with source in head by manually rotating it using roll pin on pneumatic rotary actuator.	May creep (slowly move under pressure)
				May inadvertently activate
Green light switches (2)	These switches are in series and provide a positive indication that the capsule has been retracted (closed)	None	One switch is mounted on the pneumatic rotary actuator and is externally accessible	Indicator pin on pneumatic actuator may break or bend
			The other switch is mounted on enclosure and contacts the wheel	
			NO contact/COM contact: measure continuity when power is off and capsule is retracted (shutter closed)	

Component	Function	Power Requirements	Test Points	Failure Modes
Temperature measuring device for source air column (is located near aperture)	Measure the air temperature in the air space between the source capsule and the head window	12–24 V DC	Visual Inspection: P1 pin B = + V P1 pin E = RTN P1 pin D = Temp Out+	Physical damage

14.3.2. Receiver Components

Component	Function	Test Points	Known Failure Modes/Symptoms	Diagnostic Procedures
High voltage bias supply	Provides -350 V DC ion chamber bias	On detector back-plane	Output voltage goes to nearly zero volts is most common failure mode	Check test points on receiver backplane. The ion chamber output is rather insensitive to changes of a few volts of bias although in general bias voltage is stable to within a volt.
Ion chamber	Converts beta flux to current for conversion in detector amplifier	none	Gas leak: Output voltage will go down and flag and sample ratios will go up	Refer to preventative maintenance graphs of F/A and sample ratios, and air and flag counts versus time
			Insulator around center post exit becomes dirty and provides a variable leakage path across ion chamber bias which results in drifting background	Refer to preventative maintenance graphs of background counts versus time
			Intermittent short between ion chamber and housing. This can induce a down going spike in sensor output.	Physical inspection of ion chamber and casting. Look for metal labels peeling off, debris or casting burrs.
			Loose leads	Physical inspection of ion chamber and casting

Component	Function	Test Points	Known Failure Modes/Symptoms	Diagnostic Procedures
Detector amplifier	Convert small current from ion chamber to voltage	None	Offset (background) voltage wanders	Monitor background counts (should be 0.010–0.020 V DC) and check ± 12 V DC
			Thermal drift of amplifier	Monitor head temperatures
			Damage to wire that connects to ion chamber	Visual inspection
Receiver power supply temperature PCB	24 V DC to ± 12 V DC and provide processing for receiver air column (if available)	± 12 V DC on receiver backplane	1 ± 12 V DC output bad	1 ± 12 V DC output on receiver backplane

14.4. Q4202-50 Non Alarm based trouble shooting

The following two tables provide additional trouble shooting information for the Source 12. The first table lists some symptoms that are not directly alarmed by the Experion MX system. The second table lists common failure modes by the hardware in the sensor.

14.4.1. Non-alarm troubleshooting

Symptom	Probable Cause(s)	Solution
Low or no on-sheet, sample, flag or air counts	Fire safety pin has partially or fully mistakenly activated	Contact Honeywell ACS Global Radiological Operations
	Pneumatic solenoid valve in source	Check valve by removing exit hose and listening or feeling for air
	Orifice at inlet of pneumatic actuator in source is plugged	Contact Honeywell ACS Global Radiological Operations for orifice cleaning or replacement procedure (IMPORTANT: always replace with an identical orifice from spare parts since size of hole is critical to operation)
	Excessive friction in bearing	Contact Honeywell ACS Global Radiological Operations

Symptom	Probable Cause(s)	Solution
	Leaking pneumatic gasket or O-rings. A small leak downstream of the regulator can disable source from operating since the source has high pneumatic input impedance	Contact Honeywell ACS Global Radiological Operations
	Corrosion on actuator shaft.	Contact Honeywell ACS Global Radiological Operations
	Something external to pneumatic actuator is catching on rotating pin	Visual inspection of pneumatic actuator
	Pressure regulator in source head malfunctions	Replace
	Actuator fails	Try to move manually, call Honeywell ACS Global Radiological Operations to receive instructions for replacement
	Internal stops	Call Engineering to receive instructions
Drifting or noisy air, flag or F/A ratio The F/A is supposed to vary during on-line conditions since this is how the dirt correction is made. The questions is whether the excess variation is caused by the environment, in which case nothing should be done, or is caused by a faulty component, in which case something needs to be done.	Test under stable environmental conditions. Run several sets of 30 F/A stability tests with mill off for long enough to be cool. If F/A values meet or nearly meet lab stability spec, cause is likely to be an environmental one rather than due to a sensor component malfunction.	If F/A meets specification under stable thermal conditions, system is probably behaving properly
	F/A ratio drifting so the air counts go down and the F/A goes up	Replace leaky ion chamber.

14.4.2. Sensor Failure Mode by Hardware Components: Source Components

Component	Function	Power Req's	Tests	Failure Modes
Source				
Flag/ Flag solenoid	Rotate flag into inserted or retracted positions	20 – 26 VDC		1. Flag may tear 2. Flag may become bent and jam 3. Solenoid can overheat and jam

Component	Function	Power Req's	Tests	Failure Modes
Source				
Fire safety pin	Forces capsule to retract in event of high temperature condition	Activated by temperatures exceeding 500 degrees F	Check if rod is still attached to housing by solder. Try to move actuator with source in head by manually lifting and lowering mechanical indicator flag	1. May creep (slowly move under pressure) 2. May inadvertently activate
Temperature measuring device for source air column (is located near aperture)	Measure the air temperature in the air space between the source capsule and the head window	5-24 VDC	Backplane TP5-TP6 Interlock TB2 11,10. 10 mV = 1 deg C	Physical damage
Green light switches (2)	These switches are in series and provide a positive indication that the capsule has been closed	None	NO contact/COM contact: measure continuity when power is off (shutter closed)	

14.4.3. Sensor Failure Mode by Hardware Components: Receiver Components

Component	Function	Power Req's	Test Points	Failure Modes
Receiver				
High Voltage Bias Supply	Provides -350 VDC ion chamber bias.	On detector back-plane.	Check test points on receiver backplane. The ion chamber output is rather insensitive to changes of a few volts of bias although in general bias voltage is stable to within a volt.	Output voltage goes to nearly zero volts is most common failure mode

Component	Function	Power Req's	Test Points	Failure Modes
Receiver				
Ion Chamber	Converts beta flux to current for conversion in detector amplifier	none	Refer to Preventive Maintenance graphs of F/A and sample ratios and air and flag counts versus time. Refer to Preventive Maintenance graphs of background counts versus time. Physical inspection of ion chamber and casting. Look for metal labels peeling off, debris or casting burrs.	Gas leak: Output voltage will go down and flag and sample ratios will go up. Insulator around center post exit becomes dirty and provides a variable leakage path across ion chamber bias which results in drifting background. Intermittent short between ion chamber and housing. This can induce a down going spike in sensor output. Loose leads
Detector Amplifier	Convert small current from ion chamber to voltage	none	Monitor background counts (should be .010-.020 VDC) and check ±12 VDC Monitor head temperatures Visual inspection	Offset (Background) voltage wanders Thermal drift of amplifier Damage to wire that connects to Ion Chamber
Receiver Power Supply Temperature PCB	24 VDC to ±12 VDC and provide processing for receiver air column (if available)	±12 VDC on receiver backplane	±12 VDC output bad	±12 VDC output on receiver backplane

15. Storage, Transportation, End of Life

This chapter summarizes Honeywell policy with regards to the storage and disposal of the basis weight sources.

15.1. Storage and Transportation Environment

In order to maintain integrity of scanner components, storage and transportation of all equipment must be within the parameters shown in Table 15-1.

Table 15-1 Storage and Transportation Parameters

Duration of Storage	Acceptable Temperature Range	Acceptable Humidity Range
Short term (less than one week)	-20 to 45 °C (-4 to 113 °F)	20–90% non-condensing
Long term	-10 to 40 °C (14 to 104 °F)	20–90% non-condensing

15.2. 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 of using environmental friendly methods. Contact the factory for further details and instructions.

Except where identified in this chapter, the scanner does not contain hazardous or restricted materials.

Guidelines for disposal of equipment by Honeywell or the customer for sensor-specific materials are described in Subsections 15.2.1 and 15.2.2.

15.2.1. Solid Materials

- remove all non-metallic parts (except plastic) from the sensor and dispose of through the local refuse system
- recycle plastic parts
- wires and cables should be removed and recycled (copper may have value as scrap)
- electrical and electronic components should be recycled or handled as special waste to prevent them from being put in a landfill, because there is potential for lead and other metals leaching into the ground and water
- metals should be recycled (in many cases they have value as scrap)

15.2.2. Disposal of Radioactive Sources

Contact Honeywell Radiological Operations and they will advise and facilitate safe disposal.

15.3. Storing Radioactive Sources

WARNING

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

If a sensor head 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 ACS Global Radiological Operations.

The main contact numbers for Radiological Operations are:

First level of support:

ACS Global Radiological Operations
3079 Premiere Parkway
Duluth GA 30097

+1.770.689.0500

Europe, the Middle East, and Africa are supported by Waterford at:

+ 353 (0) 51 372 151

16. Glossary

Actuator	Mechanical or electronic device that performs the control action in a control loop.
Air Gap Temperature Sensor (AGT)	Device to measure the temperature of the air in the gap or space inside the sensor between the capsule and window. Used as corrector to the total basis weight.
Air Measurement	Reading of the basis weight receiver when the shutter is opened but there is no sample in the gap. Used to normalize the on-sheet measurement; re-calculated at standardize
Back Side	See Drive Side.
Background Measurement	Shutter closed basis weight receiver voltage reading. This measurement reflects only the electronic offsets and is subtracted from every shutter open reading.
Bin	The smallest measurement zone on the frame. Also called Bucket or Slice.
Bucket	See Bin.
BWDO	Dynamic Offset Basis Weight. A corrector (in units of basis weight) that corrects between on-sheet measurements and lab verification.
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 Spread	Variation in the profile data equal to twice the standard deviation of the measured variable.
Code	See Recipe.
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 machine direction that relates to a position along the length of the paper machine.

Dirt Frac or DFRAC	Calculated amount of dirt on the sensor. This is calculated from the flag-to-air ratio. Zero percent (0%) means no dirt, 100% means an amount that corresponds to the dirt sample used in the dirt calibration.
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.
EDAQ	Ethernet Data Acquisition card. Digitization and control board used on each sensor on the Experion MX platform
F/Alast	Last flag-to-air measurement.
Flag	Mylar® sample which can be rotated into the beam to simulate a weight measurement. Usually the measurement is used in the dirt correction calculation
Flag To Air Ratio (F/A)	The signal from the basis weight receiver with the shutter open, with and without the flag inserted.
Front Side	See Tending Side.
Green Light	One of the two radiation interlock lights. Green is on when the shutter is physically closed
GSP	Gauge support processor
High End Calibrate Distance	The distance from a fixed point on the sensor head to the closest vertical member of the scanner when it is located at the **High End Limit** switch. This position is determined during scanner calibration.
High End Calibrate Position	The value of the head position when the sensor head reaches the High End Calibration Position. This is only updated during a scanner calibration procedure.
HMI	Human/machine interface. Also referred to as user program interface (UPI).
Isotope	Periodic table element with a particular atomic weight. Common isotopes used in weight measurements include Promethium-147 (Pm), Krypton-85 (Kr) and Strontium-90 (Sr).
KCM	Customer sample calibration constant. A multiplier used to correct the basis weight calculation if the samples are not Mylar®.
Linux	Computer operating system running on the EDAQ CPU as well as the Measurement Sub System (MSS) computer
Low End Calibrate Distance	The value of the head position (in millimeters) when the sensor head reaches the Low End Calibrate Position.
Low End Calibrate Position	This position is only updated during a scanner calibration procedure.
Low End Offset	The distance in millimeters from the cable end of the scanner to where bucket zero is located.

Machine Direction	The direction in which paper travels down the paper machine.
Measurement Sub System (MSS)	Intel based CPU performing data collection from sensor EDAQs and binning the data before sending to the RAE (Experion MX) system. Responsible for binning sensor data and controlling standardization operations.
MIS	Management Information System. System or subsystem that collects and manages information on the paper production.
Motor End	Location of the motor on the scanner.
Motor End Support	Formed steel channel welded to the upper and lower box beams at the motor end.
MXOpen	(obsolete) software quality control system. See QCS.
Quality Control System (QCS)	A computer system which manages the quality of the paper produced.
Real-Time Application Environment (RAE)	The system software used by Da Vinci and Experion MX QCS to manage data exchange between applications (with Performance CD being one of them).
Recipe	A list of pulp chemicals, additives, and dyes blended together to make a particular grade of paper.
Red Light	One of the radiation interlock lights. Red light is on when the driving electronics receives a command to open the shutter.
Real-Time Data Repository (RTDR)	The database managed by RAE to store system data and data for individual applications.
Scan Position	A constant position (in millimeters) measured from the cable end.
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.
Slice	See Bin.
Smoothing Width	A value that determines the amount of averaging that will be applied to a measurement bin.
Standardize	An automatic periodic measurement of the primary and auxiliary sensors taken offsheet. The standardize measurements are used to adjust the primary sensors' readings to ensure accuracy.
Streak	A narrow cross-directional section of paper where a measured quality deviates significantly from the average of the entire width of the paper. Also an area in an array of cross-directional measurements that deviates more than a certain amount from its surroundings. The amount of allowed deviation can be set up as an absolute number or as a percentage.

T0CF	Change in F/A ratio when known dirt is inserted.
T0FA	Time-zero F/A ratio. F/A ratio when the system is known to be in a clean state
Tending Side	The side of the paper machine where the operator has unobstructed access. Also called Front Side.
TES	Thermal Equalization System
Trend	The display of data over time.

A. Part Numbers

Table A-1 lists part numbers for Source 9 Basis Weight Measurement.

Table A-1 Source 9 Part Numbers

Part Number	Description
6580801552	Sx9 source harness, Experion MX
6580801553	Sx9 receiver harness, Experion MX
6580500109	Radiation Interlock board (at source)
6580801428	Sx9 sensor baseplate (source)
6580801426	Sx9/Sx12 sensor baseplate (receiver)
6581500030	EDAQ PCB
6509420162	SX9 (complete) low ash
6509420163	SX9 (complete) medium ash
6509420164	SX9 (complete) high ash
08672000	Assembly
086561XX	Receiver assembly
053239XX	Nevada Board PCB
6581500032	frame controller (FC) expansion board
03044200	Alignment Fixture Assembly
05443000	PCB
16000332	conductive grease
00285800	o-ring
6580801773	loop-back harness
05443000	air gap sensor PCB
094237XX	PCB

Table A-2 lists part numbers for Source 6 Basis Weight Measurement.

Table A-2 Source 6 Part Numbers

Part number	Description
22000070	Flag solenoid (source)

Part number	Description
08479301	Thermal Safety Nut (source)
47000006	Temperature sensor (source)
48140061	Diodes (source)
51000034	Microswitch (source)
07687600	Dashpot (source)
08441102	Flag assembly (source)
05277501	Amplifier (receiver)
08434100 (-72 model) 08353503 (-73 model)	Compensator (receiver)
08441102	Flag assembly (receiver)
05410000	PCB High Voltage (receiver)
05323900	PCB Back plane (receiver)
08353700 (-72 model) 08353706 (-73 model)	Ion chamber assembly (receiver)