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# CrystalSix<sup>®</sup>

Sensor

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PN 074-155M



O P E R A T I N G M A N U A L

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## Sensor

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PN 074-155M



[www.inficon.com](http://www.inficon.com)   [reachus@inficon.com](mailto:reachus@inficon.com)

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# Chapter 1

## Introduction and Specifications

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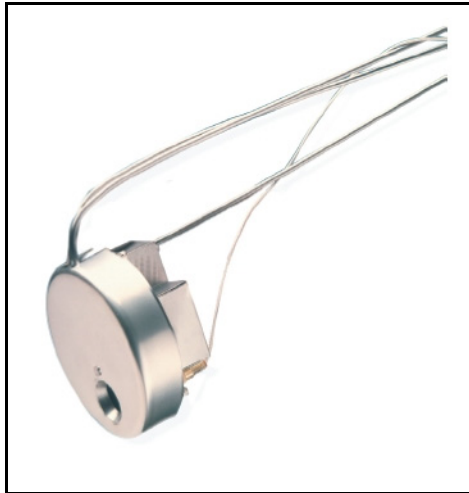
### 1.1 Introduction

INFICON CrystalSix® is a six crystal, quartz crystal deposition sensor for long processes demanding continuous rate control.

Whether an OLED, MBE, Solar, long Optical Coating, or other process with an extended period between chamber venting, the CrystalSix sensor provides six quartz monitor crystals in one sensor head. When used with an INFICON thin film controller, CrystalSix automatically rotates a new crystal into position whenever the current crystal fails or becomes unstable.

Crystal rotation is accomplished with a pneumatically driven mechanism. Water cooling tubes keep the sensor head thermally stable and allow flexibility in sensor placement. When used with certain INFICON thin film controllers, the sensor provides position feedback so specific crystals can be used with specific materials.

Figure 1-1 CrystalSix sensor



## 1.2 Definition of Notes, Hints, Cautions, and Warnings

Before using this manual, please take a moment to understand the Notes, Hints, Cautions, and Warnings used throughout. They provide pertinent information that is useful in achieving maximum instrument efficiency while ensuring personal safety.

**NOTE:** Notes provide additional information about the current topic.

**HINT:** Hints provide insight into product usage.



### CAUTION

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**Failure to obey these messages could result in damage to the instrument.**

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### WARNING

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**Failure to obey these messages could result in personal injury.**

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## 1.3 How to Contact INFICON

Worldwide customer support information is available under **Contact >> Support Worldwide** at [www.inficon.com](http://www.inficon.com):

- ◆ Sales and Customer Service
- ◆ Technical Support
- ◆ Repair Service

When communicating with INFICON about a sensor, please have the following information readily available:

- ◆ The Sales Order or PO number of the sensor purchase.
- ◆ The Lot Identification Code, located underneath the rectangular actuator cover on the back side of the sensor head.
- ◆ A description of the problem.
- ◆ The exact wording of any error messages that have been received.
- ◆ An explanation of any corrective action that may have already been attempted.

### 1.3.1 Returning Sensor to INFICON

Do not return any sensor component to INFICON before speaking with a Customer Support Representative and obtaining a Return Material Authorization (RMA) number. Sensors will not be serviced without an RMA number.

Packages delivered to INFICON without an RMA number will be held until the customer is contacted. This will result in delays in servicing the sensor.

Prior to being given an RMA number, a completed Declaration Of Contamination (DOC) form will be required. DOC forms must be approved by INFICON before an RMA number is issued. INFICON may require that the sensor be sent to a designated decontamination facility, not to the factory.

## 1.4 Unpacking and Inspection

If CrystalSix Sensor has not been removed from its packaging, do so now. The sensor and accessories are packaged in a single cardboard carton with a rigid foam insert. Carefully remove the packaged accessories before removing the sensor, then remove the red shipping plug from the sensor carousel.

- 1 Carefully examine the sensor for damage that may have occurred during shipping. It is especially important to note obvious rough handling on the outside of the container. *Immediately report any damage to the carrier and to INFICON.*

**NOTE:** Do not discard the packaging material until inventory has been taken and installation is successful.

- 2 Refer to the invoice and the information contained in [section 1.4.1](#) to take inventory.
- 3 To install CrystalSix Sensor, see [Chapter 2, Sensor Installation](#).

For additional information or technical assistance, contact INFICON. (Refer to [section 1.3.](#))

### 1.4.1 Accessory Kit

In addition to the basic sensor, the shipping package includes an accessory kit (PN 750-268-G1) comprised of the following:

Table 1-1 Contents of accessory kit

Qty	Part Number	Description
X	750-268-G1	Accessory Kit, CrystalSix Sensor
1	750-254-G1	Assembly, Alignment Tool
1	750-279-P1	Crystal Holder Extraction Tool
1	074-5000-G1	Thin Film Manuals CD
1	008-010-G10	Assembly, Sensor Crystal 6 MHz
1	059-0189	CC-1010-0225 Orifice 0.559 mm (0.022 in.) diameter
2	070-0201	#4 Split Lock Washer, Stainless Steel
2	084-032	#4-40 x 9.5 mm (0.375 in.) Long Socket Head Cap Screw, Stainless Steel
2	084-039	#4-40 x 12.7 mm (0.500 in.) Long Socket Head Cap Screw, Stainless Steel
2	084-084	#4-40 x 17.48 mm (0.688 in.) Long Socket Head Cap Screw, Stainless Steel
1	070-0828	Hex Wrench 1.59 mm (1/16 in.) SC9-3
1	070-0829	Hex Wrench 2.38 mm (3/32 in.) SC9-5
1	070-1175	Hex Wrench 1.98 mm (5/64 in.) SC9-4
1	750-037-G1	Spring Tube Bender Kit
1	008-007	Crystal Snatcher
1	750-191-G1	Molybdenum disulfide in Alcohol

## 1.5 Specifications for the CrystalSix Sensor

Maximum bakeout temperature with no water . . . . .	130°C
Maximum operating isothermal environment temperature with minimum water flow . . . . .	400°C
Size (maximum envelope) . . . . .	9.7 cm (3.8 in.) diameter by 5.1 cm (2.0 in.) high
Water tubes, air tube, and in-vacuum cable length . . . . .	76.2 cm (30 in.) tubes, 3.175 mm (1/8 in.) OD seamless stainless steel, 0.406 mm (0.016 in.) wall thickness  Includes 78.1 cm (30.75 in.) in-vacuum cable
Crystal exchange . . . . .	Front loading, extraction tool required  Crystal holder extraction tool (PN 750-279-P1) included
Mounting . . . . .	Six #4-40 tapped holes on the back of the sensor body
Crystal . . . . .	14 mm (0.550 in.) diameter

### 1.5.1 Materials

Body and Carousel . . . . .	2024 T351 Aluminum
Plate, Holders, Material Shield, Mechanical Parts . . . . .	304 stainless steel
Springs, Electrical Contacts . . . . .	Au plated Be-Cu, Au plated Inconel, 303 stainless steel
Water and Air Tubes . . . . .	304 stainless steel
Electrical Connector . . . . .	Stainless steel
Insulators . . . . .	>99% Al <sub>2</sub> O <sub>3</sub>
Cable . . . . .	Teflon <sup>®</sup> insulated copper

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## 1.5.2 Installation Requirements

Feedthrough . . . . .	<p>Two pass water 4.8 mm (3/16 in.) OD tubing, one pass air 4.8 mm (3/16 in.) OD tube with one Microdot<sup>®</sup> coax connector</p> <ul style="list-style-type: none"> <li>◆ CF40 (2-3/4 in. ConFlat<sup>®</sup>) feedthrough with one coaxial, two pass water, and one air (PN 750-685-G1, see <a href="#">Figure 1-5 on page 1-12.</a>)</li> <li>◆ CF40 (2-3/4 in. ConFlat) feedthrough with one coaxial, two pass water, and one air with Ultra-Torr compression fittings (PN 750-685-G2, see <a href="#">Figure 1-6 on page 1-13.</a>)</li> <li>◆ 2.54 cm (1 in.) bolt feedthrough with one coaxial, two pass water, and one air (PN 750-030-G1, see <a href="#">Figure 1-4 on page 1-11.</a>)</li> </ul>
Other . . . . .	<p>User provided vacuum-tight braze joints or connectors for the water and air tubes</p> <p>Valve assembly for air, PN 750-420-G1 (not provided, see <a href="#">section 3.1 on page 3-1</a>) with a 0.559 mm (0.022 in.) restrictor orifice installed by the user. (Orifice included with CrystalSix accessory kit.)</p> <p>XIU or oscillator to match specific controller/monitor</p> <p>Deposition controller designed for CrystalSix Sensor</p>
Water Flow Rate. . . . .	<p>Minimum water flow 150 to 200 cm<sup>3</sup>/min, 30°C maximum</p>
Water Quality . . . . .	<p>Coolant should not contain chlorides as stress corrosion cracking may occur. Extremely dirty water may result in loss of cooling capacity.</p>

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**CAUTION**

**Do not allow water tubes to freeze. This may happen if the tubes pass through a cryogenic shroud and the flow of fluid is interrupted.**

Air . . . . .	80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] (minimum)
	90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)] (maximum)

**NOTE:** Maximum length: 2 m of 3.175 mm (1/8 in.) tubing between sensor head and the solenoid valve.



**WARNING**

**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

## 1.6 Parts and Options Overview

CrystalSix Sensor . . . . . PN 750-446-G1

### 1.6.1 List of Supplied Sensor Drawings

The following CrystalSix Sensor Outline Drawings provide dimensions and other relevant data necessary for planning equipment configurations.

Figure 1-2 . . . . . Crystal Six Sensor Outline

Figure 1-3 . . . . . Crystal Six Sensor Assembly

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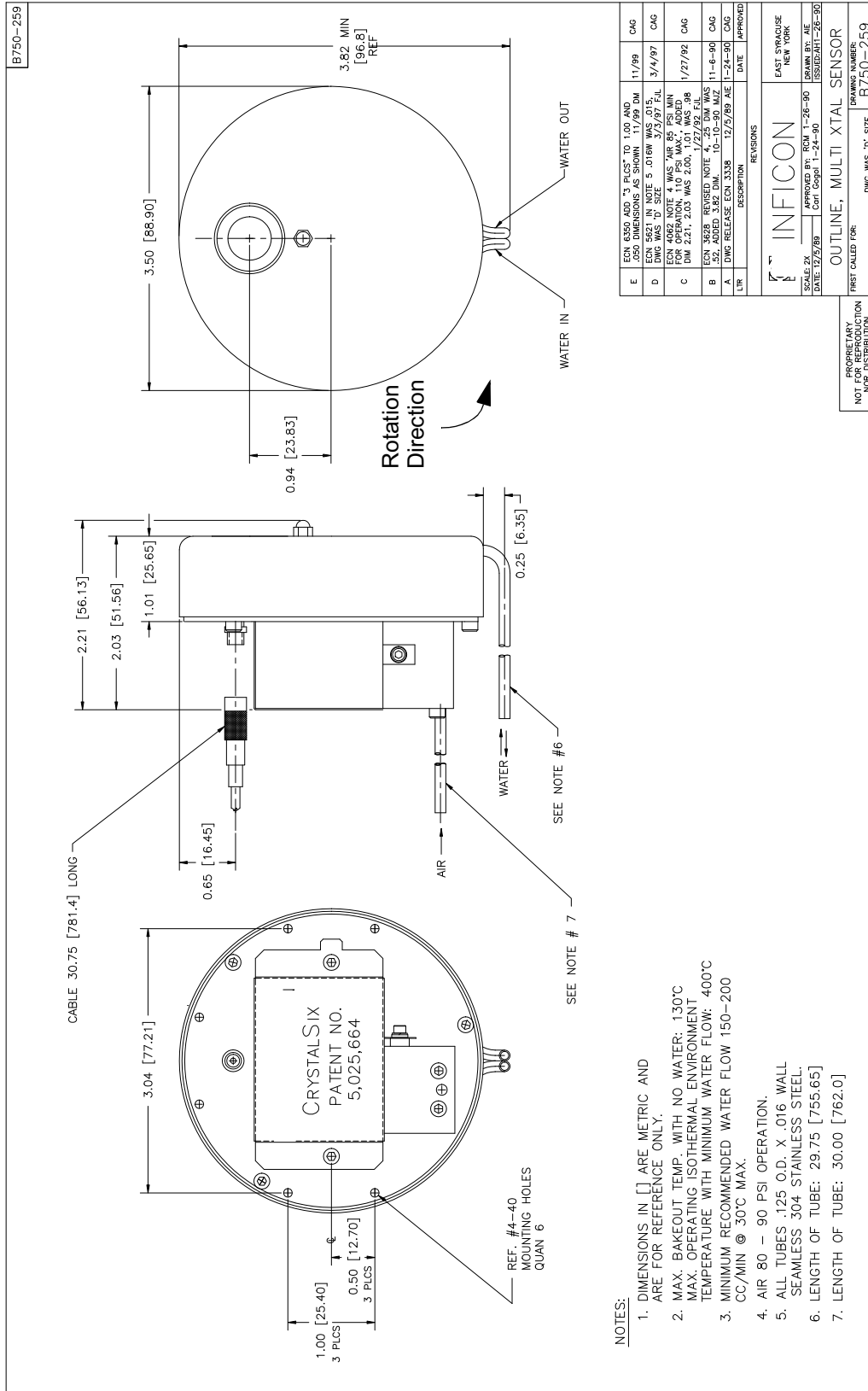


Figure 1-2 CrystalSix Sensor outline



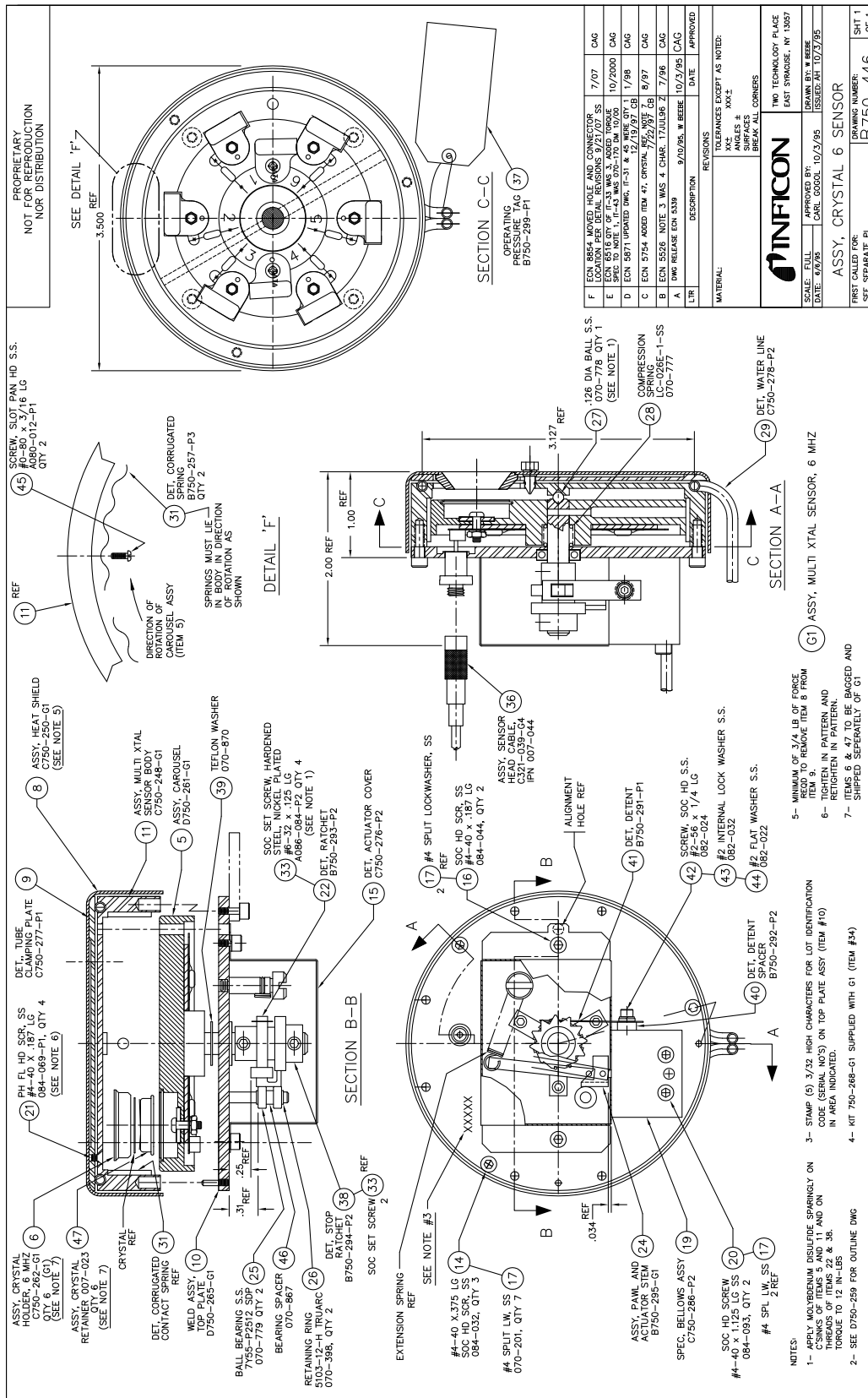


Figure 1-3 CrystalSix Sensor assembly

## 1.7 Specifications for Feedthroughs

### 1.7.1 Specifications for 2.54 cm (1 in.) Bolt with Welded Terminations

Mounting .....	25.781 mm (1.015 in.) ±0.254 mm (0.010 in.) diameter aperture
Maximum operational environment temperature with no water .....	165°C
Maximum operational environment temperature with minimum water flow .....	450°C
Materials .....	304 stainless steel, Teflon, ceramic, beryllium nickel

### 1.7.2 Specifications for CF40 (2-3/4 in. ConFlat)

Mounting .....	Mates with CF40 (2-3/4 in. ConFlat) type flanges with 3.49 cm (1.375 in.) ID (minimum)
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#### Ultra-Torr® O-ring compression fitting terminations

Maximum operational environment temperature with no water .....	165°C
Maximum operational environment temperature with minimum water flow .....	300°C
Materials .....	304 stainless steel, Teflon, ceramic, beryllium nickel, VITON®

#### Welded terminations

Maximum operational environment temperature with no water .....	165°C
Maximum operational environment temperature with minimum water flow .....	450°C
Materials .....	304 stainless steel, Teflon, ceramic, beryllium nickel

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### 1.7.3 Feedthrough Drawings

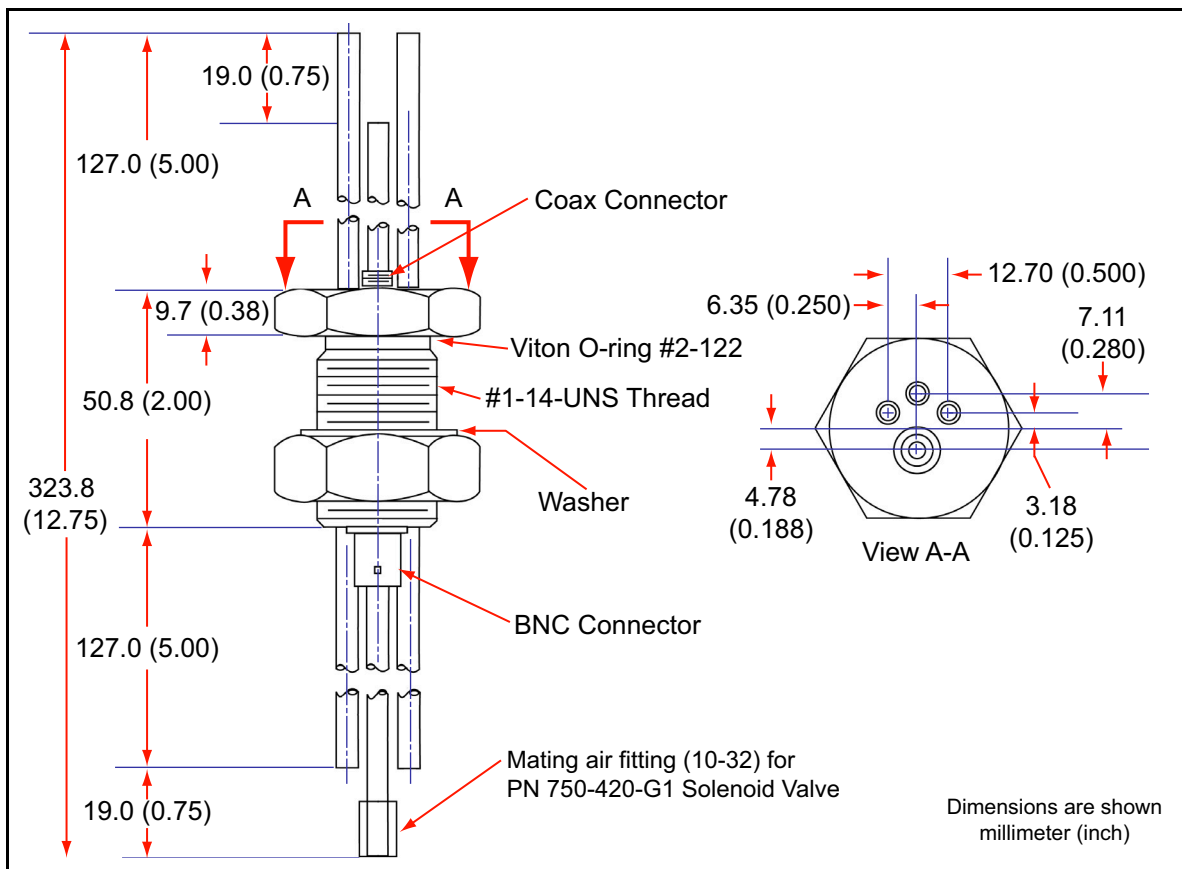
The following Feedthrough Outline Drawings provide dimensions and other pertinent data necessary for planning equipment configurations.

Figure 1-4 . . . . . 2.54 cm (1 in.) bolt feedthrough with three tubes, one coax (PN 750-030-G1)

Figure 1-5 . . . . . CF40 (2-3/4 in. ConFlat) feedthrough with three tubes, one coax (PN 750-685-G1)

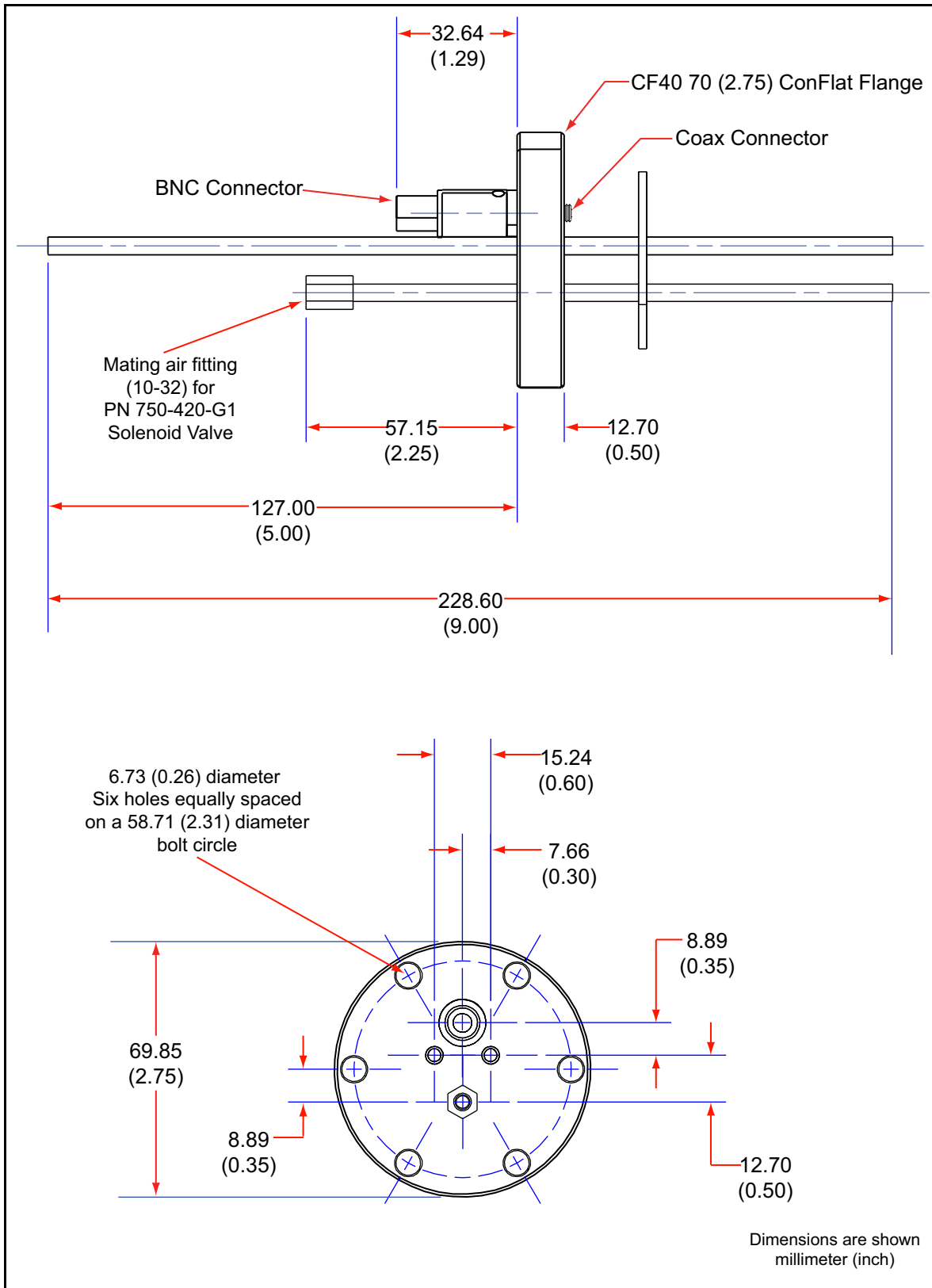
Figure 1-6 . . . . . CF40 (2-3/4 in. ConFlat) feedthrough with three tubes, one coax, with Ultra-Torr (PN 750-685-G2)

Figure 1-4 2.54 cm (1 in.) bolt feedthrough with three tubes, one electrical (PN 750-030-G1)



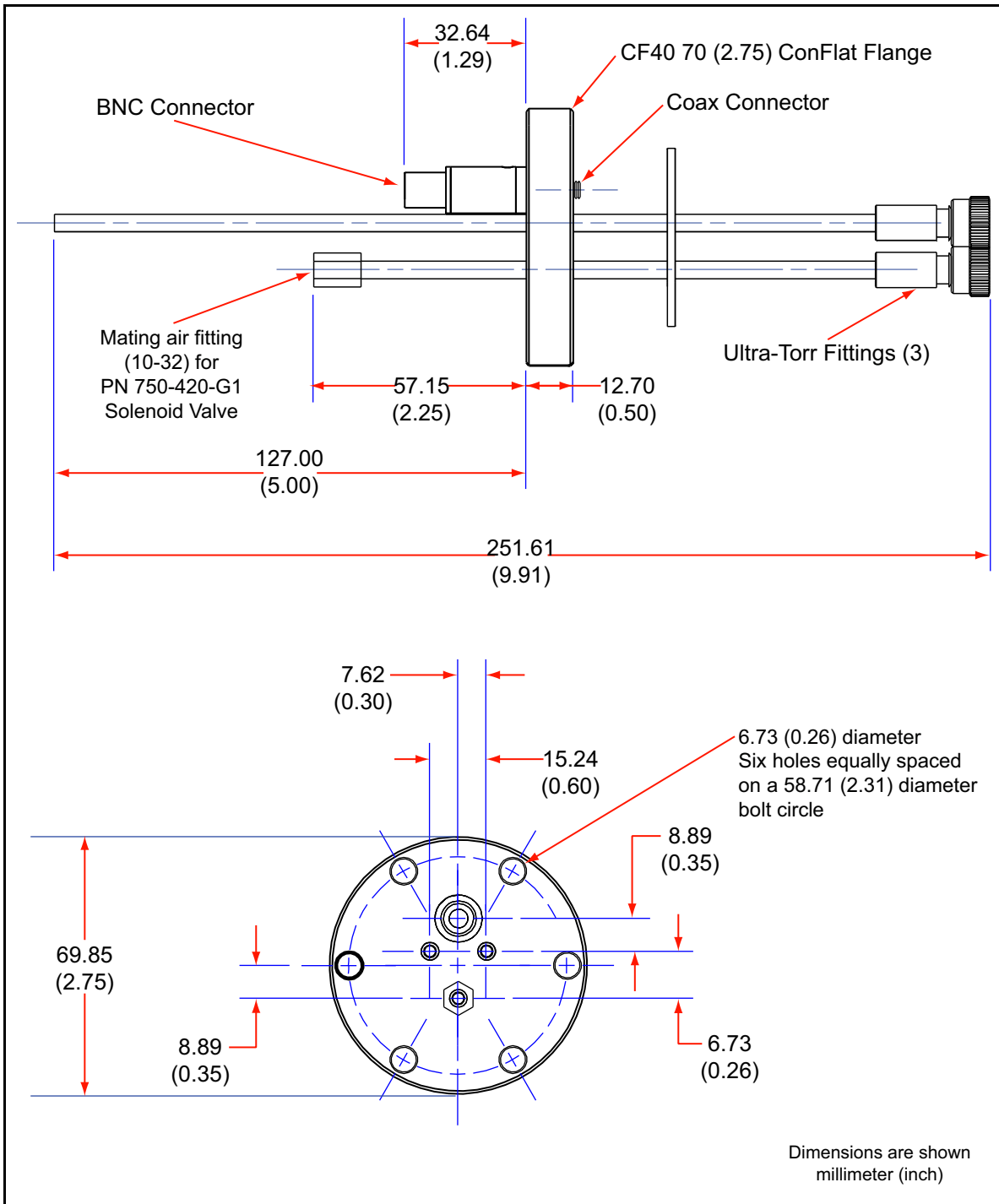
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Figure 1-5 CF40 (2-3/4 in. ConFlat) feedthrough with three tubes, one coax (PN 750-685-G1)



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Figure 1-6 CF40 (2-3/4 in. ConFlat) feedthrough with three tubes, one coax, with Ultra-Torr (PN 750-685-G2)



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## Chapter 2

# Sensor Installation

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### 2.1 Pre-installation Sensor Check

Prior to installing CrystalSix Sensor in the vacuum system, make certain that it is in proper working condition by following the appropriate procedure.

#### 2.1.1 Sensor Check with XTC/3, IC6, or Cygnus 2 Deposition Controller

- 1 Connect the in-vacuum cable from the sensor head to the feedthrough or a coax adapter (Microdot/BNC).
- 2 Connect one end of the 15.2 cm (6 in.) BNC cable (PN 755-257-G6) to the BNC connector on the feedthrough.
- 3 Connect the other end of the 15.2 cm (6 in.) BNC cable to the connector of the ModeLock oscillator (XIU) (PN 781-600-GX).
- 4 Connect one end of the XIU cable (PN 600-1261-PXX) to the mating connector of the XIU.
- 5 Connect the other end of the XIU cable to a sensor channel at the rear of the controller.
- 6 Install the crystal as instructed by [section 4.5 on page 4-11](#).
- 7 Connect power to the controller.
- 8 Set the power switch ON.
- 9 Set density at 1.00 g/cm<sup>3</sup>.
- 10 Zero thickness. The display should indicate 0 or  $\pm 0.001$  kÅ. Crystal life should read from 0 to 5%.

**HINT:** Breathe heavily on the crystal. A thickness indication of 1.000 to 2.000 kÅ should appear on the display. When the moisture evaporates, the thickness indication should return to approximately zero. If these conditions are observed, the sensor is in proper working order and may be installed.

### 2.1.2 Sensor Check with SQC-310 or IQM-233 Deposition Controller/Monitor

- 1 Connect the in-vacuum cable from the sensor head to the feedthrough or a coax adapter (Microdot/BNC).
- 2 Connect one end of the 15.2 cm (6 in.) BNC cable (PN 782-902-011) to the BNC connector on the feedthrough.
- 3 Connect the other end of the 15.2 cm (6 in.) BNC cable to the connector of the oscillator (PN 783-500-013) labeled **Sensor**.
- 4 Connect one end of the oscillator cable (PN 782-902-012-XX) to the mating connector of the oscillator labeled **Control Unit**.
- 5 Connect the other end of the oscillator cable to a sensor connector at the rear of the controller/monitor.
- 6 Install the crystal. (See [section 4.5, Crystal Replacement Instructions, on page 4-11.](#))
- 7 Connect power to the controller.
- 8 Set the power switch ON.
- 9 For the IQM-233 card, launch the appropriate software.
- 10 Set density at 1.00 g/cm<sup>3</sup>.
- 11 Zero thickness. The display should indicate 0 or  $\pm 0.001$  kÅ. Crystal life should read from 95 to 100%.

**HINT:** Breathe heavily on the crystal. A thickness indication of 1.000 to 2.000 kÅ should appear on the display. When the moisture evaporates, the thickness indication should return to approximately zero. If these conditions are observed, the sensor is in proper working order and may be installed.



## 2.2 Sensor Installation Guidelines

- ◆ Install the sensor as far as possible from the evaporation source (a minimum of 25.4 cm or 10 in.) while keeping the sensor in a position well within the evaporant stream to accumulate thickness at a rate proportional to accumulation on the substrate. [Figure 2-3 on page 2-6](#) shows proper and improper methods of installing sensors.
- ◆ Ensure that the thickness indication from the sensor represents the thickness on the substrates by determining the tooling. Refer to the monitor or controller operating manual for calibration procedures.
- ◆ Plan the installation to ensure that there are no obstructions blocking a direct path between the sensor and the source.
- ◆ For best process reproducibility, support the sensor so that it cannot move during maintenance and crystal replacement.

[Figure 2-1](#) and [Figure 2-2](#) show the typical installation of an INFICON water-cooled crystal sensor in the vacuum process chamber. Use these illustrations and the following guidelines to install sensors for optimum performance and convenience.



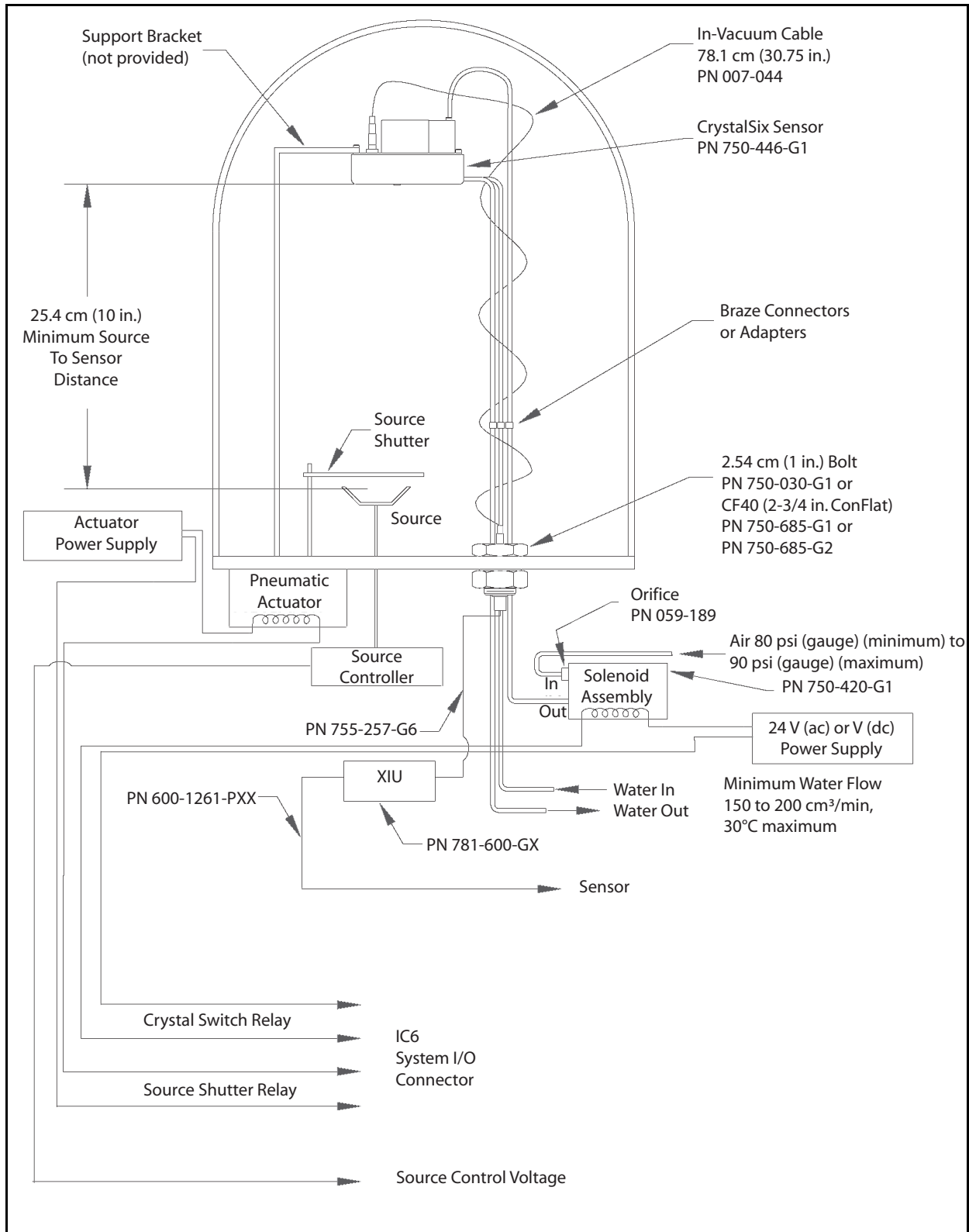
### CAUTION

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**Incorrect rotation direction with the stops disabled will cause permanent damage rendering the CrystalSix inoperative. (Refer to [Figure 1-2 on page 1-8](#) for proper direction of rotation.)**

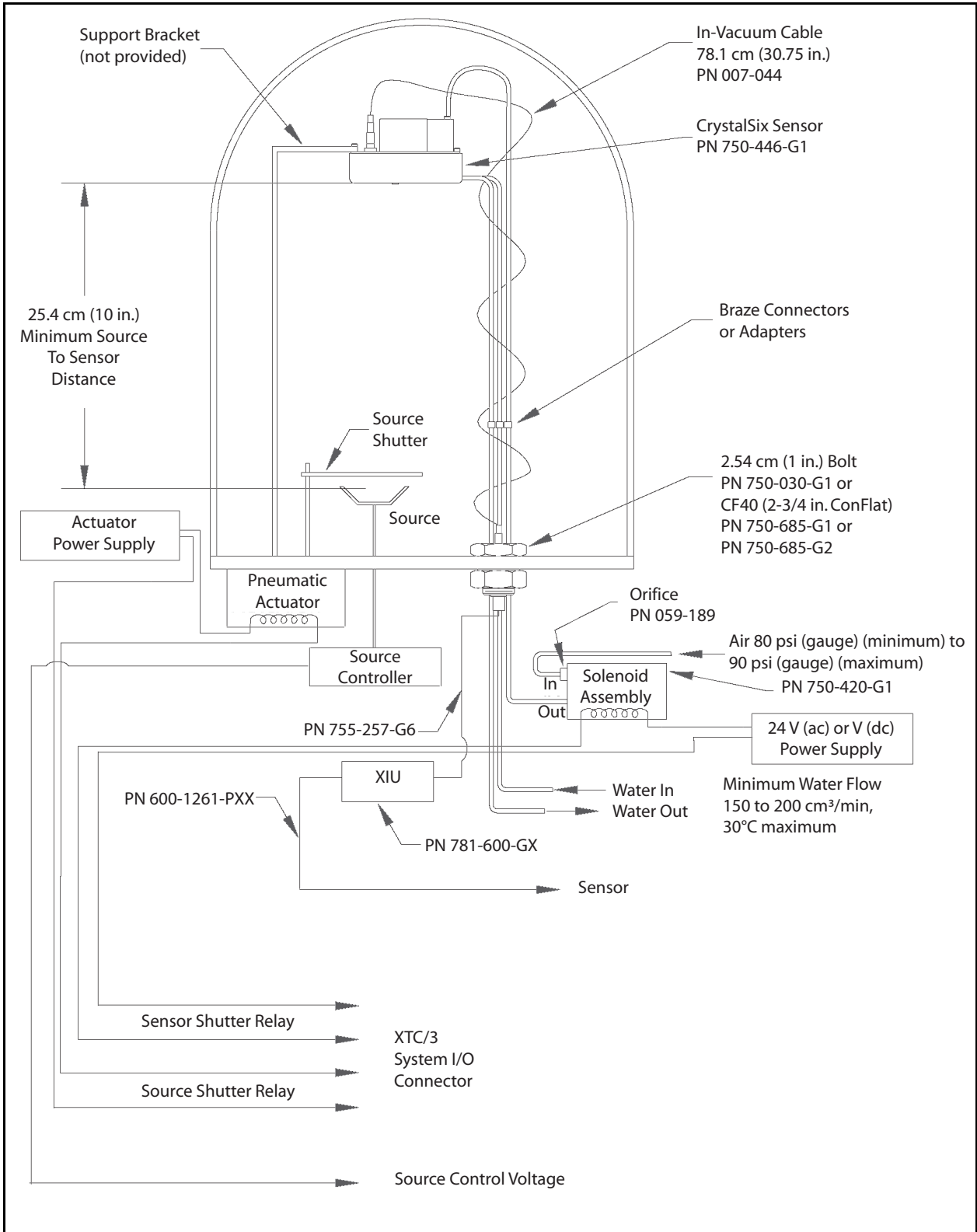
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Figure 2-1 Typical CrystalSix installation for IC6



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Figure 2-2 Typical CrystalSix installation for XTC/3



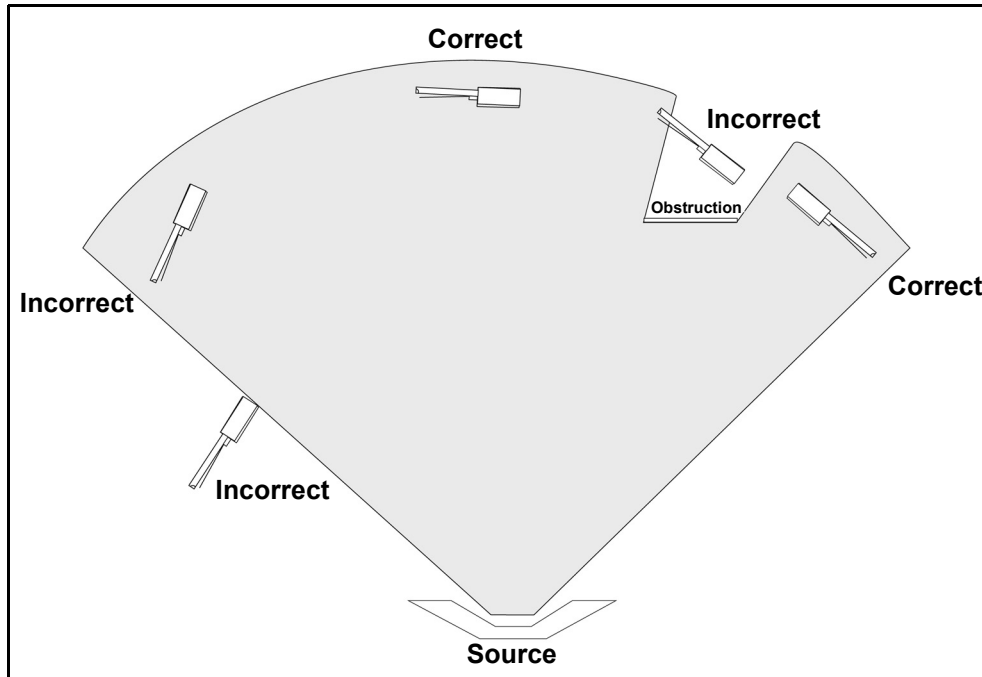
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- ◆ The sensor must be installed such that the face of the crystal is perpendicular to the evaporant stream from the source. (See Figure 2-3.)

Two effects may arise if the crystal face is not perpendicular to the evaporant stream, and the combination of these effects will have a negative effect on crystal life and increase the probability of mode hops:

- ◆ The deposit will not be even across the crystal surface. The edge of the crystal that is angled away from the source is farther away from the source and receives less material, causing the thickness of the deposit to become wedge shaped. This wedge shape in the deposited film tends to reduce the activity of the crystal at its primary resonance.
- ◆ The area of the deposit shifts from the center of the crystal. This is due to the shadowing effect of the crystal aperture. If the crystal is not perpendicular to the evaporant stream, the strength of spurious (non-thickness shear) modes of vibration are enhanced. If the activity of these spurious modes of oscillation become strong enough, they cause short-term perturbation of the fundamental frequency. If they get very strong, the oscillator can lock onto the spurious mode of oscillation, causing a mode hop, unless a ModeLock instrument is used.

Figure 2-3 Sensor installation guidelines



To guard against spattering, use a source shutter to shield the sensor during initial soak periods. If the crystal is hit with only a very small particle of molten material, it may be damaged and stop oscillating. Even in cases when it does not completely stop oscillating, the crystal may immediately become unstable, or shortly after deposition begins, instability may occur.

In many cases installing multiple sensors to monitor one source can improve thickness accuracy. The rules for multiple sensors are the same as for a single sensor installation, and the locations chosen must be as defined above. Consult the monitor or controller manual for more information regarding the availability of this feature.

**NOTE:** A technical description may be found in the 39th Annual Conference Proceedings, Society of Vacuum Coaters, *Reducing Process Variation Through Multiple Point Crystal Sensor Monitoring*, J. Kushneir, C. Gogol, J. Blaise, pp19-23, ISSN 0737-5921 (1996).

## 2.2.1 Sensor Installation Procedure



### CAUTION

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**The sensor head, water tubes, cable, etc., should be clean and free of grease when installed in the vacuum chamber. Clean nylon or talc-free gloves should be worn while handling any sensor components.**

**If parts do become contaminated, clean them thoroughly using a suitable solvent to avoid outgassing.**

---

- 1 Assemble the sensor mounting bracket (provided by customer) on the process system.  
**NOTE:** A mounting bracket is recommended to prevent movement of the sensor during crystal replacement or sensor maintenance.  
**NOTE:** Six tapped holes are provided on the back of each sensor body for attaching to the system.
- 2 Temporarily position and attach the sensor head as outlined in the general guidelines above. (Refer to [section 2.2 on page 2-3.](#))
- 3 Temporarily install the feedthrough.
- 4 Form, measure, and mark the sensor tubes (See [section 2.2.2 on page 2-10.](#))  
**NOTE:** The Tube Bender Kit, PN 750-037-G1, is recommended for bending the tubes.

**CAUTION**

---

**Do not form the water tubes with a bend radius less than 8 mm (0.315 in.) from the inside of the bend or 9.5 mm (0.375 in.) from the center line of the tubes.**

**Bends must be farther than 20 mm (0.79 in.) away from the braze joints on the tubes.**

**Do not use the sensor body as a leverage point when bending the tubes. This may result in a failure of the braze joints on the tubes.**

---

- 5 Build the Sensor/Feedthrough Assembly.
- 6 Remove the sensor and the feedthrough.
- 7 Cut the sensor water tubes and air tubes (if applicable) to the proper length. Verify that the water tubes are clear of metal particles by blowing compressed air through the water tubing.
- 8 Connect the water tubes and air tubes directly to the feedthrough, or use vacuum rated fittings.
  - ◆ Vacuum rated fittings, such as Swagelok® VCR® or VCO®, are recommended for use between the sensor and the feedthrough to speed maintenance. If brazing adapters are to be used, attach them to the sensor tubes prior to connection to the feedthrough. Make connections as follows:

**CAUTION**

---

**To prevent damage to the feedthrough or sensor during brazing, ensure that at least 2.54 cm (1 in.) of water tube remains between the sensor and the flame.**

---

- ◆ Clean the sensor tubes and adapter surfaces with solvent, if necessary.
- ◆ Apply brazing flux to surfaces being joined.
- ◆ Braze the connections using a flame temperature appropriate for the brazing material being used.

**CAUTION**

---

**Excessive application of brazing material, or excessive heat due to brazing, may result in blockage of the tubes.**

---

- ♦ Verify that the tubes are not blocked with braze material by blowing compressed air through the tubes.
  - ♦ Thoroughly clean the braze joints and helium leak test the braze joints before installing the sensor and feedthrough into the process chamber.
- 9 With all water tube and air tube connections installed, install the sensor and feedthrough assembly into the process system and secure all retaining hardware.
  - 10 Shield the sensor in-vacuum cable from heat radiating from the evaporant source or the substrate heater. This can be accomplished, if the process allows, by wrapping aluminum foil around the in-vacuum cable and sensor tubes.
  - 11 Connect the external water tubes from the feedthrough to the water supply system and flow controller. Use detachable fittings (Swagelok or equivalent) for external water tube connections.
  - 12 Apply water at the specified flow rate (refer to [section 1.5.2, Installation Requirements, on page 1-6](#)), and verify that the water connections are tight.
  - 13 If applicable, attach air connection to solenoid valve (see [Chapter 3](#)) and adjust air pressure to be 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] (minimum) to 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)] (maximum).



### WARNING

**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

**NOTE:** Because of geometric factors, variations in surface temperature, and differences in electrical potential, the crystal and substrates often do not receive the same amount of material. Calibration is required to make sure the thickness indication on the instrument accurately represents the thickness on the substrates. Refer to the monitor or controller operating manual for calibration procedures.



### CAUTION

**Use of more than 2 m (80 in.) of 3.175 mm (1/8 in.) tubing between the valve and the bellows may cause a switch failure because of the time required to bleed out sufficient air during de-pressurization. If tubing greater than 3.175 mm (1/8 in.) is used, the maximum length must be reduced proportional to the additional volume.**

## 2.2.2 Tube Bending



### CAUTION

---

**Read this entire section before attempting to bend the tubes. Incorrect tube bending that damages the tubes voids the warranty.**

---

If it is necessary to bend the tubes to clear obstacles inside the chamber or to bring the sensor head into a proper mounting location, observe the following precautions:

- ◆ Support the tubes where the bends will be placed to avoid a tube being collapsed or pinched.

**NOTE:** The Tube Bender Kit, PN 750-037-G1, is recommended for bending the tubes.

- ◆ If the water tube is collapsed, water flow will be restricted. The sensor will not have sufficient cooling.
- ◆ If the air tube is collapsed, air pressure will be restricted. The rotation will not operate correctly.



### CAUTION

---

**Do not form the sensor tubes with a bend radius less than 8 mm (0.315 in.) from the inside of the bend or 9.5 mm (0.375 in.) from the center line of the tubes.**

**Bends must be farther than 20 mm (0.79 in.) away from the braze joints on the tubes.**

**Do not use the sensor body as a leverage point when bending the tubes. This may result in a failure of the braze joints on the tubes.**

---

The 3.175 mm (1/8 in.) tubes are flexible enough to bend, but they are not designed for repeated bending. Plan bends wisely. Before the actual tube bending, verify the bend position again to avoid readjusting. If in doubt, contact INFICON support. (Refer to [section 1.3, How to Contact INFICON, on page 1-2.](#))



## **2.3 CrystalSix Sensor Installation when used with IC6 or Cygnus 2**

### **2.3.1 Programming the Relay Outputs**

- 1** On the **Menu** display, select **Sensor**.
- 2** On the **Sensor** menu, select **Sensor**.
- 3** Select the **Sensor Number (1 to 8)** corresponding to the sensor connection of CrystalSix and attached XIU.
- 4** Select **Sensor Type XtaSix (2)** for CrystalSix Sensor. This will enable the Crystal Switch output (Switch Out 0, 1 to 38).
- 5** Select a Crystal Switch output to be used.

### **2.3.2 Wiring the Relay Outputs with Relay I/O Boards**

On the relay connector, connect the leads of the solenoid valve across one side of a 24 volt supply (refer to Table 2.5 in the IC6 or Cygnus 2 Operating Manual) and one side of a relay (1-8, 1-16, or 1-24, based on the I/O expansion options). Refer to Table 2.3 in the IC6 or Cygnus 2 Operating Manual. Connect a jumper between the second side of the 24 volt supply and the second side of the selected relay.

## **2.4 CrystalSix Sensor Installation when used with XTC/3**

### **2.4.1 Programming the Relay Outputs**

- 1** On the **Menu** display, select **General Parameters**.
- 2** On the **General Parameters** menu, select **Hardware**.
- 3** Select **Sensor X Type** as **CrystalSix** for CrystalSix Sensor. This will enable the Crystal Switch output to be selected. For XTC/3S, refer to section 3.6.8.6, XTC/3S Sensor Shutter / CrystalSwitch Output, on page 3-30 in the XTC/3 Operating Manual. For XTC/3M, refer to section 4.5.3, XTC/3M Outputs, on page 4-29 in the XTC/3 Operating Manual.

### **2.4.2 Wiring the Relay Outputs with Relay I/O Boards**

Refer to Table 2.1 in the XTC/3 Operating Manual.

## **2.5 CrystalSix Sensor Requirement when Not Installed with IC/6, Cygnus 2, or XTC/3**

CrystalSix can be manually operated with other deposition controllers. The user must be aware of the functional requirements for operation. These include, but are not limited to:

- 1** The solenoid assembly must be energized and de-energized twice per crystal position. Twelve pulses complete one revolution.
- 2** The electrical pulse applied to the solenoid valve must be at least one second in duration during both the pressurization and de-pressurization phase.
- 3** A 24 V (ac) • V (dc) supply is required to energize the solenoid assembly. (See [Figure 3-1 on page 3-5](#) for wiring assignments.)
- 4** The user should provide a means of determining the quantity of good crystals when initially loaded, and quantity of good crystals remaining at any time.
- 5** Follow the guidelines shown in [section 2.2 on page 2-3](#) for installation.
- 6** The total thickness will need to be calculated as a manually generated sum of the deposit accumulated on each crystal.

---

## Chapter 3

# Installation of the Solenoid Valve Assembly

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### 3.1 Introduction

The solenoid valve assembly (PN 750-420-G1) and the feedthrough should be installed at the same time. The same solenoid valve is used for both the 2.54 cm (1 in.) bolt feedthrough and the CF40 (2-3/4 in. ConFlat) feedthrough.

- ◆ For an [Installation with a 2.54 cm \(1 in.\) Bolt Feedthrough](#), see [section 3.2 on page 3-2](#).
- ◆ For an [Installation with a CF40 \(2-3/4 in. ConFlat\) Feedthrough](#), see [section 3.3 on page 3-3](#).

#### 3.1.1 Orifice Installation

In order for CrystalSix Sensor to operate properly, a 0.559 mm (0.022 in.) diameter orifice (PN 059-189 provided in the Accessory Kit, PN 750-268-G1) must be installed between the air supply and port P of the solenoid valve assembly. This is accomplished by the following procedure. (See [Figure 3-1 on page 3-5](#).)

- 1** Unthread the tube fitting attached to the normally closed (N.C.) P Supply port of the 3-way solenoid valve. (See [Figure 3-2 on page 3-7](#), item #7.)
- 2** Install the orifice by threading it into the normally closed (N.C.) port of the 3-way solenoid valve.
- 3** Thread the tube fitting previously removed into the orifice.

**NOTE:** Do not install the orifice into the normally open output port. This will require a longer time interval for depressurization of the bellows assembly and may lead to an apparent sensor failure.

## 3.2 Installation with a 2.54 cm (1 in.) Bolt Feedthrough

When installing the solenoid valve assembly with a CrystalSix Sensor, a 2.54 cm (1 in.) bolt equipped with three pass tubes (two water and one air) and a single coaxial feedthrough (PN 750-030-G1) is required. (Refer to [Figure 1-4 on page 1-11.](#))

Most INFICON 2.54 cm (1 in.) bolt feedthroughs with air tubes are equipped with a fitting adapter (PN 007-133). This adapter provides an easy way to attach a quick disconnect fitting (included with the PN 750-420-G1 solenoid valve) to the feedthrough air tube. The fitting adapter is available from INFICON for feedthroughs not equipped with this adapter.

Follow the steps below:

- 1 Ensure that the O-ring is in the groove on the bolt.
- 2 Insert the 2.54 cm (1 in.) bolt such that the hexagonal shaped end of the bolt is on the vacuum side of the chamber.
- 3 Add the solenoid valve bracket to the bolt threads.
- 4 Add the washer.
- 5 Add the feedthrough nut.
- 6 Tighten the feedthrough nut.
- 7 Remove the quick disconnect air fitting from the exhaust port of the solenoid valve and thread it into the fitting adapter (PN 007-133) installed on the feedthrough air tube.
- 8 Connect the 3.175 mm (1/8 in.) air tube from the **A** port of the solenoid valve to the quick disconnect fitting installed in step 7. (See [section 3.3.1, Pneumatic Connections, on page 3-5.](#))



### CAUTION

**Use of more than 2 m (80 in.) of 3.175 mm (1/8 in.) tubing between the valve and the bellows may cause a switch failure because of the time required to bleed out sufficient air during de-pressurization. If tubing greater than 3.175 mm (1/8 in.) is used, the maximum length must be reduced proportional to the additional volume.**

- 9 Attach the **P** port of the solenoid valve to a source of air. The air supply must be 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] (minimum) to 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)] (maximum). (See [section 3.3.1, Pneumatic Connections, on page 3-5.](#))

**WARNING**

**Do not exceed 100 psi (gauge) {115 psi (absolute)}  
(7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal  
injury or equipment damage.**

**CAUTION**

**Maximum temperature for the solenoid valve assembly  
is 105 °C for bakeout and operation.**

- 10** Make electrical connections to the solenoid valve. (See [section 3.3.1, Pneumatic Connections](#), on page 3-5.)

### **3.3 Installation with a CF40 (2-3/4 in. ConFlat) Feedthrough**

If the solenoid valve assembly is to be used with the CF40 (2-3/4 in. ConFlat) feedthrough, modify the valve bracket as follows. (See [Figure 3-2 on page 3-7](#).)

- 1** Align the score line on the solenoid valve bracket over the edge of a table or other square edge.
- 2** Using pliers, grasp the part of the bracket extending over the edge and push down. The assembly will break along the score line.
- 3** Use a file to smooth any rough edges which occur along the break.

When installing the solenoid valve assembly with a CrystalSix Sensor, a CF40 (2-3/4 in. ConFlat) feedthrough equipped with three pass tubes (two water and one air) and a single coaxial feedthrough (PN 750-685-G1, see [Figure 1-5 on page 1-12](#)) or a CF40 (2-3/4 in. ConFlat) feedthrough equipped with three pass tubes (two water and one air) and a single coaxial feedthrough with Ultra-Torr compression fittings (PN 750-685-G2, see [Figure 1-5 on page 1-12](#)) is required.

INFICON CF40 (2-3/4 in. ConFlat) feedthroughs with air tubes are equipped with a fitting adapter (PN 007-133). This adapter provides an easy way to attach a quick disconnect fitting (included with the PN 750-420-G1 solenoid valve) to the feedthrough air tube.

Follow the steps below:

- 1** Install the feedthrough.
- 2** Add the valve bracket (modified) to the desired location (shown in [Figure 3-3 on page 3-8](#)) using two of the 6.35 mm (1/4 in.) clamp bolts located on the flange.

- 3 Tighten the flange bolts.
- 4 Remove the quick disconnect air fitting from the exhaust port of the solenoid valve and thread it into the fitting adapter (PN 007-133) installed on the feedthrough air tube.
- 5 Connect the 3.175 mm (1/8 in.) air tube from the **A** port of the solenoid valve to the quick disconnect fitting installed in step 4. (See [section 3.3.1, Pneumatic Connections](#), on page 3-5.)

**CAUTION**

---

**Use of more than 2 m (80 in.) of 3.175 mm (1/8 in.) tubing between the valve and the bellows may cause a switch failure because of the time required to bleed out sufficient air during de-pressurization. If tubing greater than 3.175 mm (1/8 in.) is used, the maximum length must be reduced proportional to the additional volume.**

---

- 6 Attach the **P** port of the solenoid valve to a source of air. The air supply range is 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] (minimum) to 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)] (maximum). (See [section 3.3.1, Pneumatic Connections](#), on page 3-5.)

**WARNING**

---

**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

---

**CAUTION**

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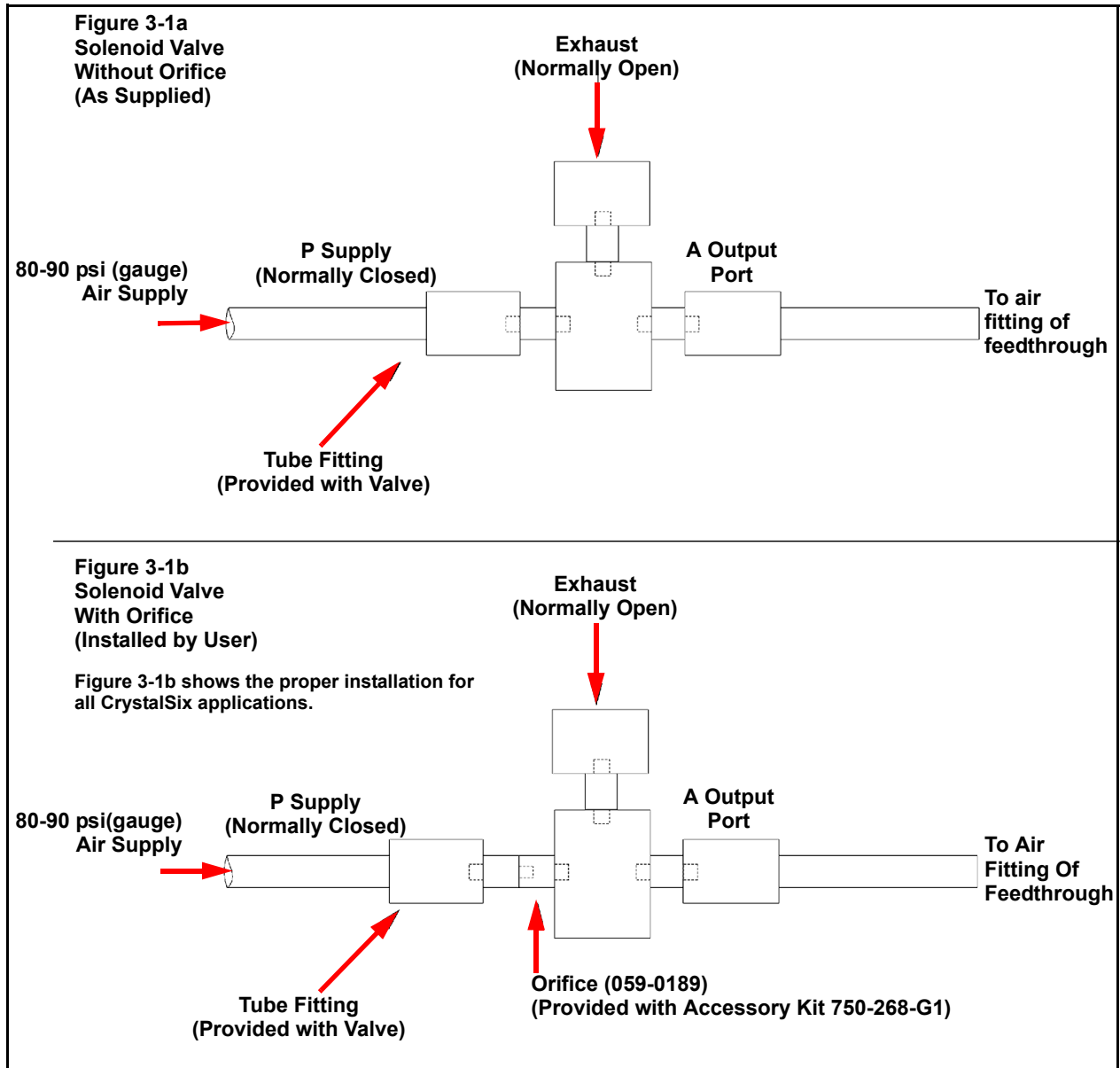
**Maximum temperature for the solenoid valve assembly is 105°C for bakeout and operation.**

---

- 7 Make electrical connections to the solenoid valve. (See [section 3.3.2, Electrical Connections](#), on page 3-5.)

### 3.3.1 Pneumatic Connections

Figure 3-1 Pneumatic solenoid tube connections



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### 3.3.2 Electrical Connections

To complete installation of the assembly, make electrical connections where indicated in [Figure 3-3 on page 3-8](#) to either 24 V(ac) • V(dc). Current required is approximately 70 mA.



#### CAUTION

Maximum applied voltage must not exceed 26 V (ac).

### 3.4 Solenoid Valve Drawings

The following Solenoid Valve Outline Drawings provide dimensions and other relevant data necessary for planning equipment configurations.

[Figure 3-2 on page 3-7](#) . . . . . Solenoid Valve (PN 750-420-G1)

[Figure 3-3 on page 3-8](#) . . . . . CF40 (2-3/4 in. ConFlat) Dual Coaxial Feedthrough and Solenoid Valve (Drawing PN 206-889)



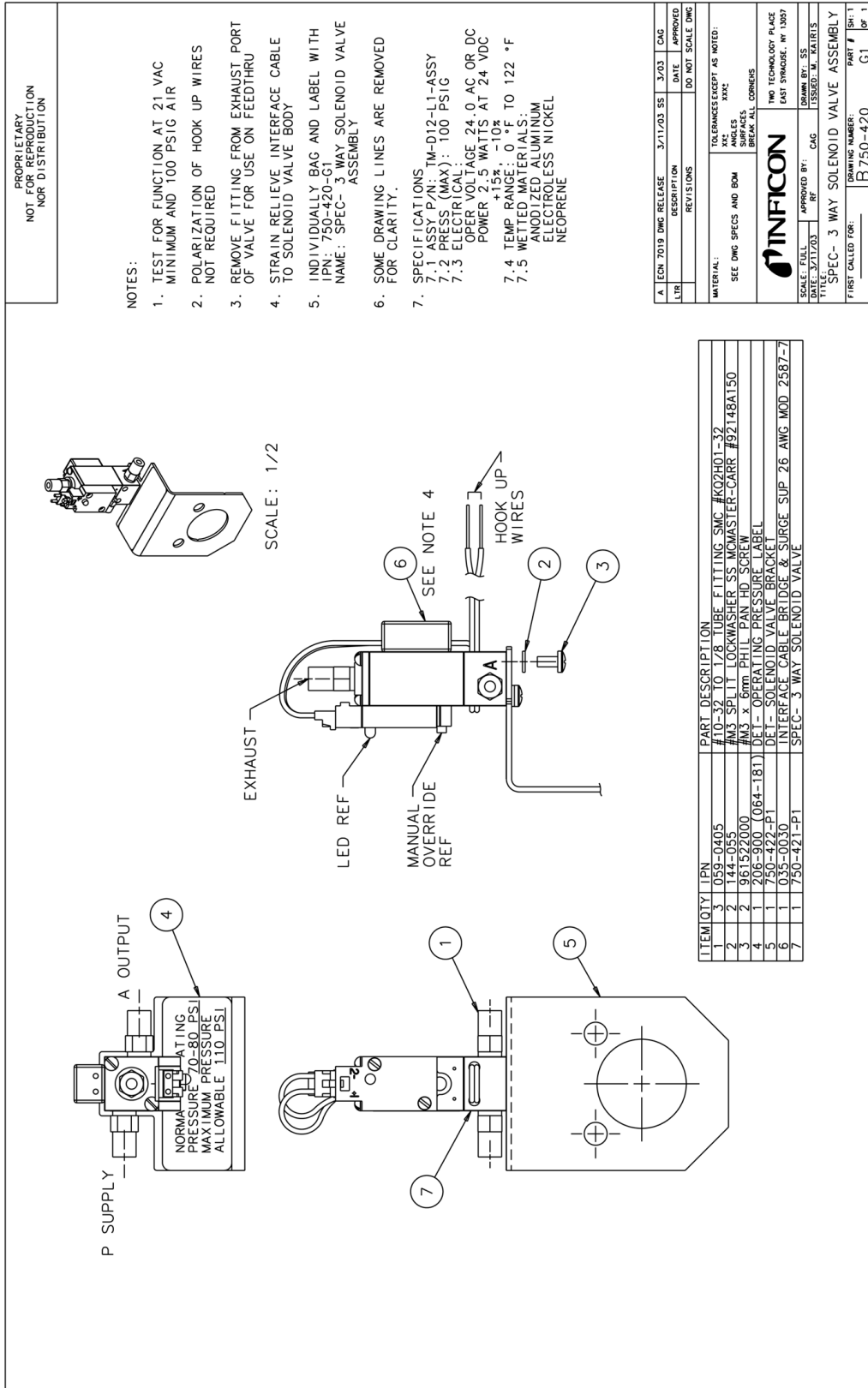


Figure 3-2 Solenoid valve

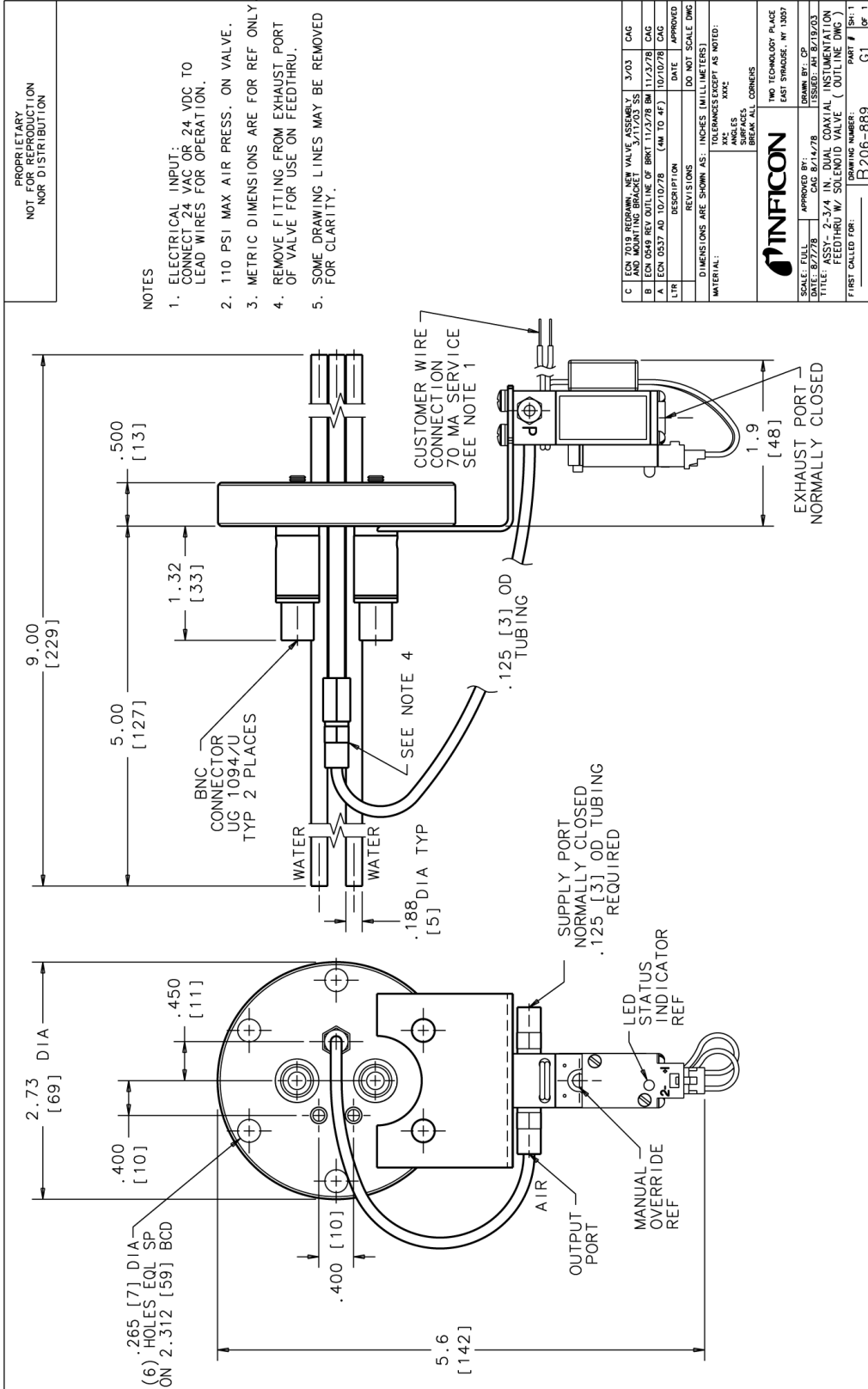


Figure 3-3 CF40 (2-3/4 in. ConFlat) dual coaxial feedthrough and solenoid valve

# Chapter 4

## Troubleshooting and Maintenance

### 4.1 Troubleshooting Guide

If CrystalSix Sensor fails to function, or appears to have diminished performance, the Symptom, Cause, Remedy table will be helpful. (See [section 4.3 on page 4-4](#).)

#### 4.1.1 CrystalSix Diagnostics

A useful tool for diagnosing sensor problems is the DMM (Digital MultiMeter). Disconnect the in-vacuum cable from the CrystalSix sensor head, leaving the in-vacuum cable attached to the feedthrough. Disconnect the short oscillator cable from the feedthrough and then measure the resistance from the center pin to the shield of the feedthrough BNC connector.

- ◆ If the reading is less than 10 megohms the source of the leakage should be found and corrected. If the reading is greater than 10 megohms, reconnect the in-vacuum cable to the sensor head.
- ◆ With the vacuum system open, check for electrical continuity by removing a crystal holder and then measuring resistance between the leaf spring in the carousel pocket and the center pin of the feedthrough BNC connector. A reading of more than 1 ohm indicates a problem. Cleaning contacts or replacing the in-vacuum cable may be required.

**NOTE:** The measured resistance may be slightly higher for the longer in-vacuum cable lengths.

Install the ceramic retainer into the crystal holder without a crystal and place it into the carousel. Measure the resistance between the center pin and shield of the feedthrough BNC connector. A reading of more than 1 ohm indicates a problem. Replacing the in-vacuum cable, reforming the leaf spring on the ceramic retainer, or cleaning the crystal holder may be required. (See [section 4.4.5 on page 4-10](#).)

A very useful tool for rapidly evaluating the cause of a persistent **Crystal Fail** is the test crystal. The test crystal utilizes a packaged crystal at 5.5 MHz and a connector that allows the direct connection to BNC cables.

The test crystal provides a known good monitor crystal that provides a fast means of isolating sensor problems.



#### **CAUTION**

**The test crystal is designed as a diagnostic tool, and is not intended for use in vacuum.**

## 4.2 Diagnostic Procedures

The following diagnostic procedures employ the test crystal and DMM to analyze a constant Crystal Fail message. The symptom is a Crystal Fail message that is displayed by the deposition controller even after the monitor crystal has been replaced with a new good monitor crystal.

### 4.2.1 System Diagnostics

- 1 Remove the 15.2 cm (6 in.) BNC cable from the feedthrough.
- 2 Connect the test crystal to the BNC cable.
  - ♦ If the **Crystal Fail** message disappears after approximately five seconds, the measurement system is working properly. Reinstall the BNC cable to the feedthrough. Go to [section 4.2.2](#).
  - ♦ If the **Crystal Fail** message remains, continue at step 3.
- 3 Disconnect the BNC cable from the oscillator and from the test crystal.
- 4 Visually inspect the BNC cable to verify that the center pins are seated properly.
- 5 Use a DMM to verify the electrical connections on the BNC cable. (Refer to [section 4.1.1](#).)
  - ♦ There must be continuity between the center pins.
  - ♦ There must be isolation between the center pins and the connector shield.
  - ♦ There must be continuity between the connector shields.Replace the BNC cable if it is defective and repeat step 2 of this procedure.
- 6 If the BNC cable is not defective, reconnect it to the oscillator and the test crystal. If the Crystal Fail message remains, contact INFICON. (Refer to [section 1.3 on page 1-2](#).)

## 4.2.2 Feedthrough Diagnostics

- 1 Remove the crystal holder from the sensor head.
- 2 Disconnect the 15.2 cm (6 in.) BNC cable from the feedthrough.
- 3 Using a DMM, verify continuity from the BNC center pin on the feedthrough to the center rivet on each of the ceramic retainers on the sensor head. (Refer to [section 4.1.1 on page 4-1.](#)) A typical value is less than 0.2  $\Omega$ .
- 4 Verify isolation of the center pin on the feedthrough from the electrical ground (feedthrough body). A typical value would be in excess of 10 M $\Omega$ .

If the feedthrough, in-vacuum cable, or BNC connector is defective, replace them, reattach the BNC, and repeat this procedure starting at step 1, otherwise continue at step 5.

- 5 Verify continuity from the center pin on the BNC connector of the feedthrough to the center rivet on each of the ceramic retainers on the sensor head.
- 6 Verify isolation from the center pin to electrical ground (feedthrough body).

If the feedthrough system is found to be defective, look for defective contacts at the feedthrough to in-vacuum cable connection. Repair or replace the feedthrough as necessary. Reattach the BNC and repeat this procedure starting at step 1. Otherwise, continue with step 7.

- 7 Connect the BNC cable to the feedthrough and disconnect it from the Crystal Interface Unit (or oscillator)
- 8 Verify continuity from the center rivet of each of the ceramic retainers on the sensor head to the un-terminated end of the BNC cable.
- 9 Verify isolation from the center rivet to electrical ground (feedthrough body).

If the feedthrough and BNC cable system is found to be defective, look for defective contacts at the feedthrough to BNC cable connection. Repair or replace the feedthrough as necessary, then reattach the BNC cable to the XIU and repeat this procedure starting at step 2.

### 4.2.3 System Diagnostics Pass But Crystal Fail Message Remains

If the system is operating properly, yet the Crystal Fail message is still displayed, perform the following tasks:

- 1 On the ceramic retainer, verify that the center rivet is secure. Repair or replace the ceramic retainer as necessary.
- 2 Inspect the inside of the sensor head for a buildup of material. Clean or replace the crystal holder as necessary.

After verifying the sensor head contacts, the sensor head to in-vacuum cable connection, and the ceramic retainer contacts, reassemble the system. If the Crystal Fail message remains, replace the monitor crystal with a good monitor crystal. Verify that the monitor crystal works properly by inserting it into a known good measurement system. If problems continue, contact INFICON (refer to [section 1.3 on page 1-2](#)).

## 4.3 Symptom, Cause, Remedy

Table 4-1 Symptom, Cause, Remedy

SYMPTOM	CAUSE	REMEDY
Crystal fail signal on front panel of unit will not disappear even though crystal can be seen through heat shield aperture.	Damaged crystal.	Replace crystal.
	Loss of electrical signal.	Check for electrical continuity between feedthrough and leaf springs that make contact with the crystal holder in the sensor. If electrical problem originates in the sensor, see <a href="#">section 4.8.2 on page 4-18</a> for disassembly instructions.  <b>NOTE:</b> Make certain the leaf springs in the carousel assembly are bent up far enough to contact the crystal holder when installed.

Table 4-1 Symptom, Cause, Remedy (continued)

SYMPTOM	CAUSE	REMEDY
Unit will not advance when crystal switch key is pressed.	Loss of pneumatic supply, or pressure is insufficient for proper operation.	Establish air supply and regulate from minimum 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] to maximum 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)]
	Operation is impaired as a result of peeling of the material accumulated on the face of the cover.	See <a href="#">section 4.8.2 on page 4-18</a> for disassembly instructions to remove material or to correct mechanical failure.
Crystal not centered in aperture.	Improper alignment.	Realign per alignment instructions in <a href="#">Chapter 4</a> .
	0.559 mm (0.022 in.) diameter orifice not installed in-line to the supply side of the solenoid valve assembly.	Install orifice where shown on <a href="#">Figure 2-1 on page 2-4</a> .
Sensor jamming.	Crystal holders come loose and jam sensor during rotation. May be caused by absence of orifice at input (port P) of solenoid valve.	Check for orifice. (Refer to <a href="#">Chapter 3</a> .)
	Electrical contacts on carousel may be damaged if CrystalSix was counter rotated.	Replace contacts.
Large jumps of thickness reading during deposition.	Mode hopping due to damaged or heavily damped crystal.	Replace the crystal.
	Crystal is near the end of its life.	Replace the crystal.
	Scratches or foreign particles on the crystal holder seating surface.	Clean or polish the crystal seating surface on the crystal holder. (See <a href="#">section 4.7 on page 4-14</a> .)
	Uneven coating.	Place the sensor such that the crystal is square to the evaporant stream. (Refer to <a href="#">section 2.2 on page 2-3</a> .)
	Particles.	Remove source of particles and replace the crystal.

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Table 4-1 Symptom, Cause, Remedy (continued)

SYMPTOM	CAUSE	REMEDY
Crystal ceases to oscillate during deposition before it reaches its normal life.	Crystal is being hit by small droplets of molten material from the evaporation source.	Use a shutter to shield the sensor during initial period of evaporation; move the sensor farther away.
	Damaged crystal.	Replace the crystal.
	Built-up material on edge of crystal holder is touching the crystal.	The crystal cover cannot have a buildup of deposition material. This material may create an unreliable connection to the crystal. Removal of the deposition material is a maintenance necessity. Do not allow seat to get roughened by the removal process. (See <a href="#">section 4.7 on page 4-14.</a> )
	Material on crystal holder is partially masking the full crystal area.	Clean the crystal holder. (See <a href="#">section 4.7 on page 4-14.</a> )
<b>NOTE:</b> Crystal life is highly dependent on process conditions of rate, power radiated from source, location, material, and residual gas composition.		
Crystal does not oscillate or oscillates intermittently (both in vacuum and in air).	Damaged crystal.	Replace the crystal.
	Existence of electrical short or poor electrical contacts.	Check for electrical continuity and short in sensor cable, connector, contact springs, and the connecting wire inside the sensor; check for electrical continuity in feedthroughs. (Refer to <a href="#">section 4.1.1 on page 4-1.</a> )
<b>NOTE:</b> Check the leaf spring contact shape as part of a routine maintenance inspection. Flattened or deformed leaf spring contacts in the ceramic retainer are common causes of crystal problems.		
Crystal oscillates in vacuum but stops oscillation after open to air.	Crystal is near the end of its life; opening to air causes film oxidation, which increases film stress.	Replace the crystal.
	Excessive moisture accumulation on the crystal.	Turn off cooling water to sensor before opening it to air; flow hot water through the sensor when the chamber is open.

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Table 4-1 Symptom, Cause, Remedy (continued)

SYMPTOM	CAUSE	REMEDY
Thermal instability: large changes in thickness reading during source warm-up (usually causes thickness reading to decrease) and after the termination of deposition (usually causes thickness reading to increase).	Crystal not properly seated.	Check and clean the crystal seating surface of the crystal holder. (See <a href="#">section 4.7 on page 4-14.</a> )
	Excessive heat applied to the crystal.	If heat is due to radiation from the evaporation source, move sensor farther away from source and use Low Thermal Shock crystals (PN SPC-1157-G10) for better thermal stability. If the source of crystal heating is due to a secondary electron beam, change from a regular sensor to a sputtering sensor.
	No cooling water.	Check cooling water flow rate.
	Heat induced from electron flux.	Use sputtering head for non-magnetron sputtering.
Poor thickness reproducibility.	Erratic source emission characteristics.	Move sensor to a different location; check the evaporation source for proper operating conditions; ensure relatively constant pool height and avoid tunneling into the melt.
		Use multiple sensor option if available on controller.
	Material does not adhere to the crystal.	Check the cleanliness of the crystal surface; evaporate an intermediate layer of proper material on the crystal to improve adhesion. Use silver or gold coated crystals, as appropriate.

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## 4.4 General Precautions



### CAUTION

**Wear clean nylon or talc-free latex lab gloves when handling sensor components. If sensor components become contaminated, clean them thoroughly using a suitable solvent to avoid outgassing under vacuum.**

#### 4.4.1 Handle the Crystal with Care

The crystal surfaces are easily contaminated; handle the crystals only by their edges, always use clean nylon lab gloves when handling crystal holders and retainers, and use clean Teflon tweezers when handling crystals. If using a vacuum pencil to handle crystals, be sure the vacuum pencil tip is clean and not contaminated.

Contamination can lead to poor film adhesion. Poor film adhesion will result in high rate noise and premature crystal failure.



#### **CAUTION**

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**Do not use metal tweezers to handle crystals.  
Metal tweezers may chip the edge of the crystal.**

---

#### 4.4.2 Use the Optimum Crystal Type

Silver crystals are recommended for sputtering and other applications with sustained high heat loads.

Certain materials, especially dielectrics, may not adhere strongly to the crystal surface and may cause erratic readings. For many dielectrics, adhesion is improved by using alloy crystals.

Gold is preferred for other applications. Contact INFICON for crystal material electrode recommendations for a specific application. (Refer to [section 1.3 on page 1-2.](#))

### **4.4.3 Maintain the Temperature of the Crystal**

Periodically measure the water flow rate leaving the sensor to verify that the flow rate meets or exceeds the flow rate value specified on [page 1-6](#).

Depending upon the condition of the cooling water used, the addition of an in-line water filtering cartridge system may be necessary to prevent flow obstructions.

Many system coaters use parallel water supplies that provide high water flow rates. With a parallel water supply, an obstruction or closed valve in the pipe that supplies water to the sensor head may not result in a noticeable reduction of total flow. Therefore, monitor the flow leaving the sensor.

The crystal requires sufficient water cooling to sustain proper operational and temperature stability. Ideally, a constant heat load is balanced by a constant flow of water at a constant temperature.

INFICON quartz crystals are designed to provide the best possible stability under normal operating conditions.

No crystal can completely eliminate the effects of varying heat loads. Sources of heat variation include radiated energy emanating from the evaporant source and from substrate heaters.

**NOTE:** Water cooling temperature near the dew point in the room should be avoided. Condensation can cause early crystal failures.

It is recommended that water cooling temperature be maintained at 5 to 10°C above the dew point in the room during a vent of the system. Water cooling temperature can be lowered to a temperature less than 30°C under vacuum.

### **4.4.4 Crystal Concerns when Opening the Chamber**

Thick deposits of some materials, such as SiO<sub>2</sub>, Si, and Ni will normally peel off the crystal when it is exposed to air due to changes in film stress caused by gas absorption. When peeling is observed, replace the crystal.

#### 4.4.5 Care of the Ceramic Retainer



#### CAUTION

**Do not use excessive force when handling the Ceramic Retainer Assembly or breakage may occur. Always use the crystal snatcher.**

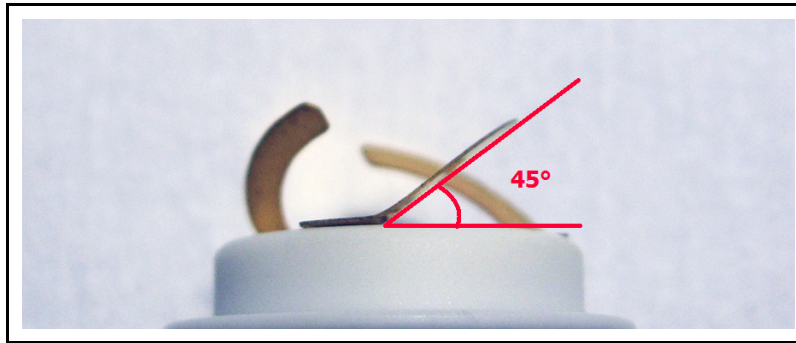
**To prevent scratching the crystal electrode, do not rotate the ceramic retainer after installation.**

**Always use clean nylon lab gloves when handling crystal holders and retainers and clean plastic tweezers when handling the crystal. Contamination may lead to poor adhesion of deposited material to the electrode.**

The circular springs found on the ceramic retainers of CrystalSix Sensors are called leaf springs.

CrystalSix Sensors have a set of three prong leaf springs on each of the six ceramic retainers that make electrical contact to the electrodes on the crystal. The proper angle for these leaf springs is approximately 45 degrees. (See [Figure 4-1.](#))

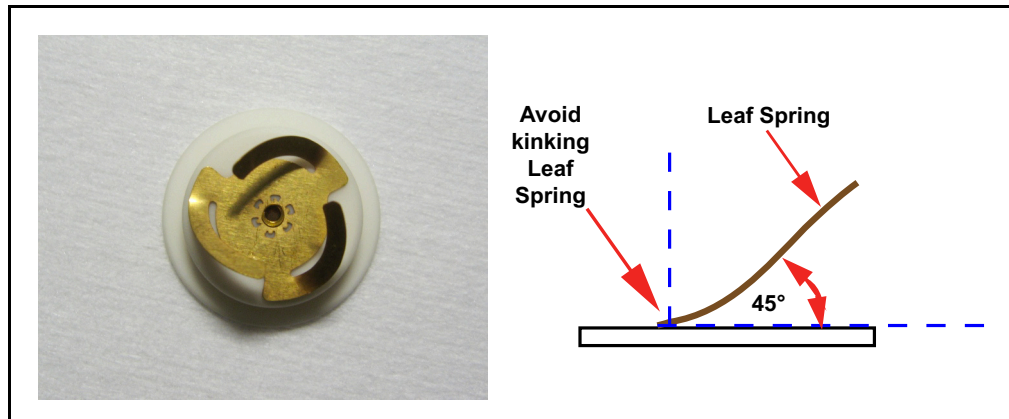
Figure 4-1 Ceramic retainer



Leaf springs create an important electrical contact and should be visually inspected and adjusted (if necessary) as part of a regular maintenance cycle. These adjustments do not require any tools, however, latex gloves must be worn to avoid contamination. Teflon tweezers can be used as an alternative to using fingers.

To adjust the leaf springs on the ceramic retainer, touch the end of the leaf spring prong with a gloved finger, or grip the end with Teflon tweezers, and gently lift upward. Be careful not to kink the leaf spring. An ideal bend has a smooth, sweeping shape. (See [Figure 4-2.](#))

Figure 4-2 Leaf spring shape



## 4.5 Crystal Replacement Instructions

Follow this procedure to install or replace the crystals in CrystalSix Sensor. (Refer to [Figure 1-3](#) on page 1-9.)

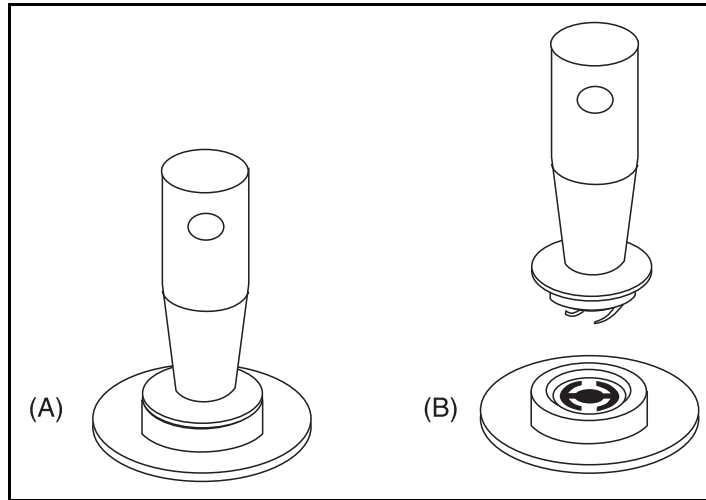


### CAUTION

**Rotating CrystalSix in the wrong direction with the stops disabled will cause severe damage! Do not rotate CrystalSix by hand to install the crystals or to check indexing.**

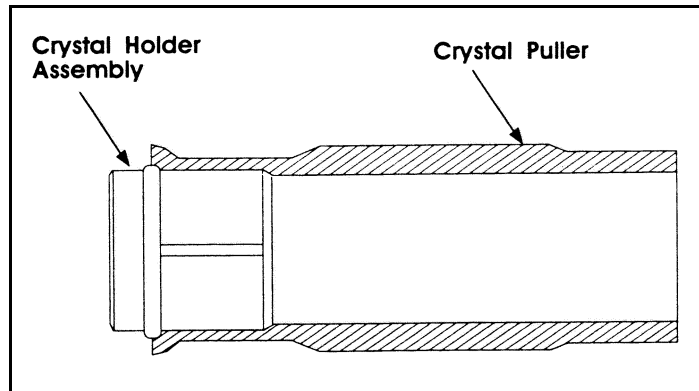
- 1** Remove the heat shield (item #8) by gently pulling on the outside circumference of the shield. The shield should snap off.
- 2** Since the crystal holders are packaged separately, skip the remainder of this step for first-time installations. Using the crystal puller (PN 750-279-P1, provided in ship kit, PN 750-268), remove the crystal holder by pushing the tips of the crystal puller over the outside circumference of the crystal holder (see [Figure 4-4](#)). Gently pull the crystal holder from its receptacle. A slight amount of pressure applied to collapse the tips of the crystal puller may be required to extract the crystal holder.
- 3** Insert the tapered end of the Crystal Snatcher (PN 008-007) into the ceramic retainer (**A**) and apply a small amount of pressure. This locks the retainer to the snatcher and allows the retainer to be pulled straight out (**B**). (See [Figure 4-3](#).)

Figure 4-3 Using the crystal snatcher



- 4 Invert the crystal holder and the crystal will drop out. (Skip step 4 for first-time installations.)
- 5 Install the new crystal. (Refer to [section 4.4 on page 4-7.](#))
- 6 Using clean nylon gloves, grasp the edge of the new crystal with a clean pair of plastic tweezers. Orient the crystal so the patterned electrode is facing up. Gently insert the edge of the crystal beneath one of the wire segments that protrude into the crystal cavity. Release the crystal.
- 7 Replace the ceramic retainer. Initially orient it at an angle to displace the spring wire segments in the crystal holder.
- 8 Release the crystal snatcher with a slight side-to-side rocking motion. Using the backside of the crystal snatcher, push on the ceramic retainer to ensure it is completely seated.
- 9 Position the crystal holder between the tips of the crystal puller. (See [Figure 4-4 on page 4-13.](#))
- 10 Push the crystal holder into the receptacle of the CrystalSix Sensor until completely seated. Snap the crystal puller to one side to release the crystal holder from the crystal puller. Using the non-slotted end of the crystal puller, apply pressure to the crystal holder until it is completely seated. Verify that the crystal fail signal on the controller display disappears. If the crystal fail signal does not disappear. (Refer to [section 4.3 on page 4-4.](#))
- 11 Press **Crystal Switch** on the handheld controller or the controller front panel. The sensor will advance to the next crystal position. Repeat this procedure from step 2 until all six new crystals have been installed.
- 12 Install the heat shield (item #8) by first orienting the slot in the heat shield to accommodate the water tubes, then secure the heat shield by applying pressure near the center of the shield. The shield should snap in place.

Figure 4-4 Using the crystal puller



## 4.6 Retainer Spring Adjustment Instructions

Occasionally, the ceramic retainer may not be secured in the crystal holder. To alter the retainer retention force, use the following procedure.

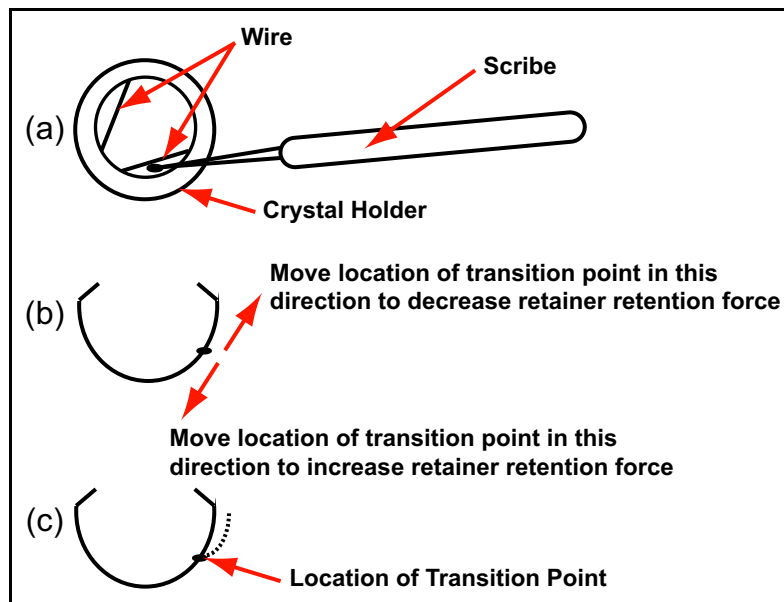
### Tools required

- ◆ Scribe or other pointed tool
- ◆ Needle nose pliers (two required)

### Procedure

- 1 Position the crystal holder with the crystal aperture oriented downward.
- 2 Insert the point of the scribe between the inside edge of the crystal holder cavity and one of the two wire segments that protrude into the crystal cavity. See Figure 4-5 (a).

Figure 4-5 Location of the transition point



- 3 Using the scribe, gently remove the spring from its groove in the crystal holder cavity.
- 4 Refer to [Figure 4-5 \(b\)](#) to determine the direction in which the transition point must be relocated to attain the desired retention forces. Moving the transition point approximately 1.59 mm (1/16 in.) is generally sufficient.
- 5 Grasp the spring, with the pliers, just below the transition point. Use the second set of pliers to bend the spring as illustrated by the dashed line in [Figure 4-5 \(c\)](#) to remove the existing transition point.
- 6 Use both pliers to form a new transition point according to [Figure 4-5 \(b\)](#), thus returning the spring to a shape similar to the solid line delineation of [Figure 4-5 \(c\)](#).
- 7 Reinstall the spring into the groove provided in the crystal cavity.
- 8 Determine if the retention force is acceptable and that the wire does not impede crystal insertion.
- 9 Repeat these instructions if unacceptable retention forces persist.

## 4.7 Crystal Holder Maintenance

In dielectric coating applications, the surface where the crystal contacts the crystal holder requires periodic cleaning. Since most dielectrics are insulators, any buildup in an evaporation process will cause erratic, or poor, electrical contact between the crystal and the sensor body. This buildup will also cause a reduction in thermal transfer from the crystal to the sensor body. Dielectric buildup or poor thermal transfer will result in noisy operation and early crystal failure.

Cleaning is accomplished in three steps:

- 1 Gently buffing the crystal seating surface in the crystal holder with a white Scotch-Brite™ cleaning pad.
- 2 Washing the crystal seating surface in the crystal holder in an ultrasonic bath in soap solution.
- 3 Thorough rinsing of the crystal seating surface in the crystal holder with deionized water and drying, or by ultrasonic cleaning and deionized water rinsing only.

**NOTE:** The crystal holder seating surface is machined to a very fine finish (16 micro inches rms). This finish is essential in providing good electrical and thermal contact with the crystal.



### CAUTION

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**Applying excessive force during cleaning or using overly abrasive cleaning materials will damage the finish and reduce sensor performance.**

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## 4.8 Alignment Instruction for CrystalSix Sensor

During shipment, CrystalSix may vibrate slightly out of position. This does not mean alignment is required. CrystalSix will return to the centered position the first time it is pneumatically activated.

CrystalSix has been aligned at the factory, no further alignment is required.

**NOTE:** Realignment is only required if CrystalSix has been disassembled for any reason, such as evaporant material removal, or any electrical problem that may occur, or if the ratchet (item #22 on [Figure 1-3 on page 1-9](#)) is loosened, or removed. This procedure is critical and must be carefully undertaken.



### CAUTION

**Incorrect rotation direction with the stops disabled will cause permanent damage rendering the CrystalSix inoperative. (Refer to [Figure 1-2 on page 1-8](#) for proper direction of rotation.)**

CrystalSix Sensor, when properly aligned, will index the crystal to a position that is centered within the aperture provided in the heat shield. CrystalSix must be aligned if the crystal is not centered within the aperture provided in the heat shield. (Refer to [Figure 1-3 on page 1-9](#).)

### Equipment Required

- ◆ 1.98 mm (5/64 in.) hex wrench (Included in PN 750-268 Accessory Kit)
- ◆ 1.59 mm (1/16 in.) hex wrench (Included in PN 750-268 Accessory Kit)
- ◆ 2.38 mm (3/32 in.) hex wrench (Included in PN 750-268 Accessory Kit)
- ◆ Alignment tool assembly, PN 750-254-G1. (Included in PN 750-268 Accessory Kit)
- ◆ Minimum 80 psi (gauge) {95 psi (absolute)}{6.5 bar (absolute)} [653 kPa (absolute)] to maximum 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)]



### WARNING

**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

**NOTE:** 75 psi (gauge) {90 psi (absolute)} (6.2 bar (absolute)) [618 kPa (absolute)] is used for alignment purposes only.

### 4.8.1 Alignment Instructions

- 1 Temporarily connect an air supply to the bellows assembly supply tube. Regulate the air pressure to 75 psi (gauge) {90 psi (absolute)} (6.2 bar (absolute)) [618 kPa (absolute)].



#### **WARNING**

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**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

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- 2 Remove the actuator cover (item 15) and related hardware.
- 3 Insert the 3.175 mm (0.125 in.) diameter alignment pin (of the PN 750-254-G1 assembly) in the alignment hole (if not already installed). (See [Figure 4-6 on page 4-18.](#)) The carousel may need to be rotated to achieve the alignment condition. (See [Figure 4-6.](#))
- 4 Loosen the set screws (two set screws per item) of the ratchet (item #22) and the stop ratchet (item #38).
- 5 Loosen the #2 fastener (item #42) that attaches the detent (item #41) to the bellows assembly (item #19). *Do not remove detent.*
- 6 Actuate the bellows assembly by applying 24 V (dc) to the leads of the solenoid valve of the solenoid valve assembly. (Refer to [Figure 3-1 on page 3-5](#) for wiring assignments.) The air pressure must be sustained.
- 7 Rotate the ratchet (item #22) counterclockwise until one tooth contacts the pin of the pawl and actuator stem assembly (item #24). Secure the ratchet to the 6.35 mm (0.25 in.) diameter shaft of the carousel assembly (item #5) utilizing the #6-32 x 3.175 mm (0.125 in.) long socket set screw (item #33).
- 8 Rotate the stop ratchet (item #38) clockwise until it contacts the stem of the pawl and actuator stem assembly (item #24). (See [Figure 4-7 on page 4-23.](#))
- 9 Secure the stop ratchet to the 6.35 mm (0.25 in.) diameter shaft of the carousel utilizing the #6-32 x 3.175 mm (0.125 in.) long socket set screws (item #33).
- 10 Rest the detent spacing tool on the top of the alignment pin. (See [Figure 4-8 on page 4-23.](#))

- 11** Position the detent spacing tool (of the PN 750-254-G1 assembly) between the detent (item #41) and ratchet (item #22). (See [Figure 4-8 on page 4-23.](#)) Pull the detent against the detent spacing tool and subsequently against the tooth of the ratchet. Tighten the #2 fastener (item #42) to secure the detent to the bellow assembly.
- 12** Remove the detent spacing tool.
- 13** Release air pressure from the bellows assembly (item #19).
- 14** Remove the 3.175 mm (0.125 in.) diameter alignment pin of the PN 750-254-G1 alignment tool assembly from the hole.
- 15** Prior to installation of the crystal holder assembly, check the continuity between the center contact of the connector and the electrical contacts associated with the carousel assembly (item #5). Install the crystal holder assembly when electrical continuity is verified. If electrical continuity is not verified, CrystalSix should be disassembled. (See [section 4.8.2 on page 4-18.](#)) The electric contact associated with the carousel will have to be adjusted to ensure electrical contact when assembled.
- 16** Press the crystal switch button on the handheld controller or the instrument front panel. The sensor will advance to the next crystal position. Each crystal should be centered in the aperture. Repeat step #10 for each crystal position. Make certain the detent drops in to engage each tooth of the ratchet (item #22) on each pulse.
- 17** Secure the actuator cover (item #15) to the top plate (item #10) using two #4-40 x 4.75 mm (0.187 in.) long socket head cap screws (items #16 and #17).
- 18** Install the heat shield (item #8) by first orienting the slot in the heat shield to accommodate the water tubes, then secure the heat shield by applying pressure near the center of the shield. The shield will snap in place.
- 19** Regulate the air supply from 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] (minimum) to 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)] (maximum). CrystalSix is ready for operation.



### **WARNING**

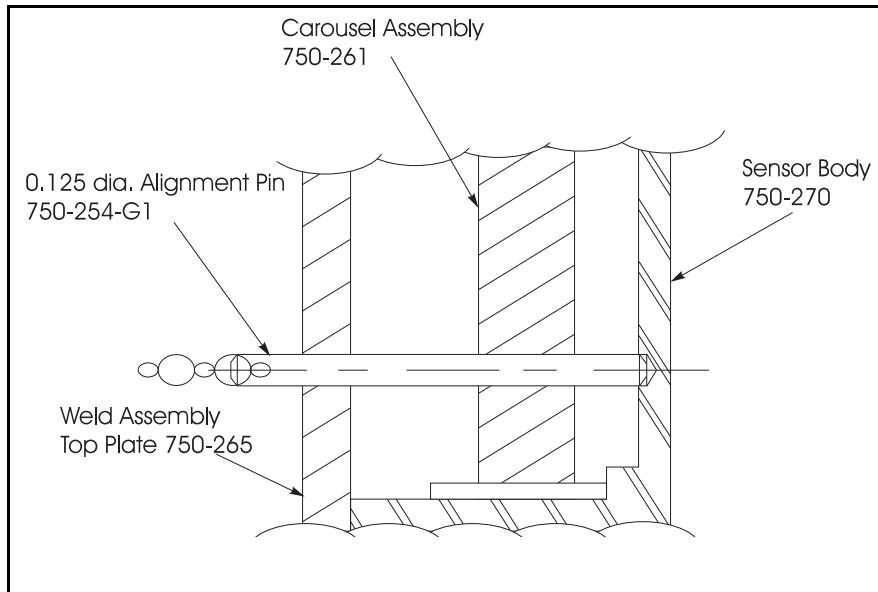
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**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

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Figure 4-6 Alignment pin installation



## 4.8.2 Disassembly Instructions

In the following steps, refer to [Figure 1-3 on page 1-9](#) and [Figure 4-6](#).

- 1 Remove the two #4 fasteners that secure the actuator cover (item #15) to the top plate (item #10).
- 2 Remove the actuator cover. Remove the heat shield (item #8) by gently pulling on the outside of the shield, the shield will snap off.
- 3 Remove the extension spring from the pawl and actuator stem assembly (item #24).
- 4 Remove the two #4 fasteners (item #20) that secure the bellows assembly (item #19) to the top plate (item #10).
- 5 Carefully remove the bellows assembly. The pawl and actuator stem assembly (item #24) and the detent (item #41) will be removed with the bellows assembly.
- 6 Using the 1.59 mm (1/16 in.) hex wrench, loosen the set screws (item #33) that secure the ratchet (item #22) and the stop ratchet (item #38) to the carousel assembly (item #5). Remove the ratchet (item #22) and the stop ratchet (item #38).
- 7 Remove the three #4 fasteners (item #14) that secure the top plate (item #10) to the sensor body (item #11).

- 8 Remove the top plate (item #10).
- 9 Remove the Teflon washer (item #39).



### CAUTION

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**When removing the top plate make certain the connector terminal does not become damaged.**

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- 10 Remove the compression spring (item #28).
- 11 Remove the carousel assembly (item #5)



### CAUTION

---

**When removing the carousel make certain the 3.2 mm (0.126 in.) diameter ball (item #27) does not become lost.**

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## 4.8.3 Assembly Instructions

In the following steps, refer to [Figure 1-3 on page 1-9](#) and [Figure 4-6](#).

- 1 Place the 3.2 mm (0.126 in.) diameter ball (item #27) in the countersunk hole of the sensor body (item #11).
- 2 Attach the corrugated springs (item #31) if not already attached to the sensor body (item #11), as illustrated in detail F of [Figure 1-3 on page 1-9](#), utilizing the 0-80 pan head screws (item #45).



### CAUTION

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**Be extremely careful when handling the corrugated springs to avoid distortion. Successful operation is dependent on the corrugated springs.**

---

- 3 With the free end of each corrugated spring outside the sensor body, install the carousel assembly (item #5) so that it rests on the 3.2 mm (0.126 in.) diameter ball. Insert the corrugated springs into the space between the carousel (item #5) and the body (item #11). Make certain that the corrugated springs are not damaged during installation.
- 4 Rotate the carousel clockwise until the alignment hole in the carousel lines up with the alignment hole of the body. Insert the 3.175 mm (0.125 in.) diameter alignment pin of the alignment tool assembly (750-254) provided. (Refer to [Figure 4-6](#).)

- 5** Place the compression spring (item #28) in the cavity surrounding the 6.35 mm (0.25 in.) diameter shaft of the carousel assembly. Install the Teflon washer (item #39) onto the 6.35 mm (0.25 in.) diameter shaft.
- 6** With the connector facing outward, pass the top plate (item #10) over the 6.35 mm (0.25 in.) diameter shaft of the carousel assembly (item #5) and the 3.175 mm (0.125 in.) diameter alignment pin.
- 7** Secure the top plate to the sensor body utilizing the three #4-40 screws (items #14 and #17).
- 8** Install the pawl and actuator stem assembly (item #24) into the bellows assembly (item #19) by threading the actuator stem into the mating hole located in the bore of the bellows assembly. Continue to thread the actuator stem until the shoulder of the actuator stem is approximately 0.889 mm (0.035 in.) away from the bellows assembly. This 0.889 mm (0.035 in.) distance specification is for reference only. The actuator stem position may have to be adjusted to obtain the desired condition. (Refer to [Figure 1-3 on page 1-9.](#))
- 9** Fasten the bellows assembly to the top plate utilizing the two #4-40 x 28.575 mm (1.125 in.) long screws (item #20). Do not tighten the screws. Position the bellows assembly in such a fashion as to allow the actuator stem to come in contact with the ball bearings (item #25). (Refer to [Figure 1-3 on page 1-9.](#)) Tighten the screws. Loosen the #2 screw (item #42) which secures the detent to the bellow assembly (item #19).
- 10** Slide the ratchet (item #22) and the stop ratchet (item #38) onto the 6.35 mm (0.25 in.) diameter shaft of the carousel assembly (item #5) as illustrated. Do not tighten the #6-32 set screws (item #33).
- 11** Attach the loop of the extension spring in the hole provided in the pawl of the pawl and actuator stem assembly (item #24).
- 12** Position the ratchet (item #22) such that it engages the pin of the pawl and actuator stem assembly (item #24).
- 13** Position the detent (item #41) so it engages the ratchet (item #22).

CrystalSix is now ready to be aligned. (Refer to [section 4.8.1 on page 4-16.](#))

## 4.9 Replacing the Pneumatic Actuator [PN 750-286-P2]

(Refer to [Figure 1-3 on page 1-9.](#))

### **Equipment Required**

- ◆ 1.59 mm (1/16 in.) hex wrench
- ◆ 2.38 mm (3/32 in.) hex wrench
- ◆ Alignment tool assembly, PN 750-254-G1
- ◆ Regulated air supply range minimum to 80 psi (gauge) {95 psi (absolute)} (6.5 bar (absolute)) [653 kPa (absolute)] to a maximum 90 psi (gauge) {105 psi (absolute)} (7.2 bar (absolute)) [722 kPa (absolute)]



### **WARNING**

**Do not exceed 100 psi (gauge) {115 psi (absolute)} (7.9 bar (absolute)) [791 kPa (absolute)].**

**Connection to excessive pressure may result in personal injury or equipment damage.**

- 1** Remove the two #4-40 fasteners that secure the actuator cover (item #15) to the top plate (item #10). Remove the heat shield (item #8) by gently pulling on the outside circumference of the shield. The shield should snap off.
- 2** Advance the carousel (item #5) using the **Crystal Switch** button on the handheld controller or on the controller front panel as many times as necessary until the alignment holes in the sensor body (item #11), carousel assembly (item #5) and the top plate (item #10) coincide.
- 3** Insert the 3.175 mm (0.125 in.) diameter alignment pin into the alignment hole. (Refer to [Figure 4-6 on page 4-18.](#))

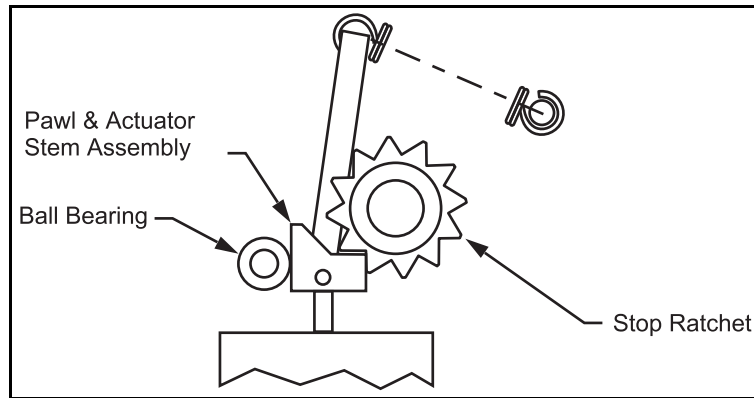
The bellows assembly must be removed. Proceed as follows:

- 4** Remove the extension spring from the pawl and actuator stem assembly (item #24).
- 5** Remove the two #4 fasteners (item #20) that secure the bellows assembly (item #19) to the top plate (item #10).
- 6** Carefully remove the bellows assembly. The pawl and actuator stem assembly (item #24) and the detent (item #41) will be removed with the bellows assembly.

- 7** Using the 1.59 mm (1/16 in.) hex wrench, loosen the 6-32 set screws (item #33) that secures the ratchet (item #22) and the stop ratchet (item #38) to the carousel assembly (item #5). Remove the stop ratchet (item #38) and the ratchet (item #22).
- 8** Thread the pawl and actuator stem assembly (item #24) out of the bore of the bellows assembly by rotating the pawl and actuator stem assembly in a counterclockwise direction. Detach the detent (item #41) and related hardware (items 40, 42-44) from the bellows assembly (item #19) by removing the #2 fastener (item #42).
- 9** Discard the bellows assembly.
- 10** Install the pawl and actuator stem assembly (item #24) into the new bellows assembly by threading the actuator stem into the mating hold located in the bore of the bellows assembly. Continue to thread the actuator stem until the shoulder of the actuator stem is approximately 0.889 mm (0.035 in.) away from the bellows assembly. This 0.889 mm (0.035 in.) distance specification is for reference only. The actuator stem position may have to be adjusted to obtain the desired condition. (Refer to [Figure 1-3 on page 1-9.](#))
- 11** Fasten the bellows assembly to the top plate utilizing the two #4-40 x 28.575 mm (1.125 in.) long screws (item #20). Do not tighten the screws. Position the bellows assembly to allow the actuator stem to come in contact with the ball bearings (item #25). (Refer to [Figure 1-3 on page 1-9.](#)) Tighten the screws. Loosen the #2 screw (item #42) which secures the detent to the bellows assembly (item #19).
- 12** Slide the ratchet (item #22) and the stop ratchet (item #38) onto the 6.35 mm (0.25 in.) diameter shaft of the carousel assembly (item #5). (Refer to [Figure 1-3 on page 1-9.](#)) Do not tighten the #6-32 set screws (item #33).
- 13** Slide the ratchet (item #22) onto the 6.35 mm (0.25 in.) diameter of the carousel assembly. Do not tighten the #6-32 set screws.
- 14** Attach the extension spring in the hole provided in the pawl of the pawl and actuator stem assembly (item #24).
- 15** Position the ratchet (item #22) such that it engages the pin of the pawl and actuator stem assembly (item #24). (See [Figure 4-7.](#))

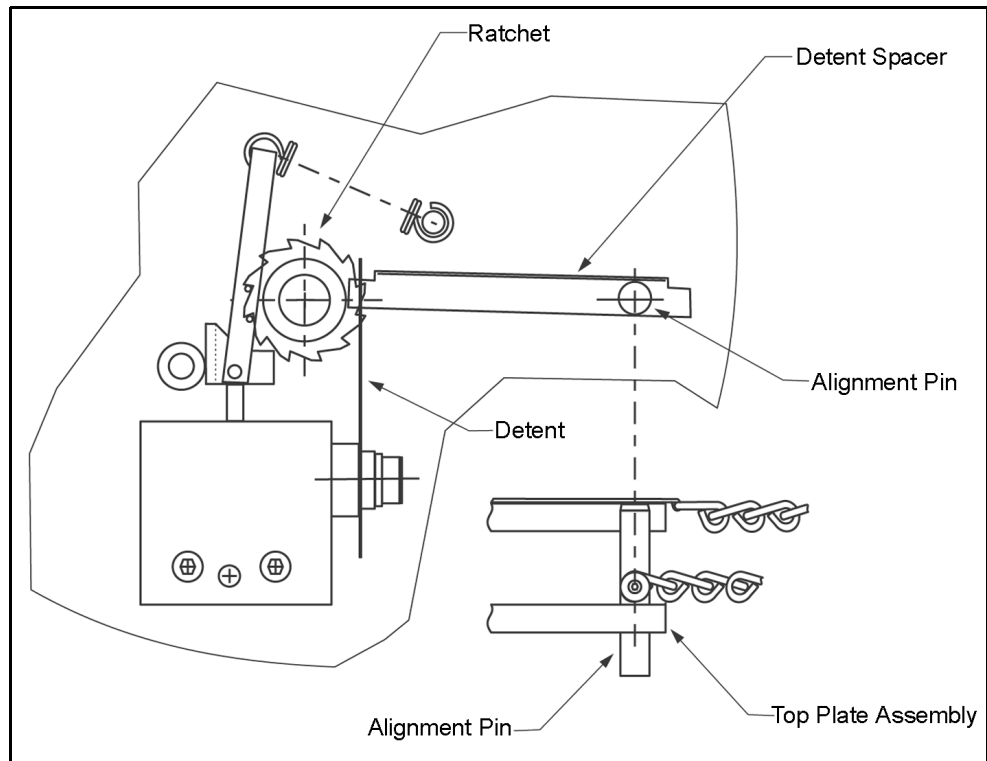


Figure 4-7 Setting the Stop Ratchet



- 16 Attach the detent and related hardware (items 40, 42-44) to the new bellows assembly. Do not tighten. Position the detent (item #41) so that it engages the ratchet (item #22). (See [Figure 4-8](#).)

Figure 4-8 Setting the detent



CrystalSix is now ready to be aligned. (Refer to [section 4.8.1 on page 4-16](#) for alignment instructions.)

### **4.9.1 Replacement Parts and Accessories**

Cover, Heat Shield . . . . .	PN 750-250-G1
Ceramic Retainer . . . . .	PN 007-023
Crystal Holder. . . . .	PN 750-262-G1
Pneumatic Actuator . . . . .	PN 750-286-P2
Crystal Holder Extraction Tool . . . . .	PN 750-279-P1