Ash Measurement

System Manual

6510020332

Ash Measurement

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Introduction

The purpose of this manual is to provide an introduction to the Ash Measurement system.

The models covered in this manual are:

Experion MX	Da Vinci
Q4237-50	2237-00
Q4237-51	2237-01
Q4267-52	2237-02
Q4237-57	2237-07

The Experion MX model numbers are primarily used throughout this manual.

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 15 chapters and one appendix.

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

Chapter 2, **Radiation Safety and Interlocks**, describes radiation safety and interlocks.

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

Chapter 4, **Theory of Operation and Detailed Parts Description**, describes system parts and the theory of operation.

Chapter 5, **Installation**, describes installation and set up tasks for the system.

Chapter 6, **Operating Modes**, describes system operational modes.

Chapter 7, **Single Ash Gauge Calibration**, describes the calibration of a single ash gauge.

Chapter 8, **Dual Ash Gauge Calibration**, describes the calibration of a dual ash gauge.

Chapter 9, **Calibration Constants**, describes calibration constants.

Chapter 10, **Preventive Maintenance**, describes recommended ongoing preventive maintenance tasks.

Chapter 11, **Tasks**, describes procedures for maintenance, diagnostic, and troubleshooting tasks.

Chapter 12, **Troubleshooting**, describes symptoms, alarms, possible causes, and links to associated diagnostic or troubleshooting tasks.

Chapter 13, **Testing Specifications**, describes factory-based, pre-installation system tests.

Chapter 14, **Storage, Transportation, and End of Life**, describes methods for storing, transporting, and disposing sensor components.

Chapter 15, **Glossary**, describes the terms and acronyms used in this manual.

Appendix A, **Part Numbers**, provides a list of part numbers for system components.

Related Reading

The following documents contain related reading material.

Honeywell Part Number	**Document Title / Description**
6510020197	Radiation Safety Manual for Honeywell Customers
6510020331	Basis Weight Measurement System Manual
6510020381	Experion MX MSS & EDAQ Data Acquisition System Manual

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

Ash gauges measure the non-cellulose composition of paper during the manufacturing process. In most cases, the additives (also referred to as fillers) are limited to calcium carbonate ($CaCO_3$), clay ($Al_2O_32SiO_22H_2O$, a hydrated aluminum silicate), and titanium dioxide (TiO_2), but a number of other compounds are used in the industry. The traditional off-line analysis technique consists of burning (oxidizing) the paper in a controlled-temperature environment. The remaining incombustible material is ash or filler. The laboratory ashing techniques are described as part of the TAPPI standards T211 and T413.

Honeywell markets two types of ash gauges:

- The single ash gauge consisting of a single X-ray source and detector. The intended application is to measure the sum of two possible ash ingredients (two of $CaCO_3$, Clay, or TiO_2), but see note with regards to the newer ash gauge model 2237-07/Q4237-57.

ATTENTION

> Honeywell has introduced a single X-ray source sensor capable of measuring the sum of the three standard ash components: the 2237-07/Q4237-57. It is available in a 525° C (977 °F) ashing mode only, and replaces the earlier 2237-06. It takes only a single slot in the head compared to two for the previous three-ash model.
>
> For reasons of fundamental physics, it is not possible to design an equivalent of the Q4237-57 sensor that corresponds to 900 °C (1652 °F) ashing. For that reason, the 4267-52 is still available and recommended when all three components are present AND the customer desires to ash the samples at 900 °C (1652 °F).

- The dual ash gauge consisting of two nearly identical X-ray sources and two receivers. By combining the information from both sensors, this set can measure the total ash when all three ingredients are present, independent of the ratio of the three components.

Table 1-1 Sensor Models Numbers and descriptions

Sensor Model: Experion MX / Da Vinci	Type of Ash Measured	TAPPI Ashing Temperature
Q4237-50/2237-00	TiO_2 and Clay	900 °C (1652 °F)
Q4237-51/2237-01	$CaCO_3$ and Clay	900 °C (1652 °F)
Q4267-52 /2237-02	Dual ash: $CaCO_3$, TiO_2, and Clay	900 °C (1652 °F)
Q4237-57/2237-07	$CaCO_3$, TiO_2, and Clay	525 °C (977 °F)

In addition to measuring different combinations of ash, some of the above models come in a 525 °C (977 °F) and 900 °C (1652 °F) ashing version. Laboratory ashing at 900 °C (1652 °F) destroys the $CaCO_3$ component, resulting in a measurement of calcium oxide (CaO) only. Clay is also dissociated but to a lesser degree. By careful choice of X-ray energy and filtering, the 900 °C (1652 °F) ashing version of the sensors emulate this effect by being less sensitive to $CaCO_3$ than either Clay or TiO_2.

1.1. Basic Operation

A typical ash gauge source and receiver pair is shown on Figure 1-1. An X-ray tube in the lower head is the source of X-rays. In the tube, electrons are accelerated towards an anode by a very high voltage.

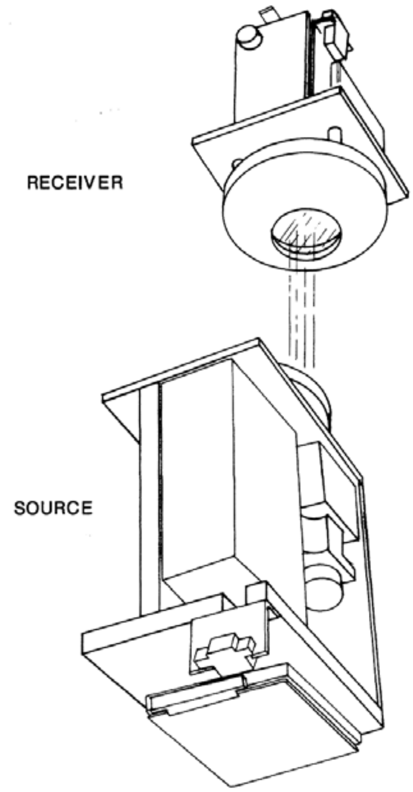


Figure 1-1 Ash Sensor Overview

The voltage is slightly different for each model (the actual voltage depends on the ash mix.). The energy in the electrons is converted to heat and X-rays. Control circuits in the sensor keep the anode current and hence X-ray flux constant. A shutter drive circuit attenuates the X-ray beam to a safe level when the sensor is offsheet. A solenoid controlled flag is inserted in the X-ray beam when standardizing.

Figure 1-2 shows a basic schematic of a typical 4237-XX ash sensor.

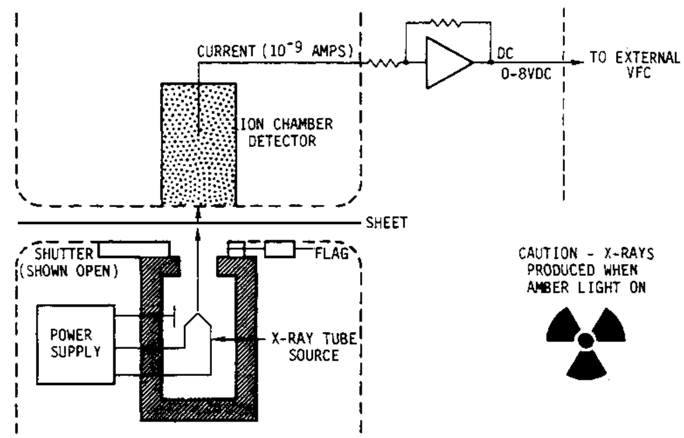


Figure 1-2 Typical 4237-XX Ash Sensor

In the receiver, the X-ray beam is detected by an ionization chamber. The weak current from the ionization chamber is converted to a voltage and amplified by the detector amplifier. The output voltage from the amplifier is connected to an analog-to-digital converter. In the Experion MX scanner, this conversion happens at 4 kHz on the Ethernet Data Acquisition (EDAQ) board.

The algorithms running as part of the real-time application environment (RAE) server convert the voltage signal to a percentage ash. For the single ash gauges, including the Q4237-57, this is a two step process: in the first step, the sensor measurement ratio is converted to an equivalent weight of Mylar®. This weight will in general be much higher than the true weight of the paper. In the second step, this difference between the Mylar equivalent weight and the measured true weight of the sheet at that same position is converted to an ash content. The first step is in all aspects equivalent to the algorithms applied to a Honeywell basis weight sensor. You will therefore find references to the *nuclear weight calculation* of the ash sensor in the RAE Experion MX software.

For the dual ash gauge (consisting of two sensors), the algorithm is quite different; no intermediate calculation is done. Instead, the two sensor ratios are used directly to calculate total ash.

1.2. The Three Ash Ingredient Model Q4237-57

The Q4237-57sensor replaces the 2237-06 dual ash 525 °C (977 °F) ashing as well as the 2237-04 and 2237-05 and will therefore be the most common single source/receiver ash sensors found on Experion MX scanners. Although it is a single ash gauge and almost identical to the 2237-04 and 2237-05 models, it is tuned to be *insensitive* to any mixture of $CaCO_3$, Clay, and TiO2. For reasons of fundamental X-ray physics, it is only able to provide total ash corresponding to 525 °C (977 °F) ashing. Unlike the dual ash sensor 2237-06, it *does not* provide a separate measurement of the Clay, which was in most cases difficult to calibrate.

The Q4237-57 should be called out where the paper maker intends to use all three components all or part of the time. It should also be recommended if the paper maker is switching over between two types of processes and needs continuity during the transition. If other ash additives are added (for example magnesium silicate ($MgSiO_3$), ferric oxide (Fe_2O_3), or talc, Engineering should be consulted.

The Q4237-57 gauge is almost identical to the existing single ash gauges and uses the same software. Power and environmental requirements are the same. The following list details the hardware differences:

- source base plate: the plate is modified and there is no aluminum foil filter
- a filter holder containing a very thin metal filter is mounted to and below the new base plate
- The high voltage setting on the power supply is 5.9 kV

An upgrade kit exists to convert any dual ash gauge to the 2237-07 triple ash gauge. For detailed information see Honeywell document number 6510030036, *Installing the 09223707 upgrade kit*.

1.3. Heads and Scanners

The ash 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 to the scanner to provide information about the condition of the X-ray 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. Both source and receiver units contain a data acquisition card, the EDAQ. 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, or refer to the *Experion MX MSS & EDAQ Data Acquisition System Manual*.

2. Radiation Safety and Interlocks

This chapter describes the safety components of the ash sensors gauge in the Q4000 scanner.

2.1. Radiation Safety

WARNING

> The ash sensor produces hazardous radiation. If you are working with this sensor you must have participated in radiation safety training, be familiar with radiation safety practices, and carry a radiation badge. Under no circumstances should any part of your body be placed in the gap.
>
> Consult the *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 green light circuit). Similarly, when the red light is OFF it does not mean that the shutters are closed.

This chapter briefly summarizes the radiation interlock differences between the Experion MX scanner and the previous scanners.

2.2. Green Light Circuit

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

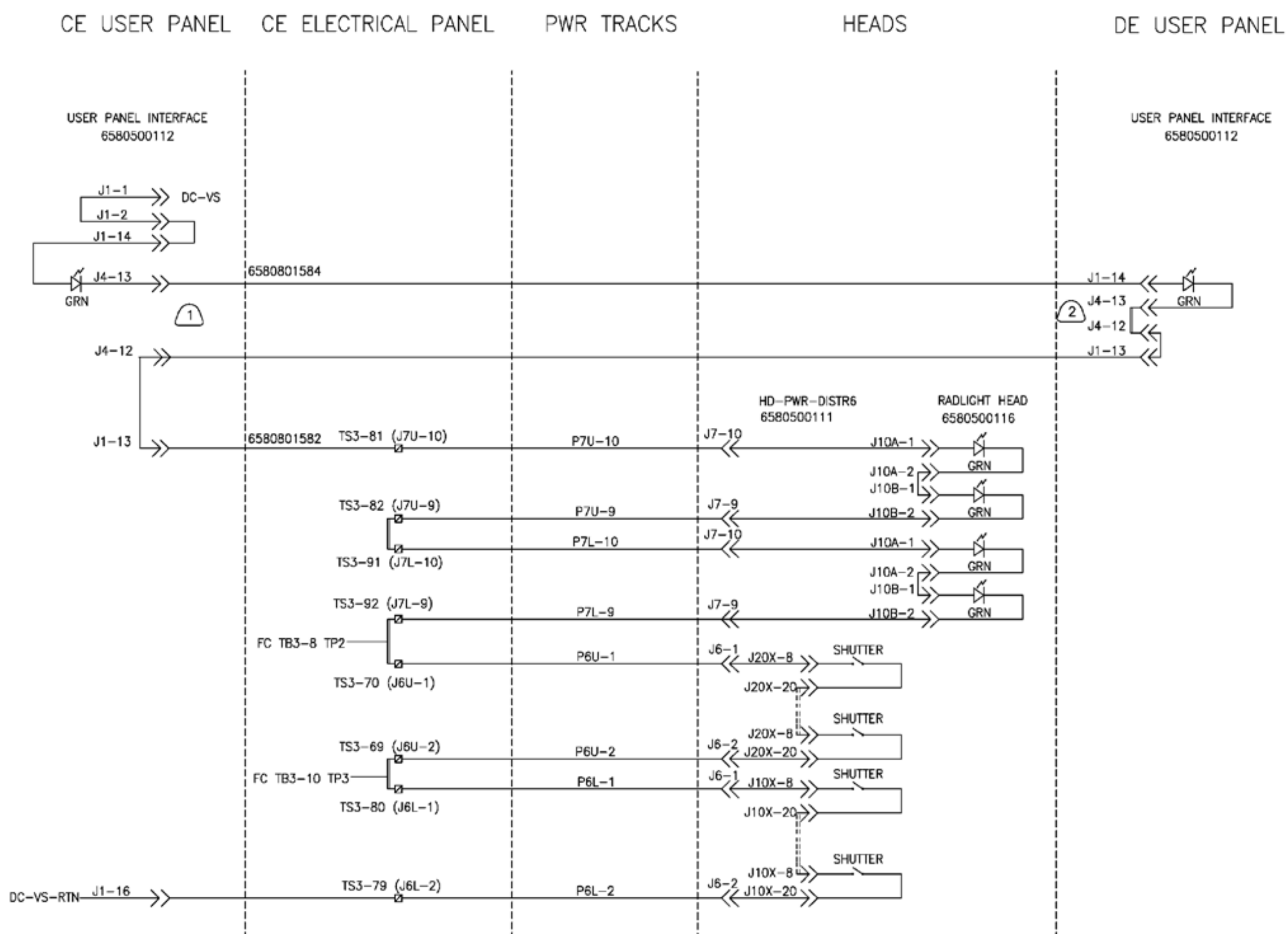


Figure 2-1 Green Light Circuit Schematic

As in the previous 4000 scanner, the ash gauge shutter does not close until power has been applied to the sensor. That means all the interlock requirements listed in Section 2.3 have to be met. For the green lights to be on, the ash gauge must be enabled at the endbell HMI/UPI panel and this implies, for example, that the heads cannot be split until the ash gauge is enabled.

The only changes in the Q4000 scanner 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). As in the 4000 scanner, 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.

2.3. Red Light Circuit

In the Q4000 scanner all red light-related signals are handled via the EDAQ boards attached to each sensor. The decision to allow shutter open commands is made on the ash source EDAQ CPU board based on information received over the Ethernet. One example 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 (FC) 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 the shutter-open command.

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 mounted at the sensor EDAQ. 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 ash sensor, the gauge controlling EDAQ requires the following conditions:

- 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 and **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.

Figure 2-2 shows the schematic for the controlling EDAQ, the power interlock board, and the shutter command line for the X-Ray gauges. EDAQ only sends the keep-alive signal when numerous interlock conditions are met. The interlock board then supplies the + 24 V to the entire gauge, which also causes the shutter to close. Note that the receiver is powered as long as the head + 24 V power supply is turned on.

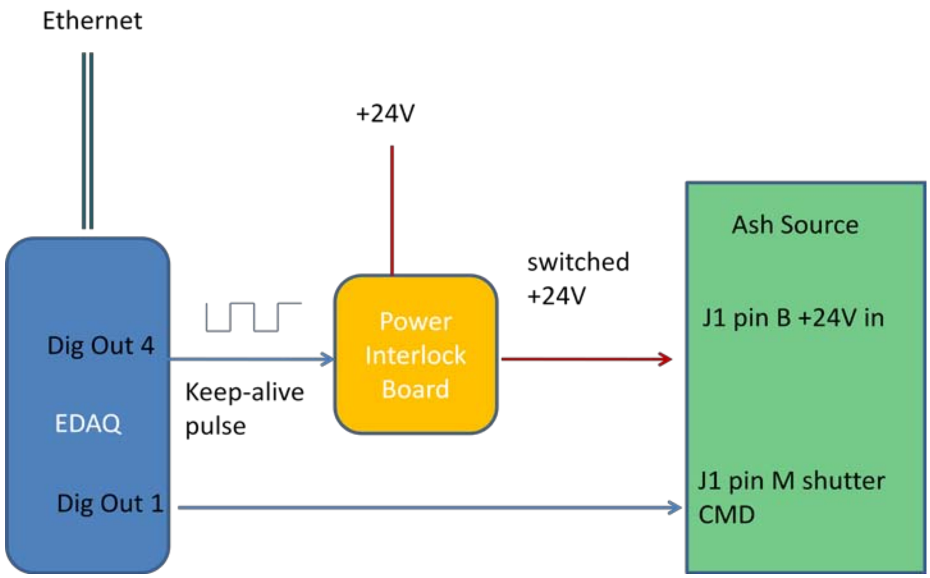


Figure 2-2 The relation between the EDAQ, the Power Interlock Board, and Shutter Command Line Schematic

Power is applied through the interlock board when interlock board receives a digital pulse.

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 the *Experion MX MSS & EDAQ Data Acquisition System Manual*.

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.

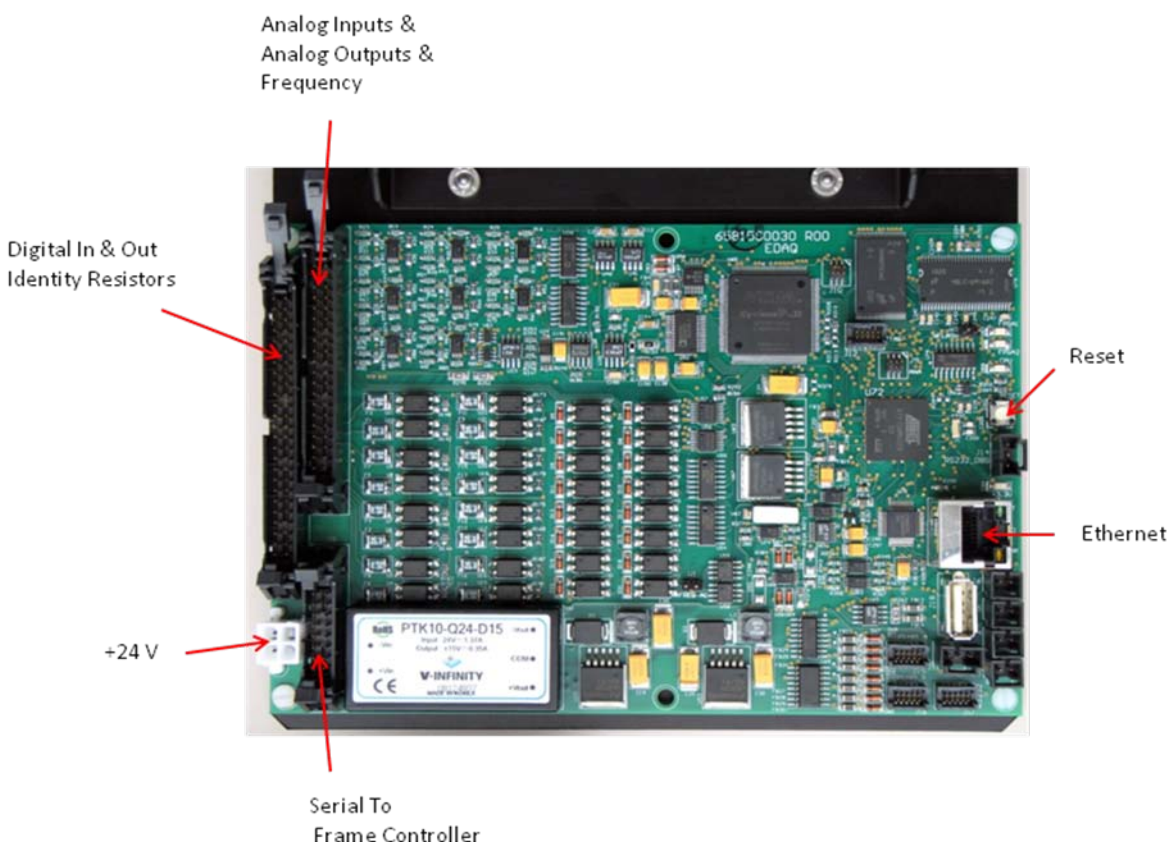


Figure 3-1 EDAQ Board

As shown in Figure 3-2, 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.

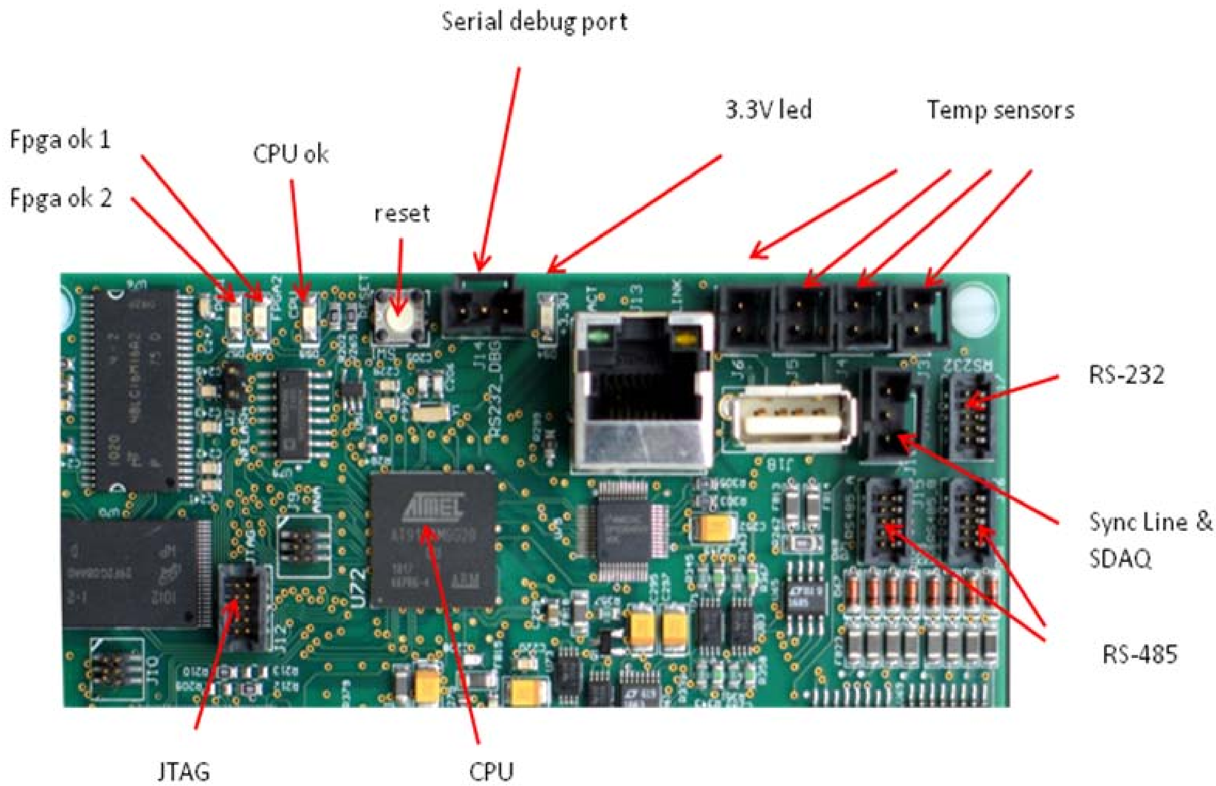


Figure 3-2 EDAQ Board: Ports and Diagnostic LEDs

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

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 system 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 frame controller (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 system 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 Status Information

3.5.1. Experion MX Platform

An overall status page is available from an 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).

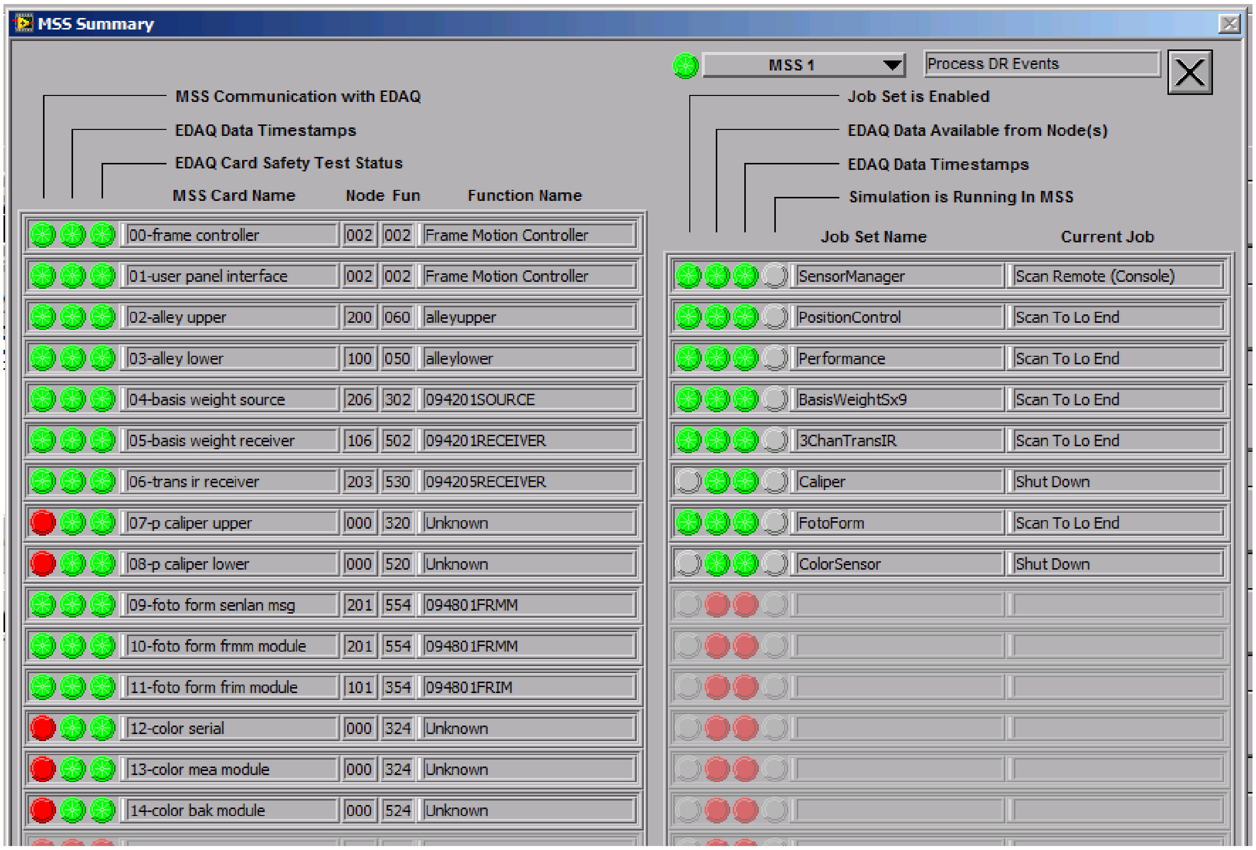


Figure 3-3 MSS Summary

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**).

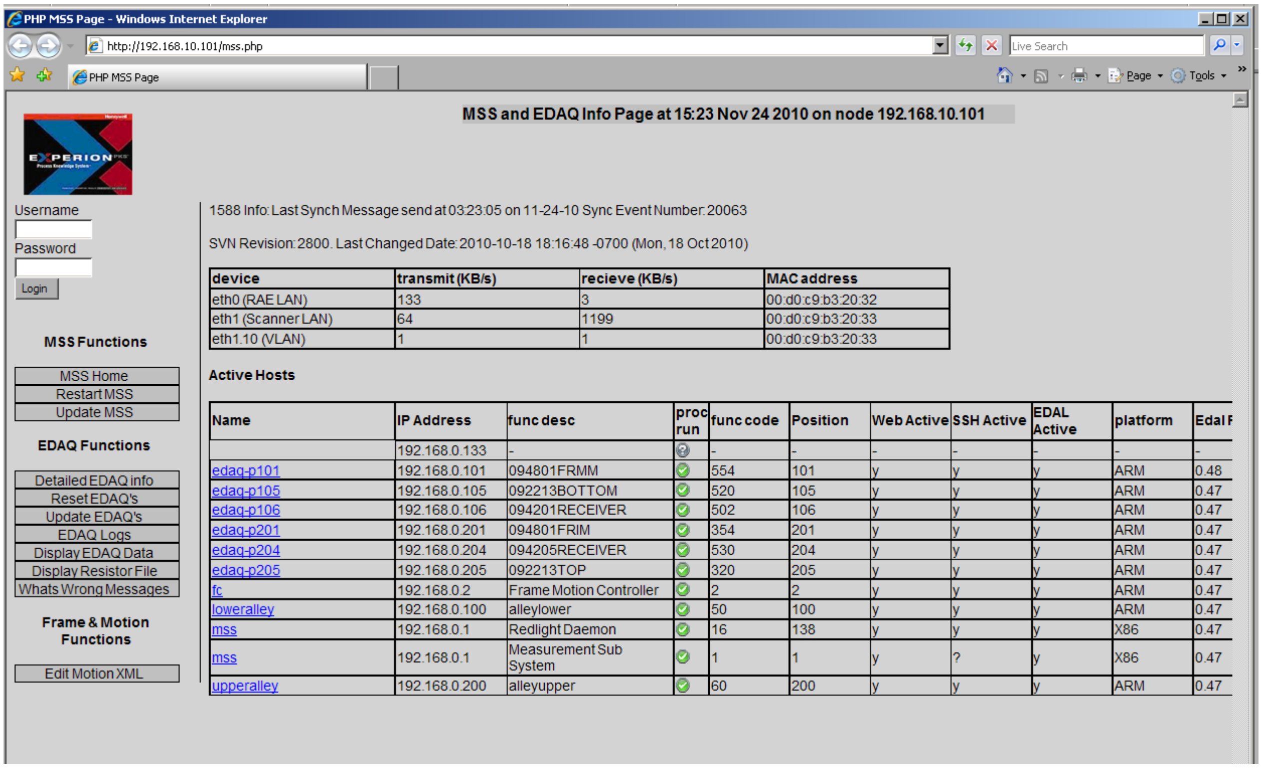


Figure 3-4 PHP MSS Page

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.

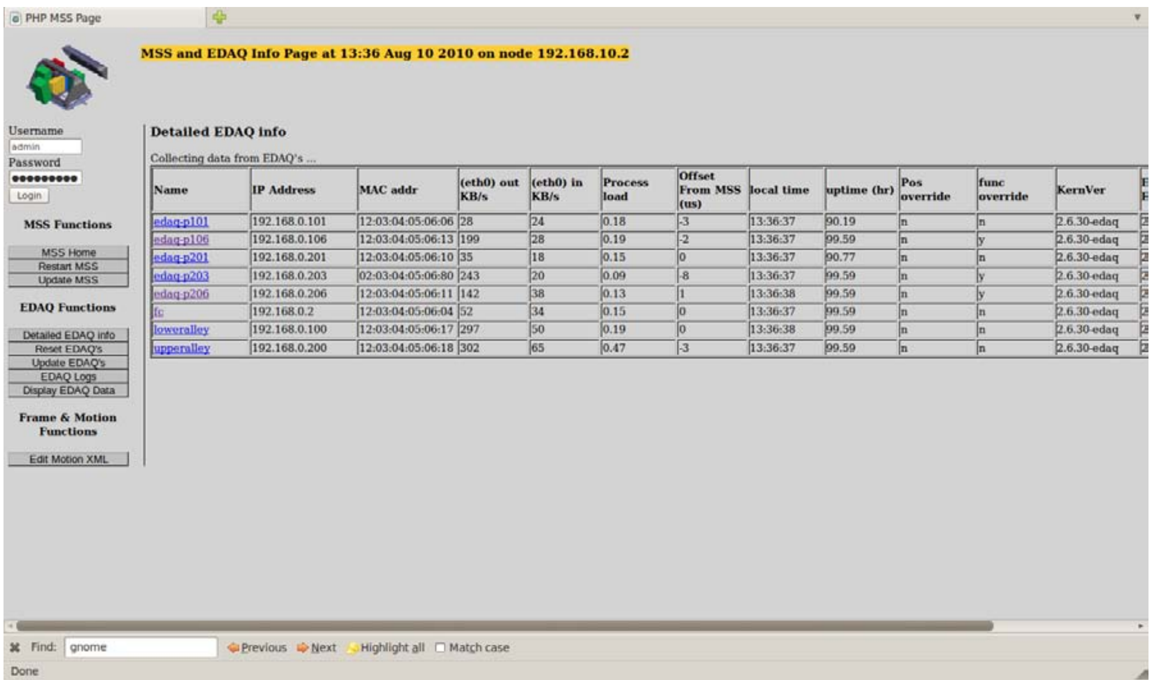
The second table lists all EDAQs discovered on the scanner LAN, their IP numbers, a brief description (related to model number), a program status column, the associated function code and position code, and whether the communication protocols are running (http, ssh, and Edal, the proprietary sensor data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



Name	IP Address	MAC addr	(eth0) out KB/s	(eth0) in KB/s	Process load	Offset From MSS (us)	local time	uptime (hr)	Pos override	func override	KernVer
edaq-p101	192.168.0.101	12:03:04:05:06:06	28	24	0.18	-3	13:36:37	90.19	n	n	2.6.30-edaq
edaq-p106	192.168.0.106	12:03:04:05:06:13	199	28	0.19	-2	13:36:37	99.59	n	y	2.6.30-edaq
edaq-p201	192.168.0.201	12:03:04:05:06:10	35	18	0.15	0	13:36:37	90.77	n	n	2.6.30-edaq
edaq-p203	192.168.0.203	02:03:04:05:06:80	243	20	0.09	-8	13:36:37	99.59	n	y	2.6.30-edaq
edaq-p206	192.168.0.206	12:03:04:05:06:11	142	38	0.13	1	13:36:38	99.59	n	y	2.6.30-edaq
fc	192.168.0.2	12:03:04:05:06:04	52	34	0.15	0	13:36:37	99.59	n	n	2.6.30-edaq
loweralley	192.168.0.100	12:03:04:05:06:17	297	50	0.19	0	13:36:38	99.59	n	n	2.6.30-edaq
upperalley	192.168.0.200	12:03:04:05:06:18	302	65	0.47	-3	13:36:37	99.59	n	n	2.6.30-edaq

Figure 3-5 Detailed EDAQ Information: Partial Display

4. Theory of Operation, and Detailed Parts Description

4.1. X-Ray Physics

The measurement of ash in paper with the use of X-rays depends on the fact that all materials absorb X-rays, and atoms with high atomic numbers do so far more than the lighter materials.

In the range of energies used by Honeywell sensors, many materials such as calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), and iron oxide III or ferric oxide (Fe_2O_3) have sharp transitions in the absorption spectrum. As a rule, X-ray absorption sensors are therefore very composition sensitive.

The requirements in the paper industry are usually to measure the sum of all non-hydrocarbons added to the sheet, regardless of the exact composition. Honeywell ash sensors use specially tuned X-ray source and filters to achieve this, but the range of standard materials that can be measured in this manner is limited to $CaCO_3$, clay ($Al_2O_32SiO_22H_2O$, a hydrated aluminum silicate), and TiO_2. Other common additives sometimes have similar characters to clay, and can be measured without introducing large errors.

An example of a typical X-ray absorption coefficient as a function of X-ray energy (in units of MeV) for titanium dioxide (X-ray absorption spectrum) is shown in Figure 4-1.

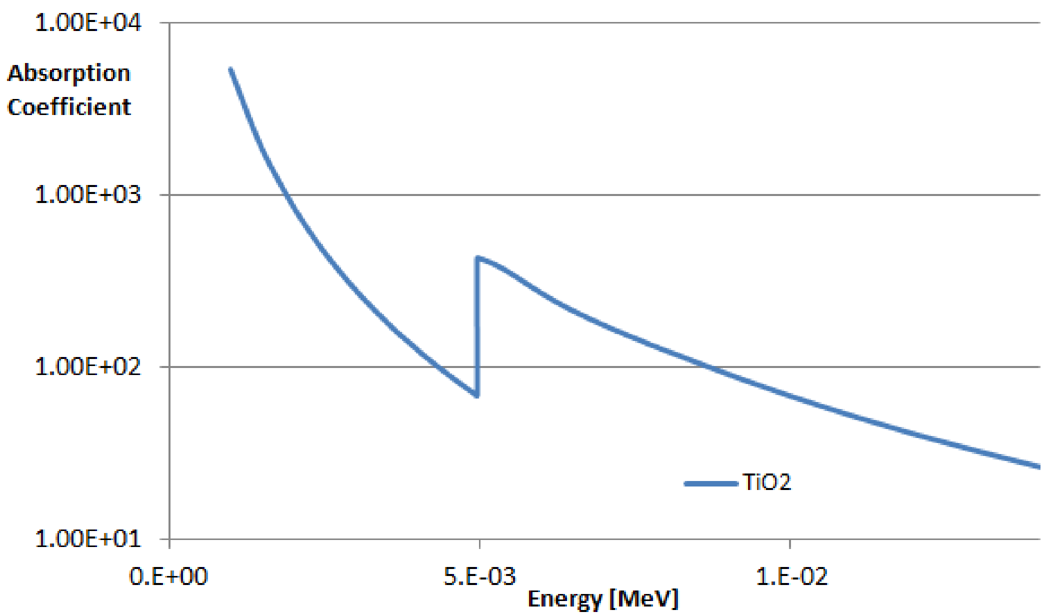


Figure 4-1 X-Ray Absorption for Titanium Dioxide as a function of energy

The graph in Figure 4-1 shows the absorption coefficient as a function of X-ray energy (which is proportional to the frequency and inversely proportional to the wavelength). X-ray tubes, however, do not produce single energy X-rays but a spectrum, ranging from very low energy to the maximum energy (high voltage) applied to the tube. A typical example of the X-ray spectrum for an ash gauge operated at 5 kV is shown in Figure 4-2.

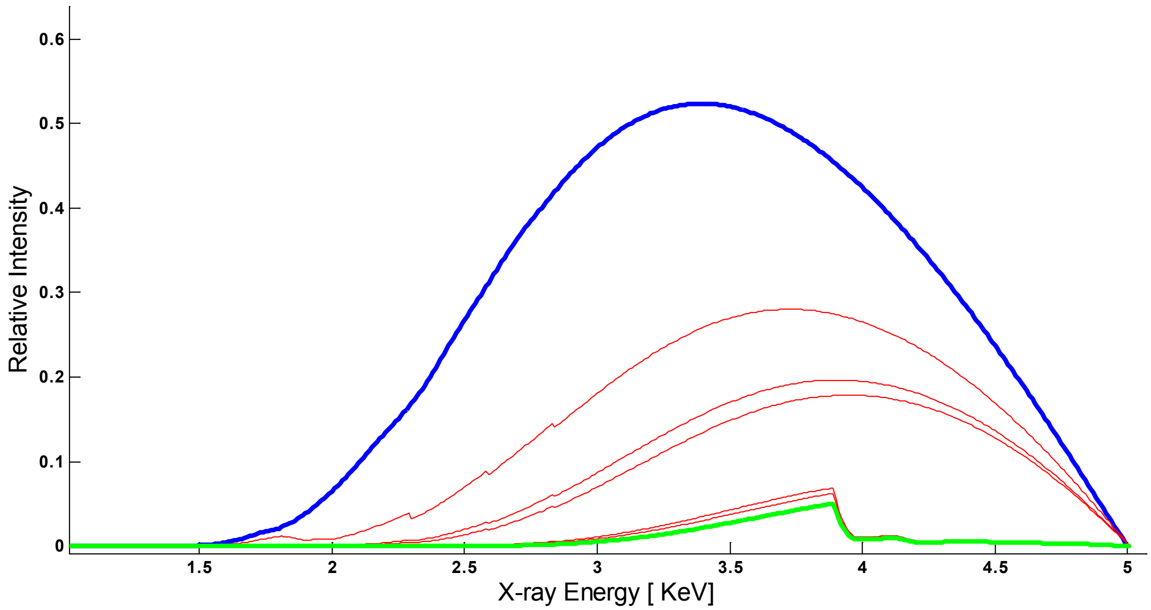


Figure 4-2 X-Ray Absorption 02

The blue line is the raw tube spectrum. The green line represents the final spectrum emitted from the sensor exit window.

The X-ray receiver is a gas filled chamber in which the X-rays release electrons. These electrons create a small current that is converted to a voltage and digitized. The number of these electrons is, to a large extent, determined by the energy of the X-ray. This means that the total signal in the ion chamber is proportional to the total energy from all X-rays that make it through the material.

The final response of a gauge to a material is therefore the sum of the convolution of the energy spectrum of Figure 4-2 with the absorption spectrum of Figure 4-1. By changing the applied voltage and the filters in the sensor, the gauges are tuned to be equally sensitive to common paper fillers. In particular, the 092237-07 (Q4237-57) gauge is equally sensitive to $CaCO_3$, TiO_2, and clay, for a large range of paper weights.

Figures such as 4-1 and 4-2 determine the X-ray filtering and the high voltage applied to the sensor to get a response that is insensitive to the particular ash ingredients and only to the total ash percentage. Once that is achieved the actual ash calculation is essentially a comparison of a paper weight measured by the gauge compared to the weight determined by a nuclear gauge or lab balance. The ash gauge will determine a much higher weight than the true weight due to higher absorption of the ash components compared to paper fibre but the first step in the determination is much like a standard basis weight application. Indeed, the ash sensor applies the same type of correctors (dirt correction, air temperature correction, z-correction) as the Honeywell nuclear weight gauges. This is detailed in Chapter 7.

4.2. Gauge Operation

4.2.1. X-Ray source

X-rays are generated by accelerating electrons onto a heavy metal target. The deceleration of the electrons onto the target generates a *Bremsstrahlungs* spectrum of X-rays as shown on Figure 4-2.

The ash source is shown in Figure 4-3.

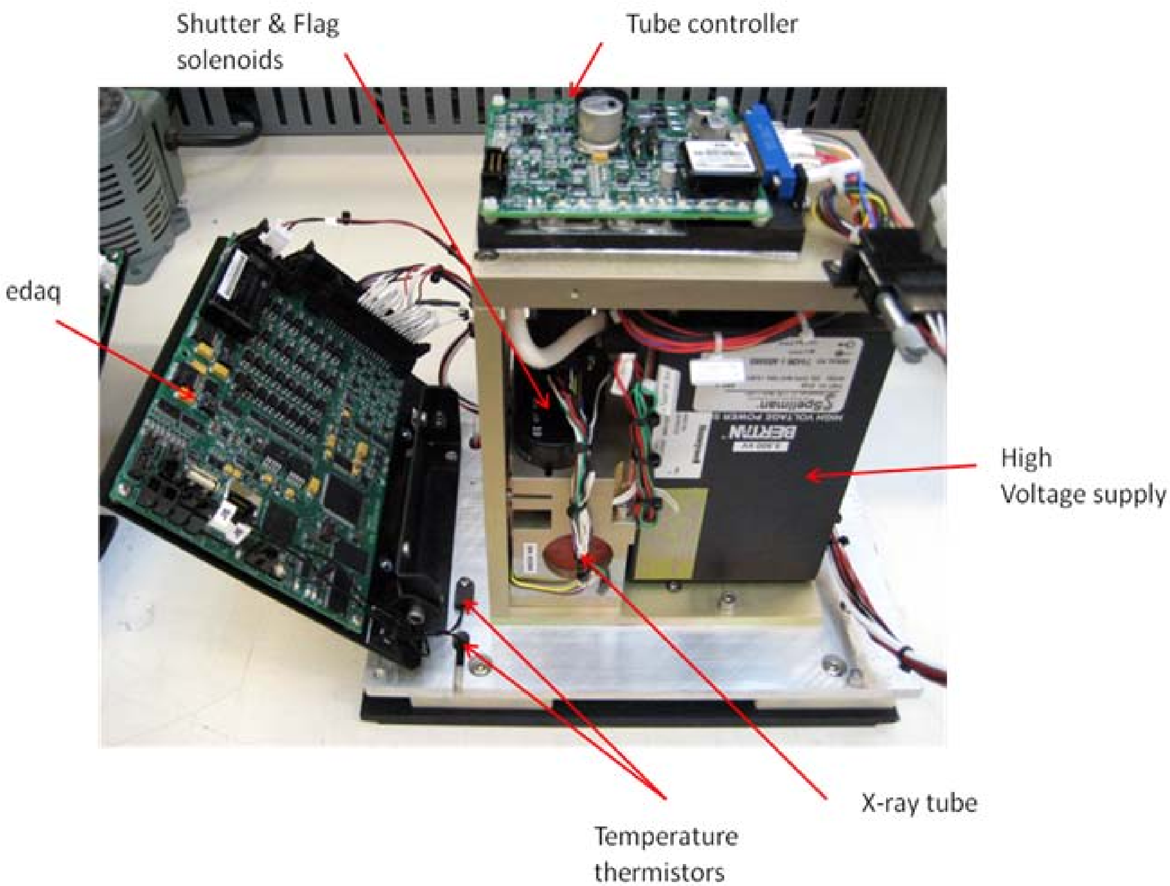


Figure 4-3 Ash Source Components

The ash source consist of the following three main components:

- X-ray tube

- high voltage power supply (part numbers dependant on model)
- X-ray tube current controller

The X-ray tubes are supplied with a positive high voltage between 4.5 and 5.9 kV depending on the model. As stated in Section 4.1, this determines the highest energy of the X-rays, but the majority of the X-ray will be at a lower energy. The electrons in the X-ray tube are generated by heating a filament inside the tube. The higher the current in this filament, the larger the X-ray flux. For accurate operation of the gauge it is essential that the flux of the X-ray remain constant. For that purpose, the X-ray tube controller contains a feedback circuit that measures the flux of electrons (current) arriving on the metal (target) anode. This current (set to 200 μA for all ash gauges) is kept constant by varying the applied voltage across the electron emitting filament.

The X-ray current controller also contains the logic for the shutter and flag. The X-ray shutter closes immediately when the power is applied to the gauge. As soon as power is removed, X-rays cease to be emitted and the shutter opens. This design, which was intended to minimize the heating of the driving solenoid, has the consequence that the scanner shutter safety green light does not light up until the X-ray gauge is enabled (and therefore powered) at the scanner endbell human/machine interface (HMI, also known as UPI) panel.

The controller contains the diagnostic LEDs described in Table 4-1, and shown as a row across the bottom of the board in Figure 4-4.

Table 4-1 Tube Controller Diagnostic LEDs

Label	Function
SHTRCOM	Red = shutter commanded open
SHTR OPEN	Red = shutter command open and lamp signal okay
LAMP FAIL	Red = + 24 V switched fail
LAMP OK	Green = +24 V switched okay
FLAG COMD	Red = flag command on
FLAG IN	Green = flag command on, shutter open
+ 24, + 15, - 15, + 12 V	Green when respective voltage okay

Note that in Table 4-1 the LAMP nomenclature is obsolete. In the Q4000 this signal is wired to the + 24 V through the interlock safety board. In other words, the LAMP OK LED is expected to be on whenever the source has power applied.

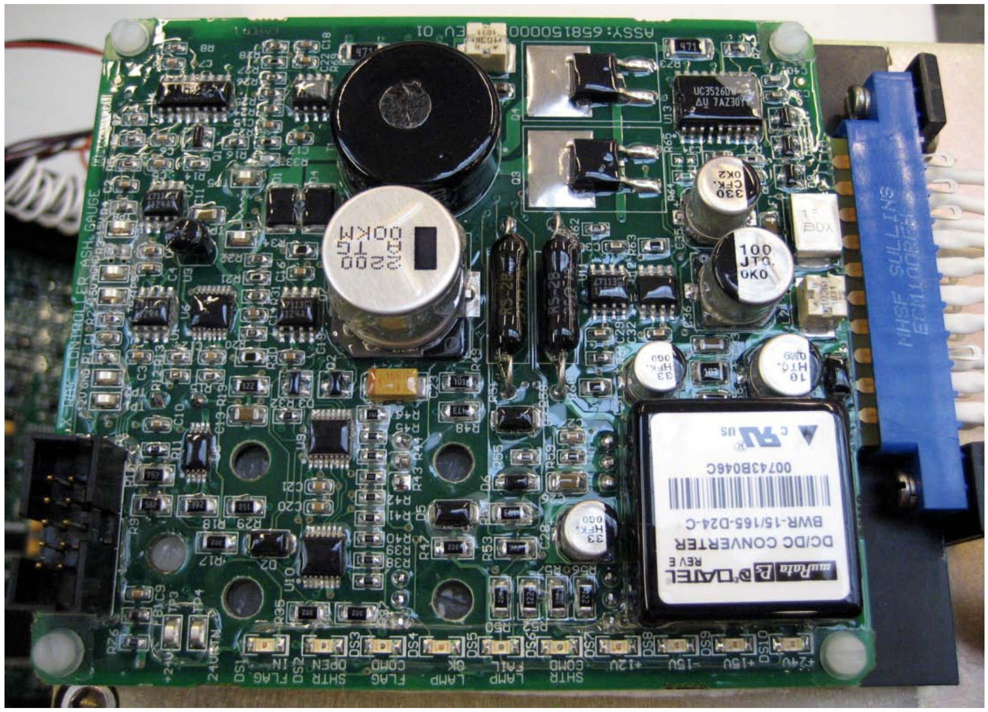


Figure 4-4 X-Ray Tube Current Controller and Interlock Board

The high voltage power supply is set to a precise value at the factory and may not be changed in the field.

The X-ray tube has a near-vacuum inside and should be handled with care. The exit window is a thin beryllium layer. Avoid touching it–if you have touched it, ensure that you wash your hands. The expected life time of the tube is a strong function of the external temperature and the current through the filament. It is recommended that the tube be replaced approximately every 7–10 years, and earlier if the current controller shows signs of failure. See Chapter 12 for a list of failure modes and diagnostics.

Figure 4-5 shows the assignment of the pins on the military style connector J303 on the ash source assembly.

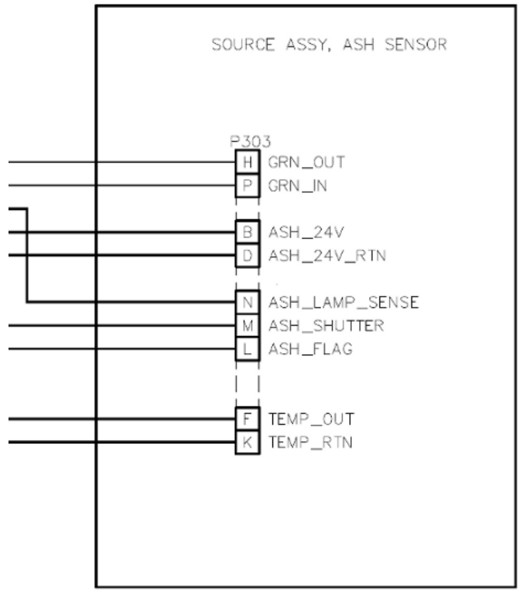


Figure 4-5 Ash Source Connector Pin-out Assignments

Most X-ray gauges have an X-ray filter to tailor the spectrum for optimal measurement characteristics, see Figure 4-6 and Figure 4-7 for their location.

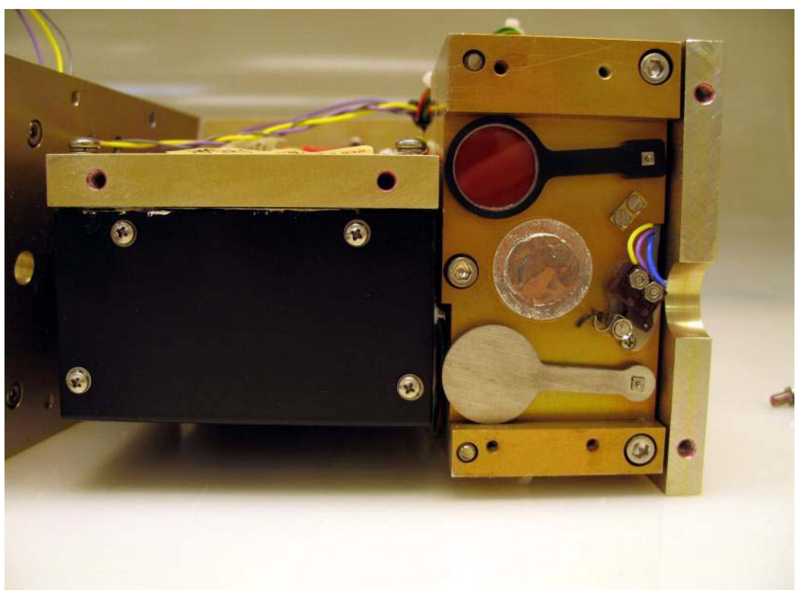


Figure 4-6 Bottom view of the source showing the shutter, flag and thin filter foil (the -57 model does not have foil window)

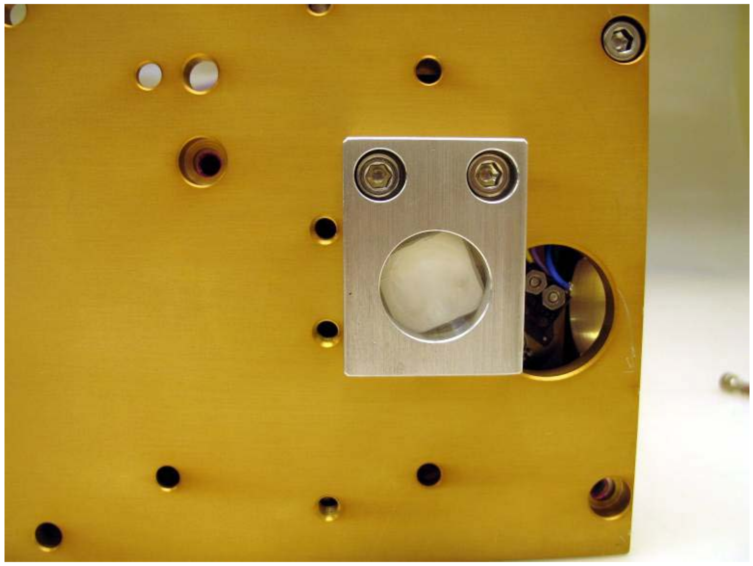


Figure 4-7 Bottom of the source mounting plate showing the filter mounted over the beam aperture

4.2.2. X-Ray Receiver

The X-ray receiver consists of an inert gas-filled ion chamber detector and a very high gain current-to-voltage converter. Details on the amplifier can be found in Section 11.8.

The ash receiver has an in-place switch that is part of the interlock. The receiver signal detects the continuity and transmits this information to the source EDAQ. If the receiver in-place switch is not closed, the gauge will not enable.

The only adjustment that can be made to the receiver is the amplitude of the background (shutter close) voltage. This is done using the voltage adjustment potentiometer on the amplifier card as shown in Figure 4-8. Note that in future releases, the new model amplifier that may be distributed with the ash gauge will still have a voltage adjustment potentiometer for the amplifier.

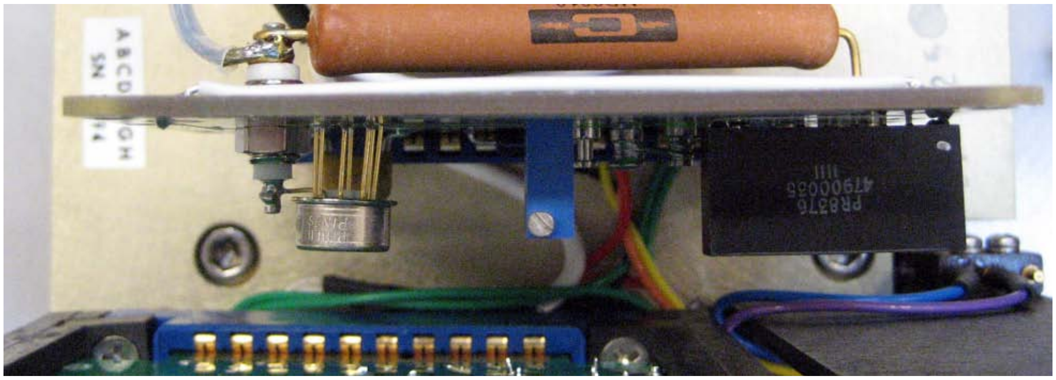


Figure 4-8 Amplifier Front Side Showing Voltage Adjustment Potentiometer (blue, at center)

Both amplifier models have a large feedback resistor (see Figure 4-9).

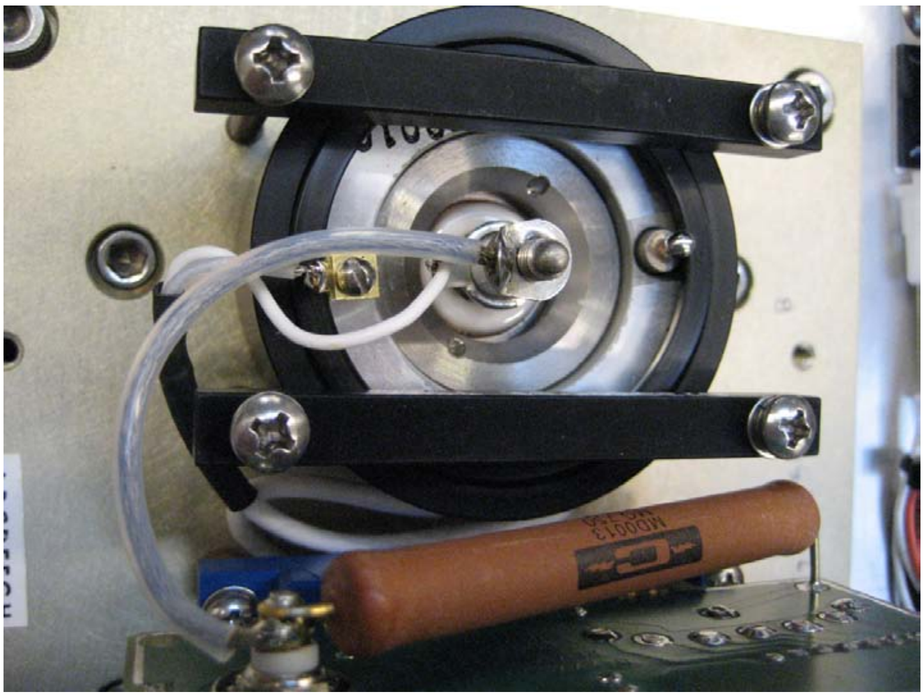


Figure 4-9 Large Feedback Resistor on Rear of Amplifier

The most common amplifier failure mode is a shorted current-to-voltage amplifier on the board. The symptom is that the output fails to +10 V. This component cannot be replaced in the field, and the entire amplifier board must be replaced.

Gauge stability is usually affected by the receiver, not the source. Two items that should be checked are:

1. Amplifier feedback resistor. It is very important that this part is not touched or allowed to get any grease on it. After doing maintenance on the gauge, clean the resistor with alcohol or other solvent.

2. The ion chamber is held in place by the wave spring washer between the ion chambers and mounting bars (see Figure 4-9). Any play will allow the ion chamber to vibrate, resulting in oscillations of the output signal. Check to make sure the ion chamber is rigidly held in place.

The receiver high voltage generation board shown in Figure 4-10 converts the ± 12 V to the -350 V required to operate the ion chamber. The two status LEDs indicate + 12 and + 350 V. The high voltage may be checked (with care) using the two test points at the top of the board.

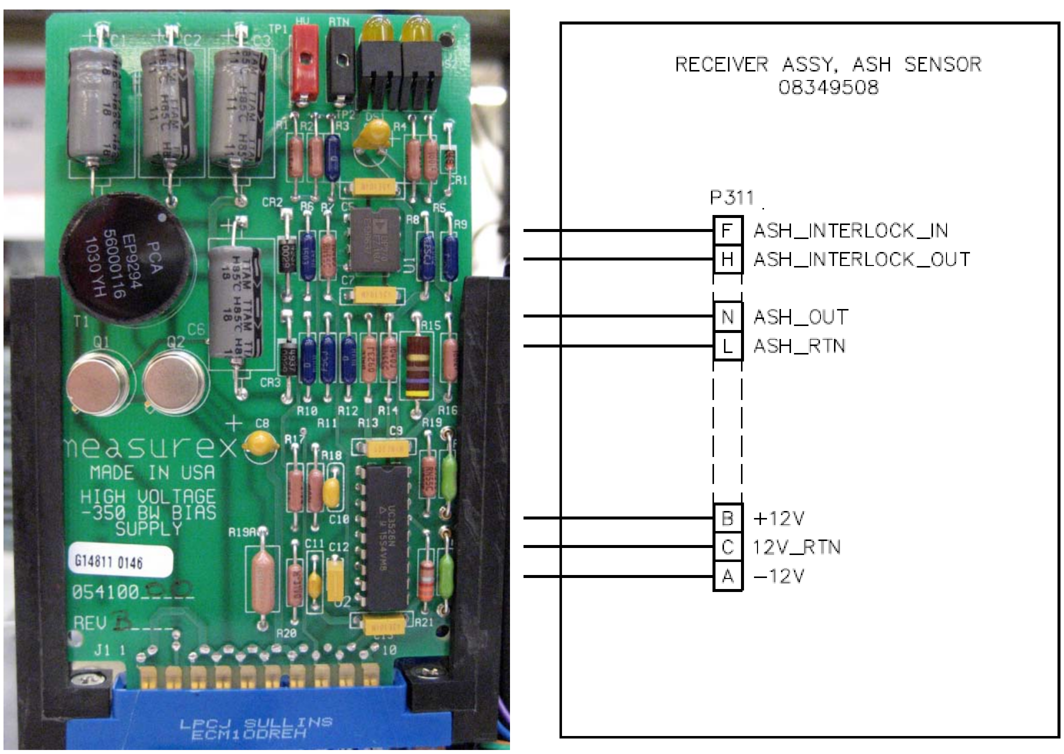


Figure 4-10 Receiver High Voltage Generation Board Pin Assignments

5. Installation

Installation (or removal) of the X-ray gauge is simplified by the fact the only external cables are a generic head power distribution cable and the Ethernet cable. The X-ray sensor can be used in any slot in the Q4000 head.

If the EDAQ CPU does not have a hard coded position number, it should be identified automatically by RAE and the new head position offset will be adjusted accordingly. Refer to the *Experion MX MSS & EDAQ Data Acquisition System Manual*.

5.1. Remove the X-Ray Gauge

When removing the sensor, the entire assembly should be removed from the sensor head rather than unscrewing individual components. To remove either the source or receiver assembly:

1. Split the heads (enable the sensor so that the green light turns on, turn the head split key at the human/machine interface (HMI, also known as UPI) panel, split the heads, disable the gauge).

2. Remove the Allen screws (using a 5 mm Allen key) from the cover as indicated by the arrows as shown in Figure 5-1.

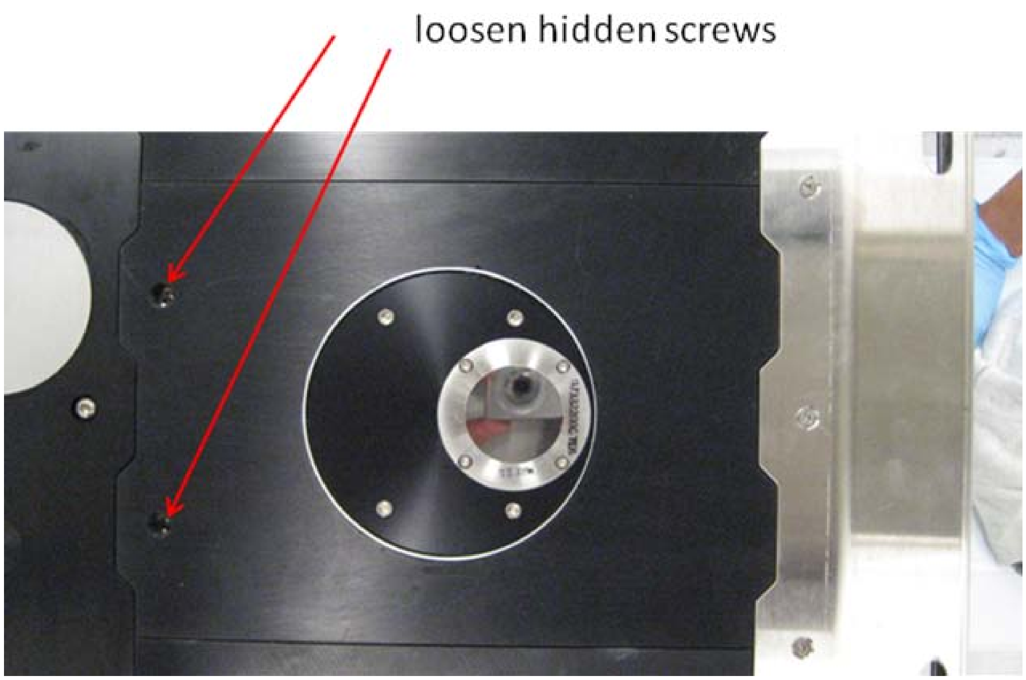


Figure 5-1 Ash Sheetguide Screws

3. Loosen the screws underneath, using a 5 mm Allen key.

4. Remove the sheet wing and end-bar by unscrewing the 5mm Allen screws on the corner of the sheetguide as shown in Figure 5-2.

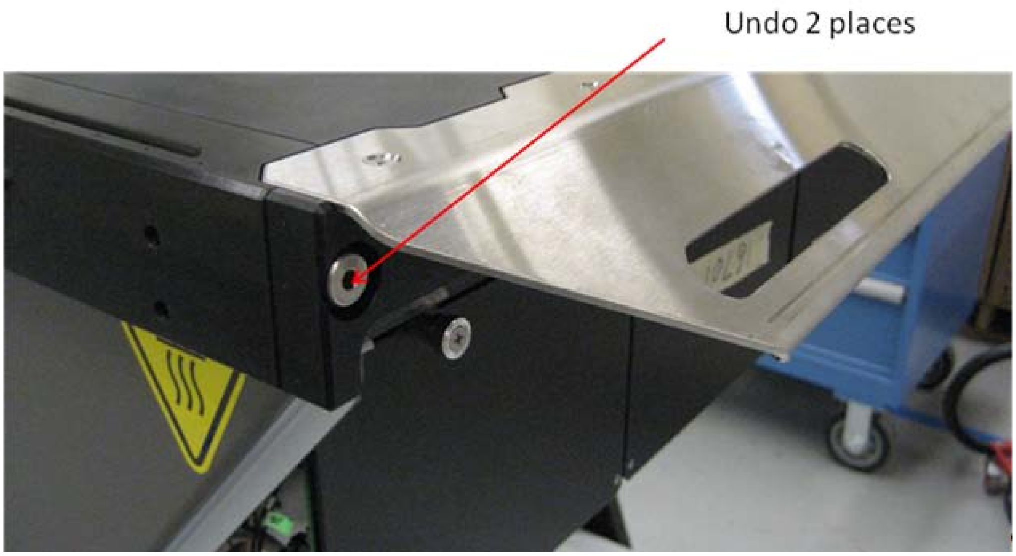


Figure 5-2 Sheet Wing Allen Screws

5. Disconnect the Ethernet cable and the head power distribution cable. Source or receiver plates should now slide out and, if required, can be replaced by a blank plate, and the green light circuit re-enabled by using a connector with a jumper.

Figure 5-3 shows the receiver assembly removed from the scanner head.

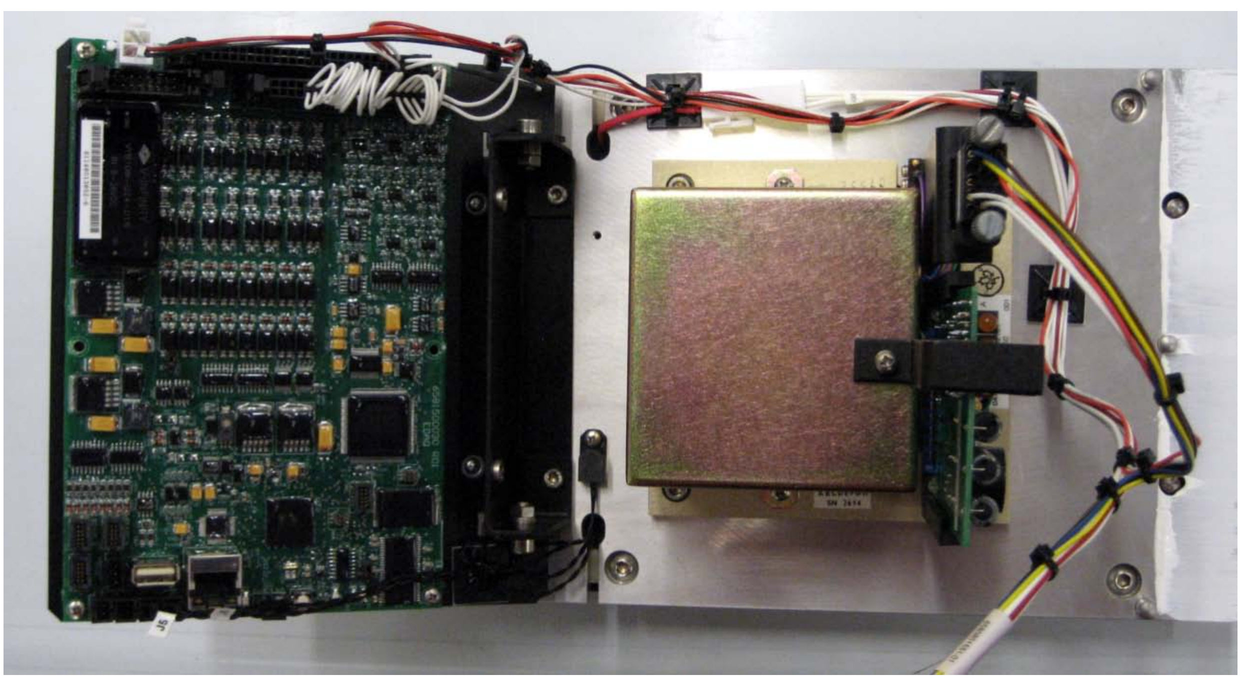


Figure 5-3 Receiver Assembly: Top View

6. Operating Modes

6.1. Background

A small background voltage is obtained when the shutter is closed, due to small electronic offset in the electronics. The amplifier is adjusted during alignment to mask this offset so that it will always be a small positive DC voltage. This eliminates possible ambiguity around the measurement threshold. This voltage is stored and subtracted from all measurement voltages before they are processed by software (the shutter-closed output is normally between 5 and 20 mV DC with 5mV peak-to-peak AC noise).

Background measurement frequency is programmable and set via the real-time application environment (RAE) Measurement Sub System (MSS) **MSS Setup Diagnostic** display.

6.2. Standardize and Reference Programs

The *Standardize* program is run at a preprogrammed interval to update measurement ratios used in subsequent measurements. The *Reference* program is run on request to update measurement ratios during calibration and maintenance of the sensor.

During the Standardize and Reference program, the flag-to-air ratio (F/A ratio) obtained are compared in software with the ratio obtained at the time of initial calibration (referred to as T0FA). During standardize, if the results are reasonably close, scanning resumes. The new ratio will be used in subsequent measurements. If out of limits, the program will run again. After three attempts (software optional) to obtain a good ratio when standardizing, scanning will stop.

ATTENTION

One out-of-limit sensor will disable all sensors on the scanner by inhibiting scanning. Limits programmed for the sensor can be changed in software so that the limit check is not performed on the defective sensor, and scanning is not inhibited. Measurements by other sensors on the scanner are valid, and measurements by the out-of-limit sensor may be useable.

In addition, the F/A ratio is used with the T0FA value to calculate a dirt correction for the sensor. This algorithm is identical to that of the basis weight sensor, see *Basis Weight Measurement System Manual*.

6.3. Measure a Sample

Samples may be measured by securing them to a sample paddle that rotates Mylar® or paper samples between the source and the receiver. The sample paddle for the Experion MX scanner is shown in Figure 6-1. It consists of a plate that locks in to the sheetguide and a paddle that locks into the guide.

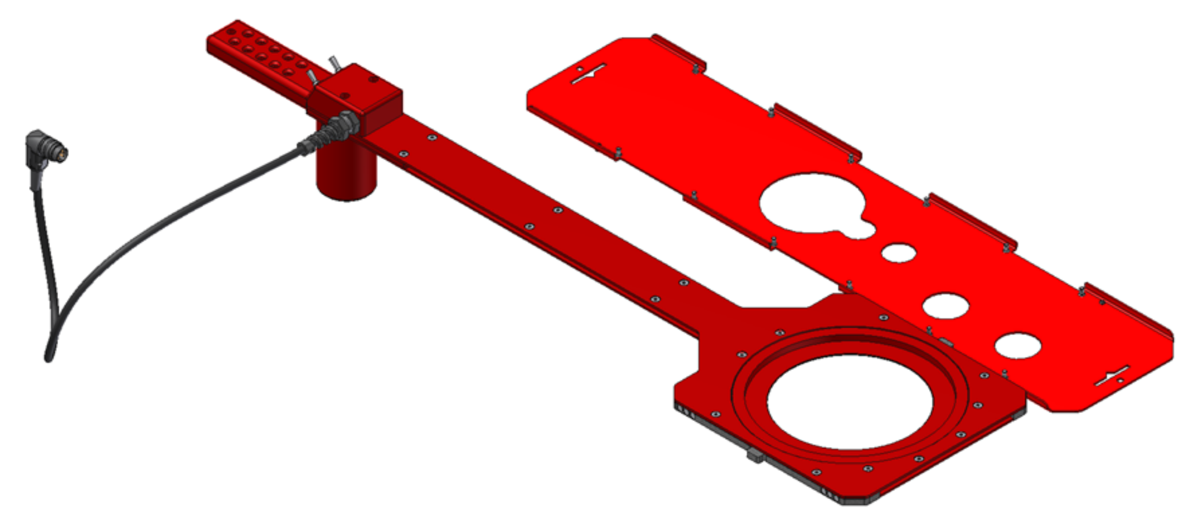


Figure 6-1 Sample Paddle

The motor rotates the sample. In addition, the paddle is manually moved forward and backward to expose the entire sample surface.

6.3.1. Set up a Sample Paddle

To set up a sample paddle:

1. Press **OFF SHEET** on the scanner.
2. Verify that the short-term stability of the sensor is within proper limits before inserting the sample paddle. (See Section 7.4 for specifications.)
3. Plug the line cord on the paddle holder into sample paddle connector on the endbell frame.
4. Turn the head split key at the endbell and split the heads (green lights must be on; ensure that the ash gauge is enabled)
5. Align the sample paddle guiding plate on the sheetguide.
6. Re-align the heads and insert the sample paddle.

6.3.2. Measure a Sample

To measure a sample:

1. Place the sample in the sample paddle by clamping it between two hold-down rings.
2. Slide the sample paddle into the gap and position it until it latches onto the magnetic in the sample jig.
3. Turn on the paddle motor to start rotating the sample.
4. Move the paddle back and forth between the stops along the centerline of the sensor. This should be done in a slow steady motion of about one second per stroke.

7. Single Ash Gauge Calibration

The single ash gauge algorithm consists of two independent sections:

- calibration on Mylar®
- calibration on customer samples

The calibration on Mylar establishes a weight curve similar to that of a nuclear gauge, and the same corrections are applied (Z-axis, dirt, air gap) to that processor when measuring on-sheet.

In the second step, the sensor response to the customer sample is compared to that of the initial Mylar curve. It is the ratio of these responses that is proportional to the ash content in the paper.

On an Experion MX real-time application environment (RAE) system, the entire calibration can be carried out using the calibration screens with no knowledge of the calculations involved; however, there might be reasons to determine the main calibration constants $ACM1$ and $ACA3$ (see Subsection 7.1.1) outside of the RAE tools, for example using a spreadsheet program. For that reason there follows first a detailed section showing the full calculation and method as if the procedure were done outside of the RAE system.

Note that the calibration for the dual ash gauge is quite different, and is described in Chapter 8.

It may be convenient to use a laptop at the scanner to display the RAE calibration screens through some remote-desktop application. A laptop can be plugged into any of the scanner switches. An address is obtained through DHCP and the RAE server can be then contacted on the IP address associated with its network card connected to the scanner.

7.1. Algorithm

7.1.1. Main Ash Calculation Term

Without considering any correctors, the ash percentage calculation is:

$$\text{ash\%} = 100 * [\frac{ACM1 * \frac{W_M}{BW} - 1}{ACA3 - 1}]$$

Here the variable $ACM1$ is the ratio of the X-ray absorption of Mylar divided by that of fiber. This value is traditionally measured by measuring filter paper (which is assumed to have no ash) and shooting Mylar samples. The value should always lie near 0.90 and this is essentially independent of the ash gauge model. Instead of shooting filter papers it is recommended that you start with an $ACM1$ value of 0.90 and then continue immediately to calibrating the customer samples.

The second constant, $ACA3$, is the ratio of X-ray absorption coefficient of the ash divided by that of fiber. A high $ACA3$ indicates a high sensitivity to ash. Typical numbers are in the range 3–5 for all of the ash gauges.

The symbol W_m denotes the weight obtained from the ash sensor ratio using the Mylar calibration. The basis weight (BW) is the total weight of the sheet as measured by in the lab on a scale or by the nuclear sensor.

Note that by default, RAE uses the total basis weight in the above equation, even though the lab ash values are calculated as a percent of dry weight (DW) (weight of fiber + ash). This is a RAE Real Time Data Repository (RTDR) setting that can be changed if required. The division by basis weight shifts the calibration constants slightly but should not introduce a significant ash error. In addition, the division by basis weight in the RAE processor appears to reduce the effect of changing moisture in the case that the moisture corrector is not used. This is because the ash sensor will respond to moisture with an increased W_m term but since the weight term is also increased the ash will barely shift. It is therefore recommended that if the moisture correction is not used, the RAE should use the default of dividing by basis weight when calculating ash, even if the calibration is done against DW lab values.

The spread of $ACA3$ values will determine the best grade-grouping possible. Typically, if $ACA3$ differ by more than 0.15, using an average for all papers in this group will produce unacceptably large ash errors. It is important to note that the two main calibration constants $ACA3$ and $ACM1$ are not independent and that small shifts in $ACM1$ may produce better or worse $ACA3$ grouping. Changing $ACM1$ between 0.89 and 0.91 is an acceptable technique for reducing the number of resulting grade groups.

7.1.2. The DCSF Corrector

As for the nuclear weight gauges, the ash Mylar weight described in Subsection 7.1.1 will have a dirt correction calculated using the usual time-zero values of the flag and the last flag measurement before going onsheet. Empirical data shows that the dirt correction calculation often over-estimates the true effect. For this reason, the ash processor has an additional constant labeled DCSF which multiplies the usual dirt correction. DCSF is calculated on the RAE system by shooting the customer samples dirty, for example, with some known thin Mylar added to the samples. Expected values are in the range 0.5 to 1.

7.1.3. Moisture Term Correction

The full calculation for the percentage ash includes a sheet moisture term of the form:

$$\mathrm{Ash}_{\text{moi correction}}\% = -100 * \frac{\frac{WW}{BW} * (ACW0 - 1)}{ACA3 - 1}$$

That is available in RAE by turning on the moiwflag flag (tickbox in the recipe based options) and setting the permanents calibration variable moi2_slope to 1. The constant $ACW0$ is the ratio of X-ray absorption of water over that of fiber and should be near 1.310. In RAE this is denoted as acw1 (rather $ACW1 = ACW0 + ACW2$*Ash but $ACW2$ defaults to zero) and defaults to the incorrect value of 0.9660. Versions of RAE up to at least 603 also have the incorrect sign for this corrector, but both these errors can be fixed by setting $ACW1$ = (1-1.310) = 0.69.

However, the calibration screens do not take this term into account when calculating the best $ACA3$ values. As a result, turning on the moisture term later in production mode always results in a negative ash correction regardless of whether the moisture in the sheet is larger or smaller than that at time of calibration. If the moisture correction is of interest, it may be preferable to perform the ash calibration in an Excel worksheet. In addition, the ash percentage should then be consistently defined, in this instance, in terms of basis weight, not dry weight. It is not recommended that the moisture corrector be used unless advised to do so by Engineering.

Sections 7.2, 7.3, and 7.5 apply to both the spreadsheet and RAE method.

7.2. Materials Required

The following materials are required:

- the standard paddle for ash for 0.4-inch gap
- sample rings with seven-inch center
- sample rings with 4.5-inch center
- one seven-inch diameter precision die
- one 4.5-inch diameter precision die
- mallet
- wood backing block or plastic backing for sample die
- Aclar® Bags
- bag sealer
- analytical balance accurate to 0.1 mg with Faraday Cage
- forced air drying oven at 1050 °C (1922 °F) ± 20 °C (68 °F)
- glazed porcelain crucibles
- a seven-inch diameter sample of 2 mil Mylar for dirt calibration
- a seven-inch diameter sample of 0.5 mil Mylar for verification
- five ash-free filter paper samples with 4.5-inch diameter
- Mylar sample set with seven-inch diameter
- customer sample set with at least one seven-inch diameter sample for each ash and level for each grade produced

7.3. Sample Preparation

The objective of this section is to produce a set of clean, precision died, reusable samples, accurate laboratory and percent ash values for each. The 4.5-inch center from a seven-inch sample is read on the sensor, while the remaining seven-inch ring is ashed. This allows for the use of the center sample as a standard in future calibrations and verifications.

It should be noted that depending on availability of samples it might be preferable to ash a larger surface of the customer sample and to die out a number of four-inch samples and to assume the determined ash percentage applies to all samples. The larger sample (taken from the same sheet) will provide better averaging of the ash distribution in the sheet as well as increasing the absolute amount of ash left after combustion, making accurate weight determination easier. The steps in Subsection 7.3.1 assume that the remainder of the seven-inch sample with four inches removed is ashed, but the alternative method is equally acceptable.

7.3.1. Customer Samples

1. Cut out a seven-inch diameter sample ensuring that there are no watermarks in the area selected.
2. Cut the center 4.5-inch diameter area of each seven-inch sample using a precision die.
3. Label the 4.5-inch samples and place them in a Ziploc™ plastic bag.
4. Divide the surrounding circle in two approximately equal pieces, these will be referred to as ash samples for the rest of this chapter.
5. Label and record the weight of an Aclar bag for each ash sample to four decimal places (two of each for each sample).
6. Bone dry the ash samples according to TAPPI standards bone dry procedures.
7. Insert the bone dry sample in Aclar bag, preferably inside the oven, seal the bag and weigh the sample and bag immediately to four decimal places. Do this step with each ash sample one at a time (do not bag everything and then weigh them, and keep the oven door shut while you are weighing).
8. Label and record the weight of a crucible for each ash sample. Ensure that the crucibles have a constant weight. Fire the crucibles in the furnace if necessary to obtain a constant crucible weight.
9. Place the ash samples in the labeled crucibles. Ash the samples at the requested temperature and time that has been specified by the customer. At the appropriate time place them in a desiccator and let them cool before weighing (between one and two hours).

10. Weigh the crucible and the sample, and record the weight to four decimal places.

11. Enter the information on the spreadsheet to calculate average percentage ash for each customer sample (see Table 7-1). The two half samples ashed should be within 0.4 % ash of each other.

12. On a spreadsheet, set up a column for each of the following:

    grade

    bag Weight

    bag and sample

    bone dry

    crucible and sample

    crucible

    ash weight

    percentage ash

    average percentage ash

    % Ash = (Ash Wt * 100)/(Bone Dry Wt)

    Avg % Ash = % Ash (1) + % Ash(2)

    Where 1 and 2 will correspond to the half circles of each sample.

7.3.2. Mylar Samples

Seven-inch diameter Mylar samples are required. Note that the range is somewhat difficult to determine before shooting the heaviest and/or highest ash-containing customer sample. It is important that the smallest sensor ratio (R) obtained when shooting the Mylar samples is less then the lowest ratio obtained with the customer samples. For example, a typical 100 g/m^2 paper with 20% ash will require Mylar samples up to 270 g/m^2 to cover the required range. This is due to the much higher X-ray absorption of the paper than the Mylar. If the Mylar weights do not cover this range, the sensor processor will extrapolate the data which can lead to very large ash calculation errors.

Weigh the Mylar samples to four decimal places on a laboratory scale, and keep them individually separated by using a pad. It is very important to keep these samples clean if you want to use them for tracking sensor performance and repeatability, or if you need to re-calibrate the sensor at some later time.

7.4. Stability Checks

Verify the reference integration time is set to 16 seconds.

To check sensor stability:

1. On the **Sensor Maintenance** tab in RAE, choose the **Ash Nuclear Sensor Processor**. Enter maintenance mode and choose a grade. Set the reference time and the sample read time to 16 seconds.

2. Take 30 successive references with no waiting between readings. References should be done with the gap taped, and nothing in the gap. The head should be properly cooled, with the upper head temp and lower head temp within 2 °C from each other, and the air wipes and caliper air, if present, turned off.

3. Check that short-term stability meets the specification 1-sigma ≤ 0.00015. Thermal drift may be causing the first group of 30 references to be larger than the specification because the gauge has not reached thermal equilibrium. Do two consecutive sets of references if time allows.

4. If time is short, use a four-second integration time, reduce the number of samples to 20, and check whether the 1-sigma data is < 0.00030.

7.5. Mylar Calibration

The Mylar calibration is essentially the same as that of the basis weight gauge. Refer to the *Basis Weight Measurement (p/n 6510020331)* system manual for details.

1. On the **Sensor Maintenance** frame, choose **Ash Nuclear Processor** and verify the reference time and the sample read time are set for 16 seconds. Select the **Advanced** function on the lower right, and select the **Verification** frame from the drop-down menu.

2. Do a background and a reference with nothing in the gap. Add four samples via the **Add Sample** button. Immediately take a sample reading. The sample ratio should be 1 ± 0.0010.

3. Check for paddle interference in the measurement. Insert the paddle with the smaller black rings in place and take a sample reading at the center. Each sample ratio should repeat to within ± 0.0010 of the sample ratio with nothing in the gap.

4. Select **Clean Calibration** from the drop-down menu.

5. Add the amount of samples that are in the **Mylar Std. Set** via the **Add Sample** button.

6. Enter the lab weight for each sample.

7. Do a background and a reference.

8. Shoot all Mylar samples clean while stirring and moving the paddle.

9. Press the **Curve fit** button verifying that the error meets specs for the applicable gauge, and press the **Accept** button. A standard rule is that the fit error should be less than 0.25%. Repeat the outlier weight(s) or reject it.

10. Select **Dirty Calibration** from the drop-down menu.

11. Press **Copy Wts**, and select **Clean Calibration**.

12. Insert a 2 mil Mylar dirt and do a reference while stirring and moving the paddle.

13. Repeat Steps 7 to 9 for the dirt calibration.

14. Save the file and print the clean and dirty calibration via the **Reports** button.

15. Press **Apply New Coefficients** verifying the calibration numbers are correct, and press **OK**.

16. Press the **Data** button to obtain a copy of the calibration constants.

7.6. *ACM*1 Determination

The constant *ACM*1 can de determined by shooting filter paper and Mylar sheets. It is recommended that at least five to six filter paper samples be shot in the gauge, followed by Mylar in the range of the customer paper samples and higher. For each of the types of samples, the following quantities should be calculated:

$$\mu_{sample\_i} = \frac{\log R_i}{(BW)_i}$$

Where $(BW)_i$ is the basis weight of the sample measured on a lab gauge and _ - Log R_i is the natural logarithm of the sensor ratio.

Calculate the average absorption coefficient μ for Mylar and divide by that of the average μ for filter paper.

This determination may be skipped and the value set to *ACM*1 = 0.91 and entered in **Ash Sensor Processor à Calibration Parameters à Ash Constants.**

7.7. Customer Paper Samples: Spreadsheet Method

A work spreadsheet can be set up using the information provided below for a manual calculation of the *ACA*3 constant with and without moisture correction. The customer samples can be shot using the sample mode on the **Ash Nuclear Calibration** display–only the sensor ratios are required from the system. In addition the following quantities are required for each sample from the previous steps (it is best if all the calculations are done in engineering units):

1. Mylar Clean calibration coefficients. The spreadsheet should calculate the Mylar equivalent of the samples using the following equation:

$$BW_M = BA0 + BA1 \times Ln(R) + BA2 \times Ln(R)^2 + BA3 \times Ln(R)^3 + BA3 \times Ln(R)^4 \ldots$$

where R is the sensor ratio obtained in the gauge.

2. The value of *ACM*1 (start with 0.9 as the default).

3. The value of *ACW*0 (set to 1.3) and the moisture weight in the samples if moisture correction is required.

4. The ash percentage and total basis weight of the samples.

Transfer the sample ratios, the ash percentage, basis weight, and moisture content (optional) to a spreadsheet. Calculate the Mylar basis weight and an *ACA*3 value for each sample using:

$$\frac{\left[\mathrm{acm1} * \frac{\mathrm{BW_m}}{\mathrm{BW_n}} - 1\right]}{\left[\frac{\mathrm{ASH\%}}{100}\right]} + 1 \ = \mathrm{aca3}$$

If moisture correction is required, the value for *ACA*3 is calculated instead using:

$$\frac{\left[\mathrm{acm1} * \frac{\mathrm{BW_m}}{\mathrm{BW_n}} - 1\right] - \frac{\mathrm{MW}}{\mathrm{BW_n}}(\mathrm{ACW0} - 1)}{\left[\frac{\mathrm{ASH\%}}{100}\right]} + 1 \ = \mathrm{aca3}$$

Where BW_n is the total paper weight and BW_m the Mylar weight calculated from the Mylar fit.

It is helpful to calculate the standard deviation of the resulting *ACA*3 values and to see if this can be minimized by adjusting the value for *ACM*1 in the range 0.89 to 0.91. This would reduce the number of grade groups.

The spreadsheet (Table 7-1) below shows *ACA*3 calculations using fixed *ACM*1 value. At the bottom are the mean and standard deviation of the *ACA*3 values. *ACM*1 can be adjusted slightly to reduce the spread of ACA3. Note that these data are generated from an X-ray model calculation and do not correspond to a customer sample.

Table 7-1 Typical Ash ACAC3 Calculation Worksheet

Grade	BW total [g/m^2]	Ash Lab [%]	Sensor Ratio	-Ln[R]	BWmyl	ACA3
A	60	16.67	0.5915	0.5251	127.4640	6.3443
B	70	14.29	0.5629	0.5747	140.1559	6.4739
C	80	12.50	0.5360	0.6236	152.8026	6.5994
D	90	11.11	0.5106	0.6722	165.4439	6.7245
E	100	10.00	0.4867	0.7201	178.0258	6.8443
F	110	9.09	0.4640	0.7679	190.6583	6.9686
G	115	13.04	0.4054	0.9029	226.8760	6.7946
H	120	16.67	0.3549	1.0359	263.2777	6.7159

stdev	0.2029
aver	6.6832
stde/mean%	3.0365

acm1	0.89

Mylar Fit Coef:	0.0499	229.73	25.716	-2.1144
	ba0	ba1	ba2	ba3

7.8. Customer Paper Samples: RAE Calibration Screen Method

After the Mylar calibration is completed, select **Ash Sensor Processor**, enter maintenance mode and choose **Advanced** (see Figure 7-1).

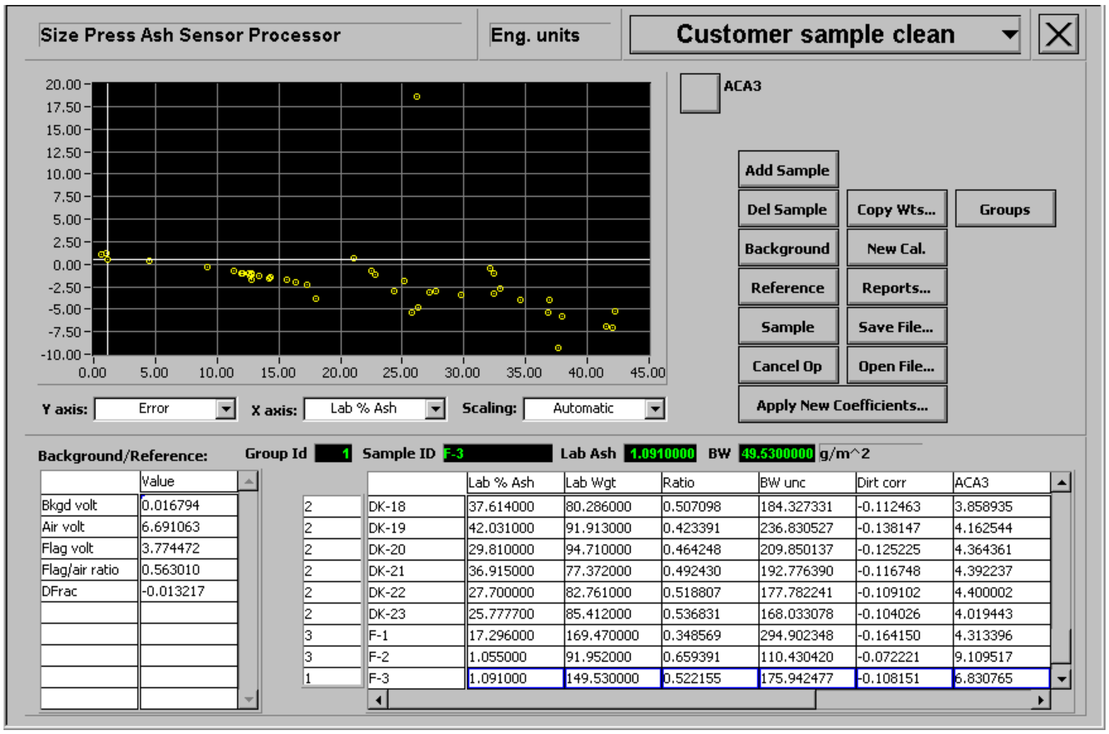


Figure 7-1 Size Press Ash Sensor Processor

7.8.1. *ACA*3 Determination

1. Weigh the customer samples in a laboratory scale to four decimal places immediately before shooting them. Calculate the basis weight in g/m^2 and **Customer Units**.

2. Verify that dirt correction is on.

3. Verify that DCSF is set to 1.0.

4. Enter maintenance mode and select **Advanced**, on the lower right, to call up the **Size Press Ash Sensor Processor** display (see Figure 7-1).

5. Select **Customer sample clean** from the drop-down menu.
6. Do a background and a reference (using black rings) with the paddle in the gap and stirring and moving.
7. Add the amount of samples from the *Ash Sensor Lab Worksheet*. Input the **Lab Ash** and measured weights.
8. Shoot the customer samples while stirring and moving the paddle.
9. Press the **ACA3** button, then **Accept**.
10. Print the *Customer Sample Clean* and *ACA3* reports.

*ACA*3 is a grade-dependent constant, so there will be a different *ACA*3 for each grade; however, grades can be grouped using the **Groups** button (see Figure 7-1). Group all grades into one grade group when their respective *ACA*3 are within 0.15 of each other. Values for *ACA*3 should not be less than 2.5 nor greater than 6.5. See Subsection 7.8.3 for details.

7.8.2. DCSF Determination

The DCSF constant determines how much dirt correction to apply in the ash calculation. The RAE utility compares the true and measured ash values with dirt in place and calculates the size of the correction.

1. Select **Customer sample dirty** from the drop-down menu.
2. Press **Copy Wts** and select **Customer sample clean**.
3. Check the available group box, then press **OK**.
4. Insert a 2 mil Mylar dirt and do a reference (using black rings) with the paddle in the gap and stirring and moving.
5. Shoot the customer samples while stirring and moving the paddle.
6. Press the **DCSF** button, then press **Accept**.
7. Print the *Customer Dirty*, *Clean*, and *DCSF* reports.
8. Input the **Average DCSF** into the system under the **Constants** tab.

7.8.3. Use Groups

Use **Group ID** to group different samples together. The group id for the selected sample (blue selection) is displayed / entered.

Groups opens a popup for selecting groups for *ACA*3 or DCSF calculation (see Figure 7-2).

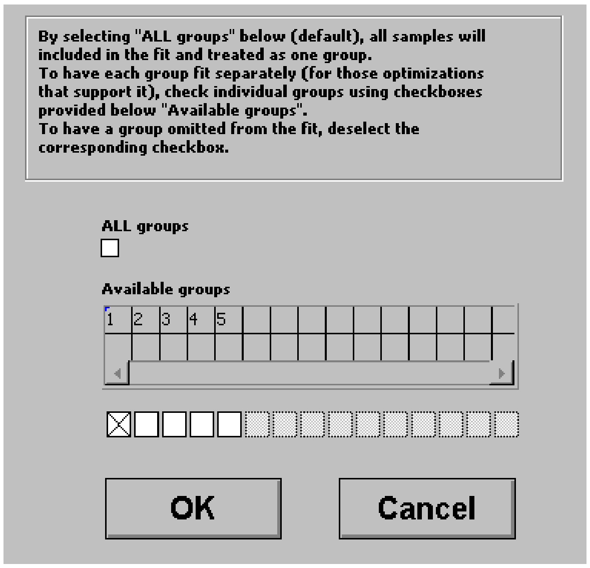
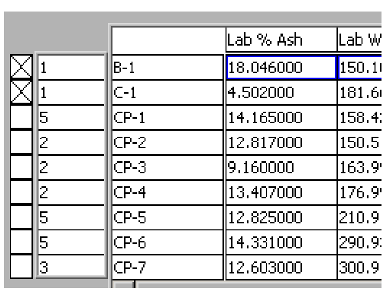


Figure 7-2 Groups Selection Popup Display

From the five available groups, only group 1 is selected (see Figure 7-2 and Figure 7-3). When *ACA*3 or DCSF is selected, only members of that group are used for calculation. Ensure that the **All groups** checkbox is *not* selected.



			Lab % Ash	Lab W
X	1	B-1	18.046000	150.1
X	1	C-1	4.502000	181.6
	5	CP-1	14.165000	158.4
	2	CP-2	12.817000	150.5
	2	CP-3	9.160000	163.9
	2	CP-4	13.407000	176.9
	5	CP-5	12.825000	210.9
	5	CP-6	14.331000	290.9
	3	CP-7	12.603000	300.9

Figure 7-3 Groups List

7.8.4. Apply New Grade Coefficients

Apply New Coefficients... allows you to store calibration constants to the recipe database. Optionally, a new table can be created that can be linked to a particular recipe. You will be allowed to select the code (grade) that the new table will be pointed to. Otherwise, the data will be stored to the table for the current code. Check or uncheck each coefficient to store. A value (other than zero) without the checkbox checked would not be written to the recipe database. Figure 7-4 shows what the checkbox display looks like.

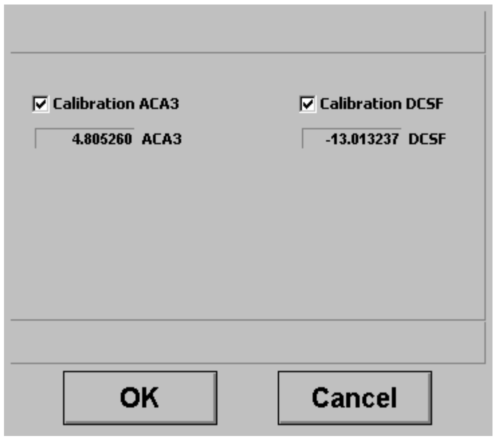


Figure 7-4 Calibration Coefficients

When **ACA3** is clicked, the average value of *ACA*3 is calculated (see Figure 7-5). Click **Accept** to write *ACA*3 to the RTDR database. This value is lost with the next code change until it is saved to recipe.

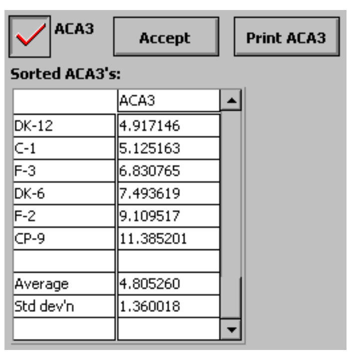


Figure 7-5 ACA3 Calculation Display

When **DCSF** is clicked, the average value of DCSF is calculated. Click **Accept** to write DCSF to the RTDR database. This value is lost with the next code change until it is saved to recipe.

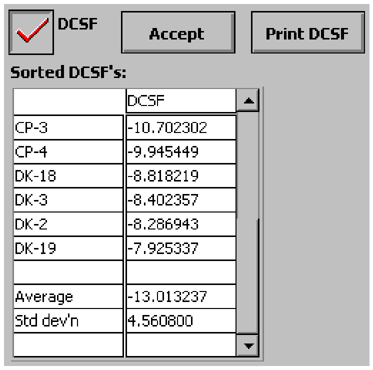


Figure 7-6 DCSF Calculation Display

Apply New Coefficients... should be used to write DCSF and *ACA*3 in to RTDR to be used during verification. For future use, DCSF must be stored in the calibration table of the ash nuclear sensor processor. *ACA*3 is stored in the calibration table of the ash processor. Use the **Recipe Maintenance** display to store these parameters.

7.9. Verification

Follow these preliminary steps before starting the verification of the customer samples, and verify that the following variables are entered correctly:

- Mylar calibration constants
- *ACM*1 calculated previously
- *ACA*3 for the current grade
- DCSF calculated previously
- enable customer units if other than g/m^2

Follow these steps for customer sample verification:

1. Select **Verification** from the drop-down menu.
2. Press **Copy Wts** and select **Customer sample clean**.
3. Select the available group checkbox, and then press **OK**.
4. CLEAN VERIFICATION: Do a reference with the empty paddle in the gap.
5. Load the applicable *ACA*3.

6. Shoot the customer samples while stirring and moving the paddle.

7. For dirt verification, do a reference using a 0.5 mil Mylar dirt sample in the sample paddle.

8. Repeat Steps 5 and 6 for each grade.

The samples should verify to ± 0.5% ash for both clean and dirty samples. If some samples do not verify, check:

- the sample weight
- ensure that the calculation is using the correct value for *ACA*3 and *ACM*1, by looking at the sample report in the printout
- check that KCM and KCMA are set to 1
- check that KCBA is set to zero

7.9.1. Static Verification

7.9.1.1. Data Storage

The static verification button, **Static DB…**, is visible when verification is selected as the calibration data type (see Figure 7-7).

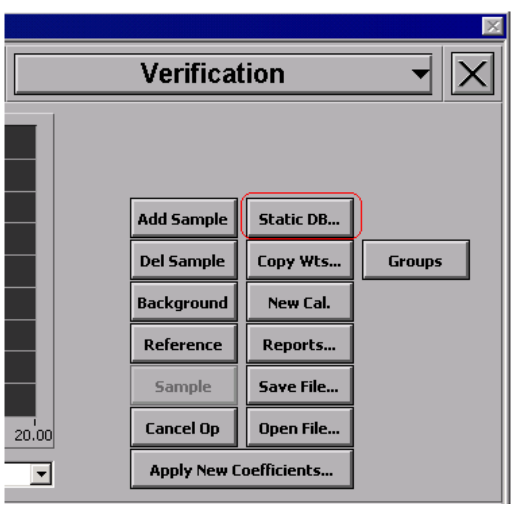
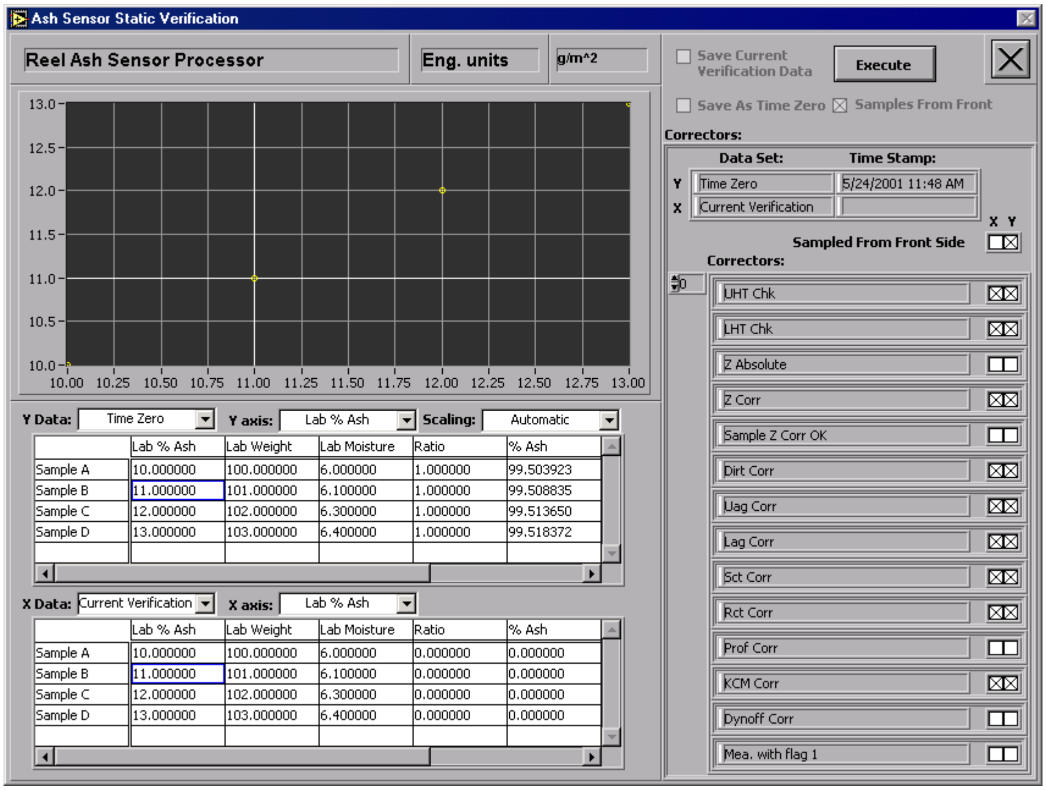


Figure 7-7 Verification Button

Pressing **Static DB…** brings up a dialog box that allows you to save **Lab % Ash**, **Lab Weight**, **Lab Moisture**, and *verification sample results* to a database (see Figure 7-8). This data can be retrieved at a later time, as a starting point for another sample verification. There are two types of stored data: Time-zero at the factory sample verifications, and last sample verifications. **Lab % Ash**, **Lab Weight**, **Lab Moisture**, **Ratio**, and **% Ash** are stored in the database along with the **Correctors** and their states.



	Lab % Ash	Lab Weight	Lab Moisture	Ratio	% Ash
Sample A	10.000000	100.000000	6.000000	1.000000	99.503923
Sample B	11.000000	101.000000	6.100000	1.000000	99.508835
Sample C	12.000000	102.000000	6.300000	1.000000	99.513650
Sample D	13.000000	103.000000	6.400000	1.000000	99.518372

	Lab % Ash	Lab Weight	Lab Moisture	Ratio	% Ash
Sample A	10.000000	100.000000	6.000000	0.000000	0.000000
Sample B	11.000000	101.000000	6.100000	0.000000	0.000000
Sample C	12.000000	102.000000	6.300000	0.000000	0.000000
Sample D	13.000000	103.000000	6.400000	0.000000	0.000000

Figure 7-8 Ash Sensor Static Verification Display

The product code, processor ID, and type (time-zero, and last verification) are used as keys for a given set of verification samples. This allows you to support multiple time-zero last verification sets of data by using a different product code as your maintenance code.

Title Display

Data on this display is related to this frame and sensor processor.

Unit Display

The data on this display is either in engineering units or customer units, to change which type of units you will need to leave the unit display and the **Advanced** display, and change the data from the **Sensor Maintenance** display.

Save Current Verification Data Checkbox

When the **Save Current Verification Data** checkbox is selected, press **Execute** to save the current **Lab % Ash**, **Lab Weight**, **Lab Moisture**, **Ratio**, and **% Ash**, data to the database (see Figure 7-9).

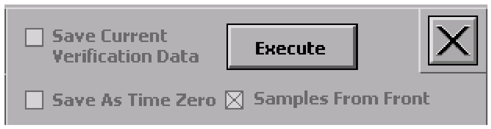


Figure 7-9 Execute Button (and checkboxes)

If the checkbox is not selected when **Execute** is pressed, time-zero and last verification will be retrieved from the database. Current verification will be initialized with the time-zero **Lab % Ash**, **Lab Weight**, and **Lab Moisture**. This option is disabled if you have not shot all of your samples.

Save as Time Zero Checkbox

When the **Save Current Verification Data** checkbox and the **Save as Time Zero** checkbox are selected, press the **Execute** button to save the current **Lab % Ash**, **Lab Weight**, **Lab Moisture**, **Ratio**, and **% Ash** as the time-zero factory calibration data set. This option is enabled when the **Save Current Verification Data** checkbox is selected.

Execute Button

This button is used to trigger the transfer of data to or from the database (see Figure 7-10).

Figure 7-10 Execute Button

The direction of transfer is selected via the **Save Current Verification Data** checkbox. If that box is selected, then data will be saved in the database. If you are saving data, the other two checkboxes will be used to determine whether the data you are saving is the time-zero factory calibration or the last verification, and from what side of the head the verification samples were obtained.

Graph

The correlation graph (see Figure 7-11) helps visualize the correlation of the selected columns from the X and Y data sets. The data on the graph is selected using the **X & Y Data:** drop-down lists, and the **X & Y Axis:** drop-down lists.

From the data lists you can select **Time Zero**, **Last Verification**, and **Current Verification**. The axis selections are from the columns in the tables.

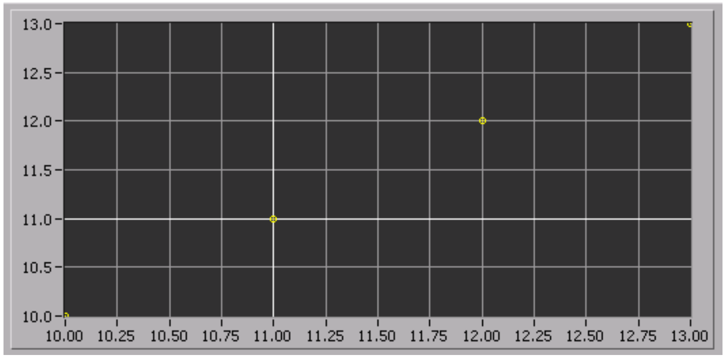


Figure 7-11 Correlation Graph

Y Data

Y-axis data set selection (see Figure 7-12). From the list you can select **Time Zero**, **Last Verification**, and **Current Verification** to be the source **Y Data** set for the graph and the **Y Time Stamp**, **Sampled ... Side**, and **Correctors** (see Figure 7-8).

Y Data: Time Zero Y axis: Lab % Ash Scaling: Automatic

	Lab % Ash	Lab Weight	Lab Moisture	Ratio	% Ash
Sample A	10.000000	100.000000	6.000000	1.000000	99.503923
Sample B	11.000000	101.000000	6.100000	1.000000	99.508835
Sample C	12.000000	102.000000	6.300000	1.000000	99.513650
Sample D	13.000000	103.000000	6.400000	1.000000	99.518372

Figure 7-12 Y Data Table

Y Axis

Y-axis selection will choose one of the columns from the table shown in Figure 7-12 to be used as the Y-coordinates of the data that will be plotted on the graph.

Scaling

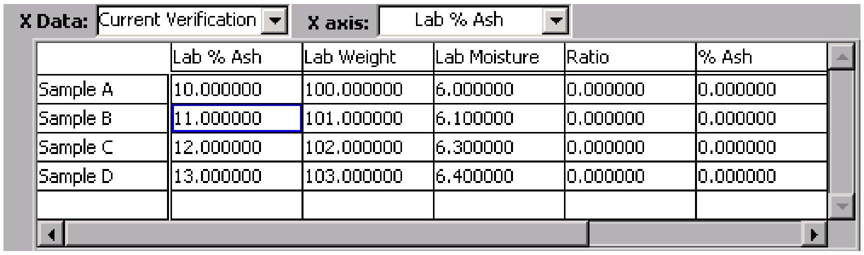
The values in this list will be used for the scaling of the Y-axis of the graph.

Y Table

The data in this table is determined from the Y data selection. It contains the static sample verification entries. This may be from **Time Zero**, **Last Verification**, and **Current Verification**. The value for the current verification will not be meaningful until all of the samples have been verified using the **Advanced** display.

X Data

X-axis data set selection (see Figure 7-13). From the list you can select **Time Zero**, **Last Verification**, and **Current Verification** to be the source **X Data** set for the graph and the **X Time Stamp**, **Sampled ... Side**, and **Correctors** (see Figure 7-8).


X Data: Current Verification X axis: Lab % Ash

	Lab % Ash	Lab Weight	Lab Moisture	Ratio	% Ash
Sample A	10.000000	100.000000	6.000000	0.000000	0.000000
Sample B	11.000000	101.000000	6.100000	0.000000	0.000000
Sample C	12.000000	102.000000	6.300000	0.000000	0.000000
Sample D	13.000000	103.000000	6.400000	0.000000	0.000000

Figure 7-13 X Data Table

X Axis

X-axis selection will choose one of the columns from the table shown in Figure 7-13 to be used as the X-coordinates of the data that will be plotted on the graph.

X Table

The data in this table is determined from the X data: selection. It contains the static sample verification entries. This may be from **Time Zero**, **Last Verification**, and **Current Verification**. The value for the current verification will not be meaningful until all of the samples have been verified using the **Advanced** display.

X/Y Correctors and Sides

This area indicates the **X Time Stamp**, **Sampled ... Side**, and **Correctors** states for the selected data sets (see Figure 7-14).

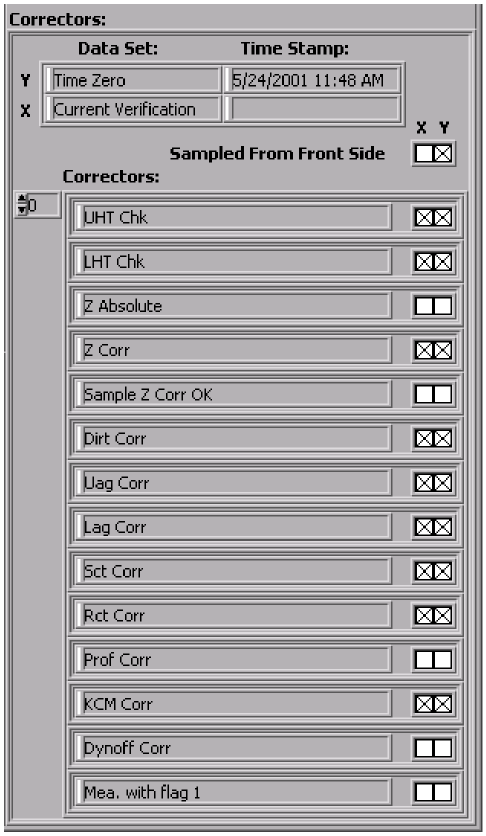


Figure 7-14 Correctors

You will not have a time stamp for the current verification when you retrieve database data. Before you store data to the database, look through the correctors to ensure that the same ones are enabled and that the samples taken for the verification came from the same machine direction side of the head.

For current verification the sample side is not updated until the data is stored.

This indicator will become invisible and the **no time zero** data indicator will become visible, showing the message *The static verification database does not have any laboratory time zero data for the maintenance code*, along with the code it was looking for in the database.

8. Dual Ash Gauge Calibration

This procedure is used to calibrate the Q4267-02 dual ash sensor only. The triple ash sensor, the Q4237-07, is calibrated as a single ash sensor and is described in Chapter 7.

The Q4267-02 sensor is designed to measure total percent ash, consisting of calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), clay ($Al_2O_32SiO_22H_2O$, a hydrated aluminum silicate), and/or talc ($Mg_3Si_4O_{10}(OH)$, in fine paper applications.

Static calibration accuracy should be at least ± 2% ash absolute, 2-sigma, for all grades but it is often much better. On request, a measurement of percentage clay can also be provided. This clay measurement requires that the customer provide precisely known values for percentage clay for each grade to be included in the calibration. The accuracy for percentage clay is typically ± 2–3%, 2-sigma. This reduced accuracy is usually due to laboratory errors in determining the clay content.

The dual ash sensor consists of two separate standard ash sensors modified to special low and high voltage power supply settings. The sensor power, shutter, flag, and signals function the same as the single ash sensors.

For materials required, sample preparation and ashing, and pre-calibration sensor stability checks, see Chapter 7.

8.1. Calibration Equation

Unlike the single ash gauges, the dual ash gauge is calibrated directly on customer samples. There is no Mylar® calibration. Percent ash is given using:

$$\% \text{ Ash} = A0 + A1 * (\text{Ln}(R_1) / DW) + A2 * (\text{Ln}(R_2)/ DW) + A3 * (WW / DW)$$

where

R1 = Ratio from ash sensor 1(A) (Low energy sensor)

R2 = Ratio from ash sensor 2(B) (High energy sensor)

DW = Dry weight in g/m^2

WW= Water weight in g/m^2

The total percentage Clay is calculated:

% (Clay) =

B0 + B1 * (lnR1 / DW) + B2 * (lnR2 / DW) + B3 * (WW / DW)

(B3=0; this term is not currently used)

Determining the constants (A0…A3) requires a minimization algorithm and is therefore more difficult to do on a spreadsheet program. The real-time application environment (RAE) calibration screens should be used.

Note that the RAE calibration screens do not take into consideration the moisture term A3, and set only the parameters A0, A1, A2. At some sites, the moisture correction is important and must be calculated by hand. This will also affect the value of A0. See Section 8.6.

8.2. Overview of the Calibration Display

The **Advanced Dual Ash Calibration** display provides a convenient user interface to perform calibration and verification procedures on the RAE platform. Pressing the **Advanced** button on the **Sensor Maintenance** display (see Figure 8-1) while the appropriate dual ash sensor is selected accesses the **Advanced Dual Ash Calibration** display.

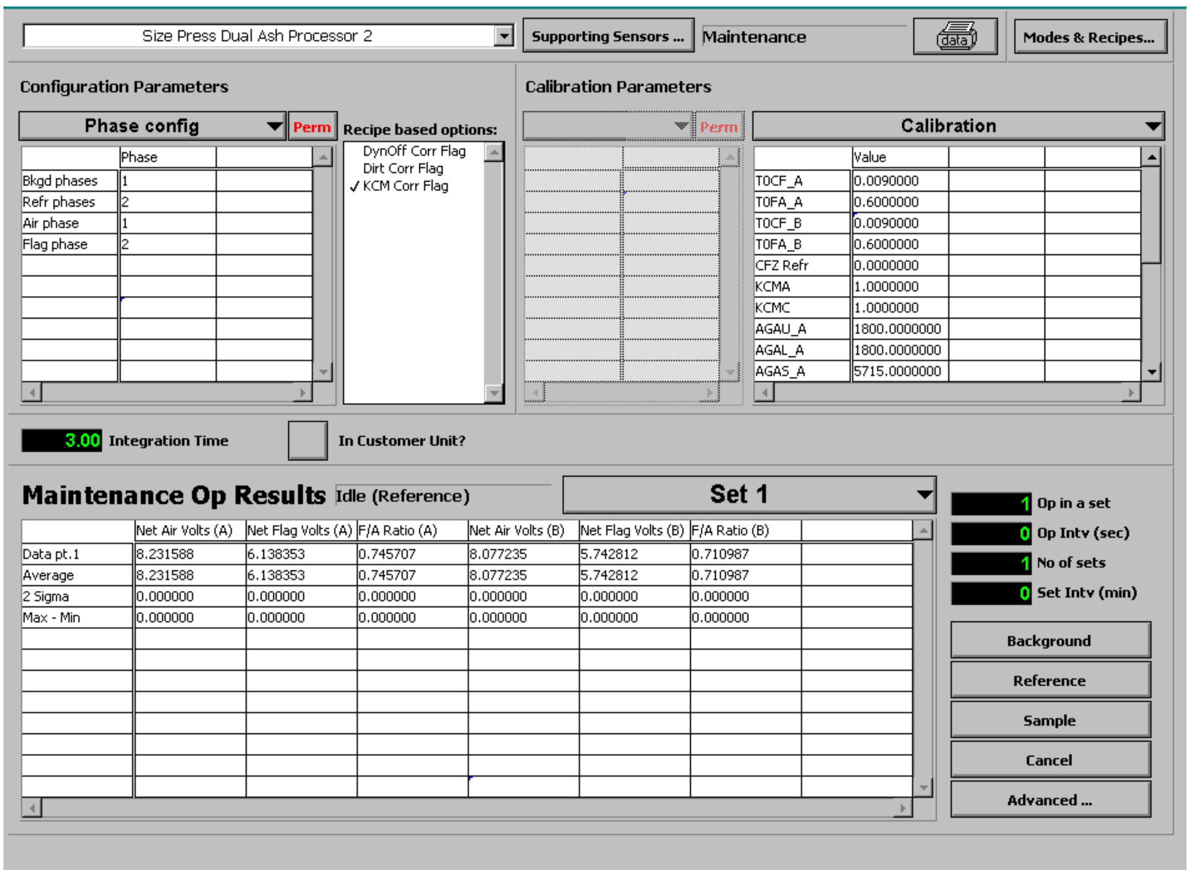


Figure 8-1 Sensor Maintenance Display

Figure 8-2 shows the **Advanced Dual Ash Calibration** display.

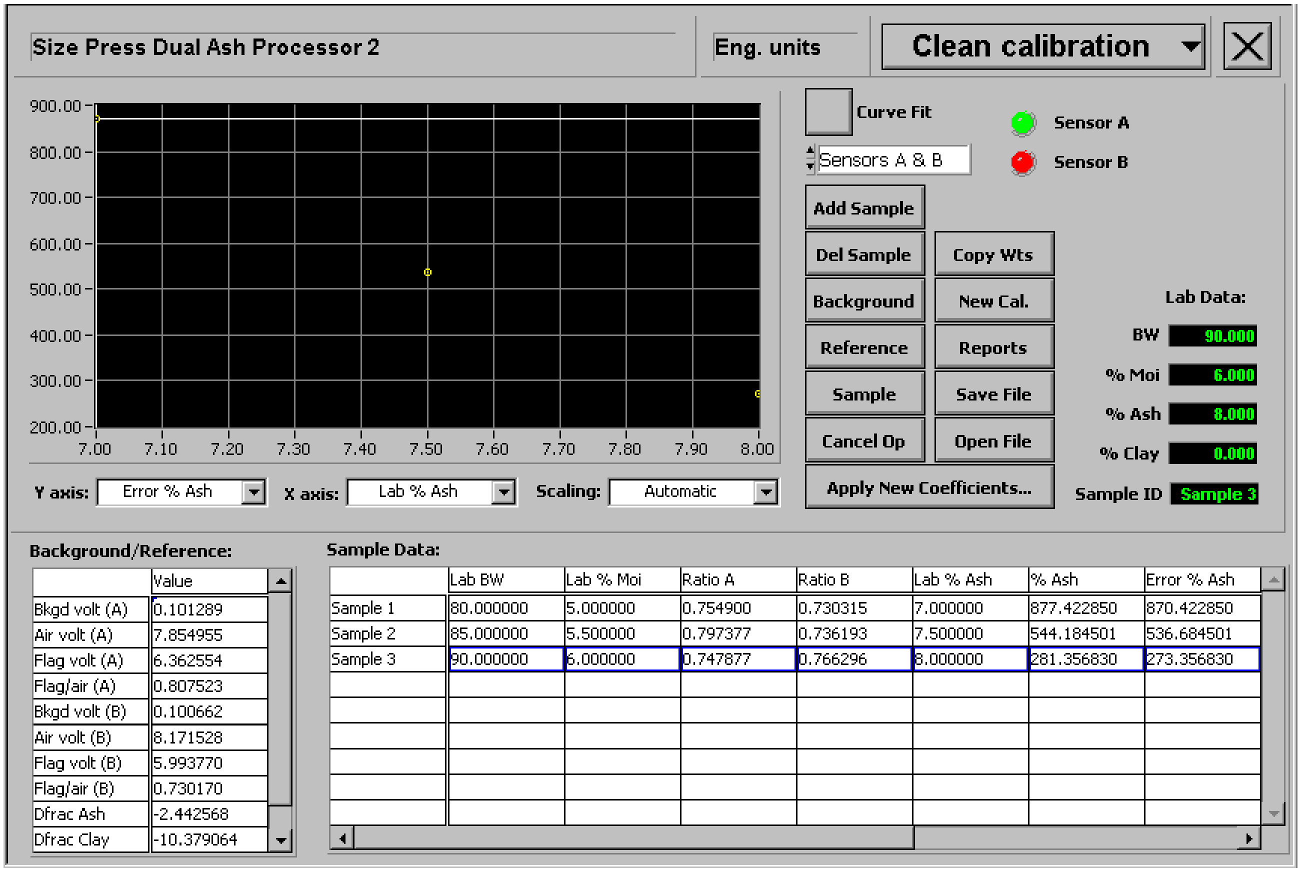


Figure 8-2 Advanced Dual Ash Calibration Display

From the **Advanced Calibration** display several operations may be performed with associated displays to view the results.

8.3. Operation Selections

This section lists and describes operation selections and what each operation accomplishes.

Press **Add Sample** to add sample lines to the sample data window with the initial values set to zero. A sample ID number is associated with each line.

Press **Del Sample** to delete the selected sample line.

Press **New Cal.** to clear the sample window. This command will remove all data, including calibration constants not yet saved, from the content table. If there is data you wish to save, use **Save File** first.

Press **Save File** to save the current data as displayed in the content table to a file, the name of which you supply. One file is saved (assume filename is *File1*): *File1* is saved in binary format for use by LabVIEW. Use *File1* with **Open File**.

The directory to which these files are saved is dependent on the environment variable **MXRTDB**. Under this directory, usually *C:\Program Data\Honeywell\Experion MX\Database*, the relative directory path *\Calibration Data\DualAsh* should be found.

Press **Open File** to open a file and read into sample window. The file must have been saved using **Save File**.

Save File stores the data from verification, clean and dirty calibration in one file. **Open File** reads this file and loads the data into memory for verification, clean, and dirty calibration.

Press **Reports** to send calibration reports to the printer. Reports for each calibration or verification function can be selected (see Figure 8-3).

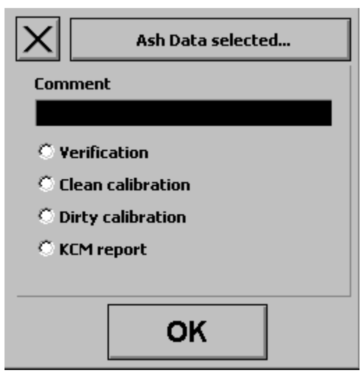


Figure 8-3 Ash Data selected... Report Selection

Press **Background** to initiate a background operation. Results can be viewed in the **background/reference** display.

Press **Reference** to initiate a reference operation. Results can be viewed in the **background/reference** display.

Press **Sample** to initiate a sample operation on the selected sample line in the **sample data** display.

Press **Cancel Op** to cancel the current operation. This applies to background, reference, and sample only.

Press the the up or down arrow in the sensor selection list to select the sensor for your operations (reference or sample). You can select either one or both (see Figure 8-4). If both are selected, the reading from sensor A is taken first, then the reading from sensor B is taken.

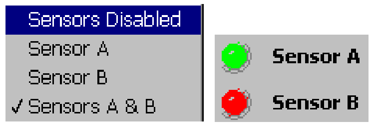


Figure 8-4 Sensor Selection

- green: active sensor
- red: inactive sensor

When **Curve Fit** is clicked, the calibration constants are calculated; the example calibration is for ash (see Figure 8-5).

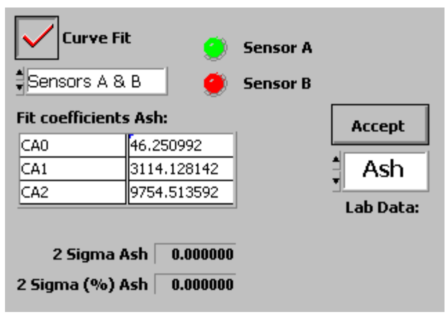


Figure 8-5 Curve Fit

Changing the selector for **Ash** or **Clay** displays the calibration parameters for the selected measurement (see Figure 8-6).

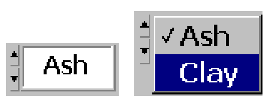


Figure 8-6 Calibration Parameters

Press **Apply New Coefficients...** to store calibration constants to the recipe database. Optionally, a new table can be created which can be linked to a particular recipe. You will be allowed to select the code (grade) that the new table will be pointed. Otherwise, the data will be stored to the current code table. Check or uncheck each coefficient to store. A value (other than zero) without the check box selected would not be written to the recipe database. Figure 8-7 shows the **Calibration coefficients** display.

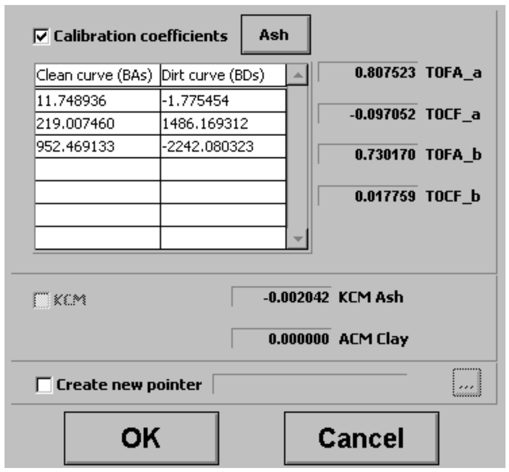


Figure 8-7 Calibration coefficients Display

Select **Create new pointer** and press browse (**...**) to store the calibration data in an existing or new table in the recipe database. **...** allows you to browse the recipe database using the dialogue display shown in Figure 8-9.

Figure 8-8 Create new pointer Check Box

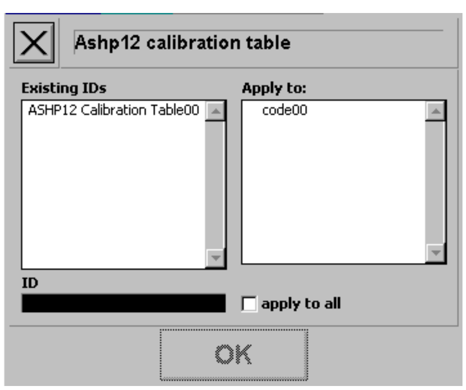


Figure 8-9 Dialogue Box

Selecting the *ASHPxy Calibration Table* and pressing **OK** stores the data in the existing table, or you can modify the name in the **Existing IDs** field to create a new table.

8.4. Sampling

Because there are no calibration sample standards, it is very important to keep the customer samples clean and in good condition. These samples will be used later on to verify the static calibration and its validity if a major electronic component (X-ray tube, high voltage supply, ion chamber, or detector amplifier) is replaced.

Although the displays imply that it is possible to shoot all the samples in sensor A and then start the entire set with sensor B, feedback from users suggests that each sample should be shot in Sensor A, then followed immediately by shooting that sample in Sensor B.

On the calibration display, select **Sensor A** and **Sensor B** (see Figure 8-4).

8.4.1. Pre-sampling Checks

Take a reference reading with nothing in the gap. Immediately take a sample reading: The sample ratio should be 1.0000 ± .0010.

1. Check for paddle interference in the measurement. Insert the paddle with the rings in place and take a sample reading at the center, all the way forward and all the way to the back. Each sample ratio should repeat to within ± 0.0010 of the sample ratio with nothing in the gap.

2. If there is paddle interference, the backwards and forwards travel must be limited. Move the paddle to the extreme backward position and then forward by small increments. Take readings at each position until it repeats as described in Step 1. Mark this position on the paddle handle.

3. Take another reference with nothing in the gap. Take five sample readings with the paddle moving back and forth in the position determined to have no interference. The average sample ratio should repeat as specified in Step 2. If the ratio does not repeat and the sensor stability is within specification, repeat the procedure above until the proper position is found.

8.4.2. Clean Calibration

1. Verify the sample integration time is set to 16 seconds. Take a reference with the paddle and rings in place.

2. Insert the customer sample between the sample rings and take a sample reading while rotating and stirring the sample. Repeat for all the samples.

3. Take a reference reading after every 10 sample readings.

8.4.3. Dirty Calibration

1. Insert the 1 mil Mylar dirt sample beneath both sample rings.

2. Take 10 reference readings with the dirt in the paddle while stirring and moving the paddle back and forth. Record the average of the readings.

3. Insert the customer sample between the two sample rings, keeping the dirt sample in place.

4. Take a sample reading while rotating and stirring the sample. Repeat for all the samples.

5. Take a reference reading with the dirt after every 10 sample readings.

6. Repeat clean and dirty calibration for sensor B.

8.5. Verification

1. Reweigh 4.5-inch samples on the analytical balance.

2. Record the 4.5-inch sample weights in grams to four decimal places.

3. Calculate the weight in g/m^2 for each 4.5-inch sample:

   $BW\ (g/m^2) = AmbWt \times 97.458$

   where

   AmbWt = 4.5-inch sample weight in grams

97.458 =conversion factor(CF) grams to g/m^2 for a 4.5-inch diameter circle

Convert g/m^2 to customer units if appropriate:

lbs/3300 sq ft = BW (g/m^2) * 0.6757

lbs/3000 sq ft = BW (g/m^2) * 0.6146

4. Calculate the percent moisture for each 4.5-inch sample using bone dry weight obtained during the sample preparation:

   % Moisture = [(Ambient wt. - Bone Dry wt.)/Ambient wt.] * 100

5. Verify that the low energy sensor and the high energy sensor are stable by running a set of 30 consecutive references at 16 seconds integration time:

   F/A ratio 1-sigma < = 0.00015 on the system for Low Energy sensor

   F/A ratio 1-sigma < = 0.00015 on the system for High Energy sensor

8.5.1. Clean Sample Verification

Choose the verification mode from the **Calibration** display. Select **Sensors A & B**. Shoot all the samples in the gauges, alternating between the A and B gauge.

For each sample, absolute delta % Ash should be within 2.5% of the laboratory percentage ash value.

8.6. Calculate the Moisture Correction

The moisture term A3 is not calculated in the RAE **Calibration** displays. It is easy to calculate this value retroactively if samples of different moisture are available or if data are available from an online moisture bump.

Physics modeling of the X-ray sources and paper predict that A3 ~ -40.0. This number should be tried if it is not possible to determine the moisture of different samples. However, with the A3 term set, the A0 term must now be corrected.

To make those corrections, assume at A3 was set to zero prior to calibration and that the moisture content is (*Moi%*) during calibration. Then the new A3 term will increase the ash content calculation by:

Change In Ash = A3 x (DW/WW) = A3 x (Moi*%) / (100*- Moi*%)*

Therefore the A0 term has to be decreased by:

A3 x (Moi*%)/(100*- Moi*%)*

for the ash to remain the same when the A3 term is used.

More generally, if the corrector A3 was previously set to $A3^{prev}$ and now changed to $A3^{now}$ then the A0 term must be reduced by:

($A3^{now}$ – $A3^{prev}$) x (Moi*%)/(100*- Moi*%)*

8.6.1. Correction Moisture During Machine Bump Test

The A3 term can be calculated after the fact if a bump in moisture on-sheet is observed and the ash value changed unacceptably.

Let the moisture on-sheet before the moisture bump be Moi^{before} and after the bump be Moi^{after}. If the ash before the bump read correctly against the lab value (Ash^{lab}), but after the bump it went to (Ash^{bump}), then the value of A3 required is:

A3 = -1 x (Change In Ash) / (Change in WW/DW)

$$= \frac{(A^{before} - A^{after})}{\left\{\frac{Moi^{before}}{100-Moi^{before}}\right\} - \left\{\frac{Moi^{after}}{100-Moi^{after}}\right\}}$$

For example, a lab reading and the Honeywell system gauge agree that the ash content of a sheet is 5% at a moisture content of 10%. When the moisture was bumped to 20%, the ash went to 10%. What values are A0 and A3 are required to get proper moisture corrections?

$$A3 = \frac{(5-10)}{\left[\frac{10}{100-10} - \frac{20}{100-20}\right]} = -36$$

The new value for *A0* ($A0'$) is now:

$$A0' = A0 - A3 \times \frac{10}{100-10} = A0 + 4$$

The calibration coefficient array may have to be manually extended to enter the A3 term. This can be done using the **Recipe Maintenance** display, Select **ASHXX Clean Calibration Coefficient Ash** and resize the array to include the fourth term if required.

9. Calibration Constants

Table 9-1 shows calibration corrector constants that are common to all single ash gauges.

Table 9-1 Calibration Corrector Constants

Name	Value	Definition
AGAU	3000	Upper air gap temp correction (pressure change to BW change)
AGAL	3000	Upper air gap temp correction (pressure change to BW change) for lower air gap
AGAS	16000 (with source temperature sensor)	Upper air gap temp correction (pressure change to BW change) for space between X-ray source and sheet guide
AGAS	0 (without source temperature sensor)	Upper air gap temp correction (pressure change to BW change)
AGAR	0	Upper air gap temp correction (pressure change to BW change) for gap between ion chamber and sheet guide
CFZ	16 (with Z-sensor)	Basis weight correction for a change of Z (gap distance) from standardize
CFZ	0 (without Z-sensor)	
CFZS	0	
BWDO	0	

9.1. Q4237-50 (TiO_2/clay, 900 °C ashing temperature)

Table 9-2 Typical Mylar Fit Coefficients

BA0 =	0.00	BD0 =	0.00
BA1 =	-253.00	BD1 =	-3.89
BA2 =	30.00	BD2 =	-0.20
BA3 =	6.30	BD3 =	0.38
T0FA =	0.54	T0CF =	0.0142

Table 9-3 Typical Paper Calibration Numbers

DCSF =	0.500
ACM1 =	0.900
ACW1 =	0.966
ACA3 =	3.8 to 4.5 (for most grades)

Table 9-4 Typical Scanning Calibration Numbers

Beam half width (mm) =	20
Delay time (ms) =	20

9.2. Q4237-51 ($CaCO_3$/clay, 900 °C ashing temperature)

Table 9-5 Typical Mylar Fit Coefficients

BA0 =	0.00	BD0 =	-.20
BA1 =	-153.00	BD1 =	-6.93
BA2 =	7.95	BD2 =	-0.92
BA3 =	0.22	BD3 =	0.04
T0FA =	0.3600	T0CF =	.0130

Table 9-6 Typical Paper Calibration Numbers

DCSF =	0.500
ACM1 =	0.910
ACW1 =	0.966
ACA3 =	3.0 to 5.5 (for most grades)

Table 9-7 Typical Scanning Calibration Numbers

Beam half width (mm) =	20
Delay time (ms) =	20

9.3. Q4237-57

- the flag-to-air (F/A) value is typically between 0.48 and 0.50
- values for *ACM*1 are in the range 0.88 to 0.92

10. Preventive Maintenance

Preventive maintenance, when performed on a periodic basis, can prevent many failures and can catch minor problems before they become major ones. This sensor has few tasks that require regular attention.

10.1. Preventive Maintenance Schedule

Table 10-1 Preventive Maintenance Internal Checklist

Procedure	Daily	Weekly	Months		Years			Task Details
			1	>	1	3	5	
Inspect Head Gap		X						Section 11.2
Verify Gauge Stability			X					Section 11.4

11. Tasks

11.1. Enable Sensor on Human/Machine Interface (HMI) Panel

In the Q4000 Experion MX scanner series, all radiation sensors must be explicitly enabled at the scanner HMI panel.

Activity Number:	Q4237-50-ACT-001	**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 real-time application environment (RAE) server will disable 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. Turn the key switch to the **ON** position. Press the **ash** gauge button on the **HMI/UPI** panels at either end of the scanner. The amber light turns on and stays on.

11.2. Inspect Head Gap

Activity Number:	Q4237-50-ACT-002	**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:			

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.

When trouble shooting ash 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.

11.3. Inspect Ash Source

Activity Number:	Q4237-50-ACT-003	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	
Availability Required:	Scanner offsheet	**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:	Digital multi-meter		

Depending on the symptom, the following should be checked on the ash gauge:

1. For poor accuracy and jumps in ash profile, check whether the ash filter is intact. The filter can only be seen in Figure 4-6 (all models except the Q4237-57/2237-7) and Figure 4-7 (the -07 model). The ash source assembly has to be removed from the base-plate and the nose piece removed.

2. Verify the tube controller status LEDs as in Section 4.2.1.

3. Verify the 1:10,000 monitoring voltage on the high voltage power supply. This is available between two of four pins on the high voltage supply. Since there is little space in between these pins and the mounting wall it is recommended that the high voltage supply is unscrewed from the plate before attempting this.

4. When troubleshooting interlock issues:

   Have someone enable the gauge from the human/machine interface (HMI, also known as UPI) panel and listen for the closing of the shutter as the power is applied.

   Verify that LED DS1 is on (+ 24 V switched is enabled), on the interlock board when the gauge is enabled.

11.4. Verify Gauge Stability

Activity Number:	Q4237-50-ACT-004	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	
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 Section 7.5 for detailed instructions.

See Chapter 9 and 13 for expected values.

11.5. Replace Receiver Ion Chamber

The ash receiver ion chamber usually has a life time of many years. However, failure of the welding joint or the punctures of the thin steel window can cause component failure. This is often seen in poor repeatability and lower signal amplitude.

Activity Number:	Q4237-50-ACT-005	**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.

The low current high voltage printed circuit board provides -350 V DC to the cathode of the ion chamber from ± 12 V supplied by the head power distribution board. Check the -350 V before replacing the ion chamber on the test terminals provided.

WARNING

Warning: the ion chamber shell is connected to a low current 350 V source. Make sure the sensor is disconnected from power before attempting to remove it.

11.6. Verify EDAQ Functionality

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

Activity Number:	Q4237-50-ACT-006	**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:			

For details of EDAQ replacement and programming, refer to the *Experion MX MSS and EDAQ Data Acquisition (p/n 6510020381)* system manual. The following steps should be performed:

1. From the MSS main web page or the **MSS Summary Page** on the real-time application environment (RAE) system (under **MSS Setup Diagnostics**), and note 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. Replace the EDAQ with a spare.

2. Check whether the new EDAQ reports with the expected position (node) and function numbers in the main MSS web page. If not, refer to the *Experion MX MSS and EDAQ Data Acquisition (p/n 6510020381)* system manual for information on how to correct the assignment.

3. Upgrade the EDAQ to the software revision present on the other EDAQs. Refer to the *Experion MX MSS and EDAQ Data Acquisition (p/n 6510020381)* system manual for details.

The removed EDAQ may be self-tested to verify whether it is functional or not. A loop-back harness p/n *6580801773* is required for this operation. The self-test can be performed from any PC connected to the EDAQ. No software is required. For details, refer to the *Experion MX MSS and EDAQ Data Acquisition (p/n 6510020381)* system manual.

An MS Windows based tool exists to retrieve and display raw data from EDAQs. This can help to analyze signal issues and sources of external noise. Contact Honeywell Engineering for a copy of this tool or refer to the *Experion MX MSS and EDAQ Data Acquisition (p/n 6510020381)* system manual.

11.7. Verify EDAQ ADCs

In case of a sensor processor reporting a value out of range, the data should be checked as close to the digitization (EDAQ) card as possible, before replacing the necessary hardware.

Activity Number:	Q4237-50-ACT-007	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	None	**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:			

1. On the RAE server system, go to the MSS Diagnostics tab and click on the IO Point Monitor.

2. Select the appropriate EDAQ (either ash receiver or ash source, depending on the reported fault) and select Analog Inputs.

3. Visually confirm that the data reported here matches the data from the sensor processor. Note that the ADC channels 0-15 are raw volts, but the channels in the range 16-23 are reported in Engineering units.

4. If the numbers are not what are expected, use the MSS web page to access the EDAQ data directly (see the *MSS and EDAQ System Manual p/n 6510020381* for details).

   If these data are also incorrect the EDAQ may need to be replaced and checked (see Section 11.6).

11.8. Diagnose Intergauge Sensor Input

In case of a sensor processor reporting an intergauge value out of range, the issue is in all likelihood with another sensor or subsystem.

Activity Number:	Q4237-50-ACT-008	**Applicable Models:**	All
Type of procedure:	Replace	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	None	**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:			

The Ash gauge requires Z and Air Gap compensation. The Z-sensor is read out by the alley EDAQs and is therefore part of the performance sensor set.

Start by using the IO point monitor under the **MSS Diagnostics** tab to look at the sensor signals. The air gap sensor is part of the nuclear basis weight gauge. Refer to the *Basis Weight Measurement System Manual*, p/n 6510020331.

11.9. Verify Wiring

Activity Number:	Q4237-50-ACT-009	**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 11-1 may be useful, and the schematics may be requested from engineering.

Table 11-1 Ash Gauge Platform Wiring Part Numbers

Part Number	Description
6580801550	source harness, Experion MX
6580801551	receiver harness, Experion MX
6580500109	BW/X-ray interlock board (at source)

11.10. 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:	Q4237-50-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:	6580500109 Interlock Board		
		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 ash source assembly 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:

- The EDAQ digital input grounds the return from the basis weight actuator.

- There is + 24 V supplied to the actuator.

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 not seen when driving the period watchdog signal.

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

11.11. Ash Receiver Amplifier Checks

The ash receiver has a very high gain current-to-voltage amplifier. It is sensitive to static. When failed, the most common characteristic is that the EDAQ ADC is railed at + 10 V, generating a closed high voltage alarm.

Activity Number:	Q4237-50-ACT-011	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner Offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	60 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:	Soldering iron		

Typical operational air volts from the receiver should be in the range 6–9 V.

CAUTION

Fingerprints on the high impedance resistors can seriously degrade the performance of the detector amplifier PCB. These resistors cannot be successfully cleaned in the field. Wear rubber gloves or touch only the edges of the board when handling the printed circuit board.

The amplifier may come in two versions. The newer model has a rotary switch to adjust the gain. The older model requires soldering together the gain select post as described in Table 11-2.

Table 11-2 Amplifier Gain Look-up

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

Table 11-2 shows the amplifier gain lookup table. In general the ash gauges will use the -00 500 MΩ model.

With the shutter closed, the amplifier should read a voltage near zero.

1. Adjust 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.

2. Remove the amplifier shielding cover, the four mounting screws and the ion chamber signal cable.

3. Note the existing gain settings, and then modify the new amplifier to have the same jumpers or rotary dial position.

Use rubber gloves or a grounding strap while replacing the amplifier to avoid static discharge.

11.12. Ash Receiver Checks

Activity Number:	Q4237-50-ACT-012	**Applicable Models:**	All
Type of procedure:	Inspect	**Expertise Level:**	Technician
Priority Level:	Average	**Cautions:**	None
Availability Required:	Scanner Offsheet	**Reminder Lead Time:**	
Overdue Grace Period:		**Frequency (time period):**	
Duration (time period):	20 min	**# of People Required:**	1
Prerequisite Procedures:		**Post Procedures:**	
	Part Number	Quantity	Lead Time
Required Parts:			
		Quantity	Lead Time
Required Tools:	Digital multi-meter		

A railed output signal regardless of the shutter state (near 10 V) usually indicates a blown amplifier chip on the amplifier board. The board will have to be replaced. See Subsection 4.2.2 for details, and Section 11.8 for a table of the amplifier gain settings.

The receiver uses only ± 12 V from the head power distribution board. Unplug the wire harness and measure the voltages either on the ash receiver connector (see Figure 4-10 for pin assignments) or on the head power distribution board pins 12, 23, 24 (+ 12, GND, -12V)

Measure the -350 V on the red and black test points on the receiver high voltage generation board. Any stable value over -330 V is considered sufficient.

12. Troubleshooting

12.1. Alarm Based Troubleshooting

12.1.1. Receiver (Rx) Sensor Not in Place

Symptom	Possible Cause(s)	Solution (Tasks)
Micro-switch between x-ray receiver body and platform is not closed as expected	Receiver module not screwed in place	Screw in Receiver Module
	EDAQ digital input failure	Verify EDAQ Functionality

12.1.2. Interlock Board

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

12.1.3. No Basis Weight Signal

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

12.1.4. Basis Weight Signal High

Symptom	Possible Cause(s)	Solution (Tasks)
BW (ash) Receiver Signal above maximum allowed voltage (usually near 10 V)	Amplifier OpAmp broken	Ash Receiver Amplifier Checks
	Amplifier gain set to high	Ash Receiver Amplifier Checks

12.1.5. 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	Ash Receiver Amplifier Checks
	Shutter did not close	Verify shutter operation

12.1.6. 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	Verify EDAQ Functionality
	Shutter did not open due to interlock board failure	Replace Interlock Board
	Receiver module not functioning	Ash Receiver Checks
	Shutter did not open due to mechanical issues (power)	Inspect Ash Source
	Thick material in the gap	Inspect Head Gap
	Source and Receiver are not aligned	Inspect Head Gap

12.1.7. 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 Human Interface Panel

12.1.8. 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	Flag Inspection
	Bad ion chamber	Replace Receiver Ion Chamber

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.

12.1.9. Dual Ash 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	Flag Inspection
	Bad ion chamber	Replace Receiver Ion Chamber

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.

12.1.10. 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 Ash Source
	EDAQ card defective	Verify ADCs on EDAQ

12.1.11. 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 Ash Source

12.1.12. 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 Ash Source

12.1.13. 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 receiver	Inspect Ash Source

12.1.14. 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 corrector, such a the z-sensor or air gap sensor	Diagnose Intergauge Sensor Input

12.1.15. 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	Verify EDAQ Functionality
		Ash Receiver Checks
		Ash Receiver Amplifier Checks

12.1.16. 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	Verify EDAQ Functionality
		Ash Receiver Checks
		Ash Receiver Amplifier Checks

12.2. Non-alarm Based Troubleshooting

Preventive maintenance procedures are minimal. The frequency of preventive maintenance checks is usually defined by the operating environment.

WARNING

X-rays are hazardous to your health. Be sure the X-ray sensor is off or that the shutter is closed before cleaning the windows.

Keep windows on sensors clean. Clean with cotton swabs or lint-free cloths dipped in methanol or isopropyl alcohol.

CAUTION

> The windows are fragile. Inspect them carefully after cleaning to ensure they are not damaged. Any damaged windows should be repaired immediately.

Inspect the log of reference measurements that are run daily for error trends. This may permit you to catch potential problems and repair them during scheduled downtime.

12.2.1. Sensor Stability

A change in output voltages of up to 30 % is normal for head temperature changes from 21–60 °C (70–140 °F). A variation of temperature will not affect the accuracy of calibration as long as the variation is small between consecutive standardizations (a software calibration adjusting program).

During the standardize program, software verifies that this ratio is within predefined limits of the ratio measured at the time of initial calibration, and scanning automatically resumes. If the resulting ratio is out of limits, the standardize program will run again, trying to obtain a good standardize. After three unsuccessful tries, scanning will stop.

12.2.2. Causes of Sensor Instability

In general, instability can be traced to poor regulation of the DC–DC converters, dirt on the windows, or defective printed circuit boards. Isolate problems in printed circuit boards by replacing the boards. Tubes older than 10 years should be replaced regardless of instability.

12.2.3. X-ray Sensor Flag/Shutter Operation

A Mylar® flag is positioned by a solenoid across the aperture in the source body. The flag is used as a reference to correct for changes in readings caused by dirt on the window of the receiver, and also for determining the stability of the sensor. The flag solenoid is energized by a contact output from the EDAQ.

The shutter is closed when the shutter solenoid is energized by a contact closure in the EDAQ. When closed, the shutter prevents X-ray radiation from the source. This is in contrast to the nuclear sensor in which the shutter is closed when power is off to prevent radiation from the source isotope. The shutter on X-ray sensors can remain open when power is off because the source cannot generate X-rays without a source of power.

12.2.4. Power On/Off and Radiation lights

A + 24 V DC power control and interlock circuit allows power to be switched on to the X-ray source assembly only by an authorized person with a key. The key may be removed after the power is turned on. If an interlock opens or the sensor is turned off, DC power is removed and cannot be restored without the key (power to the receiver is never removed). The EDAQ does not allow power to be applied to the gauge until a number of safety conditions are satisfied (see Chapter 2 for more detail). However, the green lamps integrity is not sensed; a green lamp failure will not affect the ash shutter. If the green lamps are not lit up and the gauge is enabled at the HMI panel, assume the shutter is open.

12.2.5. Stability Checks and Adjustments

The most important criteria for accurate operation are sensor stability. Check the input to the EDAQ from the receiver of the X-ray sensor with the shutter closed. With the shutter closed, the reading should be less than 20 mV and stable to 1 mV.

Monitor the high voltage inverter board on the receiver at TP2. The reading should be -350 V. Change the board if the voltage is unstable.

If the gauge is still unstable:

1. Replace or clean the receiver amplifier.
2. Replace the source controller PCB. If the problem remains, reinstall the original board.
3. Replace the source high voltage power supply. If the problem remains, reinstall the original board.
4. Replace the X-ray tube and solenoid assembly. If the problem remains, reinstall the original assembly.

CAUTION

When handling or working with the X-ray tube/solenoid, take great care to avoid damage. Never disconnect the high voltage to the X-ray tube with power on.

CAUTION

Fingerprints on the high mega ohm resistors can seriously degrade the performance of the detector amplifier PCB. The resistors cannot be successfully cleaned in the field. Wear rubber gloves or touch only the edges of the board when handling the printed circuit board.

5. Replace the ionization chamber.

12.2.6. Common Problems and Failure Modes for Q4237-57

Because the gauge is functionally identical to the other single ash gauges, the same failure modes may be expected.

The metal filter is thin and fragile. By removing the ash source nose piece it can be visually inspected. There should be no cracks.

13. Testing Specifications

The results described in this chapter should be obtained in the factory prior to installation in the scanner.

13.1. Receiver Output

The shutter open, flag out condition should be approximately 6–8 V.

The shutter closed output should be 2–20 mV DC with 5 mV peer-to-peer AC noise.

ATTENTION

The AC noise check should be made with the current-to-voltage amplifier metal dust cover in place.

Adjust cooling flow such that lower head internal average temperature is between 37–45 °C (98.6–113 °F).

13.2. Gauge Stability

Power should be supplied to the ash gauge for a minimum of 24 hours before any calibration or short-term stability is attempted. The gauge should be run with 24 V to the source and shutter open for at least 16 hours before a long term stability check is done.

13.2.1. Stability Specifications

- Long term (eight hours), σ will be ≤ 0.0005 on flag-to-air (F/A).

- Short term (30 consecutive references) σ will be $\leq$ 0.00015 on F/A.
- Stability should be run with the gap taped and no air perturbations (usually requires air temp sensor off).

If the gauge fails to pass the stability specifications, troubleshoot it until the problem is solved:

1. Ensure that the EDAQ card is functioning normally.
2. Switch out the control card.
3. Switch out the detector amplifier.
4. Ensure that the flag or shutter is functioning normally.
5. Remove the source and switch out the high voltage power supply.
6. Remove the source and switch out the tube.

14. Storage, Transportation, and End of Life

This chapter summarizes Honeywell policy with regards to the storage and disposal of the basis weight sources.

14.1. 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 14-1.

Table 14-1 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

14.2. 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 14.2.1, and 14.2.2.

14.2.1. 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)

14.2.2. Disposal of Radioactive Sources

Contact Honeywell Radiological Operations and they will advise and facilitate safe disposal.

14.3. 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 Radiological Operations.

The main contact numbers for Radiological Operations are as follows.

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

15. Glossary

Cable End	Location of the electronics and/or the entry point for communications and power on the scanner.
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.
C-frame	The C-shaped metal support for the sensor head.
Code or Code Name	See Recipe. Alternately, another name for alloy.
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.
Data Storage and Retrieval (DSR)	A mechanism provided in real-time application environment (RAE) for storing recipe- or grade-dependent data, such as tuning, calibration, and setup values, and retrieving them when a recipe is loaded. The recipe- or grade-dependent data are saved to a database known as the *Recipes* database.
Error Profile	A profile in cross direction bin resolution that is the difference between the target profile and the current profile of a measurement, both in cross direction bin resolution.
HMI/UPI	Human/machine interface. Interface at endbell for controlling sensors and scanner movement.
Machine direction	The direction in which paper travels down the paper machine.
Measurement Sub System (MSS)	CPU responsible for binning data before sending to the RAE server.
Motor End	Location of the motor on the scanner.
Quality Control System (QCS)	A computer system that manages the quality of the product produced.
Real-Time Application Environment (RAE)	The system software used by Experion MX to manage data exchange between applications.
Recipe	A list of pulp chemicals, additives, and dyes blended together to make a particular grade of paper. Also called codes.

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.
Tending Side (TS)	The side of the paper machine where the operator has unobstructed access. Also called front side.
Trend	The display of data over time.

A. Part Numbers

Table A-1 lists part numbers and descriptions for the ash measurement system.

Table A-1 Part Numbers

Part Number	Description
05277500	Detector amplifier
05410000	Receiver high voltage generation board
57000005	X-ray tube
6509888900	Upgrade kit to convert a dual ash gauge to a triple ash gauge
6581500030	EDAQ board
6581500003	X-ray tube current controller
6581500024	New model detector amplifier