Operating Manual

KJLC Element

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1 Disclaimers and Copyright

Disclaimer

The information contained in this manual is believed to be accurate and reliable. However, your distributor assumes no responsibility for its use and shall not be liable for any special, incidental, or consequential damages related to the use of this product.

Due to our continuing program of product improvements, specifications are subject to change without notice.

Copyright

2 Declaration of Conformity

EU Declaration of Conformity

We, Kurt J. Lesker Company, hereby declare that the equipment mentioned below complies with the provisions in the following standards and directives.

Product

Residual Gas Analyzer (RGA)
KJLC Element

Directives

- 2014/35/EU (LVD)
- 2014/30/EU (EMC)
- 2011/65/EU (RoHS)
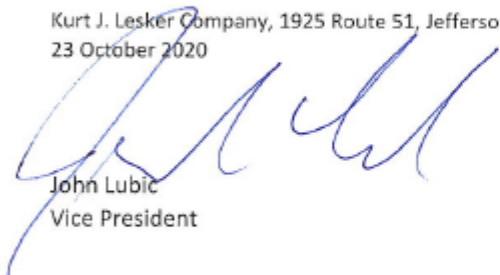
Standards

Harmonized and international/national specifications:

- Safety
    - EN 61010-2:2010 (Safety requirements for electrical equipment for measurement, control, and laboratory use
- Emissions:
    - EN 61326-1:2013 (Radiated and Conducted Emissions Class A: EMC – measurement, control, and laboratory equipment)
    - CISPR 11/EN 55011 Edition 2009-12 (Emission standard for industrial, scientific, and medical (ISM) radio RF equipment)
- Immunity:
    - FCC 47 CFR Part 18 Class A (emission requirement USA)
    - ICES-001 Issue 4 ISM (emission requirements Canada)
    - EN 61326-1:2013 (General EMC) Class A: Immunity per Table 2 (EMC – measurement, control and laboratory equipment)
- RoHS: Fully Compliant

Manufacturer / Signatures

Kurt J. Lesker Company, 1925 Route 51, Jefferson Hills PA 15025, USA
23 October 2020

John Lubic
Vice President

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3 Warranty

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No warranty is made by Seller of any Seller product which has been installed, used or operated contrary to Seller's written instruction manual or which has been subjected to misuse, negligence or accident or has been repaired or altered by anyone other than Seller or which has been used in a manner or for a purpose for which the Seller product was not designed nor against any defects due to plans or instructions supplied to Seller by or for Buyer.

This manual is intended for private use by KJLC and its customers. Contact your distributor before reproducing its contents.

4 Getting Started

This section explains how the KJLC Element produces measurements. For a discussion of how to interpret these measurements, see Applications Guide [⟩ 59].

4.1 Introduction

The gas analysis system is a quadrupole-based mass spectrometer residual gas analysis (RGA) instrument designed for use in high vacuum environments for monitoring trace contaminants and process gases. The KJLC Element can be operated using the onboard web server, LabView™, or via API commands.

This chapter provides an overview of the Element gas analysis system. Topics include: the purpose of the KJLC Element, its specifications, a list of supplied items, installation instructions and customer support contact information.

4.2 Using This Manual

Please read this Operating Manual before operating the KJLC Element.

4.2.1 Caution, Warning, and Note Paragraphs

The following Caution and Warning paragraphs are used to alert the reader of actions which may cause either damage to the instrument or bodily injury.

⚠ CAUTION

This is a Caution paragraph. It cautions against actions which may cause an instrument malfunction or the loss of data.

⚠ WARNING

This is a General Warning paragraph. It warns against actions which may cause bodily injury.

⚠ WARNING

This is an example of a Electrical Warning paragraph. It warns of the presence of electrical voltages which may cause bodily injury.

ⓘ This is a note. Notes provide additional information about the current topic.

4.3 How To Contact Customer Support

Contact the Kurt J Lesker Company for:

- technical support
- repair service

More information is available at www.lesker.com.

- data sheet / brochure
- operating manual
- frequently asked questions
- LabVIEW drivers
- 3D CAD models (.stp)
- instructional videos

If you are experiencing a problem with the KJLC Element, please have the following information readily available:

- the Element serial number
- a description of the problem
- an explanation of any corrective action already attempted
- the exact wording of any error messages

4.4 Quick Start

Read this operating manual in full prior to operating the KJLC Element. Then, follow the steps below to quickly start using the KJLC Element.

√ Ensure that all supplied items have been received. See Supplied Items [} 119].

 1   Install the hardware. See Hardware Installation [} 16].

 2   Install the communication cable. See Installing Ethernet Communications [} 22].

4.5 Purpose of the Gas Analysis System

The Element gas analysis system identifies and performs a quantitative analysis of residual gas species present inside a vacuum system. The sensor, a quadrupole mass spectrometer, analyzes gases by:

- ionizing some of the gas molecules
- separating the ions by their mass-to-charge ratio
- measuring the quantity of ions at each mass

  The ions exit the quadrupole at their specific mass-to-charge ratio and generate a signal at the detector which allows for qualitative identification of the gas species in the vacuum chamber. The magnitudes of these signals are proportional to the quantity of the respective gases present inside the vacuum system.

  The KJLC Element is an important aid for detecting leaks and contaminants in high-vacuum systems. The KJLC Element can indicate the abundance of process specific gases present within a vacuum or other vessel. It is used to investigate a process at a molecular level or to monitor process conditions.

4.6 General Description of the Instrument

Sensor

The sensor functions only in a high-vacuum environment with pressures below 5×10^{-4} Torr (6.7×10^{-4} mbar) [6.7×10^{-2} Pascal].

The sensor itself is comprised of three components:

- the ion source (ionizer)
- the quadrupole mass filter
- the ion detector

The sensor is mounted on an electrical feedthrough flange, which is bolted to the vacuum space where the gas analysis measurements are made.

Electronics module

The electronics module controls the sensor and communicates to the computer. The electronics module attaches to, and is supported by, the sensor.

The onboard web server

The onboard web server controls the electronics module and displays the data from the sensor.

4.7 Specifications

See Specifications [} 110] for Element specifications.

4.8 Supplied Items

See Supplied Items [} 119] for items that are packaged with an Element gas analysis system.

4.9 Physical Requirements

The following sections show the physical dimensions, weight, mounting requirements, ventilation requirements, and the perimeter required for maintenance access to the KJLC Element.

4.9.1 Physical Dimensions

The image below shows the overall physical dimensions for the KJLC Element.
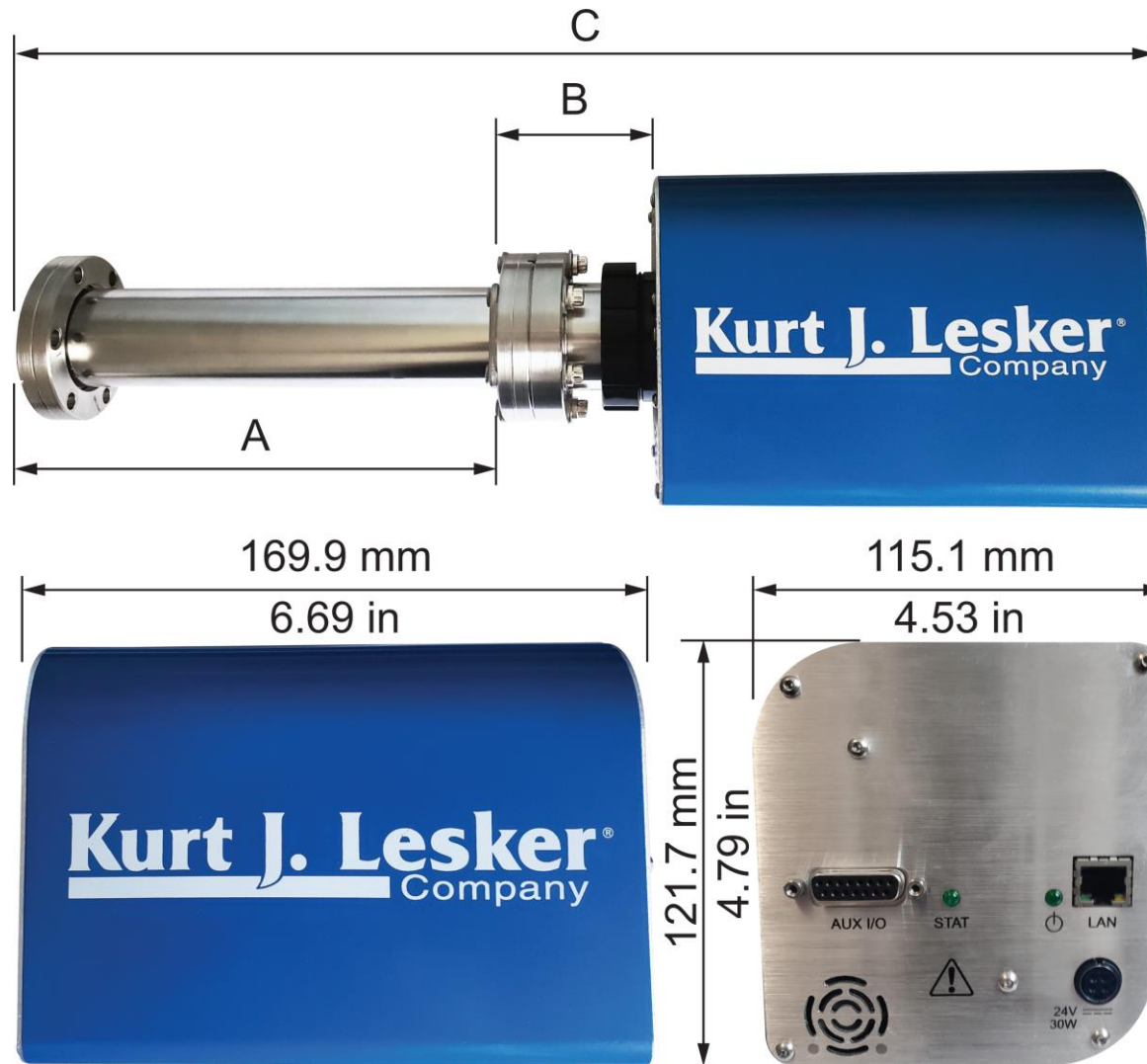
Element	(A)	(B)	(C)
100F, 200F	143 mm (5.63 in.)	50 mm (1.98 in.)	365.7 mm (14.40 in.)
100M, 200M	199 mm (7.83 in.)	50 mm (1.98 in.)	421.6 mm (16.60 in.)

4.9.2 Weight

The Element electronics module weighs 1.53 kg (3 lb. 6 oz.). The Element system's total weight depends on which sensors are used.

4.9.3 Mounting Requirements

The sensor is mounted to a high-vacuum chamber with a 69.9 mm (2.75 in.) DN40 ConFlat® flange with an extension tube with an outer diameter (O.D.) of 41.2 mm (1.62

KJLC

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in.) and an inner diameter (I.D.) of 38.1 mm (1.5 in.).

The electronics module attaches to, and is supported by, the sensor. The KJLC Element can be mounted in any orientation. Ventilation Requirements

At least 25.4 mm (1 in.) of open space around the KJLC Element electronics module must be maintained for proper ventilation.

4.9.4 Maintenance Access

Easy access to the KJLC Element should be maintained for installation and maintenance activities.

4.10 Electrical Power Requirements

The KJLC Element must be connected to a source of power as specified:

Required Supply Voltage	20 to 30 V (dc), 24 V (dc) typical
Current Rating	1.25 maximum
Electrical Connection	Latching, 4-pin DIN connector, internally isolated from system ground.

electrical connection

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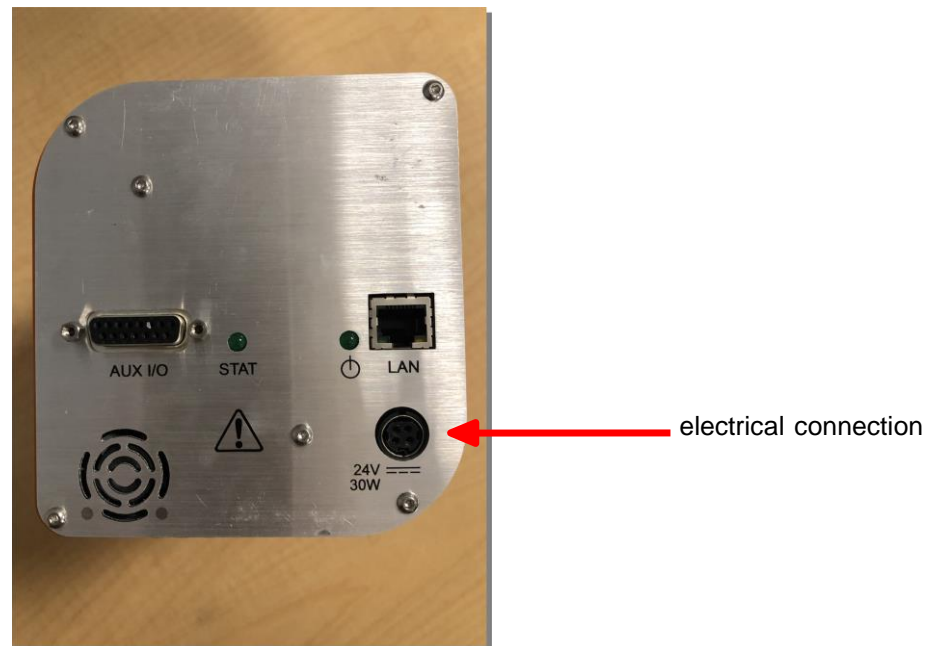
4.11 Overvoltage Category

The instrument is assigned overvoltage category II (per EN61010-1).

4.12 Required Vacuum

The required vacuum level is < 5 x 10^{-4} Torr (6.7 x 10^{-4} mbar) [6.7 x 10^{-2} Pascals]

4.13 Environmental Requirements

The following paragraphs explain the use, altitude range, humidity, pollution degree, and operating temperature for the KJLC Element.

Use   Element is designed for indoor use only.

Altitude Range   Element can be used up to a maximum altitude range of 2000 m (6561 ft.)

Pollution Degree   Pollution Degree 2 (per EN61010-1)

Operating Temperature   Element is designed to operate within a temperature range of 5°C to 50°C (41°F to 122°F).

Humidity   Element is designed to operate in an environment with up to 98% relative humidity.

4.14 Hardware Installation

Three pieces of hardware must be installed in the following order:
1   Install the sensor as explained in Sensor Installation [⟩ 17].

2   Install the electronics module as instructed in Electronics Module Installation [⟩ 20].

3   Install the communications cables from the computer to the electronics module as explained in Installing Ethernet Communications [⟩ 22]

4.14.1 Sensor Installation

⚠ **CAUTION**

Do not touch any surface on the vacuum side of the sensor with bare fingers.

If it is necessary to touch any of these parts, always wear clean linen, nylon, powder free latex or vinyl laboratory gloves.

Before installing the sensor on your system, check for any signs of loose or broken parts.

Do not attempt to clean the sensor in any kind of solvent. Cleaning the sensor requires its disassembly. If the sensor is contaminated and needs cleaning, contact your distributor.

4.14.1.1 ConFlat Flanges

The sensor is installed on a vacuum system with a 2.75 in. DN40 ConFlat flange. ConFlat flanges, and similar compatible types made by other manufacturers, are used for attaching devices to ports on high vacuum systems. If there are no concerns with the installation of this type of flange, proceed to Attach the Sensor to the Vacuum Chamber [} 19].
If the system does not have a port with a compatible mating flange, an adapter is necessary.

To install these flanges without leaks, follow the operating procedures. The flanges are sealed with a metal gasket and can be heated for bakeout to temperatures of up to 300°C. For the correct bakeout temperature when a sensor is installed, see the table in Attach the Sensor to the Vacuum Chamber [} 19].

4.14.1.1.1 Assembling ConFlat Flanges

To assemble a pair of ConFlat flanges:

1   Wipe the sealing areas of the flanges with a laboratory towel using a clean solvent, such as water-free alcohol. The sealing areas must be clean and free of particulate matter.

⚠   **CAUTION**

Do not touch the gasket and flange faces with your fingers during the installation process.

2   Install the copper gasket between the two flanges. Always use a new gasket. Do not attempt to use gaskets more than once.

flange

copper gasket
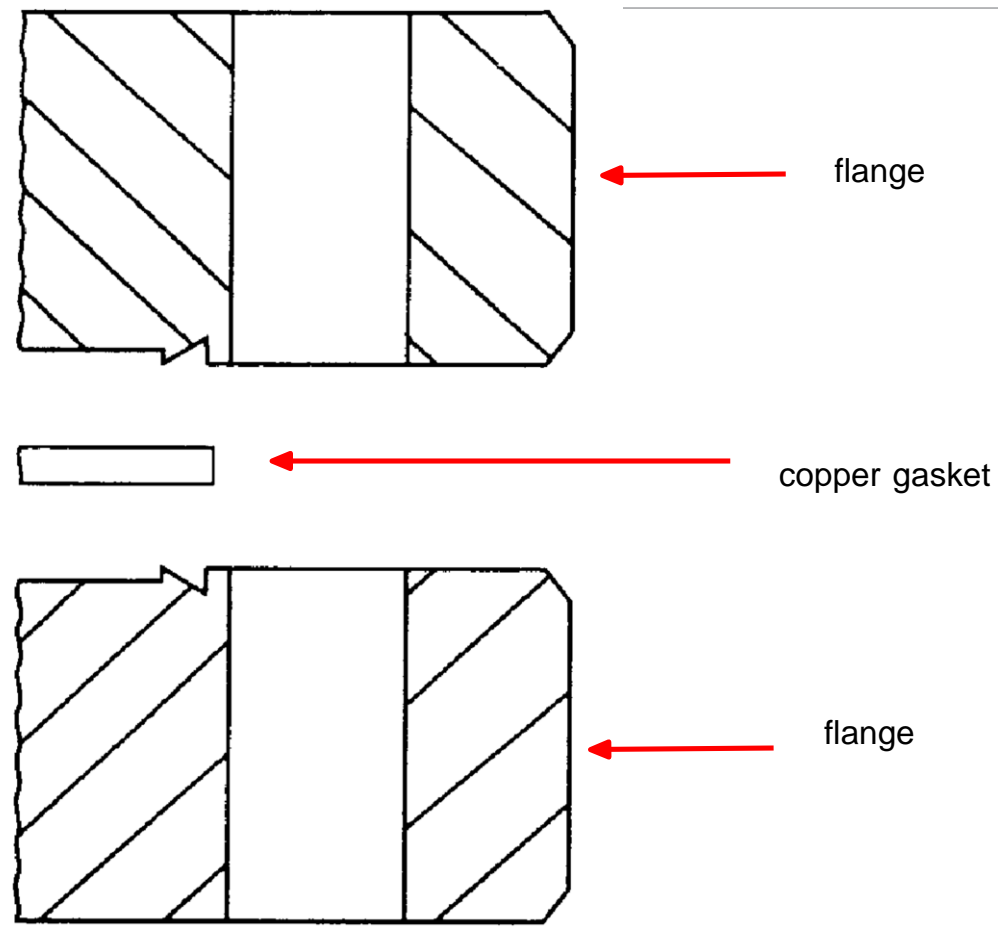
flange

3   Bring the two flanges together making sure that the gasket fits in the recess in both flanges. Flange faces should be parallel. If the gasket is properly seated, it should not be possible to slide the two flanges laterally with respect to each other.

4   Install the supplied silver-coated stainless steel bolts into the bolt holes of the flanges and finger-tighten.

    ð If the factory-supplied silver-coated stainless steel hardware is not used and the flanges are going to be baked, coat the bolt threads with an anti-seize compound (FelPro® C 100 or equivalent).

⚠ **CAUTION**

Do not get any of the anti-seize compound on the gaskets or vacuum parts of

the flange.

5 After the bolts have been finger-tightened and the flange faces are parallel,

tighten the bolts, gradually and evenly, in a star pattern, until the flange faces are

brought into even contact with each other.

4.14.1.2 Attach the Sensor to the Vacuum Chamber

The sensor may be mounted in any orientation when attaching it to the vacuum vessel
or chamber.

> ⚠ **CAUTION**
>
> Avoid mounting the sensor near any magnetic fields greater than two gauss.

It is important that the connection between the sensor and the vacuum
chamber does not interfere with gas exchange to ensure that the gas
composition accurately reflects that which exist in the vacuum chamber.

If materials are evaporated or coatings are deposited in the vacuum chamber,
the sensor must be protected against the deposition of these materials on its
surfaces by installing a baffle or deflector.

In systems which are baked, include the sensor in the bakeout zone or provide
it with separate heaters.

Dimensions of the quadrupole sensors are shown below.

249.1 mm (9.81 in.)

193 mm (7.83 in.)

LIN100M, LIN200M

198.9 mm (7.61 in.)

143 mm (5.63 in.)

LIN100F, LIN200F

The sensor is shipped inside an extension tube with a 38.1 mm (1.5 in.) ID. This tube
attaches the sensor to your vacuum chamber. The part number for the 203.2 mm (8
in.) long extension tube kit is KJL-RGA-EXTKIT.

⚠ **CAUTION**

The silver-plated bolts used for mounting the sensor to the vacuum system

must be oriented such that the bolt heads are on the same side of the sensor as the electronics box. Otherwise, there may be interference between the black mounting nut and sensor mounting hardware.

⚠ **CAUTION**

The maximum bakeout temperature for sensors is shown below.

Sensor	Maximum Operating Temperature	Maximum Bakeout Temperature Electronics Removed
ELE100F/200F	200°C	300°C
ELE100M/200	150°C	300°C

⚠ **CAUTION**

The Element electronics module must be removed prior to bakeout at

temperatures greater than 200°C (FC).

Do not turn on the electron multiplier (EM) at sensor temperatures above 150°C. Turning on the EM at an elevated temperature could result in permanent damage to the detector.

⚠ **WARNING**

During or immediately after bakeout, the heating jacket and metal surfaces in

the vicinity of the heating jacket may be extremely hot. These surfaces may exceed 100°C at the maximum ambient operating temperature (50°C), which will cause burns if touched directly without using the proper personal protection equipment.

4.14.2 Electronics Module Installation

The Element electronics module must be mounted in an area where the ambient temperature does not exceed 50°C and there is free air circulation around the electronics module. Best performance is achieved if the electronics module is not located close to major heat sources where it is subjected to wide temperature variations.

After the sensor has been installed on the vacuum system, the Element electronics module must be mounted on the sensor:

1 The Element sensor mounting connector assembly includes a mounting nut and
   an O-ring. When the mounting nut is tightened, the O-ring compresses, making a
   tight fit on the sensor housing. For proper installation, place the nut over the end
   of the sensor and roll the O-ring back to the groove on the sensor.

2 Note the recessed area on the sensor feedthrough and the ground tab on the
   Element electronics module. Match the recessed area of the feedthrough to the
   ground tab and carefully slide the Element electronics module onto the sensor.
   Ensure the Element electronics module slides on fully.

3 Hand-tighten the mounting nut on the Element sensor.

4 Continue to the next section for instructions regarding installing the
   communications cable.
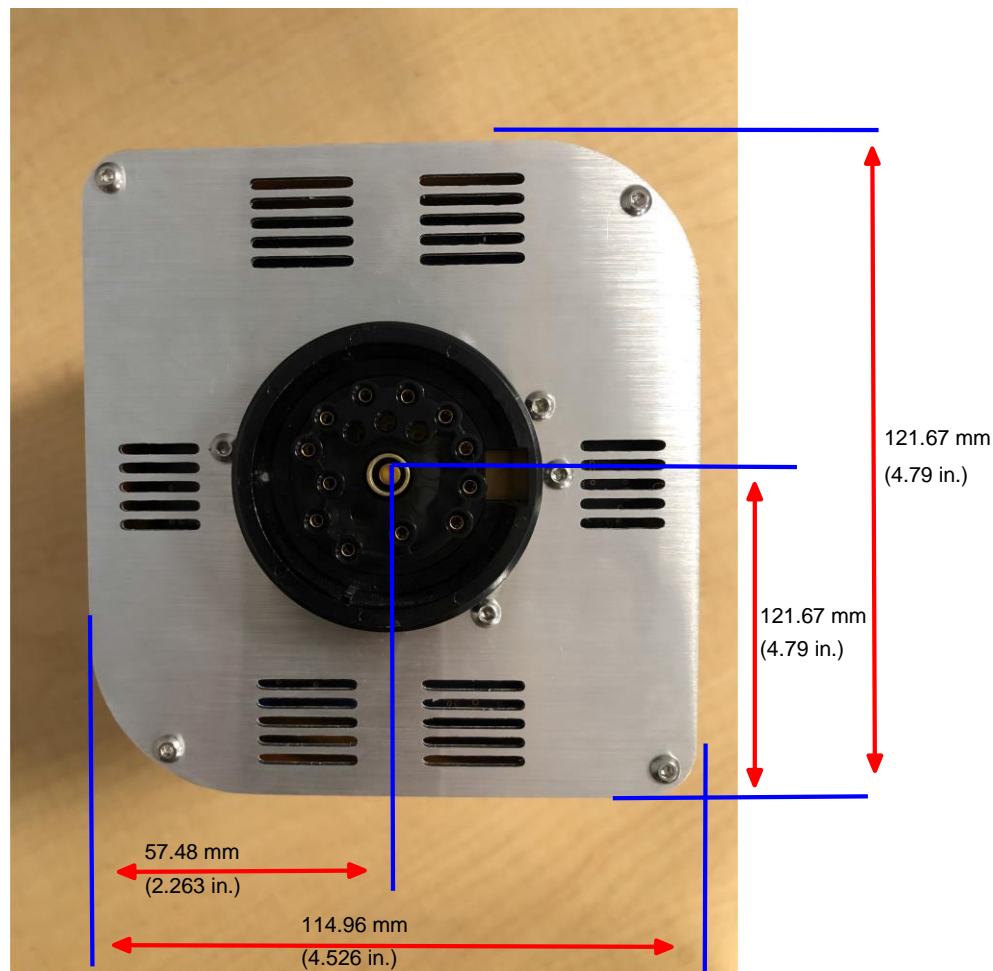
See also

4.14.3 Installing Ethernet Communications

Ethernet communication is the default communication method for the KJLC Element. Ethernet communication uses standard RJ45, Cat5e Ethernet cables. To use Ethernet communications, attach the supplied Cat5e Ethernet cable to the LAN port on the back of the Element electronics module.

For networking information, see Connecting Your Instrument [} 25]

Ethernet port
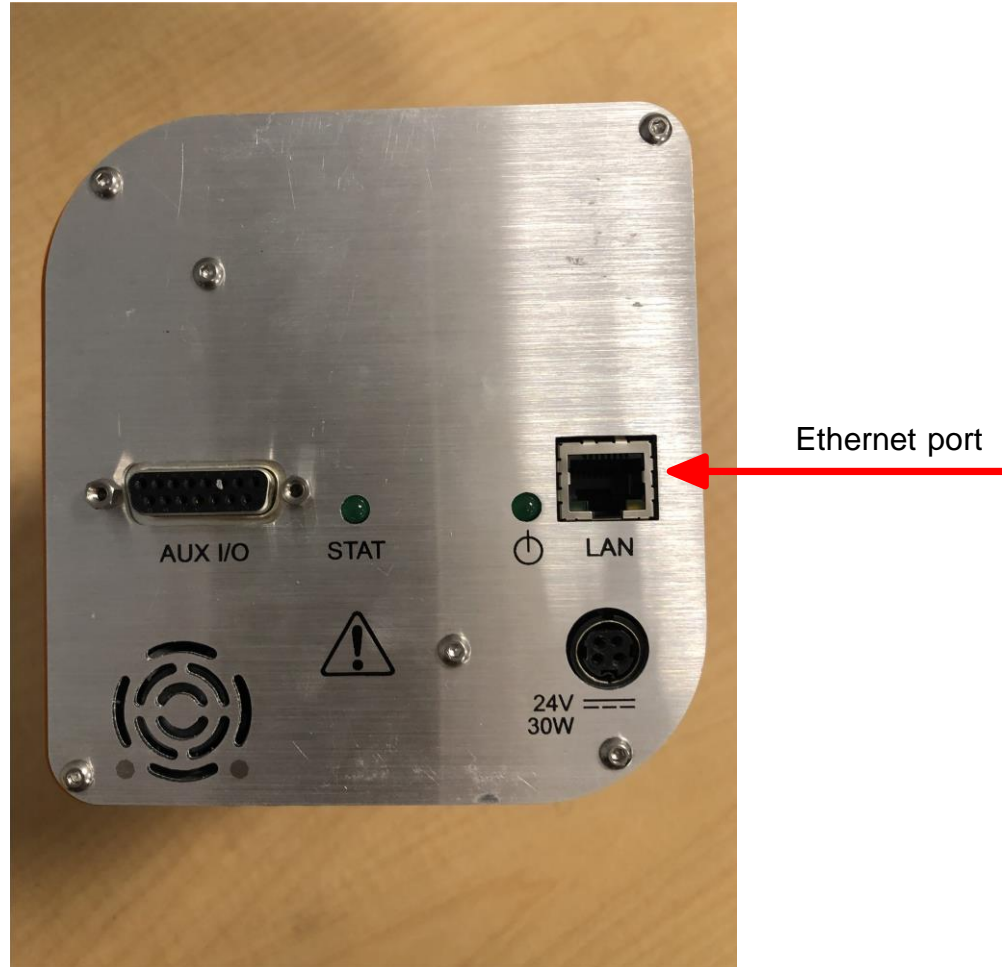
4.14.4 Connecting the 24 V(dc) Power Supply

1 Connect the +24 V (dc) power supply cable to the 24V connector on the Element electronics module by sliding back the latch, installing the cable, and then releasing the latch.

ð The latch locks the connector to the electronics module, and must be slid back to detach the cable from the Element electronics module.

2 Plug the AC line cord into the mating IEC320 connector on the power supply module.ð The AC line input for the +24 V(dc) power supply must be rated: 90-260 V(ac), 40 W maximum, 47-63 Hz.

3 Plug the AC line cord into an appropriate AC outlet.

4 Verify that the green power indicator on the Element back panel is illuminated. If

the green indicator is not illuminated, check the power connections.

4.15 Input/Output (I/O)

This section describes the input and output (I/O) for the KJLC Element.

The Element electronics module supports the following I/O functions through the auxiliary (AUX) I/O connector located on the back panel.

4.15.1 Two Digital Inputs

Logic Inputs 1 and 2 are by default set to remotely control emission status. Connecting Pin 14 (Logic Input 1) to Pin 15 (Ground) turns on the emission. Connecting Pin 13 (Logic Input 2) to Pin 15 turns off the emission.

Emission ON	PIN 14
Emission OFF	PIN 13
GND	PIN 15

⚠ **CAUTION**

Controlling the emission through the digital inputs bypasses all the onboard

web server or hardware interlocks. When using digital inputs for controlling the Element emission, develop an interlock that will not allow the emission to turn on if the pressure is too high for operation of the Element.

4.15.2 One Status Relay Output

One status relay output is active (closed) when the emission is on.

EMISSION ON	Relay closed. PIN 2 and PIN 1 connected
EMISSION OFF	Relay open
CONTACT RATING	24 V(dc) at 0.5 A

PIN 1   RELAY COMMON
PIN 2   RELAY NORMALLY OPEN
PIN 3   RELAY NORMALLY CLOSED
PIN 4   RESERVED
PIN 5   RESERVED
PIN 6   RESERVED
PIN 7   +24V AUX RET
PIN 8   +24V AUX VS
PIN 9   ANALOG IN+
PIN 10 ANALOG IN-
PIN 11 RESERVED
PIN 12 RESERVED
PIN 13 REMOTE LOGIC 2 (EMISSION OFF)
PIN 14 REMOTE LOGIC 1 (EMISSION ON)
PIN 15 GROUND

AUX I/O

AUX I/O   STAT   LAN

PIN 1 TD+
PIN 2 TD-
PIN 3 RD+
PIN 4 +3.3V
PIN 5 +3.3V
PIN 6 RD-
PIN 7 NO CONNECT
PIN 8 CHASSIS GROUND

+24V

LAN

PIN 4 +24V
PIN 3 -24V

+24V

PIN 1 +24V RETURN
PIN 2 -24V RETURN

4.15.3 One Analog Input

The analog input is supported through the onboard web server.

One analog input is differential and can handle inputs between 0 to +10 volts and common mode voltages of 100 volts.

ANALOG INPUT 1	(+)	PIN 9
ANALOG INPUT 1	(-)	PIN 10

5 Connecting Your Instrument

5.1 Introduction

The Element uses Ethernet as its default communications method. The Element has an IP address and a MAC address.

IP addresses are used as a means of identifying individual devices on a network. IP addresses are unique on a network but not universally, meaning that only one device on a network can have a specific IP address but two devices on separate networks can have the same IP address.

MAC addresses are another identifier that are unique for each device. MAC addresses are never duplicated. The onboard web server uses IP addresses to locate and identify sensors on a network.

5.2 General Networking Information

This section discusses some of the general networking variables that affect the connection of the Element.

5.2.1 IP Addresses

IP addresses can be set either manually or automatically.

- Static (manual) IP addresses are set by the user and can be manually changed by the user.
- Dynamic (automatic) IP addresses are automatically set by a host.

KJLC recommends using Static IP addresses for the Element, but allows for dynamic IP addresses set through DHCP (dynamic host communication protocol).

When using static IP addresses, a block of addresses should be reserved for static use and prohibited from being assigned by the DHCP server (host). This avoids duplicate IP address conflicts.

⚠ **CAUTION**

Since the onboard web server uses the IP address to identify each connected

Element, the IP address must not change during operation of the Element.

Using DHCP, the host may generate a new IP address every time the Element is taken offline and then returns online.

DHCP may also change the IP address automatically if there is an IP address conflict on the network.

If the Element IP address is randomly changed during data acquisition, the onboard web server will not automatically reconnect to the Element sensor because it does not know the newly assigned IP address. This leads to loss of communication and loss of data.

Static IP addresses do not change unless the IP address is manually changed. Static IP addresses help protect the Element from losing communication and data.

The Element uses IPv4 IP addresses. IPv4 IP addresses consist of 32 bits that are traditionally displayed in dot-decimal notation, which consists of four decimal numbers, each ranging from 0 to 255, separated by dots. An example of an IP address in dot-decimal notation would be 192.168.1.100. Each part represents an octet. Normally, the IP address consists of a network prefix and a host protocol.

5.2.2 Subnetworking

A subnetwork (or subnet) is a logically visible subdivision of an IP (internet protocol) network. Splitting an IP network into multiple subnets is referred to as subnetting. Subnetting sets the region of the IP address that will be used as a network prefix for all IP addresses inside of a subnet. This is accomplished through a subnet mask. Different types of subnet masks and their implications to IP addresses are shown below.

	Example 1	Example 2	Example 3
IP address	192.168.1.104	192.168.1.105	192.168.1.150
Subnet mask	255.255.255.0	255.255.0.0	255.255.255.192
Network profile	192.168.1.0	192.168.0.0	192.168.1.128
Host protocol	0.0.0.104	0.0.1.105	0.0.0.22

As seen in the table above, the subnet masks determine which octets of the IP address are used as the network prefix.

In order for two network devices to communicate, they must be on the same subnet. This means that they must not only be connected to the same internet network, but must also have the same network prefix. If two devices have two different network prefixes, this means that the two devices are on different subnets.

5.3 IP Address

By default, the Element ships with an IP address of 192.168.1.100 with a subnet mask of 255.255.0.0.

When connecting the Element to an existing local network, there must be a static IP address for each Element being installed. Contact the network administrator for IP address assignments.

5.3.1 Changing Instrument IP Address

You may change either the RGA's IP address or the computer's IP address. The RGA's IP address can be changed using the onboard web server. For instructions on how to change the RGA's IP address, refer to the onboard web server.

5.3.1.1 Changing the Computer IP Address

An alternative to changing the the Element's IP address is to change the host computer's IP address to allow for communication between the host computer and the Element. To change the computer's IP address, follow these instructions:

5.3.1.1.1 Windows 10 Instructions

Changing the IP address of the host computer requires administrator rights. You will need to use an administrator account to change the IP address.

1 Click Start to display the Start menu, then click Settings. Start is located on the taskbar on the Windows 10® desktop.
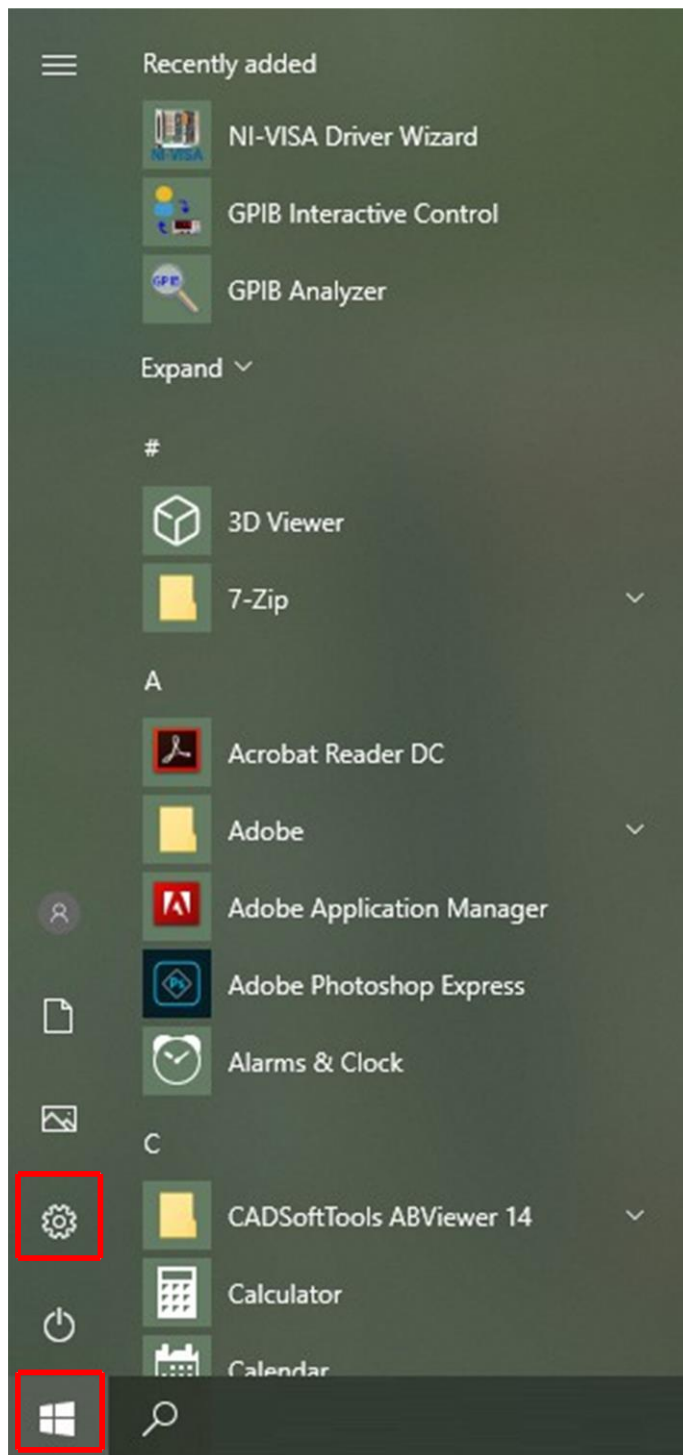
2 In the Settings window, click Network & Internet.
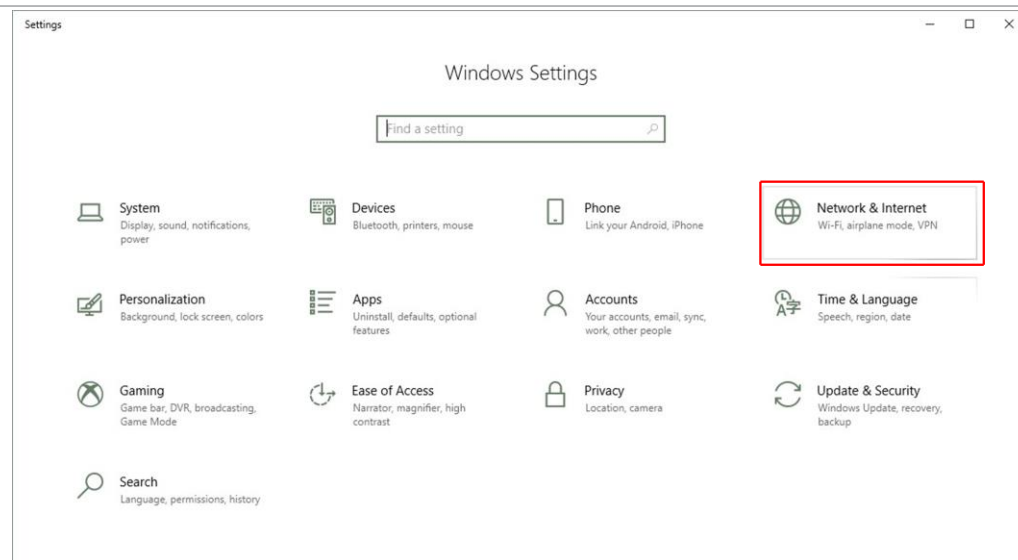
3   In the next window that appears, click Change adapter options.

4   If the host computer is connected to the Element through the Ethernet port of
    the computer, right-click Local Area Connection and select Properties.

5   Select Internet Protocol Version 4 (TCP/IPv4), then click Properties.

6 In the TCP/IPv4 properties menu, select Use the following IP address.

7 In IP address: type 192.168.1.XXX. The last octet can be any number as long as it is unique to the network.

8 In Subnet mask: type 255.255.0.0.

9 Click OK.

10   The IP address is now set to the manual IP address chosen in step 7. Exit all of the menus and then connect to the Element.

11   To change the IP address back to its default settings, follow steps 1 through 6 and return the IPv4 properties to their original settings.

5.3.1.1.2 Windows 7 Instructions

Changing the IP address of the host computer requires administrator rights. You will need to use an administrator account to change the IP address.

1   Click Start to display the Start menu, then click Control Panel. Start is located on the taskbar on the Windows 7 desktop.
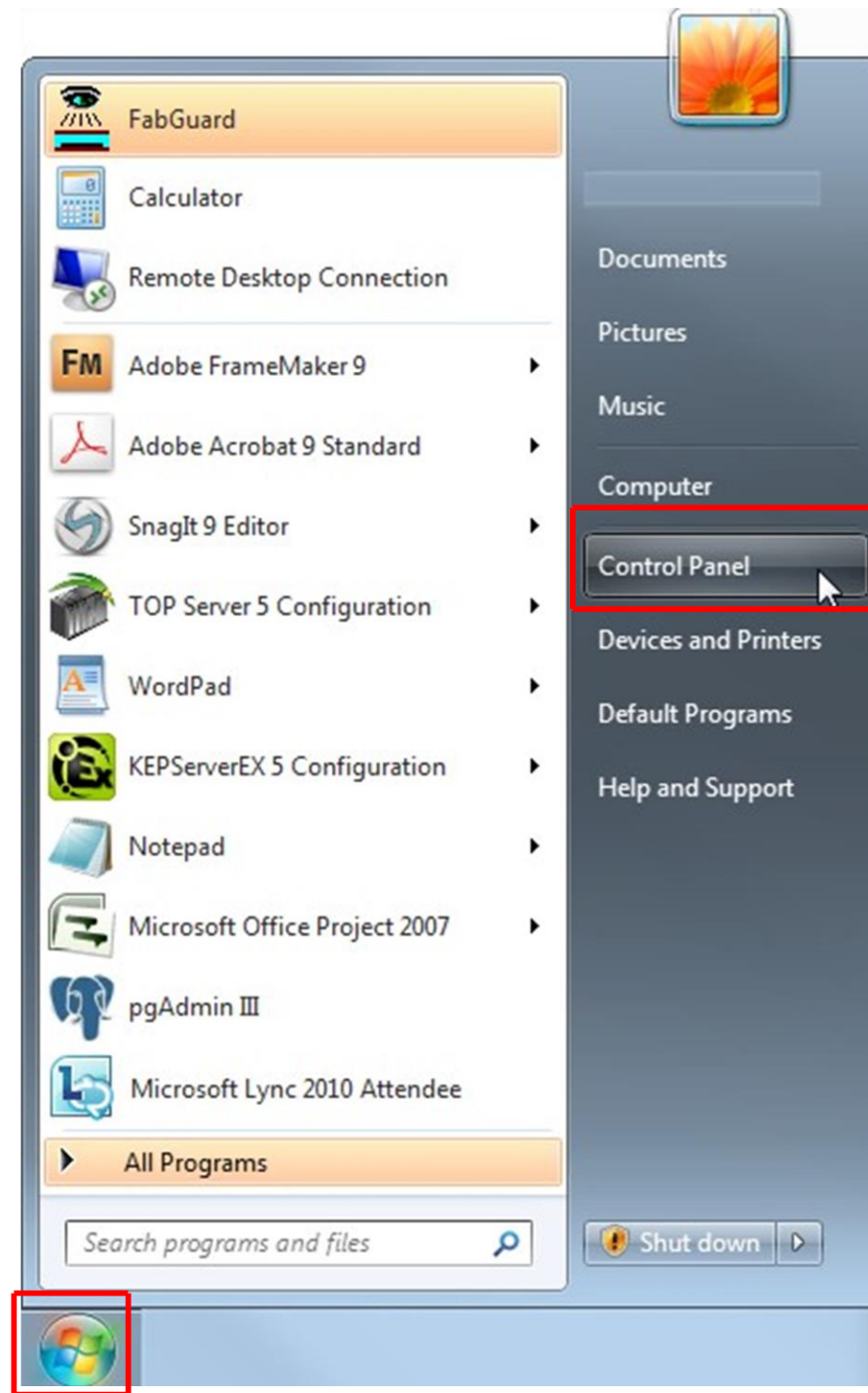
2   In the Network and Internet group, click View network status and tasks.
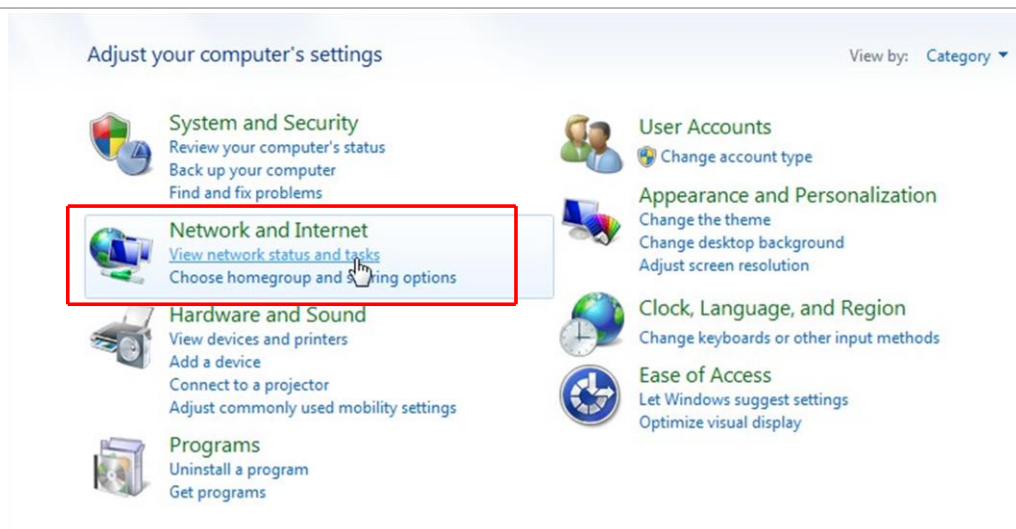
3   On the network status and tasks window, click Change adapter settings.


4   If the host computer is connected to the Element through the Ethernet port of
   the computer, right-click Local Area Connection and select Properties.

5   Select Internet Protocol Version 4 (TCP/IPv4), then click Properties.

6 In the TCP/IPv4 properties menu, select Use the following IP address.

7   In IP address: type 192.168.1.XXX. The last octet can be any number as long as
    it is unique to the network.

8   In Subnet mask: type 255.255.0.0.

9   Click OK.

10 The IP address is now set to the manual IP address chosen in step 7. Exit all of the menus and then connect to the Element.

11 To change the IP address back to its default settings, follow steps 1 through 6 and return the IPv4 properties to their original settings.

5.3.1.1.3 Windows XP Instructions

1 Click Start to display the Start menu, then click Control Panel. Start is located on the taskbar on the Windows XP desktop.
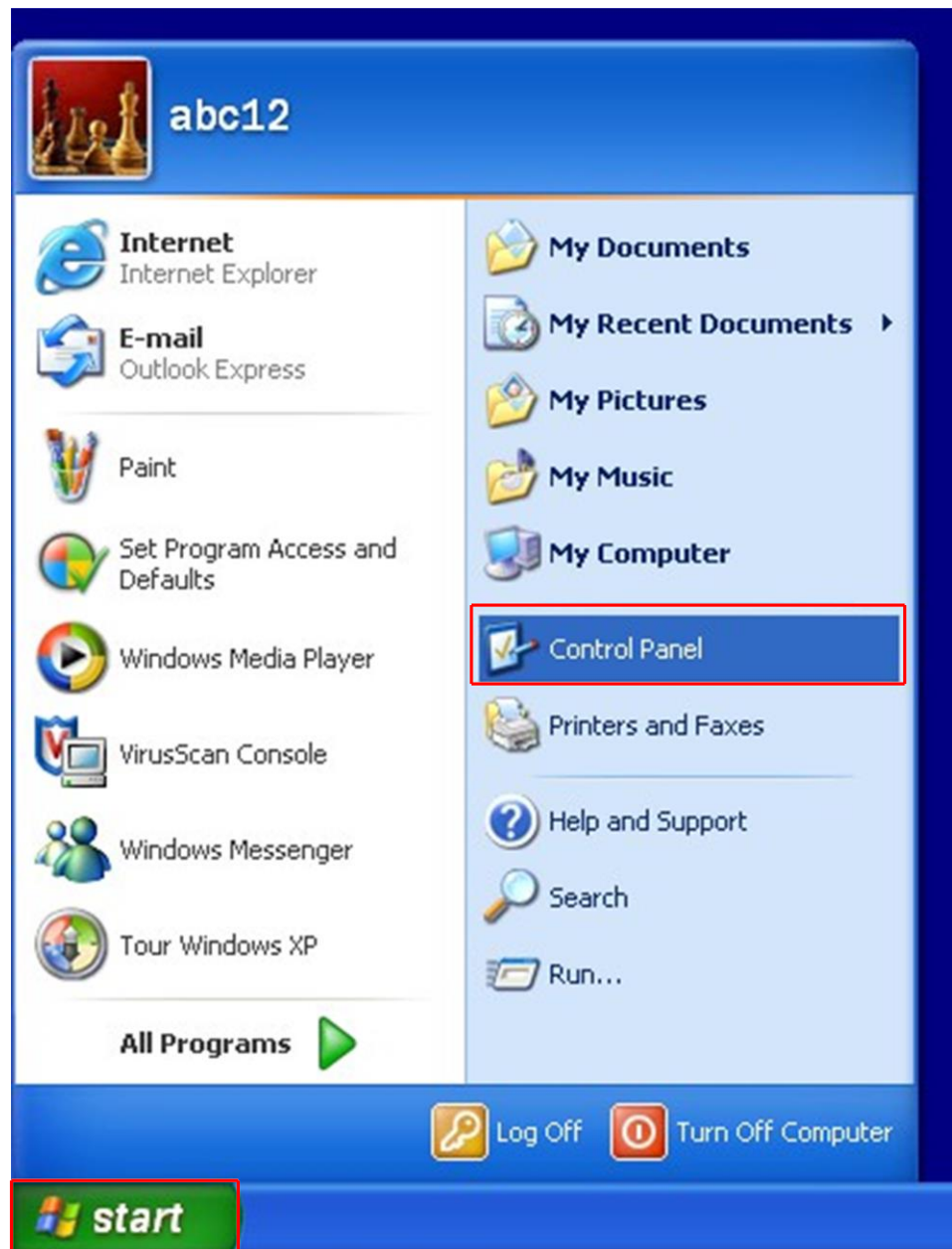
2 On the Control Panel, click Network and Internet Connections.
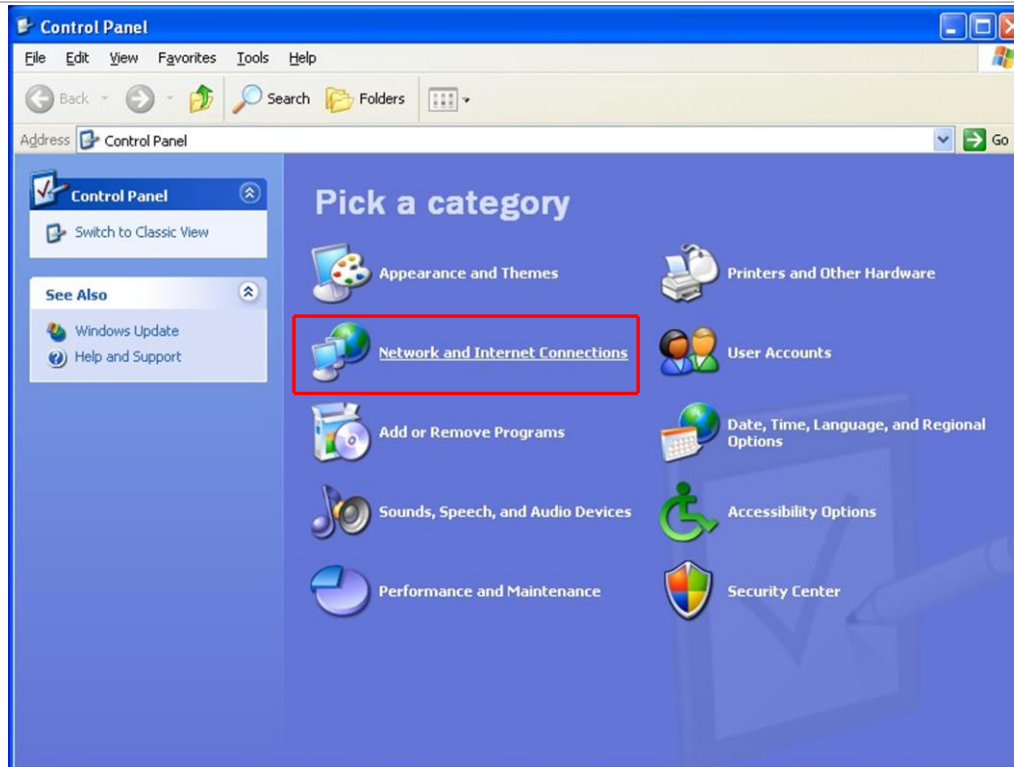
3   In the Network and Internet Connections window, click Network Connections.
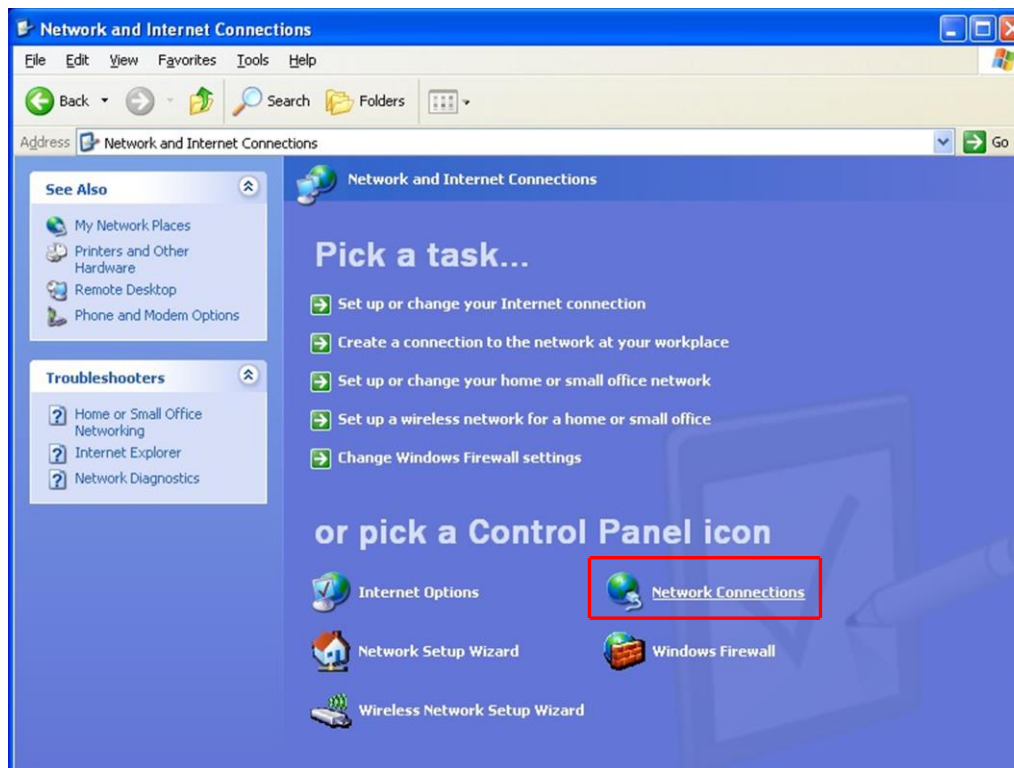
4   Double-click the Local Area Connection icon.

ð The icon may have a number after it if more than one connection has been
installed. Make sure to choose the correct Local Area Connection.
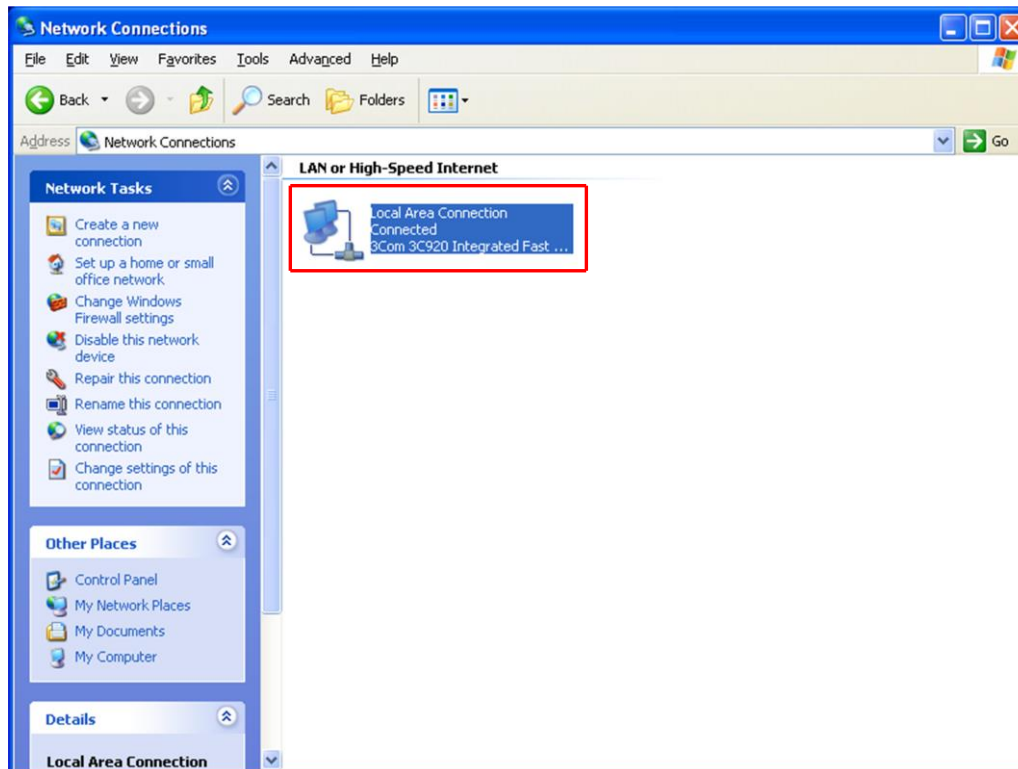
5 Click Properties.
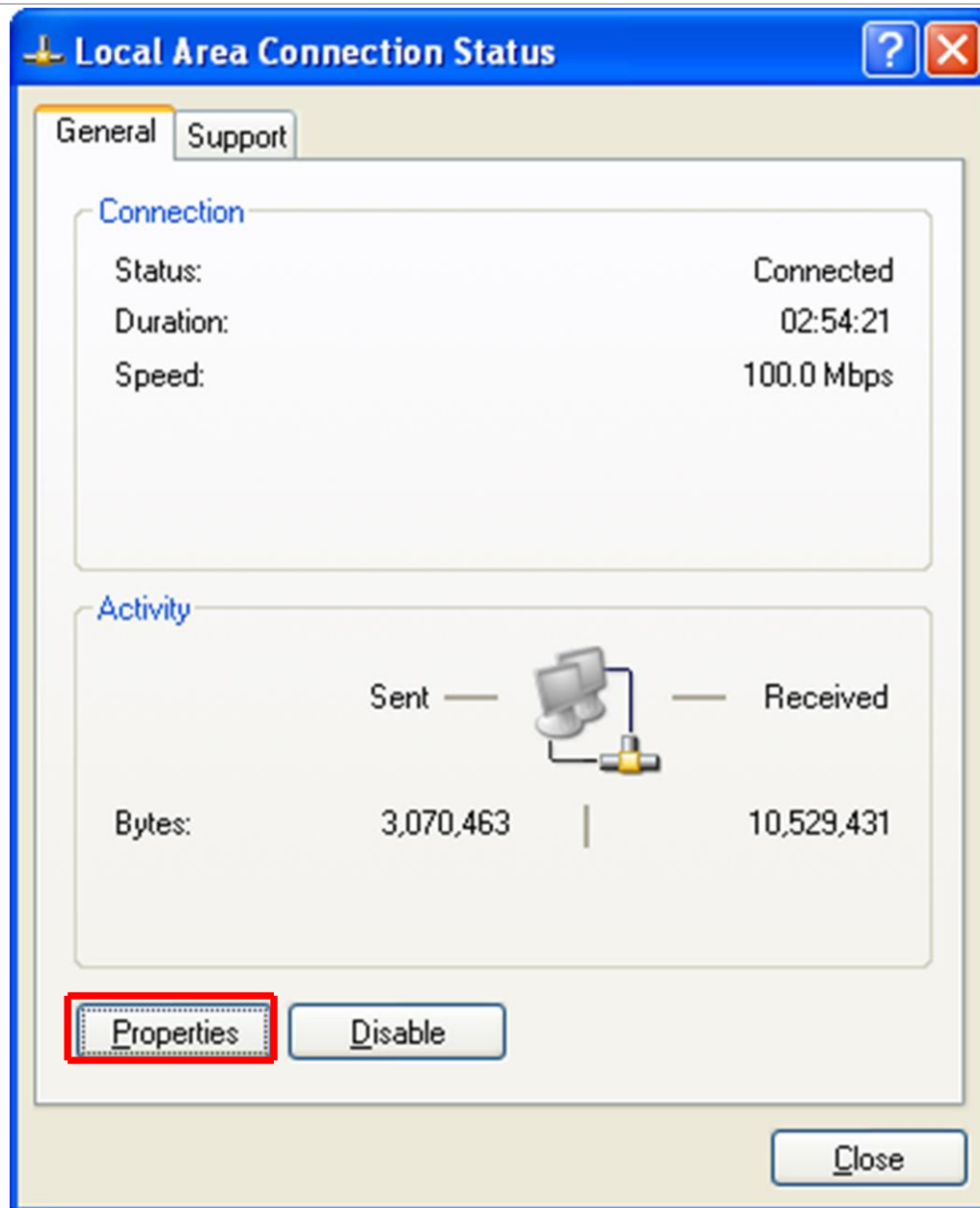
6 Select Internal Protocol (TCP/IP), then click Properties.
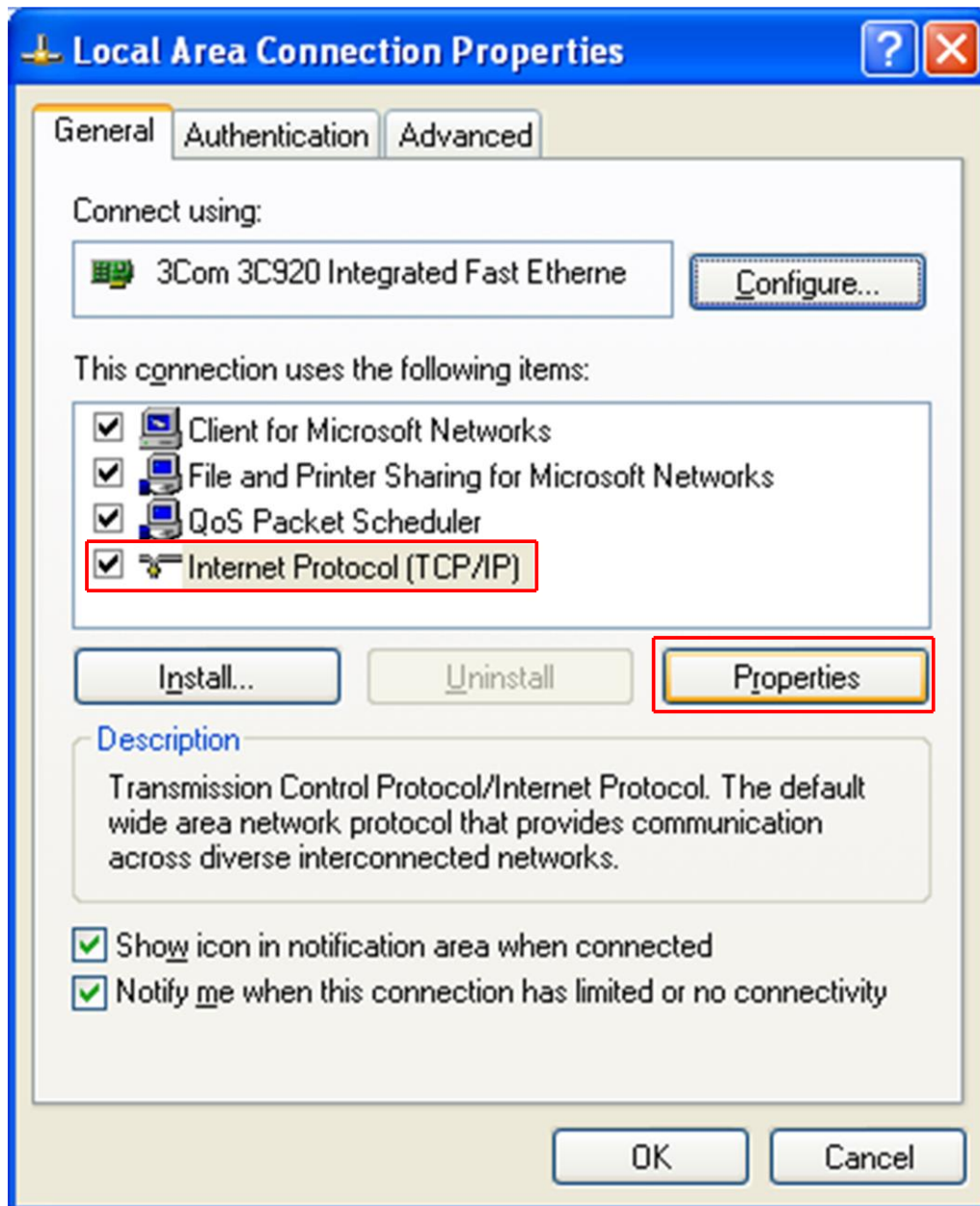
7   Select Use the Following IP Address and enter in the desired IP address, then
    click OK.
    ð The IP address updates.
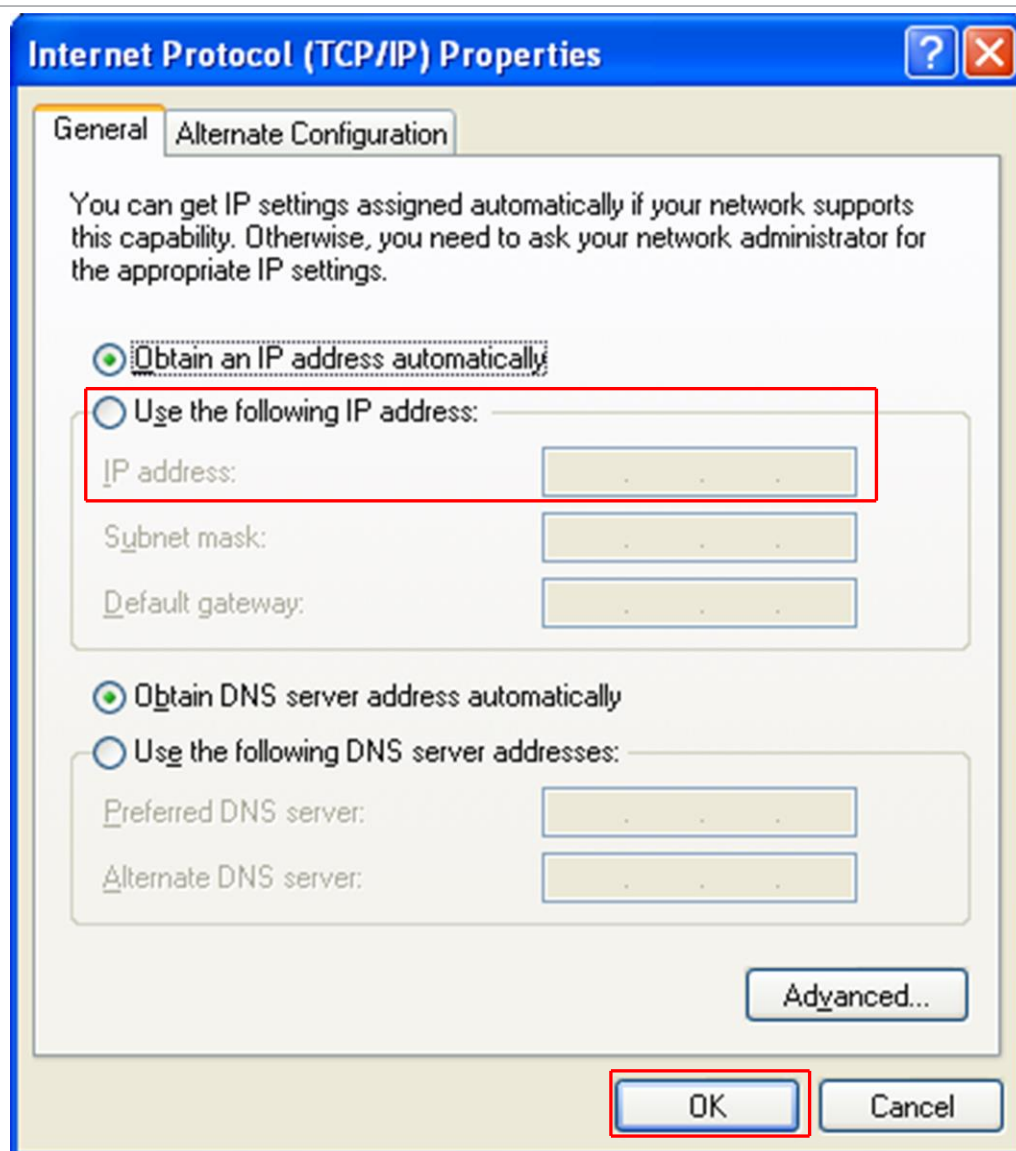
5.4 Connecting The Instrument

Before connecting Element, decide:
Is the Element going to be set up on:

- a private network (installed directly onto either a computer or a router that is not hooked up to the internet), or

- an internal network where multiple computers are connected with access to the internet?

Is more than one Element sensor being installed at the same time?

5.4.1 Connecting a Single Instrument

5.4.1.1 Single Instrument Direct Connection Installation

When installing a single Element on a private network, or directly connecting it to a computer, changing the IP address of the Element is only necessary if the computer being used to connect to the Element has a different network prefix than the Element.

The network prefix of the Element is 192.168.x.x. The IP address of the host computer used to control Element must have a subnet mask of 255.255.0.0 and a network prefix of 192.168.x.x.

If this is not the case, change the computer IP address to match the network prefix of the Element. For example, giving the computer an IP address of 192.168.1.101 allows the Element to communicate directly with the computer. Refer to Changing the Computer IP Address [} 27].

5.4.1.2 Installing a Single Instrument on an Existing Local Network

When installing a single Element on an existing local network, the default IP address of the Element may not be compatible with the network.

The Element can have either a static IP address (*recommended*) or a dynamic IP address set by DHCP (*not recommended*).

Contact your network administrator for information regarding valid IP addresses and have them assign an IP address for the Element. See Changing Instrument IP Address [} 27].

5.4.2 Installing Multiple Sensors

Since each Element is shipped with the same default IP address, the IP address of each Element must be changed one at a time so that each sensor has a unique IP address. See Changing Instrument IP Address [} 27].

⚠ **CAUTION**

Do not connect multiple Element sensors to a network at the same time

without first changing the IP addresses. Since the IP addresses are not unique, connecting multiple units at the same time causes IP address conflicts on the network.

5.4.2.1   Installing Multiple Instruments Directly to a Host Computer

If multiple Element sensors are to be connected to a single host computer, and not to an existing local area network, a private local network must be created. Element will have to be installed on either a router or Ethernet switch. The router or switch is then connected to the host computer through the LAN port of the router/switch.

5.4.2.2   Installing Multiple Instruments on an Exisiting Local Network

If multiple Element sensors are to be connected to an existing local network, use an Ethernet switch instead of a router.

Routers can cause conflicts with local networks because the router attempts to set IP addresses for all network connected devices.

Since Element sensors are network connected devices, each sensor must have an IP address assigned to it by a network administrator. After changing each IP address manually, connect all of the sensors to the Ethernet switch and connect the switch to the local network.

6 How The Instrument Works

6.1 Introduction

This section explains how the Element produces measurements. For a discussion of how to interpret these measurements, see Applications Guide [} 59].

6.2 Overview

The Element gas analysis system is a quadrupole based residual gas analyzer which analyzes the presence and relative abundance of gases in a mixture. The Element gas analysis system consists of three parts:

- a sensor, which functions only in a high-vacuum environment
- an electronics module, which operates the sensor
- an onboard web server, which controls the electronics module

ℹ A high-vacuum environment correlates to pressures below or approximately 5 x 10^{-4} Torr (6.7 x 10^{-4} mbar) [6.7 x 10^{-2} Pascals].

By attaching the sensor to a small vacuum system with a suitable controlled leak or other gas-inlet device, the Element Gas Analysis System can measure gases or volatile materials at pressures higher than those at which the sensor itself can operate.

The Element sensor analyzes gases by:

- ionizing some of the gas molecules (in the ion source)

- separating the ions by their mass-to-charge ratio (m/z) (in the quadrupole mass filter)

- measuring the quantity of ions at each mass (in the detector)

The masses and their fragmentation patterns, unique for each substance, can be used to identify the gas molecules from which the ions were created. The magnitudes of these signals are used to determine the relative abundance of the respective gases.

The sensor consists of three main parts:

- ion source (ionizer)
- quadrupole mass filter
- ion detector

These parts are mounted on an electrical feedthrough flange, bolted to the vacuum space where the gas analysis measurements are made.
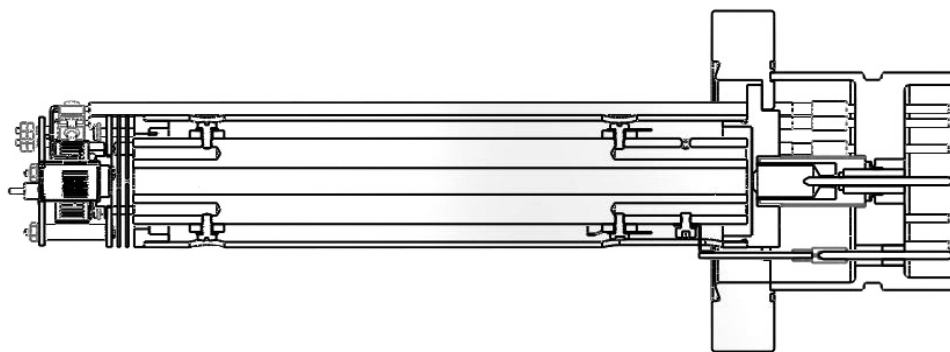
The sensor works only in a high-vacuum environment because the ions, once created, must not collide with neutral gas species or the walls of the ion source. Otherwise, they cannot be detected. At low pressure, the total flight path of the ions is long enough to pass through the quadrupole without collisions.

6.3 The Ion Source

The ion source of the Element is optimized for detecting residual gases in a vacuum system. The sensor has an open construction that facilitates the flow of gas species into the ionization region. The figure below shows the open ion source in more detail.

Inside the ion source, a large current is put through a filament. This current heats the filament and causes it to emit electrons, which collide with the gas species forming ions. Once a gas specie is ionized, electric fields can be used to manipulate it.

The ions formed in the ion source result from the loss of electrons and thus are positive in charge.

electron repeller   filament (cathode)

focus lens

source exit lens

anode (with cage)
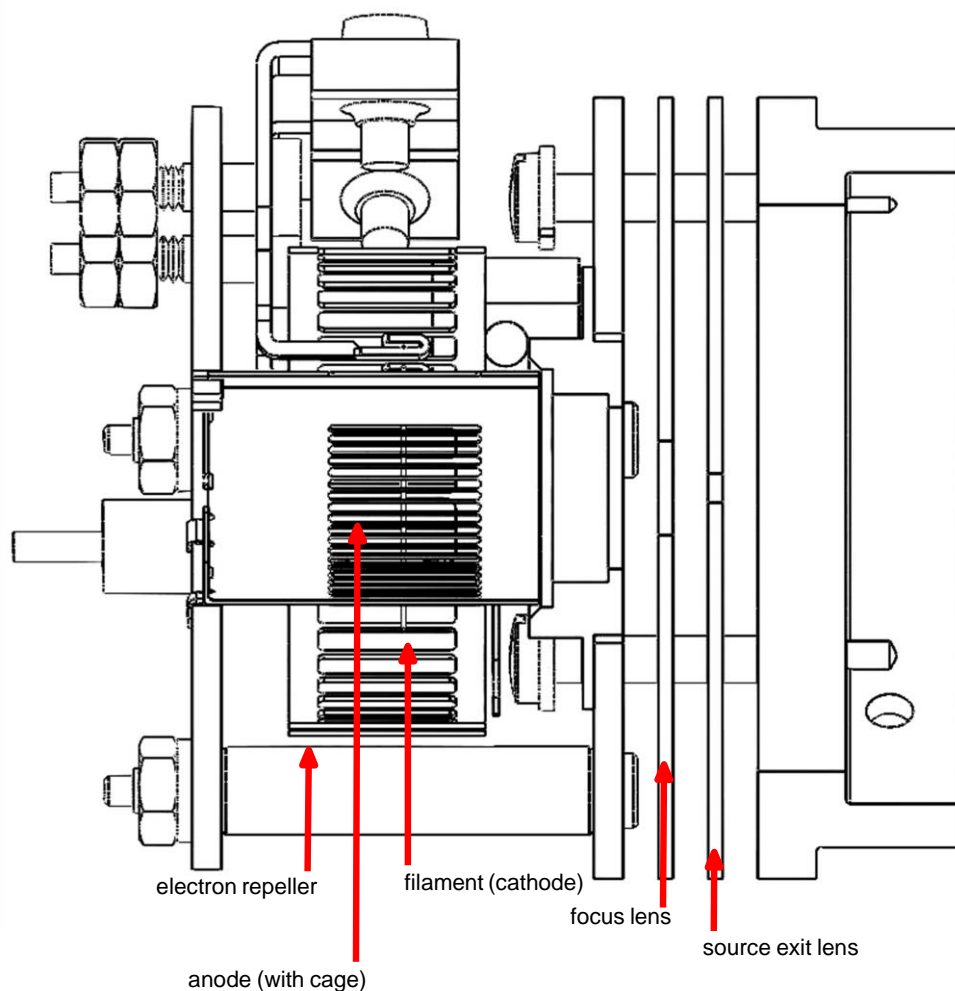
The Element offers two different filament materials:

- dual yttria-coated iridium filament
- dual tungsten filament

Emission current refers to the stream of electrons emitted by the filament. The filament is heated with a DC current controlled by the emission regulator circuit, with the resulting temperature of the filament used as the means of controlling the emission current.

Centered inside the curved filament is the ion cage, which is mounted to the anode plate. The cage has an open mesh structure to facilitate the flow of gas molecules into the ionizing region. The potential (voltage) on the anode is positive with respect to the electron repeller (also an open mesh structure); the potential on the filament lies somewhere between these other two electrodes. The potential difference between the filament and the anode determines the kinetic energy (usually called the electron energy) of the emitted electrons. The electron energy in turn determines how gas molecules will ionize when struck by the electrons.

The ions formed within the anode cage are pulled away by the potential on the focus lens and formed into a beam. The focus lens is sometimes called an extractor, since it extracts the ions from the region in which they are created. The focus lens also serves to focus the ion beam into the hole in the source exit lens. To attract positive ions, the focus lens is biased negatively with respect to the anode.

The potential on the source exit lens is negative with respect to the anode, and (for the particular design illustrated here) the focus lens as well. Part of the ion beam passes through the hole in the exit lens and is injected into the mass filter.

The remaining portion of the beam strikes the exit lens and is neutralized, resulting in a current flow. The magnitude of this current is related to the pressure in the ion source, and can therefore be used as a measure of the total pressure. When this current exceeds a preset level, the voltages operating the sensor are turned off to protect the sensor from damage due to an over-pressure condition.

ℹ️ This protection feature works only after the filament has been operating for a short period of time. Therefore, the filament will not be protected from excessive pressure if the sensor is turned on too early in a pumpdown cycle.

6.3.1 Choosing the Proper Filament

Dual yttria-coated iridium and the optional dual tungsten filaments are available for the Element. Determining which one should be used for a specific application can be difficult. This section details the different scenarios wherein one filament type is preferred over the other.

6.3.1.1 Yttria-Coated Iridium Filaments

Yttria-coated iridium filaments have a coating of yttrium oxide over an iridium core. Yttria is a rare-earth element that, in its oxide form, is fully oxidized. This means that the surface of the yttria-coated iridium filament is inert with respect to oxygen damage. For applications which will include exposure to oxygen, choosing the yttria-coated iridium filament is appropriate.

Yttria-coated iridium filaments do not withstand exposure to halogens. Upon exposure to halogens, the yttria coating forms yttria-oxyhalides which chip off of the filament and cause direct exposure of the iridium core, shortening the lifetime of the filament. Use tungsten filaments when an application includes exposure to halogens (fluorine, chlorine, bromine or iodine).

6.3.1.2 Tungsten Filaments

Tungsten filaments are used for monitoring processes that use a large amount of halogens (such as the etch process). The tungsten filament is not easily attacked by halogens and has a much longer lifetime than the yttria-coated iridium filaments.

Tungsten filaments are not able to withstand environments with a large level of water or oxygen present (combined partial pressure of water or oxygen greater than 1E-6 Torr). The heated tungsten filament forms tungsten oxides which can either coat the ion source or contaminate a process. Use yttria-coated iridium filaments for oxygen-heavy and/or water rich applications.

6.4 The Quadrupole Mass Filter

The ions produced in the ion source are injected into the mass filter, which rejects all ions except those of a specific mass-to-charge ratio. Most ions contain only one unit of charge. In the Element, the mass filter is a quadrupole type, to which a combination of RF and DC potentials is applied. The RF frequency and amplitude determine the specific mass/charge ratio, and the RF/DC ratio determines the filter selectivity.
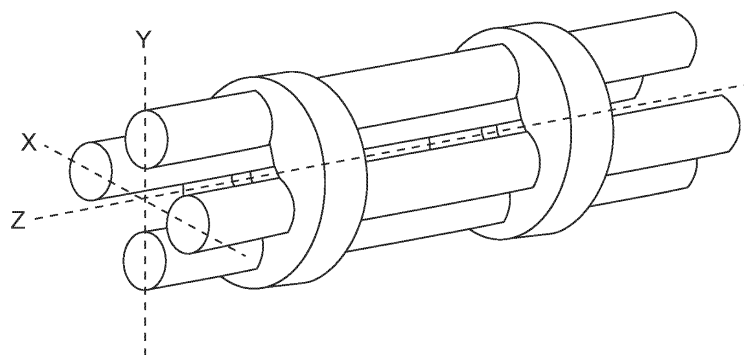
The mass filter's four rods are alternately charged to direct ions of specific masses down through the center, deflecting all larger and smaller masses (hence the term mass filter).

The mass filter consists of four parallel rods, or poles, in a square array. The rods, and the insulators in which they are mounted, form an extremely precise mechanical assembly. The distance between the center of the square array and the closest rod surface is known as the quadrupole radius, with the symbol r_0. If the ratio of the round rod radius to r_0 is made equal to 1.148, the resulting electric field generates the maximum quadrupole field.

Opposite rods are electrically connected together. The ions are directed down the central axis of the assembly in a direction nominally parallel to the length of the rods. There the ions are separated by their mass-to-charge ratios by the lateral forces resulting from the potentials applied to the poles.

The applied potentials consist of an RF component and a DC component. The RF potential on one set of rods is out of phase by 180° with respect to the RF potential on the other set of rods, but of the same amplitude. For one pair of rods, the "X" pair, the DC potential is positive. For the other, the "Y" pair, the DC potential is of the same magnitude, but negative. The DC and RF potentials are referenced to a center voltage (sometimes called the pole zero). The following equations summarize the potentials applied to the rods:

$X = V\cos(2ft) + U + PZ$
$Y = -V\cos(2ft +) - U + PZ$

where, V is the RF amplitude, f is the RF frequency, t is time, U is the DC potential, and PZ is the pole zero.

The RF component removes the low-mass ions from the beam. Ions of sufficiently low mass have their motions remain in phase with that of the applied RF. These ions will gain energy from the field and oscillate with increasingly large amplitudes. Eventually, as they travel along the length of the rods, they will strike one of the rods and be neutralized. On the other hand, high-mass ions are focused by the RF component to an area close to the quadrupole's long axis, the "Z" axis.

The DC component is superimposed on the RF to remove high-mass ions from the beam. The DC field deflects the high-mass ions toward the negative poles, opposing the focusing effects of the RF field. Eventually, these high-mass ions strike the negative rods and are neutralized. By a suitable choice of DC-to-RF ratio, the mass filter can be made to discriminate against both high and low-mass ions to the desired degree.

The kinetic energy directed along the Z axis of the mass filter (usually called the ion energy) is primarily dependent on the difference between the potential at which the ions were formed (approximately the anode voltage) and pole zero. The ion energy is usually only slightly modified by the electric field (the fringing field) between the source exit aperture and the quadrupole. Imbalances in the amplitude of the two phases of RF applied to the rod pairs, and of the DC voltages also applied, result in a further modification of the ion energy.

The mass of the ions passed by the filter is determined by the RF amplitude, the RF frequency, and the quadrupole radius, as shown by the following equation:

$$V = 14.438 M f^2 r_0^2$$

where, V is the peak-to-peak RF amplitude in Volts, M the mass of the ion in atomic mass units (amu) per electron charge, f the RF frequency in megahertz, and r_0 the quadrupole radius in centimeters.

For example, a 200 amu singly charged ion would pass through a quadrupole with nominal 1/4 in. diameter rods (an r_0 of 0.277 cm), operating at 1.78 MHz, at a peak-to-peak RF amplitude of approximately 700 Volts.

The mass of ions transmitted (M) is directly proportional to the RF amplitude (provided f is constant). As the RF amplitude is increased, progressively higher mass ions are made to oscillate in phase with the RF field and thus gain sufficient energy to strike the poles. The DC voltage must also be increased to maintain the high-mass rejection properties of the filter. A mass spectrum can therefore, be obtained by sweeping the RF amplitude, along with the DC voltage.

The next section (Scanning Characteristics) discusses the variation in the efficiency of transmission of ions through the filter with mass. Following that, The Zero Blast [⟩ 55] section discusses the behavior of the filter at very low masses where the applied voltages approach zero.

See also

6.4.1 Scanning Characteristics

As described above, the quadrupole acts as a mass filter for a mixed beam of ions, rejecting those of both high and low mass, while passing those of an intermediate mass. The selectivity of the mass filter is expressed in terms of resolution, R, which is numerically given by the ratio of the center mass, M, to the width, ΔM (both in amu), of the pass band. Since the number of the ions passed by the filter falls off gradually as the edge of the pass band is approached, the width is defined at the point where the ion current falls to some specified fraction (usually 1/2 or 1/10) of the maximum value. The width of the pass band is determined by the DC-to-RF ratio.

While the quadrupole drive circuits can be designed so that R varies in any desired manner with M, it is usually most convenient to keep ΔM constant at a value, which ensures adequate separation of masses that are 1 amu apart. This mode of scanning is called Constant ΔM. As a result, R is proportional to M, and therefore, the efficiency with which ions of mass M are transmitted through the quadrupole decreases with M. Thus, the sensitivity of the sensor decreases as M increases.

6.4.2 The Zero Blast

When the mass filter is tuned to very low masses, the RF and DC voltages applied to the rods approach zero. The quadrupole then ceases to act as a filter, and a large current of unseparated ions is detected. This current is called the zero blast.

The zero blast, present in all quadrupole-based sensors, can interfere with the observation of masses 1 and 2 when significant quantities of higher-mass ions are present. In some instruments, the magnitude of the zero blast is concealed by preventing the voltages from reaching zero. When using theElement, the zero blast only produces parts-per-million interference to masses 1 and 2.
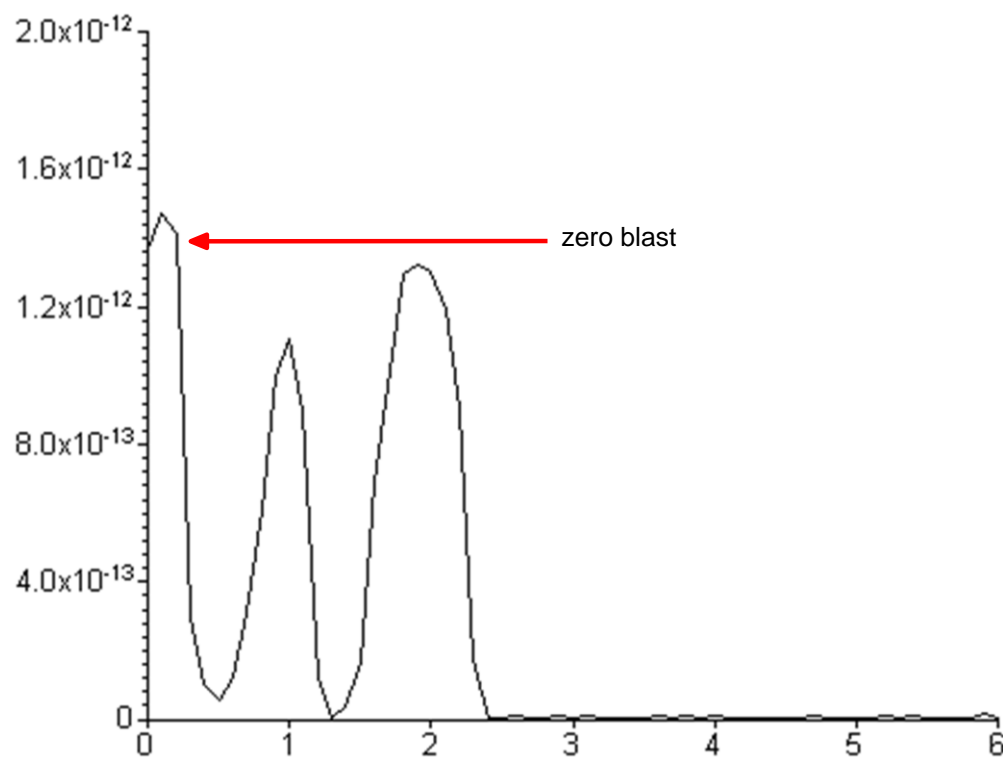
6.5 The Ion Detector

The ion detector region of the sensor consists of the quadrupole exit lens and the detector itself. Often, the quadrupole exit aperture is biased negatively with respect to the anode, focusing ions that have been transmitted through the quadrupole into the detector element. The detector can be a simple Faraday cup (FC), an electron multiplier (EM), or a combination of both.

6.5.1 The Faraday Cup Detector

The Faraday cup detector is typically a metal plate or a cup-shaped electrode, on which the ion beam impinges. Ions strike the detector and are neutralized, thus drawing a current from the circuitry connected to the electrode. Usually, the current flow that results is exactly equal to the incident ion current. In Element instruments, the Faraday cup is at ground potential.

The minimum sensitivity for a 100 amu Element instrument equipped with a simple Faraday cup detector is typically 6×10^{-4} amps per Torr. The detected currents can be as small as 1×10^{-15} amps for ultra-high vacuum levels.

6.5.2 The Electron Multiplier (EM) Detector

The Electron Multiplier (EM) acts as an in situ preamplifier for improved sensitivity. Although there are several different types of EM, their operating principals are the same. Incoming ions are accelerated into the input of the EM by a high negative voltage (usually -1.0 kV or more). When an ion strikes the surface of the EM, one or more secondary electrons are emitted. These electrons are accelerated to a second surface which is at a more positive potential, where additional electrons are generated.

This process repeats itself until a pulse of electrons emerges from the output of the EM and is collected on a Faraday cup. The result is that as many as a million electrons or more can be produced by each incident ion. The current from a Faraday detector is positive (for positive ions). An EM detector current is negative.

The ratio of the electron output current to the incident ion current is known as EM gain. The gain primarily depends on the EM type, the voltage applied to the EM input, the voltage applied across the EM, the condition of the EM, and, to a lesser extent, the mass and chemical nature of the incident ion. In general, EM gain decreases as ion mass increases.

The advantage of the EM detector sensor is its high sensitivity (at least 500 amps/ Torr), thus making it possible to measure partial pressures as low as 2×10^{-15} Torr for a 100 amu Element sensor. A typical Faraday cup sensor of the same mass range would have a sensitivity of only 6×10^{-4} amps/Torr, resulting in a minimum detectable partial pressure of 3×10^{-13} Torr.

6.5.3 The Continuous Dynode Electron Multiplier/Faraday Cup Detector

The continuous dynode electron multiplier/Faraday cup (CDEM/FC), used for the EM containing Element models, offers the advantages of both the FC and EM detectors combined in one unit.
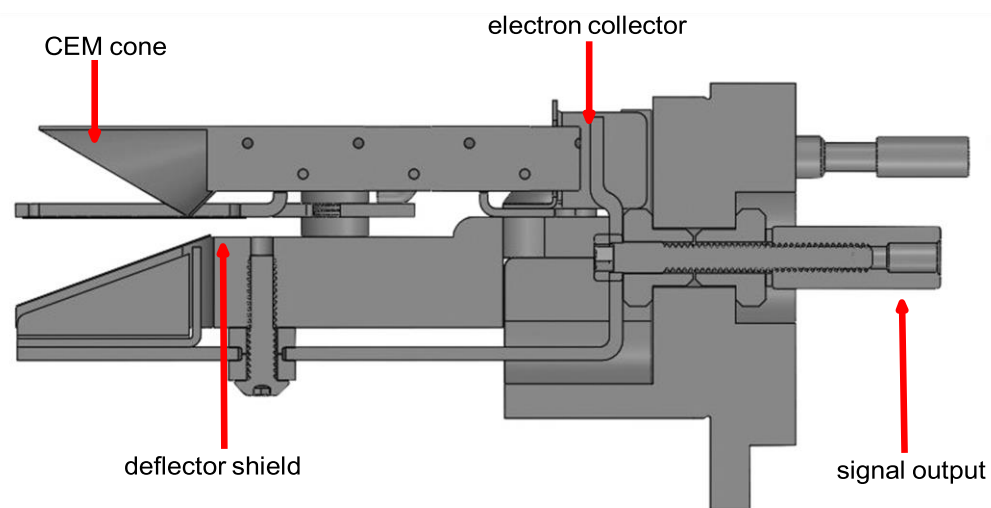
In CDEM/FC detectors, the EM cone amplifies the electron pulse, significantly increasing the analyzer's sensitivity.

The Element CDEM/FC detector uses a continuous dynode element made of a special type of glass, rather than discrete dynode EMs, which are made from a copper-beryllium alloy. The principal advantage of the CDEM is that its performance does not degrade when exposed to air. In order to prolong its useful life, a copper-beryllium dynode multiplier must be stored under vacuum; exposure to air for more than a brief period can result in a significant decrease in the maximum available gain.

The CDEM has some disadvantages. The maximum operating temperature for the CDEM is 150°C. (It can still be baked out at 300°C, provided that the high voltage is off.) Also, the CDEM is slightly slower to recover after exposure to excessive input or output currents, and it may take a bit longer to stabilize its gain after the high voltage is changed.

The CDEM is operated at high voltages between -600 and -2,000 V. A new CDEM will typically have a gain of between 10 and 1,000 at -800 V.

⚠ **CAUTION**

Do not operate the CDEM at temperatures above 150°C. Permanent damage may result. Also, avoid output currents in excess of 1×10^{-6} amps; either decrease the high voltage or, if possible, decrease the pressure.

Use the minimum CDEM voltage required to obtain the necessary peak amplitudes and/or signal-to-noise ratio. Operating at higher voltages than necessary results in premature aging of the electron multiplier, requiring early replacement. As the CDEM ages, more voltage is needed to achieve a target EM gain.

Since EM performance depends on the condition of its interior surfaces, prevent hydrocarbon or other contamination as follows:

- Ensure that diffusion-pumped vacuum systems are properly trapped to reduce oil back-streaming.

- Ensure that turbomolecular pumped systems are interlocked to eliminate mechanical pump oil back-streaming through a nonspinning turbo pump.

Electron multiplier gain reduction from these kinds of problems can range from 50% to more than 90%. The initial gain of the EM is generally high enough to accommodate some degradation and yet still be usable. With repeated instances of contamination, the multiplier lifetime is shortened, requiring more frequent replacement.

> In addition to hydrocarbon contamination, multipliers can be adversely affected by exposure to highly reactive chemicals. Avoid any substance that either causes the deposition of a surface film on the EM or etches its surface. Avoid high levels of reactive fluorides, such as tungsten hexafluoride, hydrogen fluoride, and nitrogen trifluoride.

7 Applications Guide

7.1 How to Interpret the Result

This chapter discusses how to interpret Element measurements:

- The section Qualitative Interpretation of Mass Spectra [} 59] explains how to determine which substances are present in the gas sample being analyzed.

- The section Quantitative Interpretation of Mass Spectra (Calculating Partial Pressures) [} 65] shows how to estimate how much of each substance is present.

- The section Additional Information for Interpreting Mass Spectra [} 70] provides additional information that may help you interpret mass spectra.

The onboard web server includes routines which serve as aids in the interpretation of spectra and the calculation of partial pressures and relative concentrations.

For a discussion of how Element produces measurements, refer to How The Instrument Works [} 48].

7.1.1 Qualitative Interpretation of Mass Spectra

The basic graphical output of Element is the mass spectrum. A mass spectrum is a plot of ion intensity as a function of ion mass-to-charge ratio. Each chemical substance has a characteristic mass spectrum. Different instruments give slightly different spectra for the same substance. The particular characteristics of the ionizer, mass filter, and detector, not to mention the manner in which the sample is introduced into the mass spectrometer, all influence the spectrum that is produced.

A mass spectrum of pure substance is rarely obtained. Most of the time (especially for

residual gas analyzers), the spectrum obtained is a composite of the individual substances which together comprise the actual sample present.

7.1.1.1 Ionization Process

When a sufficiently energetic electron strikes a gas molecule, there are many processes that can occur, some of which are summarized in the table below.

Reactions	$XYZ^+ + e^-$
1	$XYZ^+ + 2e^-$
2	$XYZ^{2+} + 3e^-$
3	$XY + Z^+ + 2e^-$
4	$XY^+ + Z + 2e^-$
5	$X^+ + YZ + 2e^-$
6	$X + YZ^+ + 2e^-$
7	$XZ + Y^+ + 2e^-$
8	$XZ^+ + Y + 2e^-$

In all cases, the reactants are a high energy electron, e^-, and a gas molecule, XYZ. The products of the first reaction are the molecule with a single electron removed (the so-called parent ion) and two low energy electrons. In the second reaction, two electrons are removed from the gas molecule, resulting in a doubly charged ion. Triply (or even more highly) charged ions are also possible, provided the incident electron has enough energy.

Reactions 3 through 8 are examples where the original molecule is broken into fragments, at least one of which is positively charged (negative ions can also be produced in this manner). Only the positive ion fragments are observed; the neutral (i.e., uncharged) fragments are not detected. The mass spectrum obtained when the parent molecule breaks apart under electron impact is commonly referred to as the fragmentation pattern (or, sometimes, the cracking pattern). For example, a fragmentation pattern for nitrogen shows $^{14}N^+$ (14 amu), $^{14}N_2^+$ (28 amu), and $^{14}N^{15}N^+$ (29 amu).

In general, peaks from multiply-charged species are less intense than those for the corresponding singly-charged ion. For example, the doubly-charged peak for argon is typically less than one fifth as intense as the singly-charged peak (it should be noted that this intensity ratio is sensitive to the incident electron energy).

There are some situations when it is difficult to determine whether the ion is singly or multiply charged. When a molecule is composed of two atoms of the same element, Element has difficulty distinguishing between the singly-charged one atom fragment ion and the doubly-charged two atom molecular ion; which will both have the same mass-to-charge ratio.

Most ions (with the important exception of complex hydrocarbons) have masses very close to integer values. When the mass of an ion is not evenly divisible by the number of charges on it, the mass-to-charge ratio will not be an integer. This means that an ion such as Ar^{3+} appear at 13.33 amu, while F^{2+} is detected at 9.5 amu.

7.1.1.2 Isotope Ratios

An additional cause of multiple peaks in the mass spectrum of a pure substance is that most (but not all) elements are composed of more than one isotope. For example, 99.63% of all nitrogen atoms have a mass of 14 amu; only 0.37% have a mass of 15 amu. Some elements have many intense isotopes (e.g., xenon is 0.096% mass 124, 0.090% mass 126, 1.92% mass 128, 26.44% mass 129, 4.08% mass 130, 21.18% mass 131, 26.89% mass 132, 10.44% mass 134, and 8.87% mass 136).

Isotope ratios, like fragmentation patterns, are a very useful aid in recognizing specific materials. Under normal ionization conditions, the peak height ratios for the various isotopes of an element will be the same as the ratios of their natural abundances. That is, the probability of ionizing, for example, the mass 35 isotope of chlorine (^{35}Cl) is the same as the probability of ionizing the mass 37 isotope (^{37}Cl). Thus, the peak height ratio of mass 35 to 37 from HCl will be 3.07 to 1 (75.4% / 24.6%).For a listing of the isotopic ratios for the lighter elements, see the table below. For a complete listing of the natural abundances for the isotopes of all the elements, see the *Handbook of Chemistry and Physics* from CRC Press.

Isotope Ratios		
Element	Mass No.	Relative Abundance
H	1	99.985
	2	0.015
He	3	0.00013
	4	~100.0
B	10	19.78
	11	80.22
C	12	98.892
	13	1.108
N	14	99.63

	15	0.37
O	16	99.759
	17	0.0374
	18	0.2039
F	19	100.0
Ne	20	90.92
	21	0.257
	22	8.82
Na	23	100.0
Al	27	100.0
Si	28	92.27
	29	4.68
	30	3.05
P	31	100.0

Isotope Ratios		
Element	Mass No.	Relative Abundance
S	32	95.06
	33	0.74
	34	4.18
	36	0.016
Cl	35	75.4
	37	24.6
Ar	36	0.337
	38	0.063
	40	99.600

7.1.1.3 Electron Energy Effects

The exact fragmentation pattern observed depends on the energy of the bombarding electrons. The figure below graphs the number of argon ions (of different charge states) produced per incident electron per Torr of gas pressure as a function of electron energy.
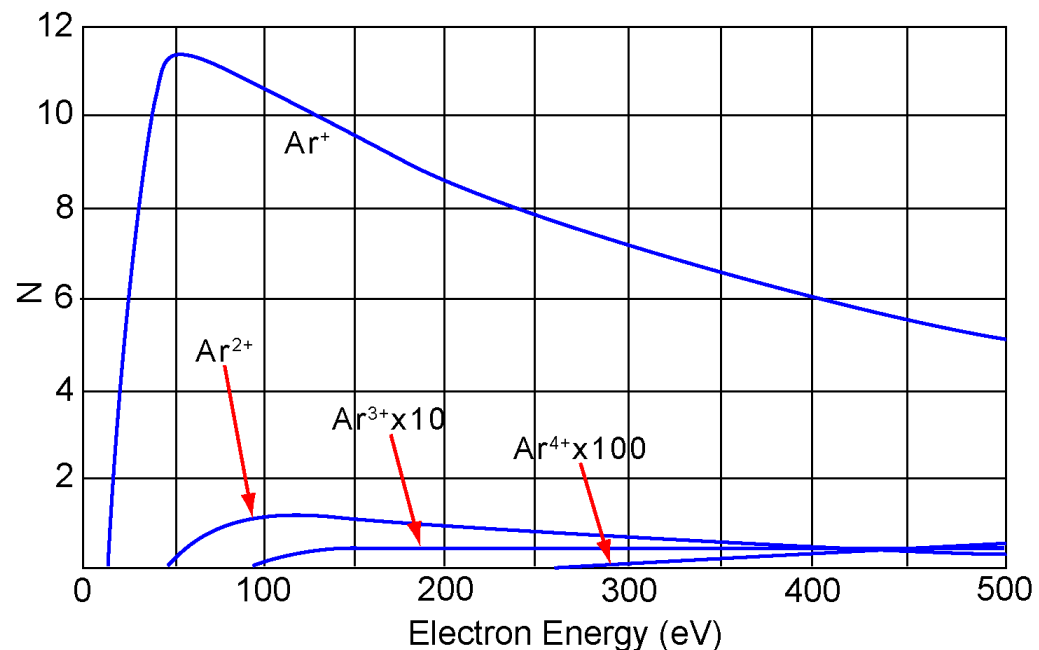
From a paper by W. Bleakney, Physical Review, 36, p. 1303, published in 1930.

The appearance potential (i.e., the minimum electron energy required to produce a specific ion) for Ar^+ is 15.7 eV. The number of argon ions produced rises steeply with energy until a maximum is reached at about 55 eV. As the electron energy rises above this level, the rate of Ar production slowly decreases. The appearance potential for Ar^{2+} is 43.5 eV, and the ion production rate does not maximize until the electron energy exceeds 100 eV. The appearance potential for Ar^{3+} is approximately 85 eV, while the appearance potential for Ar^{4+} is over 200 eV.

7.1.1.4 A Qualitative Interpretation Guide

To use Element to identify unknown substances, three characteristics must be recognized:

- fragmentation patterns
- multiply charged ions
- isotope ratios

Simple spectra are, in general, relatively easy to interpret and yield useful identifications. The analysis of complicated mixtures of substances is much more difficult.

The table below is intended as a spectrum interpretation guide which may be of use when first examining an unknown spectrum. The guide lists the masses of peaks, possible ion identities for each of these masses, and common sources for each of these ions.

This list is not all-inclusive

Spectrum Interpretation Guide		
AMU #	Chemical Symbol	Sources
1	H	water F or hydrogen F
2	H_2, D	hydrogen, deuterium (^2H)
3	HD, ^3H	hydrogen-deuterium, tritium (^3H)
4	He	helium
5	No known elements	
6	C	DI ^{12}C (rare)
7	N	DI ^{14}N (rare)
8	O	DI ^{16}O (rare)
9	No known elements	
10	Ne, ^{10}B	DI ^{20}Ne (rare), BF_3, BCl_3
11	Ne, ^{11}B	DI ^{22}Ne (rare), $^{11}BF_3$, $^{11}BCl_3$
12	C	carbon, carbon monoxide F, carbon dioxide F
13	C, ^{13}C	methane F, carbon isotope
14	N, CH_2	nitrogen, methane F or Note 1
15	CH_3	methane F or Note 1
16	O, CH_4, NH_2	Oxygen, carbon monoxide F, ammonia
17	OH, NH_3	Water F, ammonia F
18	H_2O	Water
19	F	Fluorine, freon F
20	Ar2+, Ne, HF	DI argon, neon, hydrofluoric acid
21	No known elements	
22	^{22}Ne, CO_2	Neon, DI CO2
23	No known elements	
24	C_2	See Note 1
25	C_2H	See Note 1
26	C_2H_2, CN	See Note 1, hydrogen cyanide F
27	C_2H_3, Al, HCN	See Note 1, aluminum, hydrogen cyanide
28	N_2, CO, C_2H_4, Si	Nitrogen, carbon monoxide, ethylene P, silicon
29	CH_3CH_2	Ethane F, ethanol F, isopropyl alcohol
30	C_2H_6, NO	Ethane P, nitric oxide
31	P, CH_2O	Oxygen, methanol F
32	O_2, S	Oxygen, sulfur, methanol P
33	HS	Hydrogen sulfide F
34	H_2S, ^{34}S, O_2	Hydrogen sulfide P, sulfur isotope, oxygen isotope

Spectrum Interpretation Guide		
AMU #	Chemical Symbol	Sources
35	Cl	Chlorine isotope, See Note 2
36	HCl, ^{36}Ar, C_3	Hydrochloric acid, argon isotope, hydrocarbons
37	^{37}Cl, C_3H	Chlorine isotope, See Note 2, hydrocarbons
38	^{37}HCl, C_3H_2	Hydrochloric acid, See Note 2, hydrocarbons
39	C_3H_3	See Note 3, hydrocarbons
40	Ar, C_3H_4	Argon, See Note 1, hydrocarbons
41	C_3H_5	See Note 1, hydrocarbons
42	C_3H_6	See Note 1, hydrocarbons
43	C_3H_7, CH_3CO	See Note 1, acetone F, methyl ethyl ketone F
44	CO_2, C_3H_8	Carbon dioxide, See Note 3
45	CH_3CH_2O	Ethanol F, isopropyl alcohol F
46	CH_3CH_2OH	Ethanol P
47	$C^{35}Cl$	See Note 2
48	$HC^{35}Cl$, SO	See Note 2, sulfur dioxide F
49	$C^{37}Cl$	See Note 2
50	$C^{37}Cl$, CF_2, C_4H_2	See Note 2, freon F, See Note 3
Notes		
1.	Fragments of several hydrocarbons, such as mechanical pump oil, diffusion pump oil, vacuum grease, cutting oil, or organic solvents.	
2.	Fragments of several chlorinated ydrocarbons, such s carbon tetrachloride, trichloroethylene, and many freons.	
3.	Fragments from both straight chained hydrocarbons and benzene ring hydrocarbons.	
4.	F = Fragment Ion, P = Parent Ion, DI = Doubly Ionized	

7.1.2 Quantitative Interpretation of Mass Spectra (Calculating Partial Pressures)

Partial pressure is defined as the pressure of a designated component in a gas mixture. According to Dalton's Law, the sum of all the partial pressures is the total pressure. Element is designed so that the height of a peak in a mass spectrum is proportional to the number of ions giving rise to that peak. Also by design, the number of ions is more or less proportional to the partial pressure of the substance giving rise to that peak (over some specified operating pressure range). Therefore, the height of a peak is proportional to the partial pressure of the substance giving rise to that peak.

The following equation shows the relationship between the partial pressure of substance a determined by measuring the ion current at mass b:

$PP_a = K_{ab} \times I_{ab}$

The partial pressure of substance a is symbolized by PP_a, while K_{ab} is the proportionality constant for the peak at mass b from substance a, and I_{ab} is the ion current at mass b from substance a.

The proportionality constant, K_{ab}, depends on the nature of the substance being detected and on the characteristics of Element. The substance dependent part is

called the material factor, M_{ab}. The instrument dependent part is called the analyzer factor, A_b, and depends primarily on the ion mass, b. Therefore, the original equation can therefore, be rewritten as follows:

$PP_a = (M_{ab} \times A_b) \times I_{ab}$

The material factor, M_{ab}, depends on the fragmentation pattern for the particular substance, the fragmentation pattern for a reference gas (usually nitrogen), and the ease with which the substance can be ionized relative to the same reference gas. The relationship involved is shown in equation:

$M_{ab} = 1/FF_{ab} \times 1/XF_a$

FF_{ab} is the fragmentation factor for substance a at mass b. It is equal to the fraction of the total current of all ions from substance a which have a mass b. XF_a is the ionization probability of substance a, relative to nitrogen (i.e., $XF_N = 1$). That is, it is the ratio of total ion current (for all masses) from substance a to the total ion current from nitrogen, both measured at the same true partial pressure. Both fragmentation factors and ionization probabilities depend strongly on the energy of the ionizing electrons. If the correct values of these factors are not known for the exact conditions of the particular analyzer being used, they can be approximated using published values for other conditions with, generally, only a small loss in accuracy.

Fragmentation factors can be calculated from fragmentation patterns given in the general references cited in Chapter 8. Other valuable references include the Index of Mass Spectral Data from ASTM, EPA/NIH Mass Spectral Data Base by Heller and Milne, and an extensive library of spectra available from the National Institute of Standards and Technology.

The table below lists the fragmentation factors (FF) for the major peaks for selected substances.

---

i

Actual fragmentation factors vary significantly depending especially on the ionizer, electron energy, and mass filter tuning. For best accuracy, measure fragmentation factors with the same instrument used for the analysis, under the same tuning conditions

---

Mass	FF	Mass	FF	Mass	FF
acetone $(CH_3)_2CO$ 43	0.63	helium He 4	1.00	nitrogen N_2 28	1.00

Mass	FF	Mass	FF	Mass	FF
58	0.23			14	0.12
42	0.04			29	0.01
27	0.03				
argon Ar		hydrogen H_2		oxygen O_2	
40	0.83	2	1.00	32	0.95
20	0.17			16	0.05
benzene C_6H_6		krypton Kr		toulene $C_2H_5CH_3$	
78	0.53	84	0.45	91	0.46
51	0.11	86	0.13	92	0.34
52	0.11	82	0.10	60	0.07
50	0.10	83	0.10	65	0.05
carbon dioxide CO_2		methane CH_4		trichlorethylene C_2HCl_3	
44	0.70	16	0.46	95	0.22
28	0.11	15	0.40	130	0.22
16	0.06	14	0.07	132	0.21
12	0.01	13	0.04	97	
				60	0.13
carbon monoxide CO		methanol CH_3OH		water H_2O	
28	0.91	31	0.43	18	0.75
12	0.05	32	0.23	17	0.19
16	0.03	29	0.18	1	0.05
		28	0.03	16	0.02
ethanol C_2H_5OH	0.49	neon Ne		xenon Xe	0.26
31		20	0.90	132	
45	0.21	22	0.10	129	0.26
27	0.09			131	0.22
29	0.07			134	0.11
				136	0.09

Ionization probability factors can be approximated by substituting the relative ion gauge sensitivities for various gases. The table below gives relative ion gauge sensitivities for some common gases.

ℹ The data was compiled from Empirical Observations on the Sensitivity of Hot Cathode Ionization Type Vacuum Gauges by R. L. Summers (NASA Technical Note NASA TN D5285, published in 1969). Similar, although more limited, lists of ionization sensitivities can be found in the books by O'Hanlon (Chapter 8, Section 1.1) and Drinkwine and Lichtman (Table I, page 5).

ℹ Actual ionization probabilities vary significantly depending on the ionizer and the electron energy. For best accuracy, measure the relative ionization probability using a hot cathode ionization gauge (calibrated for nitrogen) to monitor a known pressure of the substance of interest. The ratio of the gauge reading to the known true pressure is the relative ionization probability. To determine the true pressure, use a gauge which is gas species independent (for example, a capacitance manometer) or a gauge with a known sensitivity factor (for example, a spinning rotor gauge).

Substance	Formula	Relative Ionization Gauge Sensitivity	Substance	Formula	Relative Ionization Gauge Sensitivity
acetone	$(CH_3)_2CO$	3.6	hydrogen chloride	HCl	1.6
air		1.0	hydrogen fluoride	HF	1.4
ammonia	NH_3	1.3	hydrogen iodide	HI	3.1
argon	Ar	1.2	hydrogen sulfide	H_2S	2.2
benzene	C_6H_6	5.9	krypton	Kr	1.7
benzoic acid	C_6H_5COOH	5.5	lithium	Li	1.9
bromine	Br_2	3.8	methane	CH_4	1.6
butane	C_4H_{10}	4.9	methanol	CH_3OH	1.8
carbon dioxide	CO_2	1.4	neon	Ne	0.23
carbon disulfide	CS_2	4.8	nitrogen	N_2	1.0
carbon monoxide	CO	1.05	nitric oxide	NO	1.2
carbon tetrachloride	CCl_4	6.0	nitrous oxide	N_2O	1.7
chlorobenzene	C_6H_5Cl	7.0	oxygen	O_2	1.0
chloroethane	C_2H_5Cl	4.0	n-pentane	C_5H_{12}	6.0
chloroform	$CHCl_3$	4.8	phenol	C_6H_5OH	6.2
chloromethane	CH_3Cl	3.1	phosphine	PH_3	2.6
cyclohexane	C_6H_{12}	6.4	propane	C_3H_8	3.7
deuterium	D_2	0.35	silver perchlorate	$AgClO_4$	3.6

Substance	Formula	Relative Ionization Gauge Sensitivity	Substance	Formula	Relative Ionization Gauge Sensitivity
dichloridefluromethane	CCl_2F_2	2.7	stannic iodide	SnI_4	6.7
dichloromethane	CH_2Cl_2	7.8	sulfur dioxide	SO_2	2.1
dintrobenzene	$C_6H_4(NO_2)_2$	7.8	sulfur hexafluoride	SF_6	2.3
ethane	C_2H_6	2.6	toluene	$C_6H_5CH_3$	6.8
ethanol	C_2H_5OH	3.6	trinitrobenzene	$C_6H_3(NO_2)_3$	9.0
ethylene oxide	$(CH_2)_2O$	2.5	water	H_2O	1.0
helium	He	0.14	xenon	Xe	3.0
hexane	C_6H_{14}	6.6	xylene	$C_6H_4(CH_3)_2$	7.8
hydrogen	H_2	0.44			

The analyzer factor, Ab, depends on the transmission and detection characteristics of the analyzer, the electron multiplier gain (if the analyzer is so equipped), and the basic sensitivity, as indicated in the equation below:

$A_a = 1/ TF_b \times DF_{ab} \times G \times S$

Here, TF_b is the transmission factor of the mass filter at mass b. The transmission factor is the fraction of ions at mass b which pass through the mass filter, relative to nitrogen ions at mass 28. Nominally, the transmission factor is equal to 28 divided by the mass of the ion, b.

The detection factor, DF_{ab}, is equal to 1 for a Faraday cup detector. For an electron multiplier, the detection factor is a function of the mass of the ion and its chemical nature, and is measured relative to that of a reference gas, typically nitrogen. In general, as the mass ion increases, the electron multiplier detection factor decreases.

The gain of the electron multiplier, G, measured at mass 28 for nitrogen, is the electron multiplier output current divided by the Faraday mode output current, under otherwise identical conditions. The multiplier gain is a strong function of the high voltage applied.

The sensitivity of the instrument, S, is the ratio of Faraday mode ion current for a given pressure of pure nitrogen measured at mass 28, and is typically expressed in amps/ Torr.

The overall relation between partial pressure and ion current, given in the equation below, is quite general. The constants for this equation can be obtained from various tables, but for the best accuracy, they should be measured for each instrument.

$PP_a = \{FF_{N28}/ FF_{ab} \times XF_{ab} \times TF_b \times DF_{ab} \times G \times S\} \times I_{ab}$

Where:

PP_a	Partial pressure of substance a (usually in torr)

FF_{ab}	Fragmentation factor, or fraction of total ion current from substance a having mass b (dimensionless; see first table in section 4.1.2)
FF_{N2}	Fragmentation factor for N2+ ions at 28 amu from nitrogen (dimensionless; typically around 0.9)
$^{8}XF_{ab}$	Ionization probability of substance a relative to nitrogen; approximately the same as the relative ion gauge sensitivity as shown in (dimensionless)
TF_{b}	Transmission factor, the fraction of total ions at mass b which pass through the mass filter, relative to ions with a mass of 28 amu; nominally, $T_{FM} = 28 / M$ (dimensionless)
DF_{ab}	Detection factor for mass b ions from substance a, relative to nitrogen at 28 amu; assumed to be 1.00 for Faraday detectors, but varies for electron multiplier detectors (dimensionless)
G	Electron multiplier gain for nitrogen ions at 28 amu (dimensionless; set equal to 1 for a Faraday cup detector)
S	Sensitivity of instrument to nitrogen, the ion current at 28 amu per unit of nitrogen partial pressure (usually in amps/Torr)
I_{ab}	Ion current of mass peak b resulting from substance a (in amps; assumes that there are no other substances present which contribute significantly to the total current at mass peak b)

7.1.3 Additional Information for Interpreting Mass Spectra

7.1.3.1 Ion Source Characteristics

Element (especially the ion source) and the vacuum system configuration both have an effect on the relative concentrations of the gases detected. In order to minimize these effects: have the right type of ionizer, the right type of filament, and the right configuration of the vacuum system. This is particularly true when a differential pumping arrangement is used because the pressure of the gas to be sampled is too high for the sensor to operate. J. O'Hanlon's book, A User's Guide to Vacuum Technology, has a brief discussion (in Chapter 8, Section 2) of some of these concerns.

When using Element as a residual gas analyzer, the sensor should be installed such that the conductance between the ion source and the vacuum region to be analyzed is maximized. If possible, install the sensor without any intervening valves or vacuum

hardware. If the sensor is equipped with a residual gas analyzer ion source, there are four classes of interactions between the sensor and the immediate vacuum environment which can have a significant effect on the detected gas composition.

First, the analyzer itself is a source of gas molecules because of outgassing from its surfaces. Usually, the outgassing levels can be reduced by baking the analyzer in vacuum and by using the Degas function (wherein the ion source surfaces are bombarded by high energy electrons). When operating in the ultra-high vacuum (UHV) region, it is best to bake the sensor overnight at the maximum permissible temperature with the electronics removed and thermal insulation applied around the sensor feedthrough flange. A second overnight bakeout should be performed at the maximum sensor operating temperature.

> ℹ️ It can take more than three hours for all parts of the sensor to reach maximum temperature during a bakeout, and more than six hours to cool down.

> ⚠️ **CAUTION**
>
> Ensure that the Electron Multiplier (EM) is turned off if the (second) bakeout temperature exceeds the maximum EM operating temperature. Otherwise, permanent damage to the EM may result.

Second, it is possible that the opposite of outgassing can occur; that is, gas molecules can be captured by the surfaces of the sensor. This effect is called pumping. In such cases, the magnitude of the signals of the gases pumped will be lower than is properly representative of the composition of the gas in the vacuum chamber. Significant temporary pumping effects will frequently occur following degassing of the ion source.

Third, reactions involving gas molecules on surfaces of the analyzer can result in a change of composition. Gases can either be consumed by the surfaces, or produced by the surfaces. One example of gas consumption is the reaction of oxygen with a hot filament, particularly when tungsten filaments are used. The typical result is an anomalously low concentration of oxygen detected. See O'Hanlon's book (Chapter 8, Section 2) for more information on filament materials and their interactions with the gas being analyzed. An example of gases being produced from surfaces is the liberation of carbon monoxide molecules from a yttria oxide coated iridium filament by a sputtering mechanism in the presence of significant quantities of argon. This latter mechanism makes the combination of a pressure reduction system and a Element sensor unsuitable for measuring nitrogen contamination in argon at the low parts-per-million (PPM) level from a sputter deposition process. A special type of inlet system and ion source (a closed ion source (CIS)) should be used for this type of application.

Fourth, there are cases where at least some of the ions detected are emitted from surfaces in the ion source under electron bombardment and are not generated in the gas phase from neutral molecules. This process is known as electron stimulated

desorption (ESD) or sometimes as electron induced desorption (EID). When the sensor has been exposed to fluorine containing substances (such as sulfur hexafluoride, chlorofluorocarbons, perfluorotributylamine, or perfluorokerosene) for extended periods of time, it is not uncommon for a strong F^+ peak at 19 amu to remain

even after the fluorine containing substance has been removed. When operating in the UHV region, EID/ESD of H^+, C^+, O^+, and CO^+ (and other ions) is not uncommon. The

clue to diagnosing this problem is that the observed fragmentation patterns do not match known gas phase patterns. Refer to pages five and six, and typical spectra TS-2 through 5, 16, 28, and 30 of Partial Pressure Analyzers and Analysis by Drinkwine and Lichtman for more information on EID/ESD.

Element is also characterized by varying degrees of mass discrimination; that is, the sensitivity of the instrument is a function of mass. Ion sources show mass discrimination because various substances offer different degrees of difficulty of ionization. Generally, heavy, large molecules are ionized more readily than light, small molecules. There is also a rough correlation between the number of electrons in a molecule and its ease of ionization. Although the total ion yield (that is, the sum of ions of all masses) is electron energy and ionizer dependent, a reasonable estimate for the number of ions produced (relative to some standard, usually nitrogen) in an Element is the relative ionization gauge sensitivity.

7.1.3.2 Scanning Characteristics

Quadrupole mass filters can also exhibit mass discrimination characteristics depending on how the control voltages are varied during the sweep through the mass range. Most instruments are designed to operate with a constant peak width (constant مM) which results in a resolution which is proportional to the mass. This characteristic provides a good degree of peak separation throughout the mass spectrum, but results in an ion transmission efficiency (that is, the fraction of all ions of the selected mass entering the mass filter which are transmitted through it) that decreases as mass increases.

The way the mass scale is calibrated or tuned (that is, the way the peak positions and widths are adjusted) can have a significant effect on the transmission efficiency of the mass filter across the mass spectrum. If the adjustments are not made properly, the ratios of peak heights across the mass range will not be correct.

7.1.3.3 Fragmentation Factors

The fragmentation factor is the fraction of the total ion current contributed by ions of the chosen mass. Only peaks contributing at least one percent to the total ion current are included in the list. The sum of the factors for all the peaks in a mass spectrum

cannot exceed 1.00. The sum can be less than 1.00 if only some of the peaks are listed (either there are many peaks, or some of the ions produced lie outside the mass range of the particular instrument used).

The data presented in the second table in Quantitative Interpretation of Mass Spectra (Calculating Partial Pressures) [} 65], is compiled from more than one source and is for illustrative purposes only. For maximum accuracy in determining partial pressures, the fragmentation factors for the substances of interest should be measured with the same instrument with the same adjustments as the samples to be analyzed.

8 Using the Onboard Web Server

8.1 Introduction

Element includes an onboard browser-based user interface (UI) that provides remote Element control and monitoring from network connected devices.

This chapter will discuss the requirements for running the onboard web server, and instructions for operating the onboard web server.

8.1.1 What is the Onboard Web Server

The onboard web server:
- displays data in a spectrum window
- can perform leak checking when the computer that controls Element is located away from Element
- provides a diagnostic window that displays instrument status and errors
- allows you to save and review historical data

8.2 System Requirements

8.2.1 Using the Onboard Web Server on Computers

The onboard web server allows for Element control through standard Internet browsers. The onboard web server is fully supported for use in:
- Microsoft Edge®
- Mozilla Firefox® 20+
- Google Chrome™ 7+

The onboard web server is not supported for use in Opera™ or Apple Safari®.
The minimum computer requirements are shown in the table below.

Parameters	Onboard Web Server Requirements
Processor	Pentium 4 1.8 GHz or greater
RAM	1 GB or greater
Resolution	1024 x 768 Bit color or greater
Operating System*	Windows 8, Windows 7, Windows 10, Windows Vista, Windows XP**

Parameters	Onboard Web Server
Communications	Requires Ethernet Port or Wi-Fi†

* The onboard web server itself does not have operating system requirements. The requirements for the operating system are dependant on the browser being used.

** Windows XP does not support Internet Explorer 9. Firefox or Chrome are recommended for use with Windows XP

† To use Wi-Fi, Element must be connected to a Wi-Fi equipped router.

8.2.2 Using the Onboard Web Server on Mobile Devices

The onboard web server is optimized for 10.1 in. tablet devices such as the Samsung Galaxy Tab, and 9.7 in. devices such as the Apple iPad.

Because the onboard web server is browser based, OEM Android/Apple browsers will not work with the onboard web server. A third party browser must be installed.

The onboard web server has not been optimized for use on Android Smart Phones and iPhones.

8.3 Connecting to the Onboard Web Server

To connect to the onboard web server, the device that is being used for operating the onboard web browser must be connected to the same network as the Element.

If the device is not connected to the same network as the Element, the onboard web server will not work. In this situation, connecting to a computer that is on the same network via remote desktop is necessary. The onboard web server will then run on the remote desktop computer.

8.3.1 Connecting to the Onboard Web Server with Default Factory IP Address

The default web address for the Element is 192.168.1.100. To connect to the onboard web server, type 192.168.1.100 into the browser address box, then press Enter.
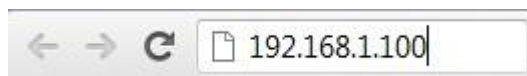
ⓘ The device running the browser must also be configured with an address on this network (e.g., 192.168.1.101).

The browser will connect to the Element. If the Element is powered on and connected to the same network as the device, the onboard web browser will display.

If the onboard web browser does not display, refresh the browser.

If the onboard web browser still does not display, verify that the IP address was not changed from the factory default IP address.

If the IP address was not changed from the factory default, make sure there are no other devices connected to the onboard web browser.

8.3.2 Connecting to the Onboard Web Browser with a User- Defined IP Address

If the IP address has been changed from the default factory IP address, the new user-defined IP address must be entered into the browser. If the IP address was changed and the new address has been lost, contact your distributor.

8.4 Using Wi-Fi

The Element connected to a Wi-Fi router allows access to the onboard web server from any Wi-Fi device (laptops, tablets, etc.). Leak checking using the handheld Wi-Fi device to monitor for leaks is a much easier task.

8.5 Troubleshooting

The main problems that will occur with operating the onboard web server involve communications problems. If the onboard web server cannot be opened, check the following:

1. Is anyone else using the onboard web server? The onboard web server will block any incoming requests when it is actively being used.

2. Is the web address (IP address of the Element) correct? If the IP address was recently changed, make sure that the browser is directed to the correct address.
3. Does Element have 24 V (dc) power supplied to it? If yes, try resetting the power.
4. Is the Ethernet cable connected to the Element and the network?

5. Try clearing the web browser cache. For instructions, visit the help files of the browser being used.

6. If these steps do not solve the problem, connect the Element directly to the computer (bypassing the router/network) and try connecting.

If the onboard web browser starts working, it is likely that the Element has a conflict with its IP address (another device on the network has the same IP address) or the port that the Element is using is being blocked by the network/router.
If the Element is still not working, contact your local KJLC Sales Representative.

9 Maintenance

9.1 Introduction

The Element sensor is subject to aging in normal use and some of its components eventually require repair or replacement.

The Element electronics module does not normally require repair or maintenance.

⚠ WARNING

Opening the Element electronics module should only be done by qualified service personnel. There are no user-serviceable parts inside the electronics module.

KJLC provides the complete maintenance service for both sensors and electronic modules. Refer How To Contact Customer Support [} 12].

9.2 Maintenance Procedures

9.2.1 Bakeout of Quadrupole

If the symptoms in Symptom-Cause-Remedy Chart [} 96] suggest that the sensor is contaminated, try first to restore normal performance by baking the sensor under a high vacuum—at least 1 x 10^{-5} Torr (1.333 x 10^{-5} mbar) [1.333 x 10^{-3} Pa]—for several hours, preferably overnight. The table below represents the maximum bakeout temperatures.

If baking the sensor doesn't increase the sensor performance, it may be necessary to perform the tasks described in Filament Kit Replacement [} 80], and also in Ion Source Replacement [} 84].

If the procedures explained above do not solve the problem, contact your distributor. Refer to How To Contact Customer Support [} 12].

		While Operating	With Electronics Removed
Faraday cup sensor		200°C	300°C
Electron multiplier	EM Mode	150°C	300°C
Faraday cup combination	FC Mode	200°C	300°C

> ⚠ **CAUTION**
>
> When heating the sensor above 200°C, the electronics module must be
>
> removed from the sensor.

9.3 Repair Procedures

9.3.1 How to Determine if a Filament Kit Replacement is Required

Follow these steps to determine if a filament replacement is required. Remember that the Element has dual filaments, so if one filament is blown, but the second filament is intact, the Element can still be used with the second filament.

> ℹ Performance of the second filament may be impacted by previous use of the Element.

1   Measure the resistance of each filament. This can be accomplished while the sensor is under vacuum by measuring the resistance between pins 3 and 10 for filament 1 and pins 4 and 10 for filament 2. A failed filament will measure open while an intact filament will measure 0.3Ω.
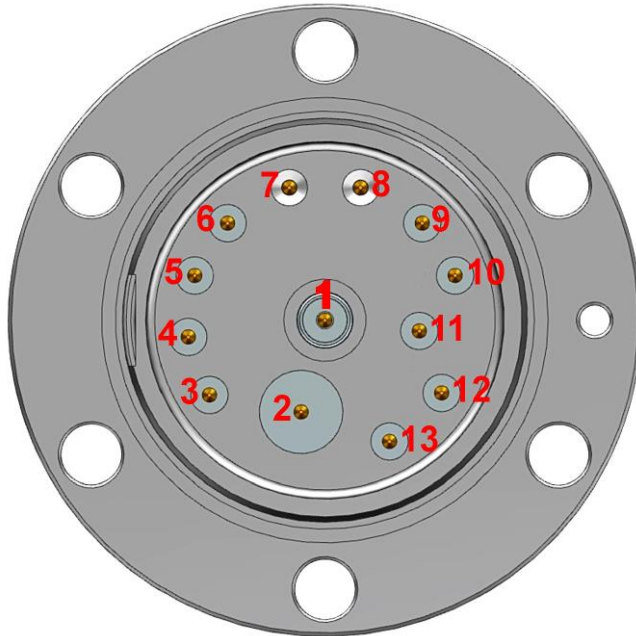
ℹ️ Although the following measurements may measure below 30 Mῼ with the filament assembly and ceramic shield in place, they must be above 30 Mῼ when measured with the filament assembly and ceramic shield removed.

2   Measure the resistance of each of the pins with respect to ground (pin 7 and 8). These measurements must be above 30 Mῼ.

3   Measure the resistance of each of the pins with respect to each other. All of these measurements must be above 30 Mῼ, with the exception of measurements between each filament pin and the filament common pin if the filaments have not failed.

Pin	Assignment
1	PP
2	EM HV
3	Filament 1
4	Filament 2
5	Anode
6	RF-
7	GND
8	GND
9	RF+
10	Filament Common
11	Reserved
12	Focus
13	TP

9.3.2 Tools Required

Tools for Replacing the Filament Kit
- ohmmeter (DMM)
- 3.2 mm nut driver
- 3 mm (1/8 in.) flat blade jeweler's or precision screwdriver

Tools for Replacing the Ion Source
- 3 mm (1/8 in.) flat blade jeweler's or precision screwdriver
- #1 Phillips head screwdriver
- precision pliers (smooth jaw)
- ohmmeter

Tools for Replacing the Electron Multiplier
- ohmmeter (DMM)
- 3 mm (1/8 in.) flat blade jeweler's or precision screwdriver

- #1 Phillips head screwdriver
- 1.5 mm hex key screwdriver
- 2.0 mm hex key screwdriver
- precision pliers (smooth jaw)
- tweezers

9.3.3 Filament Kit Replacement

A filament replacement kit can be purchased from your distributor. This kit contains a new filament assembly mounted on a shipping fixture. Perform the following steps to replace the filament.

Refer to Tools Required [⟩ 79] before continuing.

⚠ CAUTION

Neither the filament assembly or the ion source can be cleaned. When dirty,

they must be replaced.

1   Using the 3 mm nut driver, remove the three nuts and lock washers (A) from the standoffs.
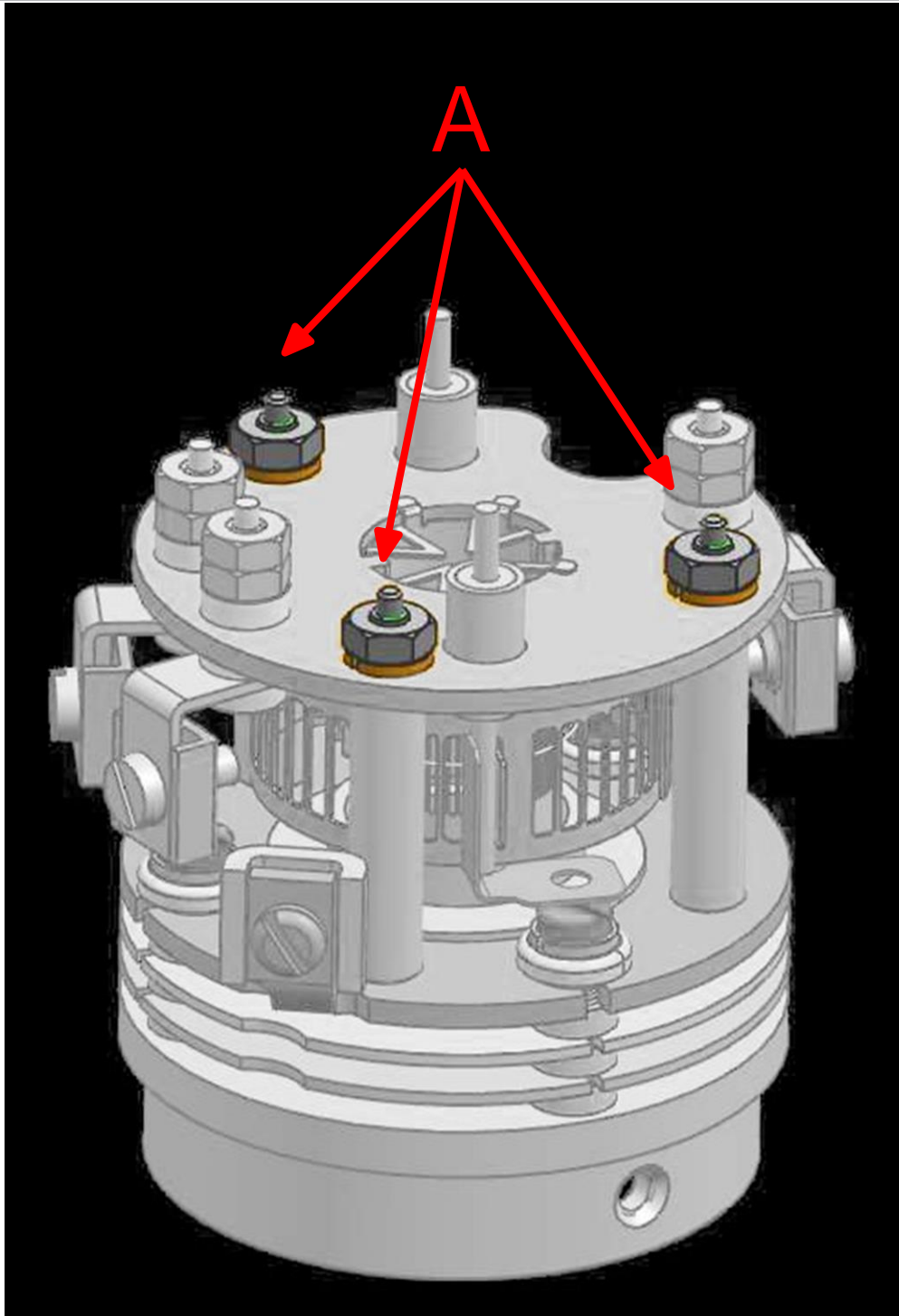
2   While holding the clamps with pliers, use the flat blade screwdriver to loosen the clamps holding the filament leads (B). Gently pull the leads away from the filament assembly.
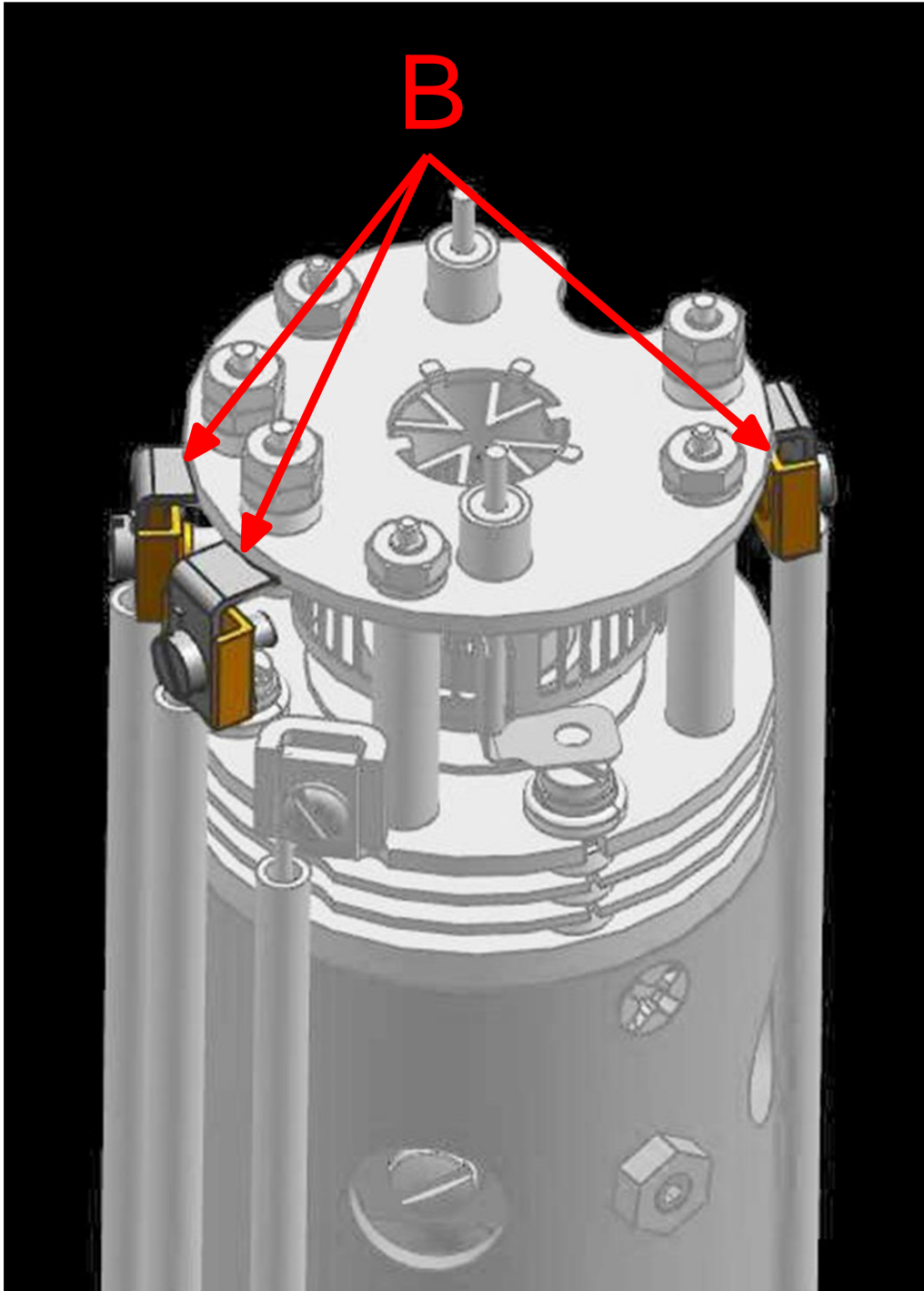
3 Carefully lift the filament assembly from the ion source.
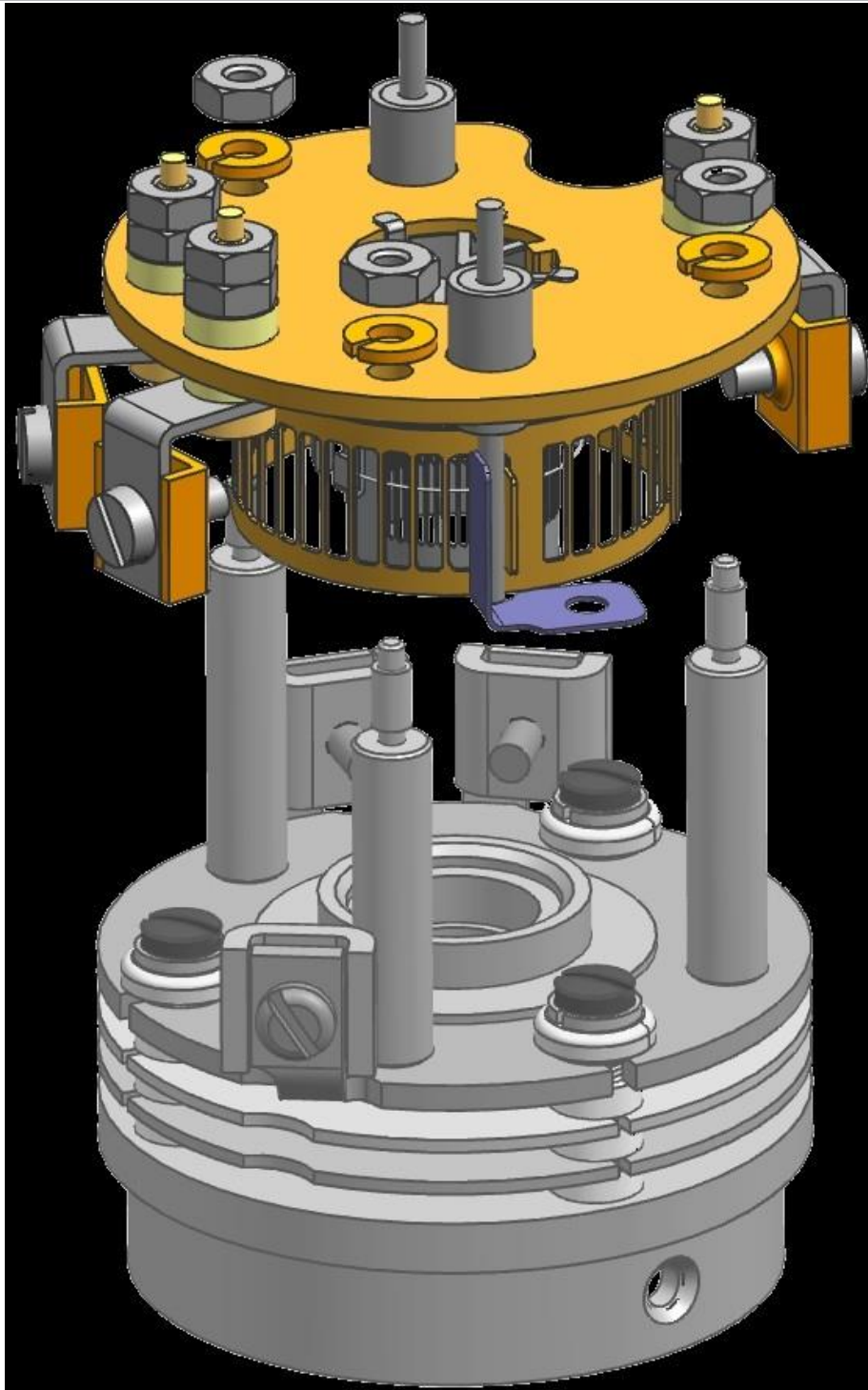
4   Carefully remove the new filament assembly from its packaging and place it on the ion source standoffs.

⚠ CAUTION

The new filament assembly must be carefully placed onto the ion source.

Excessive horizontal movement will cause damage to the anode.
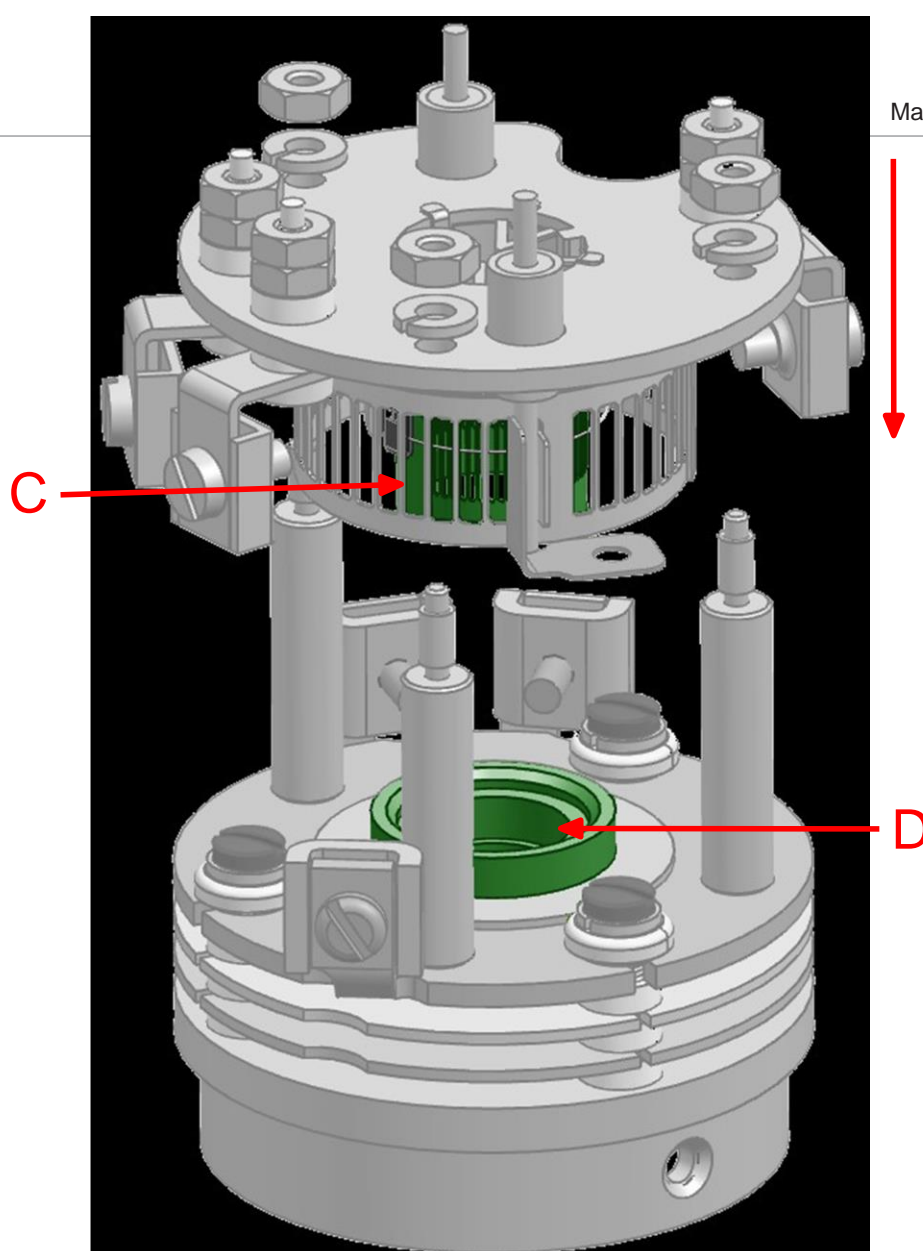
5 Replace the three washers and locknuts, and ensure that the anode (C) aligns
   with the mating bore (D).

6 Tighten the washers (A).

7 Insert the filament leads back into the clamps and tighten.

8 Using an ohmmeter, check that the filament is not shorted to ground and that the
   filament shows a resistance of approximately 0.3 Ω at the feedthrough.

9.3.4 Ion Source Replacement

Proceed as follows to remove the ion source.

Refer to Tools Required [} 79] before continuing.

1   While holding the clamps with pliers, use the flat blade screwdriver to loosen the clamps holding the filament leads (circled in red) and ion source leads (circled in green - one is hidden in the figure). There are a total of six leads that need to be loosened.
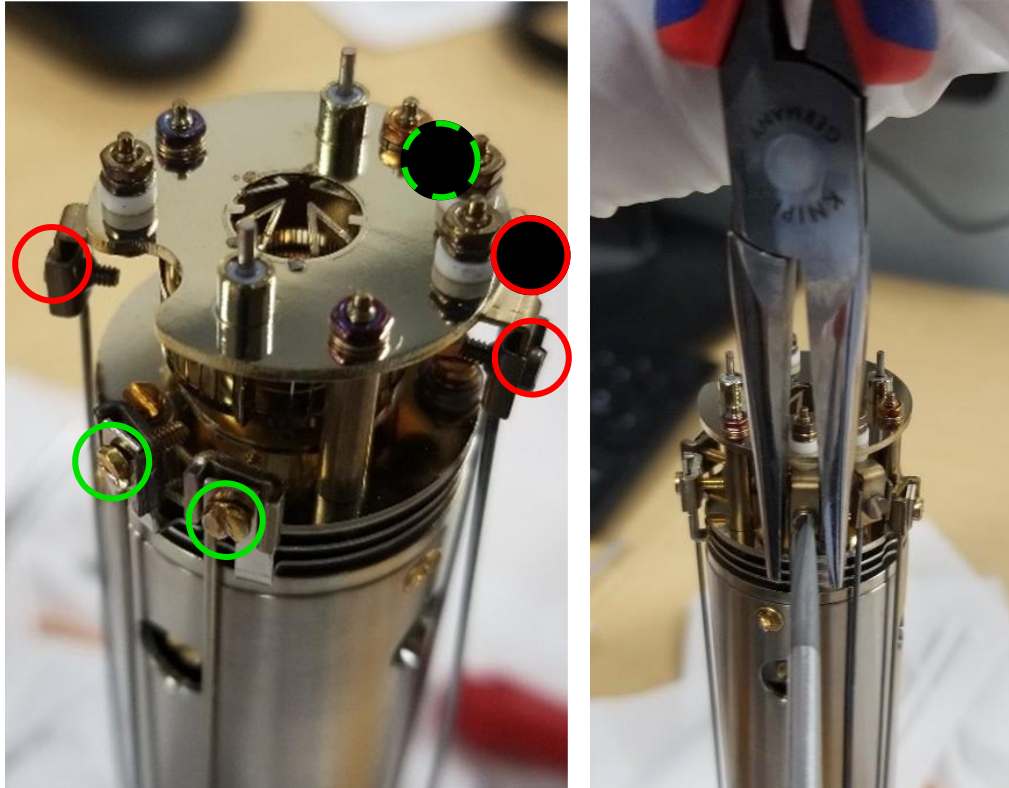
2   Pull the electrical leads away from the sensor.

⚠ CAUTION

Do not bend the leads.

3   Using the Phillips head screwdriver, remove the gold screws (C - one is hidden in the figure) that hold the ion source onto the quadrupole. There are three screws.
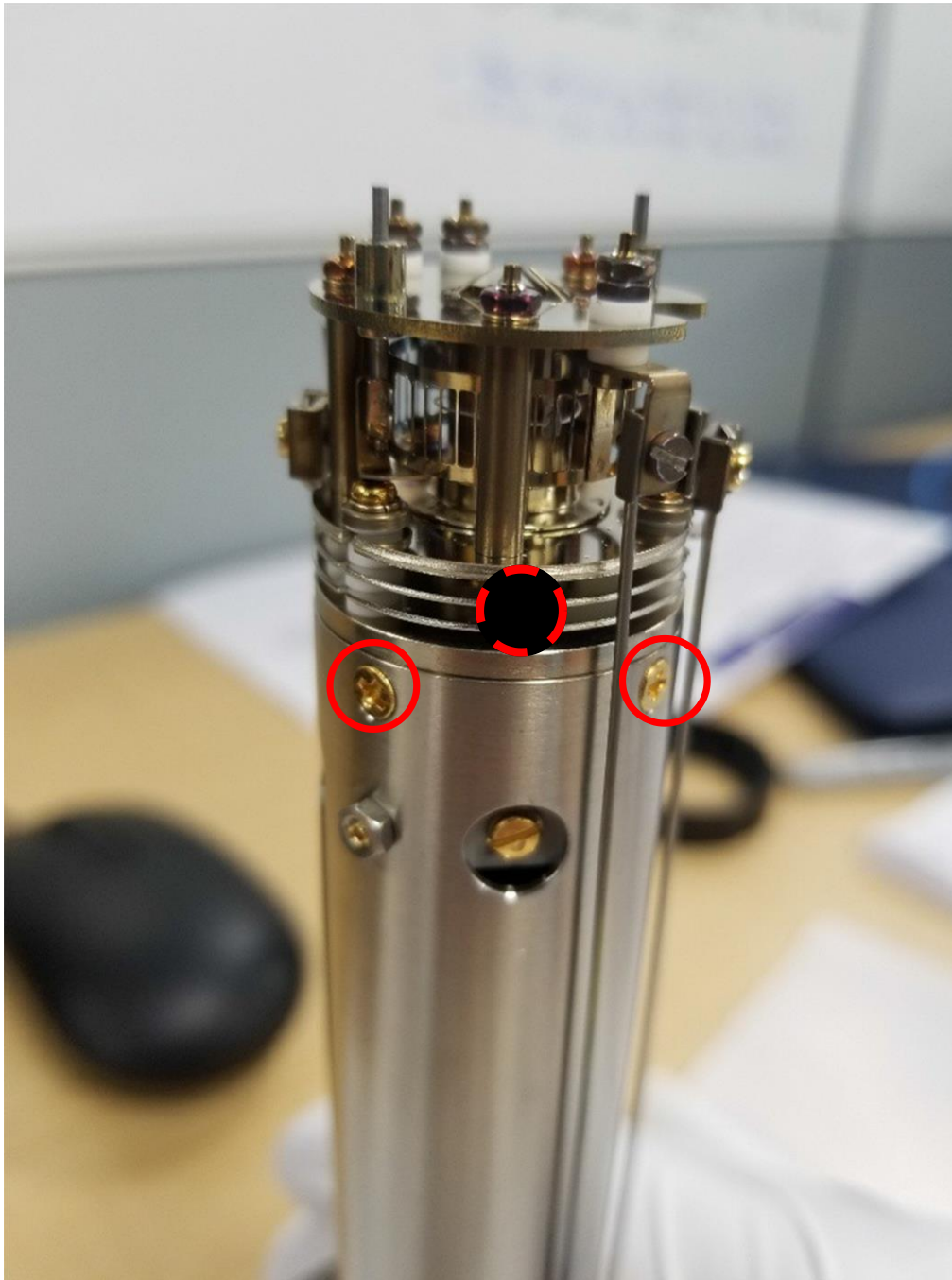
4   Lift the ion source off the quadrupole assembly.
5   Install the new ion source by reversing the above steps.
6   Using an ohmmeter, check:
ð that both filaments are not shorted to ground or to any of the lenses

ð that the filament leads show a filament resistance of approximately 0.3 ظ at
the feedthrough between each filament pin and the filament common pin,
refer to the figure in How to Determine if a Filament Kit Replacement is
Required [78] for pin out locations.

9.3.5 Electron Multiplier Replacement

The following steps should be performed to remove the ion source:

Refer to Tools Required [} 79] before continuing.

1   While holding the clamps with the pliers, use the flat blade screwdriver to loosen the clamps holding the filament leads (circled in red) and ion source leads (circled in green - one is hidden in the figure). There are a total of six leads that need to be loosened. Using the 1.5 mm hex driver, unscrew the screws (circled in orange) holding the two RF leads. Make sure to remove the lock washers as well.
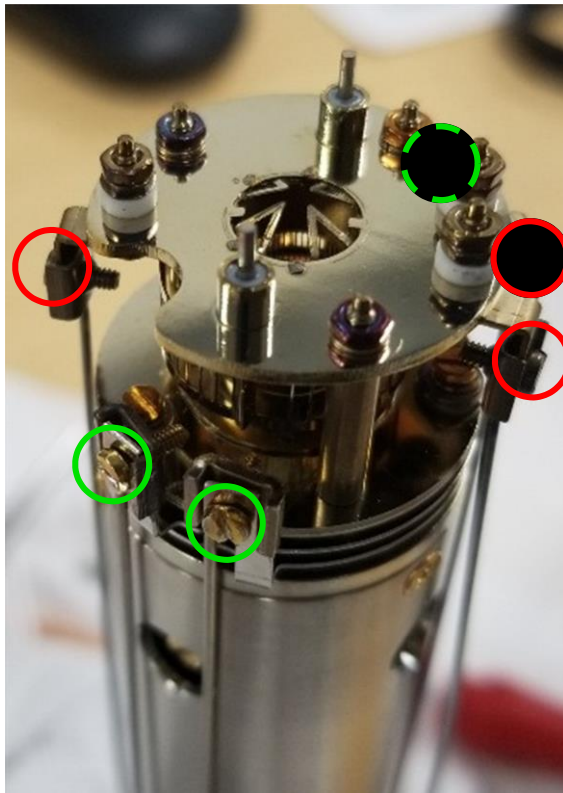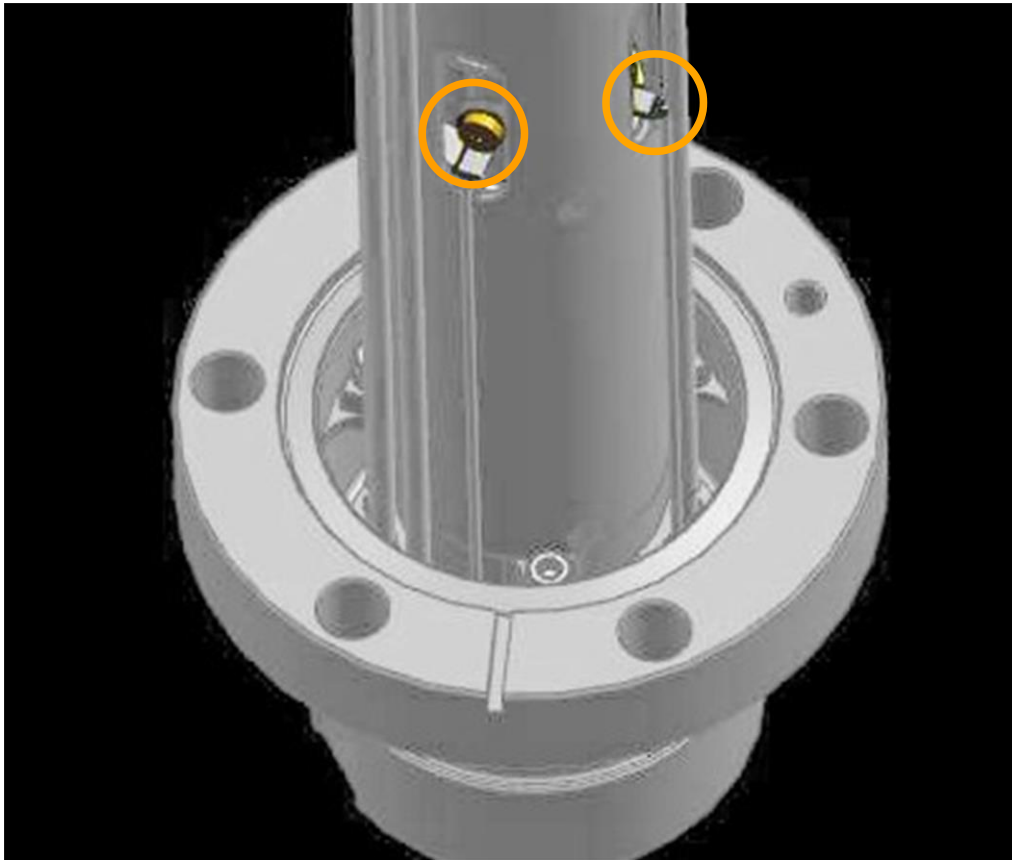
2   Gently pull the electrical leads away from the sensor.

⚠ CAUTION

Do not bend the leads.

3   Using the 2.0 mm hex driver, unscrew the three screws (D - one is hidden in the figure) holding the sensor assembly to the feedthrough. Gently remove the sensor assembly from the feedthrough.
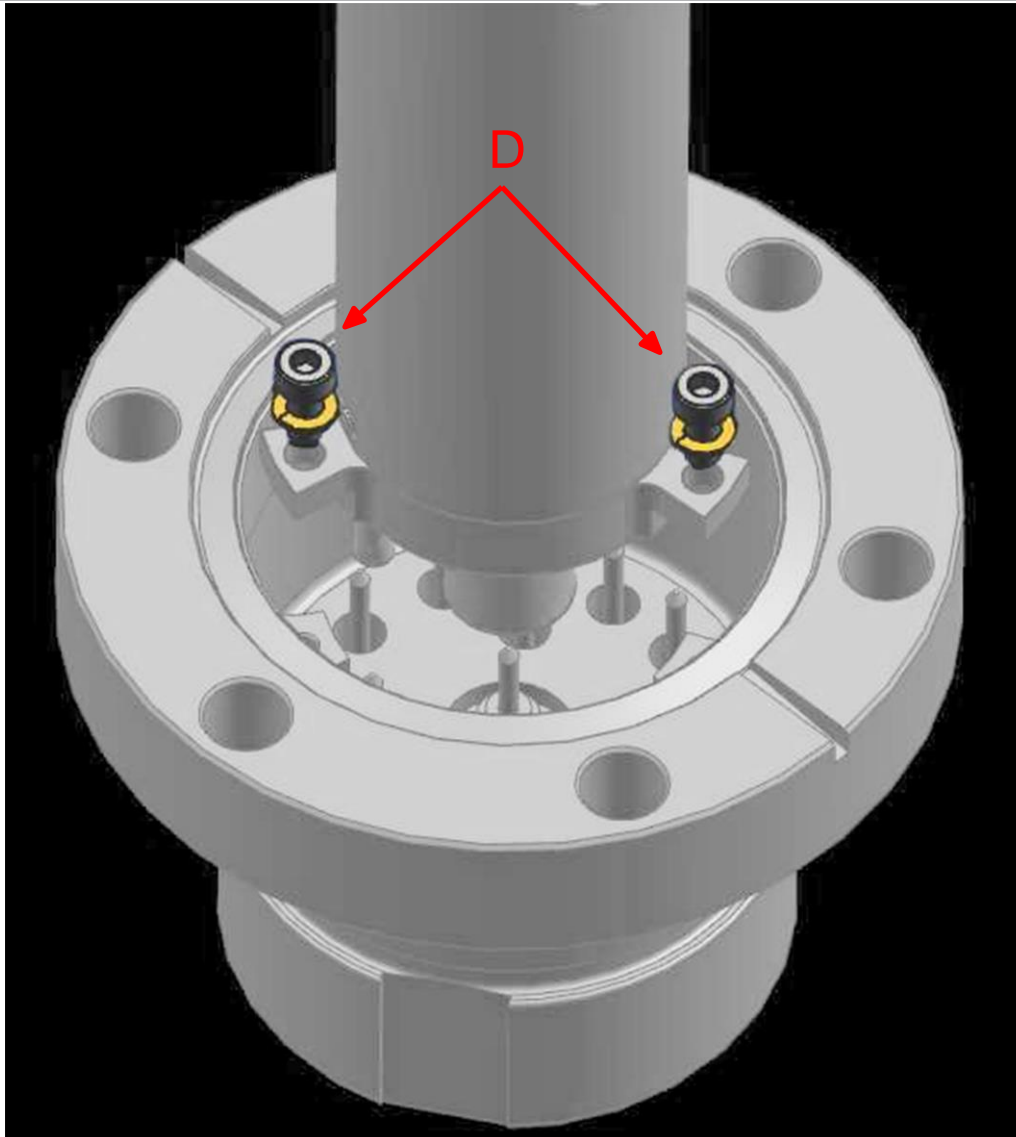
4   Using the Phillips head screwdriver, remove the three gold flathead screws (E - one is hidden in the figure) holding the EM assembly inside of the sensor assembly.
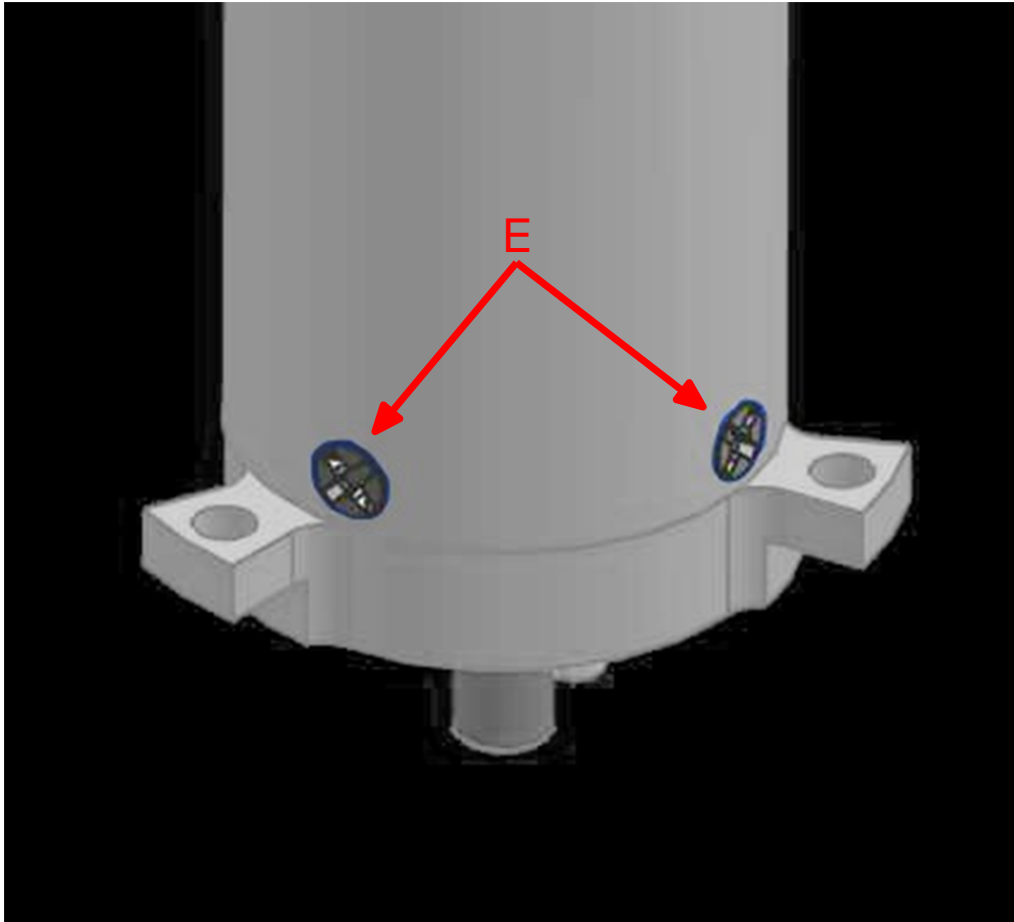
5   Gripping the bottom of the EM assembly, gently remove the EM from the sensor
    assembly.
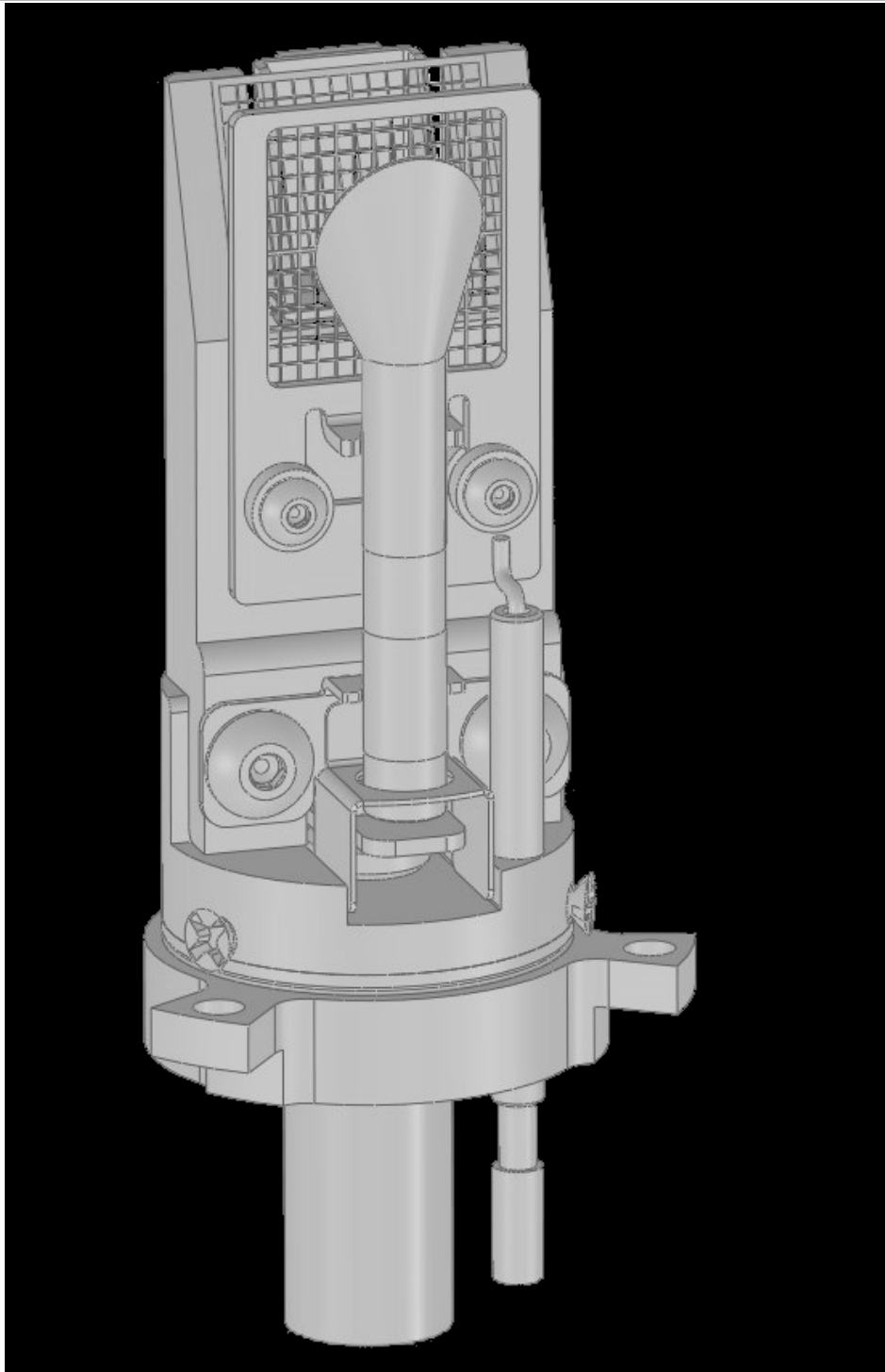
6 Remove the conductor shield on the bottom of the old detector assembly.
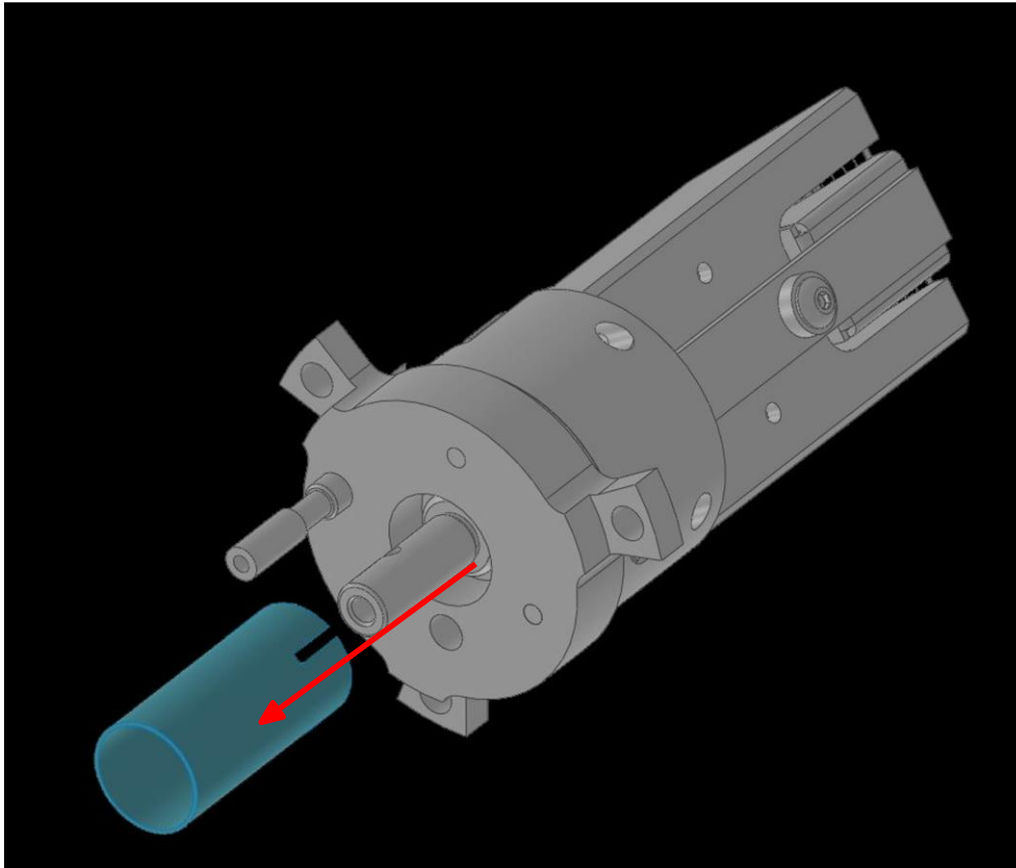
7 Install the conductor shield removed in step 6 onto the new electron multiplier assembly.

8 Install the new electron multiplier assembly into the sensor can.

9 When installing the sensor back into the feedthrough, ensure that the two pins on the bottom of the detector align with the two pins shown below.
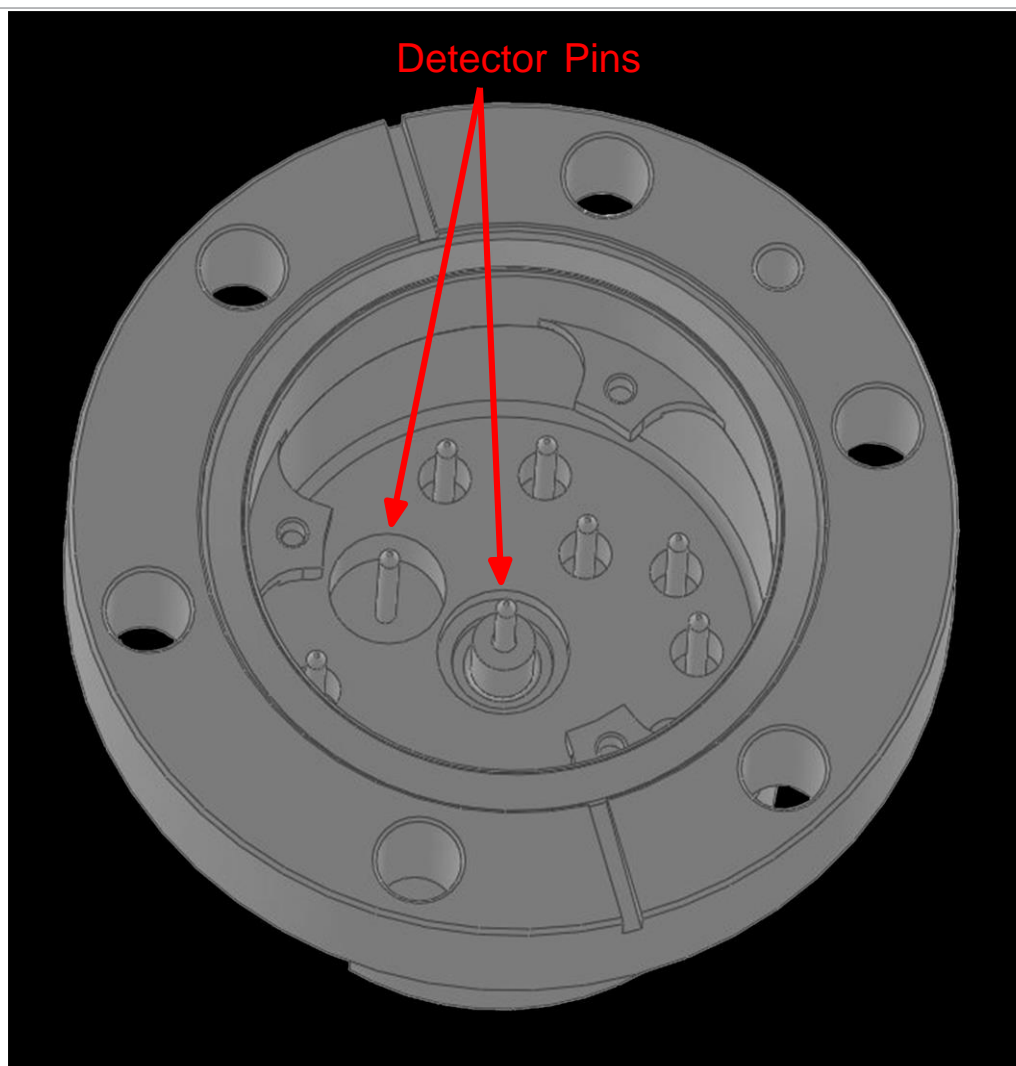
10   Reverse steps 1-4 to reassemble the Element sensor.

9.4 Calibration

9.4.1 Mass Alignment

The Element is tuned such that it generates a known RF/DC ratio that allows one mass to exit the quadrupole at a time. When tuning the mass scale of the Element, the RF/DC ratio is fine-tuned to each tune mass.

9.4.1.1 Factory Tuning

In the factory, the Element is tuned to different masses depending on the mass range of the Element. The factory tune masses and width standards are displayed below.

100 amu		200 amu	
Mass	10% R	Mass	10% R
1	0.5 ± 0.10	1	0.5 ± 0.10
2	0.9 ± 0.05	2	0.9 ± 0.05
4	0.9 ± 0.05	4	0.9 ± 0.05
28	0.9 ± 0.05	28	0.9 ± 0.05
86	0.9 ± 0.05	86	0.9 ± 0.05
		134	0.9 ± 0.05

The gases that are used for factory tuning of these masses are:
- hydrogen (mass 1 and 2)
- helium (mass 4)
- nitrogen (mass 28)
- krypton (mass 86)
- xenon (mass 134)

9.4.1.2 Selecting Tune Masses

The most important portion of mass scale tuning is determining which masses are to be tuned.
There are three different methods of tuning:

- To tune using a user-supplied test mixture, continue to Selecting Masses for Tuning with a User-Supplied Test Mix [} 94].

- To tune using process gases, continue to Selecting Masses for Tuning with Process Gases [} 95].

- To tune with background gases, continue to Tuning with Background Gases [} 95].

9.4.1.2.1 Selecting Masses for Tuning with a User-Supplied Test Mix

In some applications, it can be useful to have a test mix manufactured by a gas supplier. The ideal mix would include the factory tune masses for the mass range of Element to be tuned. The factory tune masses can be found in Factory Tuning [} 93].

See also
2 Mass Alignment [} 93]

9.4.1.2.2 Selecting Masses for Tuning with Process Gases

In general, Element tuning requires access to a low mass, a mid mass and a high mass.

Do not tune mass 1 or 2 if hydrogen is not present in the process, but do not delete them from the tune table.

Preferably, mass 4 should be tuned especially if the Element is used for leak checking. One way of doing this would be to create a leak and spray in helium. This will satisfy the low mass.

For a mid mass, try to use nitrogen or another mass in that area (water, oxygen, etc.). Tuning higher masses can be more difficult.

- If the process does not contain gases with masses over 40 amu, tune with argon.
- If the process does contain gases with higher masses.
- Tune one mass between the mid-mass and 100 amu for 100 amu sensors.
- Tune one mass between 100 and 200 amu for 200 amu sensors.

9.4.1.2.3 Tuning with Background Gases

Mass 4 must be calibrated for proper leak detection. If the Element is used as a leak detector, make sure that helium is available for tuning. If the Element is only used for leak checking, mass 4 is the only mass to tune. To tune mass 4, find a way to introduce helium into the vacuum chamber.

The following procedure may be used if test mixture or helium is not available.

1   Default all tune parameters.
2   Delete all masses except 1, 2, and 4.
3   Add mass 28 (or 40) and tune.
4   Delete mass 4.

5   Tune highest mass available in the system; in some cases this may be mass 40 or 44.

10 Diagnosing Problems

10.1 Introduction

If you are experiencing trouble with your the Element, first look at the table in Symptom- Cause-Remedy Chart [} 96] and see if your problem is listed there. If not, contact your distributor (refer to How To Contact Customer Support [} 12]).

10.2 Symptom-Cause-Remedy Chart

Make sure that the insulation on all cables is intact and there is no damage on the insulating material before using the table below.

Symptom	Cause	Remedy
The power indicator does not turn on.	The + 24 V external power supply has failed.	Check the input AC line voltage connected to the external power supply.
		Check the +24 V input. Verify that the input is between 20 -30 V.
		Replace the power supply.
	The electronics module has failed.	Return to KJLC for repair.
There is no communication to the host computer.	The sensor IP address is not compatible with the network.	Refer to Connecting Your Instrument [} 25].
	Element communications port (port 80) is not open on the host computer.	Either open port 80 on the host computer or change the communications port of Element.
	The cable connections are faulty.	Make sure the cables are connected to the proper connectors.
	The host computer's Ethernet card is malfunctioning.	Replace the Ethernet card on the host computer.
Error Message: Emission (There was a cold start or a warm start. The system is unable to start or maintain the specified emission current).	The filament is open, shorted to ground, or shorted to the anode.	Check the sensor with an ohmmeter.
		Replace sensor or filament.
	The electronics have failed.	Return to KJLC for repair.
	There is insufficient vacuum.	Verify that the pressure is less than 5E-4 Torr.

Symptom	Cause	Remedy
	The sensor or the operating voltages are incorrect.	Verify that the settings are correct. Contact your distributor for assistance.
	The Element electronics box is not fully engaged on the sensor.	Make sure that the Element electronics module is pushed all the way onto the sensor.
Error Message: Anode (The system is unable to start or maintain a specified anode voltage.)	The sensor is defective, causing the anode to short.	Check sensor with an ohmmeter for shorts. See How to Determine if a Filament Kit Replacement is Required [} 78]. Fix or replace sensor.
	The electronics module has failed.	Return to KJLC for repair.
Error Message: RF board	The sensor is defective, the RF leads are open, or there is an RF/DC card fault.	Fix or replace sensor.
	The electronics have failed.	Return to KJLC for repair.
Error Message: Electron multiplier	The sensor is defective, causing the EM to short.	Check sensor with an ohmmeter. See How to Determine if a Filament Kit Replacement is Required [} 78]. Fix or replace sensor.
	The new electron multiplier is installed improperly.	Verify that the EM is properly plugged into the HV pin.
	The electronics module has failed.	Return to your distributor for repair.
Error Message: Temperature	The Element internal ambient temperature is greater than 70°C.	Verify that the unit is installed properly and that the ambient temperature is below 50°C.
		Verify that there are no heat sources in local proximity.
		Verify that the internal fan is running.
	The electronics module has failed.	Return to KJLC for repair.
Error Message: Total pressure	The total pressure plate current has exceeded the trip threshold.	Reduce the pressure.
	The total pressure plate is contaminated.	Replace the ion source.
Error Message: Electrometer	The current exceeds 2E-6 amps.	Reduce the pressure.
		Reduce the EM voltage.

Symptom	Cause	Remedy
	The electronics module has failed.	Return to KJLC for repair.
Error Message: Mass filter	The tune file is bad.	Return the RGA.
	The quadrupole is contaminated.	Return to KJLC for repair.
Error Message: Ion source	The ion source settings are incorrect.	Load the original configuration file.
	The ion source is contaminated.	Return to KJLC for repair.
Error Message: Detector	The EM voltage is set too high.	Reduce the EM voltage.
	The detector is not working correctly.	Replace the EM detector.
Error Message: DSP communications	An incorrect DSP response is detected.	Reset the electronics box.
		Return electronics box to KJLC for repair.
Error Message: DEC communications	An incorrect DEC response is detected.	Reset electronics box.
		Return electronics box KJLC for repair.
Error Message: Peak find	There is no peak at the target mass.	Upload the original configuration file.
		Return electronics box to KJLC for repair.
Error Message: Filament potential	There is insufficient vacuum.	Verify that the pressure is less than 5E-4 Torr.
	The filament is broken.	Verify the integrity of the filament.
	The filament is shorted.	Verify that the filament is not shorted to ground.
Error Message: Filament current	There is insufficient vacuum.	Verify that the pressure is less than 5E-4 Torr.
	The filament is broken.	Verify the integrity of filament.
	The filament is shorted.	Verify that the filament is not shorted to ground.
Error Message: Focus	Unable to start or maintain focus voltage.	Reset the sensor.
		Return the electronics box to KJLC for repair.
There is no spectra.	The emission is OFF.	Turn the emission ON.
	The EM is ON, when operating.	Turn the EM OFF.
	The sensor is contaminated.	Degas, or service the sensor.
		Replace the sensor.

Symptom	Cause	Remedy
There is poor sensitivity.	The electronics module has failed.	Return to KJLC for repair.
	The pressure is too low for Faraday cup mode.	Use the electron multiplier (EM) detector.
	The EM voltage is too low.	Increase the voltage.
	The Element electronics box is not fully engaged on the sensor.	Push Element electronics module completely onto sensor.
	The mass calibration is faulty.	Adjust the mass calibration.
	The sensor is contaminated.	Degas sensor.
		Bake-out sensor.
		Service sensor.
	The system pressure is too low.	Increase the sample pressure, if possible.
	The mass calibration (resolution) is faulty.	Adjust the mass calibration and increase the peak width.
	The sensor operating parameters are set wrong.	Check the ion source settings: electron energy, ion energy, focus voltage, and emission current.
	The system was not calibrated properly.	Ensure that the total pressure gauge used for sensitivity calibration was properly calibrated.
	The electronics module has failed.	Return to KJLC for repair.
	The EM has low gain.	Bake-out the sensor.
		Replace the sensor.
There is poor peak shape.	The sensor is contaminated.	Degas the sensor.
		Bake-out the sensor.
		Service the sensor.
	The system pressure is too high.	Verify that the pressure is less than 5E-4 Torr for Element.
	A mass calibration is required.	Perform a mass calibration.
	The electronics have failed.	Return to KJLC for repair.
There is a high noise level.	The system is not grounded properly.	Verify that the vacuum system is grounded.
	The electronics have failed.	Return to KJLC for repair.
	The Element electronics box is not mounted properly on the sensor.	Push the Element electronics box all the way onto the sensor.

Symptom	Cause	Remedy
	The EM is defective.	Replace the EM assembly or the sensor.
	The scan speed is too fast for gain setting.	Increase the dwell time.

10.3 Communication Problems

To correct communication problems, check the following:

- Is the Ethernet cable connected to the Element and the host computer (either directly or through a router/switch)?
- Does the Element IP address have the same network prefix as the host computer?
- Is Port 80 open on the host computer?
- Is there an IP address conflict between the Element and another network device?

- Refer to Connecting Your Instrument [} 25] for more information on communications problems.

11 Bibliography

For further information on partial pressure analyzers, see Partial Pressure Analyzers and Analysis, M. J. Drinkwine and D. Lichtman, American Vacuum Society Monograph Series, or A User's Guide to Vacuum Technology, J. F. O'Hanlon, John Wiley and Sons (1989). The latter book also contains a wealth of information on related topics including gas flow, pressure gauges, pumps, materials, and the design of vacuum systems.

12 Glossary

anode	The anode is the structure in the ion source in which ions are created by electron impact. It can be formed from a mesh, such as in the open ion source, or from a solid tube, such as in the closed ion source. Its electrical potential is positive with respect to the filament, focus lens, total pressure plate, pole zero, exit aperture and Faraday cup.
appearance potential	The minimum electron energy required to produce, by electron bombardment, a given ion in its lowest energy state.
atomic mass unit (amu)	An atomic mass unit is a unit of measurement for the mass of a molecule or ion. It is based on the definition that the mass of an atom of the carbon-12 isotope is exactly 12.
background	The background is the residual atmosphere in a vacuum apparatus when no gases are being deliberately introduced.
bakeout	A bakeout is the process of heating a vacuum chamber above the ambient temperature in order to accelerate the desorption of species such as water vapor and hydrocarbons which are adsorbed onto the inner surfaces of the vacuum chamber.
center voltage	The center voltage is the DC potential to which the quadrupole rod RF and differential DC potentials are referenced.
closed ion source (CIS)	The closed ion source is an ion source in which the pressure in the ionization region is higher than in the rest of the analyzer sensor. This is usually accomplished by fabricating the anode from a solid walled tube instead of an open mesh. This type of source is usually employed to measure trace contaminant levels in a process gas.
conductance	The conductance of a gas flow channel is the ratio of the gas quantity flowing through the channel to the pressure drop across that channel.
cracking pattern	See Fragmentation Pattern.
detection factor	The detection factor is the ratio of the detected signal for a given ion current from a certain substance to the detected signal for the same ion current of nitrogen ions as measured at mass 28. For Faraday cup detectors, the detection factor is usually 1. For electron multiplier detectors, this factor depends on the mass and chemical nature of the ion.
detector	The detector is that part of the mass spectrometer sensor which converts a beam of ions into an electrical signal.
doubly charged ion	For positive ions, a doubly charged ion is a parent or fragment ion where two electrons have been removed.

electron energy	The electron energy is the kinetic energy of the ionizing electrons in an electron bombardment ion source and is typically measured in units of electron volts (eV). The electron energy is approximately equal to the difference between the bias voltage on the filament and the anode potential, times the electron charge.
electron multiplier	An electron multiplier is an in situ amplifier which is used to increase the sensitivity of a mass spectrometer. When a high voltage is applied to an electron multiplier, positive ions are accelerated into the multiplier, causing the release of a large number of electrons per incident ion at the output.
emission current	The emission current is the current of electrons leaving the surface of a heated filament.
exit aperture (quadrupole)	The exit aperture is a focus lens at the ion exit (detector) end of a quadrupole mass spectrometer. This lens is often biased by a potential that is negative with respect to the quadrupole center voltage such that ions are extracted from the exit end of the quadrupole and focused into the detector.
extractor	See Focus Lens.
Faraday cup	The Faraday cup is a detector for ions and/or electrons consisting of a cup shaped, conductive electrode.
filament	The filament is a fine wire or ribbon, which, when heated by means of electrical current, emits electrons. The filament typically made of iridium with a thorium or yttrium oxide coating, or of tungsten or a tungsten alloy.
focus lens	The focus lens is a conductive aperture located next to, and usually biased negatively with respect to, the anode. Its purpose is to draw the ions out of the anode, form them into a beam, and focus them into the next lens element.
fragment ion	A fragment ion is an ion with fewer atoms than the parent gas molecule from which the ion is produced. The mass of the fragment ion is always less than that of the parent ion.
fragmentation factor	The fragmentation factor is the fraction of the total ions produced from a specified substance which have a given mass. The sum of the fragmentation factors for all of the ions produced from a specified substance is equal to one.
fragmentation pattern	The fragmentation pattern is the pattern of ion masses and intensities produced by electron bombardment of a specified gas species as transmitted by the mass filter, detected and recorded.
gain (electron multiplier)	The gain of an electron multiplier is the ratio of incident ion current to electron current output. The gain of the multiplier is a strong function of the bias potential applied across it.
ion	An ion is a molecule or atom which has either lost or added one or more electrons. Those molecules which have lost electrons are positive ions. Those molecules which have added electrons are negative ions.
ion current	An ion current is the rate of flow of electrical charge associated with the flow of ions.

ion energy	The ion energy is the kinetic energy associated with a beam of ions. It is equal to the potential difference across which the ion beam is accelerated (or decelerated) times the charge on the ion, and is typically measured in electron volts (eV). Specifically, in a quadrupole mass spectrometer, it is the kinetic energy, along the axis, of the ions as they pass through the mass filter. The ion energy is approximately equal to the anode potential minus the quadrupole center voltage time the ionic charge.
ion source	The ion source is that part of a mass spectrometer in which neutral gas molecules or atoms are ionized by electron bombardment.
ionization probability	The ionization probability for a chemical substance is the ratio of the total ion current (at all masses) produced from a given partial pressure of that substance, to the total ion current produced from nitrogen at the same partial pressure.
isotope	The atom is composed of nucleus protons and neutrons surrounded by an electron cloud. The chemical properties of an element are determined by the number and arrangement of electrons (with -1 charge) in an atom. The number of electrons in a neutral atom in turn depends on the number of protons (with +1 charge) within the nucleus of that atom. Atomic nuclei also contain neutrons which, being uncharged, do not affect the chemistry of an element. Protons and neutrons have approximately the same mass, which is approximately 1,800 times the mass of an electron. All atoms of a given element have the same number of protons but not necessarily the same number of neutrons. Atoms of the same element which have a different number of neutrons are called isotopes. See also Natural Abundance.
linearity	Linearity is the mathematical relationship between an ion current and the total or partial pressure giving rise to that current. A mass spectrometer is said to have good linearity when the ion current is proportional to the pressure over a specified pressure range within a specified tolerance. Typically (but not always), the ion current will be linear with pressure at the low end of an instrument's pressure range. At some pressure near the high pressure end of an instrument's range, the ion current will be less than proportional to the pressure.
mass to charge ratio	The mass to charge ratio is ratio of the mass of an ion to its charge, usually expressed in atomic mass units per unit electron charge.
mass filter	The mass filter is that part of the mass spectrometer which separates a beam of ions by their mass to charge ratios.
mass spectrometer	A mass spectrometer is an instrument which ionizes a gas sample, separates the resulting beam of ions by mass to charge ratio, and detects the filtered ions as an electrical signal.
mass spectrum	A mass spectrum is a record of ion current as a function of mass to charge ratio obtained with a mass spectrometer. The spectrum can be presented as a graph with mass to charge ratio on the X-axis and ion current on the Y-axis.

material factor	The material factor for a chemical substance is that part of the proportionality constant between the partial pressure of that substance and the resulting mass filtered ion current which depends on the chemical nature of that substance but not the particular instrument used for that measurement. The material factor is a function of the ionization probability and fragmentation factor for the specified substance.
mean-free-path	The mean-free-path is the average distance an ion, electron, atom, or molecule can travel before colliding with an ambient gas molecule. The mean free path is inversely proportional to the pressure.
molecular flow	Molecular flow is that motion of gas molecules wherein the collisional mean free path is greater than the critical dimension of a flow constraining element such as an orifice of tube diameter. The gas flow characteristics are dominated by collisions between the gas molecules and the appropriate surfaces of the vacuum system.
natural abundance	The natural abundance of an isotope is the average percentage of all atoms of a given element which have the same number of neutrons. For example, 99.985% of all naturally occurring hydrogen atoms have no neutrons, giving an atomic mass of approximately 1, while 0.015% have one neutron, giving an atomic mass of approximately 2. There is a third isotope of hydrogen which contains two neutrons, giving an atomic mass of 3, but this isotope is unstable with such a short radioactive half life that it is not normally naturally occurring in any significant quantity on earth.
open ion source (OIS)	There are occasions when an observed isotopic abundance will not reflect the natural abundance. For instance, in semiconductor processing tools know as ion implanters, it is not unusual for the BF_3 boron dopant source to be isotopically enriched to 99%+ of the boron-11 isotope (instead of the naturally occurring 80.22%).
	An open ion source is an ion source constructed with an open grid structure with high conductance between the ionization region and the vacuum region surrounding it. Residual gas analyzers are typically equipped with this type of ion source.
outgassing	Outgassing is the evolution of gas which was dissolved in or adsorbed on solid surfaces inside a vacuum chamber.
parent ion	A parent ion is an ion made by removing a single electron from the original, or parent, gas molecule, and therefore has the same mass.
partial pressure	The partial pressure is the pressure of a specific chemical component of a gas mixture. The sum of all the partial pressures is the total pressure.
pole zero	See Center Voltage.

quadrupole	A quadrupole is a mass filter consisting of four parallel electrodes or poles (hence quadrupole) arranged in a square array. Opposite poles are connected together electrically such that an electric field of hyperbolic geometry is produced. The potentials applied to these poles are a superposition of variable DC and RF voltages, generally of fixed RF frequency.
repeller (electron)	The electron repeller is an electrode located on the opposite side of the filament than the anode. The repeller is usually biased at the same potential as the negative side of the filament, or a more negative potential.
residual gas analyzer	A residual gas analyzer is an instrument which is used to determine the quantities and chemical nature of gases present in a vacuum system. The instrument is typically a mass spectrometer equipped with an open ion source.
resolution	Resolution is the ability of a mass filter to select between nearby masses. It is typically measured as the mass of the peak divided by the width of a given mass peak at 10% or 50% of the peak maximum intensity.
secondary electron	A secondary electron is an electron emitted from a surface when that surface is struck by a sufficiently energetic ion, electron, neutral molecule or photon.
sensitivity	The sensitivity of a mass spectrometer is the ratio of ion current at a specified mass from a specified gas to the partial pressure of that gas, suitably corrected for background. The specified gas is typically nitrogen, measured at 28 amu, although argon at 40 amu is sometimes used instead, depending on the instrument.
total pressure	The total pressure is the force per unit area exerted by a gas on the walls of its container. It is equal to the sum of all the partial pressures of the different chemical species which comprise that gas.
total pressure plate	The total pressure plate, or collector, is an electrode in the ion source on which at least a part of the ion beam impinges. The current striking this plate is a function of the total pressure in the ion source.
transition flow	Transition flow is that motion of gas molecules wherein the collisional mean free path is approximately the same as the critical dimension of a flow constraining element such as an orifice of tube diameter.
transmission factor	The transmission factor is the ratio of ion current detected at the exit end of the mass filter (set to transmit a given mass) to the current of ions of the same mass entering the filter from the ion source. Typically, the transmission factor for nitrogen ions at 28 amu is set equal to 1. The transmission factor at other masses is given relative to that for nitrogen.
viscous flow	Viscous flow is that motion of gas molecules wherein the collisional mean free path is less than the critical dimension of a flow constraining element such as an orifice of tube diameter. The gas flow characteristics are dominated by collisions between gas molecules.

zero blast	Zero blast is the ion current which is not mass filtered and is detected when the
	mass spectrometer is scanning near mass zero.

13 Spare Parts

13.1 Introduction

Element has several accessories and spare parts for purchase. Contact your distributor for spare parts.

13.2 Spare Parts

13.2.1 Preventative Maintenance Parts

Part Number	Description
ELE163312	Filament Kit – dual yttria-coated iridium filaments
ELE163311	Filament Kit – dual tungsten filaments
ELE163212	Ion source kit – dual yttria-coated iridium filaments
ELE163211	Ion source kit – tungsten filaments
ELE163500	Electron multiplier kit

13.2.2 Replacement Spare Parts

Part Number	Description
ELE163545	Spare o-ring and nut kit (for connection between box and sensor)
KJL-RGA-EXTKIT	Element EM/FC extension tube kit (including nuts/bolts)
ELE163604	Communications cable ethernet 7
ELE163605	Communications cable ethernet 15 m
ELE163600	Power supply kit: 80-250 V(ac), 1.2 m (4 ft.) US
ELE163601	Power supply kit: 80-250 V(ac), 1.2 m (4 ft.) EU
ELE163602	Power supply kit: 80-250 v(ac), 1.2 m (4 ft.) UK
ELE163603	Power supply kit: 80-250 v(ac), 1.2 m (4 ft.) IL plug
ELE163606	Power supply cable 4.5 m
ELE163607	Power supply cable 9.0 m

13.2.3 Spare Electronics Module

(one of the following)	
Part Number	Description
EL-A10S	Element 100 amu FC electronics box with standard I/O
EL-A11S	Element 100 amu FC electronics box with extended I/O
EL-A20S	Element 200 amu FC electronics box with standard I/O
EL-A21S	Element 200 amu FC electronics box with extended I/O
EL-B10S	Element 100 amu EM/FC electronics box with standard I/O
EL-B11S	Element 100 amu EM/FC electronics box with extended I/O
EL-B20S	Element 200 amu EM/FC electronics box with standard I/O
EL-B21S	Element 200 amu EM/FC electronics box with extended I/O

13.2.4 Spare Sensor

(one of the following)	
Part Number	Description
EL-1FAS	ELE100F yttria-coated iridium filaments
EL-1MAS	ELE100M yttria-coated iridium filaments
EL-2FAS	ELE200F yttria-coated iridium filaments
EL-2MAS	ELE200M yttria-coated iridium filaments
EL-1FBS	ELE100F tungsten filaments
EL-1MBS	ELE100M tungsten Filaments
EL-2FBS	ELE200F tungsten filaments
EL-2MBS	ELE200M tungsten filaments

14 Specifications

14.1 Introduction

The following sections detail the specifications for the Element Gas Analysis System. As a result of kjlc continuing product improvement and quality assurance programs, these specifications are subject to change without notice or obligation.

ℹ️ All specifications are measured after a 30 minute warm-up period at constant STP unless specified.

14.2 Sensor Length (Vacuum Side)

100F	100M	200F	200M
143 mm (5.63 in.)	193 mm (7.82 in.)	143 mm (5.63 in.)	193 mm (7.82 in.)

14.3 Mass Range

100F	100M	200F	200M
1 to 100 amu		1 to 200 amu	

14.4 Detector Type

100F	100M	200F	200M
Faraday cup	Continuous dynode electron multiplier/	Faraday cup	Continuous dynode electron multiplier/

14.5 Resolution

Peak Width (AMU) at 10% of peak height			
100F	100M	200F	200F
0.9 amu			

14.6 Temperature Coefficient

During an eight hour period, after thirty minutes of warm up			
100F	100M	200F	200M
For FC Only—Less than 1% of peak height per °C			

14.7 Sensitivity

Amps/Torr [mbar] (Pa)				
	100F	100M	200F	200M
FC	3×10^{-4} $[3\times10^{-4}]$ (3×10^{-6})	3×10^{-4} $[3\times10^{-4}]$ (3×10^{-6})	3×10^{-4} $[3\times10^{-4}]$ (3×10^{-6})	3×10^{-4} $[3\times10^{-4}]$ (3×10^{-6})

14.8 Minimum Detectable Partial Pressure

Torr [mbar] (Pa)				
	100F	100M	200F	200M
FC	2.6×10^{-12} $[3.5\times10^{-12}]$ (4×10^{-10})	N/A	2.6×10^{-12} $[3.5\times10^{-12}]$ (4×10^{-10})	N/A
EM	N/A	1.5×10^{-14} $[2\times10^{-14}]$ (2×10^{-12})	N/A	1.5×10^{-14} $[2\times10^{-14}]$ (2×10^{-12})

14.9 Zero Blast Interference at Mass 2

ppm			
100F	100M	200F	200M
<100 ppm			

14.10 Maximum Operating Pressure

Torr [mbar] (Pa)			
100F	100M	200F	200M
5×10^{-4} [6.7×10^{-4}] (6.7×10^{-2})			

14.11 Maximum Sensor Operating Temperature

Degrees C				
	100F	100M	200F	200M
FC	200°C	200°C	200°C	200°C
EM	N/A	150°C	N/A	150°C

14.12 Maximum Bakeout Temperature

Degrees C — with electronics removed			
100F	100M	200F	200M
300°			

14.13 Operating Temperature

100F	100M	200F	200M
5 to 50°C ambient			

14.14 Power Input

100F	100M	200F	200M
20-30 V(dc), 24 V(dc) Typical, Latching, 4-pin Din connector, internally isolated from system ground, 1.25A maximum			

14.15 Ethernet Communication Interface

100F	100M	200F	200M
Standard: Cat5e Ethernet cable connection			

14.16 Relay Outputs

100F	100M	200F	200M
1 relay, 24 V at 0.5 amps			

14.17 Interface

The Element supports input and output functions through the auxilary I/O 15-pin connector (A), and the optional extended I/O 62-pin connector (B).
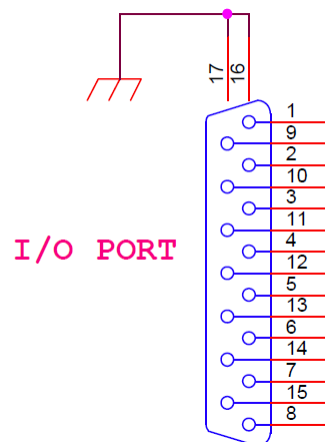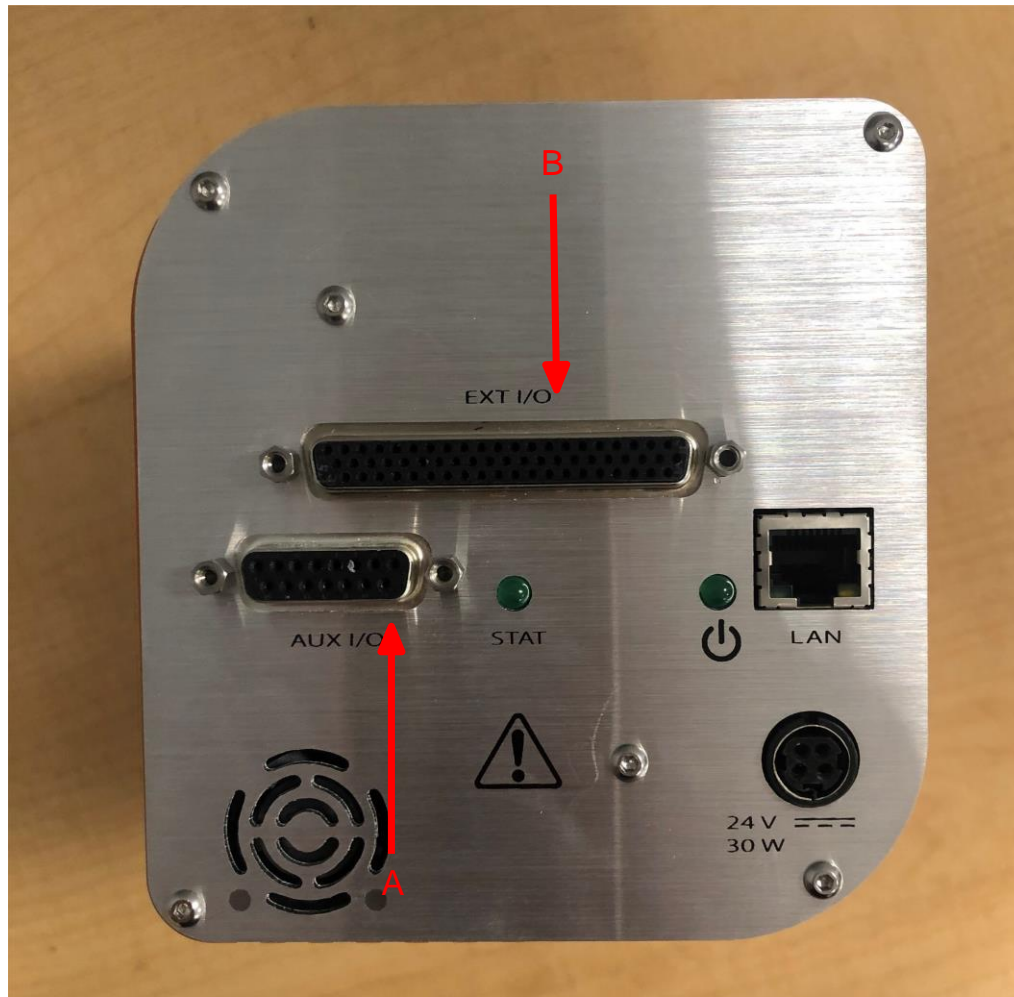
Pin #	Description
1	Relay 1 common

Pin #	Description
2	Relay 1 normal open
3	Relay 1 normal closed
4	1 wire return (reserved, do no connect)
5	CANH (reserved, do not connect)
6	ISO 5V (reserved, do not connect)
7	24 V return
8	+24 V
9	Analog in 1 (+)
10	Analog in 1 (-)
11	1 Wire (reserved, do no connect)
12	CANL (reserved, do not connect)
13	Digital in 1
14	Digital in 0
15	Ground
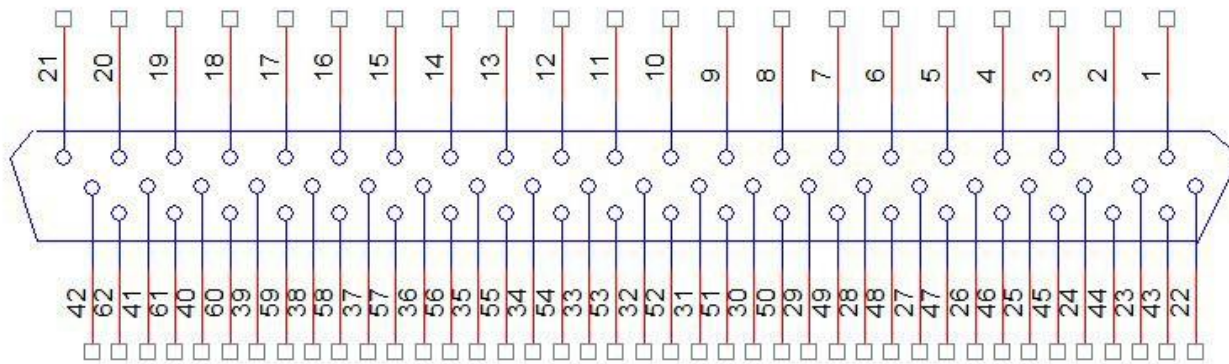
Pin #	Description	Pin #	Description
49	Analog Input 2 (+)	27	Digital (input or output) 11
50	Analog Input 2 (-)	26	Digital (input or output) 12
51	Analog Input 3 (+)	25	Digital (input or output) 13
52	Analog Input 3 (-)	48	Relay 2 common
53	Analog Input 4 (+)	47	Relay 2 normal open
54	Analog Input 4 (-)	44	Relay 2 normal close

Pin #	Description	Pin #	Description
55	Analog Input 5 (+)	46	Relay 3 common
56	Analog Input 5 (-)	45	Relay 3 normal open
16	Analog Output 0	43	Relay 3 normal close
19	Analog Output 1	2	Relay 4 common
14	Analog Output 2	1	Relay 4 normal open
15	Analog Output 3	22	Relay 4 normal close
10	Digital (input or output) 2	3	Relay 5 common
31	Digital (input or output) 3	5	Relay 5 normal open
9	Digital (input or output) 4	4	Relay 5 normal close
30	Digital (input or output) 5	12, 13, 20, 33, 34	Reserved
8	Digital (input or output) 6	58, 59	24V Aux supply
29	Digital (input or output) 7	61, 62	24V Aux return
7	Digital (input or output) 8	11, 17, 18	GND_signal
28	Digital (input or output) 9	21, 32, 35	GND_signal
6	Digital (input or output) 10	57, 60	GND_signal

14.17.1 Analog Input

There are a total of five analog input channels available through auxiliary I/O and extended I/O. These analog inputs are 16 bits, and have an input range of 0 to 10 volts.

- From the extended I/O connector, there are four analog input channels.
- From the auxiliary I/O connector, there is one analog input channel.

Software Parameter Designation	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub connector of auxiliary I/O board
Analog input 1 (-)	-	10
Analog input 1 (+)	-	9
Analog input 2 (-)	50	-
Analog input 2 (+)	49	-
Analog input 3 (-)	52	-
Analog input 3 (+)	51	-
Analog input 4 (-)	54	-

Software Parameter Designation	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub connector of auxiliary I/O board
Analog input 4 (+)	53	-
Analog input 5 (-)	56	-
Analog input 5 (+)	55	-

14.17.2 Analog Output

There are a total of four analog output channels available through extended I/O board. These analog outputs are 16-bits and have an output range of 0 to 10 volts.

All analog output channels are coming out from the extended I/O board through the 62-pin D-sub connector.

i These analog outputs are referenced to signal ground pins (pin: 11, 17, 18, 21, 32, 35, 57, and 60).

Software Parameter Designation	Pin number from 62 pin D-sub connector of extended I/O board
Analog Output 0	16
Analog Output 1	19
Analog Output 2	14
Analog Output 3	15

14.17.3 Digital Input/Output

There are a total of 14 channels, configured as digital input or output through control software.

- From the auxiliary I/O connector, there are two channels, configured as digital input.
- From the extended I/O connector, there are 12 channels, configured as digital input or digital output.

Software Parameter Design	Configured	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub connector of auxiliary I/O board
Digital 0	Input	-	14
Digital 1	Input	-	13

Software Parameter Design	Configured	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub
Digital 2	Input or Output	10	-
Digital 3	Input or Output	31	-
Digital 4	Input or Output	9	-
Digital 5	Input or Output	30	-
Digital 6	Input or Output	8	-
Digital 7	Input or Output	29	-
Digital 8	Input or Output	7	-
Digital 9	Input or Output	28	-
Digital 10	Input or Output	6	-
Digital 11	Input or Output	27	-
Digital 12	Input or Output	26	-
Digital 13	Input or Output	28	-

14.17.4 Relay

There are a total of five relays available through auxiliary I/O and extended I/O (four relays from extended I/O and one relay from auxiliary I/O).

The extended I/O relays have both normally open (NO) or normally closed (NC) contacts with the relay common available on the 62-pin connector.

The relay is active when the relay common channel and relay NO channel are connected. The relay is inactive when the relay common channel and relay NC channel are connected.

Software Parameter Design	Channels	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub connector of auxiliary I/O board
Relay 1	Common	-	1
	Normal Open	-	2
	Normal Closed	-	3
Relay 2	Common	48	-
	Normal Open	47	-
	Normal Closed	44	-
Relay 3	Common	46	-
	Normal Open	45	-
	Normal Closed	43	-

Software Parameter Design	Channels	Pin number from 62 pin D-sub connector of extended I/O board	Pin number from 15 pin D-sub connector of auxiliary I/O board
Relay 4	Common	2	-
	Normal Open	1	-
	Normal Closed	22	-
Relay 5	Common	3	-
	Normal Open	5	-
	Normal Closed	4	

14.18 Indicators (Green)

100F	100M	200F	200M
1 for power status, 1 for emission status			

15 Supplied Items

15.1 Introduction

You will receive the following:

- ship kit (see Ship Kit [} 119])
- electronics module (see Electronics Module [} 120])
- sensor (see Sensor [} 120])
- extension kit (see Extension [} 121])
- computer cable
- sold separately: electronics module power supply (see Power Supply [} 120])

15.1.1 Ship Kit

Part Number	Quantity	Description
ELE-0020-G1 includes:	1	Ship kit
	1	Gasket DN40CF copper ROHS
	2	Poly bag 4 x 6
	3	Nut plate 1/4-28 SS ROHS
	1	O-ring 1.625 ID .125 W VITON BLK
	1	Poly bag 9 x 12
	1	Label 3.25 x 1.75
	6	Bolt 1/4-28 x 1.25LG 12 PT SS Ag
	6	Washer 1/4 flat SS
	1	Ethernet communication 7.6M
	1	Coupling nut
	1	Hexagonal wrench 3.0-3.2

15.1.2 Electronics Module

(one of the following)	
Part Number	Description
EL-A10S	Element 100 amu FC electronics box with standard I/O
EL-A11S	Element 100 amu FC electronics box with extended I/O
EL-A20S	Element 200 amu FC electronics box with standard I/O
EL-A21S	Element 200 amu FC electronics box with extended I/O
EL-B10S	Element 100 amu EM/FC electronics box with standard I/O
EL-B11S	Element 100 amu EM/FC electronics box with extended I/O
EL-B20S	Element 200 amu EM/FC electronics box with standard I/O
EL-B21S	Element 200 amu EM/FC electronics box with extended I/O

15.1.3 Power Supply

Part Number	Description
ELE163600	Power supply kit - 85-250 V(ac) 1.2 m (4 ft.) US plug
ELE163601	Power supply kit - 85-250 V(ac) 1.2 m (4 ft.) EU plug
ELE163602	Power supply kit - 85-250 V(ac) 1.2 m (4 ft.) UK plug
ELE163603	Power supply kit - 85-250 V(ac) 1.2 m (4 ft.) IL plug

15.1.4 Sensor

(one of the following)	
Part Number	Description
EL-1FAS	ELE100F Y_2O_3/Ir filaments

(one of the following)	
Part Number	Description
EL-1MAS	ELE100M Y_2O_3/Ir filaments
EL-2FAS	ELE200F Y_2O_3/Ir filaments
EL-2MAS	ELE200M Y_2O_3/Ir filaments
EL-1FBS	ELE100F tungsten filaments
EL-1MBS	ELE100M tungsten filaments
EL-2FBS	ELE200F tungsten filaments
EL-2MBS	ELE200M tungsten filaments

15.1.5 Extension

Part Number	Description
KJL-RGA-EXTKIT	Element sensor extension tube