PATHFINDER-EN

10.0-meter Gas Cell

User's Guide

S/N _______________

Special Notices

1. This gas cell has been fitted with _____________________ O-rings; the recommended maximum operating temperature is _____ **deg C.**

2. To ensure proper operation of the Temperature Controller for this cell, please **re-AUTOTUNE** it at first use.

3. Take note of recommended cleaning and storage Procedures in **Appendix A** when taking off-line.

4. Please read this entire manual
BEFORE
using the gas cell.

CIC Photonics, Inc.

INSERT

FOREWORD

Thank you for purchasing a CIC Photonics sampling accessory. We strive to build the best sampling accessories available and believe that you will be pleased with the performance of this long path gas cell. Should you have any difficulties at all please call 505-343-1489 for technical assistance. We should be able to help you immediately.

If you have any comments on this or any of our other products we would like to hear from you. We can be reached at the address, telephone numbers or E-mail address as given below. Thank you again for your business.

Sincerely,

Richard T. Meyer
CEO & President
CIC Photonics, Inc.

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OUR WARRANTY

I. Since CIC Photonics builds its products to last, we warrant them that way. If you have a problem with our accessory, within the first year of ownership, that is a result of a defect in workmanship or the wearing out of a component that should not wear out, we shall fix it.

II. Parts that normally wear out or are consumed or can be damaged in the normal operation of the accessory, such as fragile optical elements (lenses, windows, crystals, mirrors, filters, etc.) are warranted against defect in manufacture for a period of 30 days after original delivery to the purchaser.

CONTENTS

Appendices

1.0 INTRODUCTION

The Pathfinder-EN is a variable pathlength folded-path White cell. The pathlength is variable from 0.4-meter to 10.0-meters in increments of 0.8-meter. The volume of the cell is 2.2 liters. A heated version is available with external heating elements, insulation and type K thermocouples to allow heated operation of the cell up to 200 °C (with Viton O-rings) or 260 deg C (with Kalrez O-rings). The rated pressure of the cell body is 50 psig (3 atm), but the system will most often be limited in pressure by the windows. The standard 25 x 4 mm KBr windows effectively limit the cell to 14.7 psig (1 atm) positive pressure; however, 25 x 4 mm ZnSe windows are rated to 750 psig (50 atm).

As you read through the text of the manual, you may want to refer to the gas cell drawings on the next three pages.

The standard gas fittings and supplied with the cell are 1/4” VCR, with optional fittings (Swagelok, VCO, stainless bellows, etc.) available at the time of purchase. The cell is constructed of electropolished 304 SS and can be plated with nickel for use with particularly corrosive samples. Standard seals are Viton O-rings but Kalrez O-rings may be specified to extend the maximum service temperature to 250 °C and enhance chemical resistance.

The optical configuration of the Pathfinder-EN is that of a White cell with a basepath of 200 mm. At the top of the cell two mirrors, the “objective mirrors”, successively re-image the beam passing through the cell to focus in the plane of the rectangular “field mirror” at the bottom. The beam is introduced into and exits the cell through apertures in the field mirror. While inside the cell the beam makes 48 total passes with each pass equal to the basepath of 200 mm, for a total pathlength of 9.6 meters. For more information on the optical geometry and behavior of White cells see Appendix A. Two planar mirrors below the cell act as transfer optics coupling a typical FTIR beam within a sample compartment into and out of the cell. The entrance and exit axes are symmetric with respect to the axis of the cylindrical cell body. Details on initial alignment of the transfer optics can be found in the INSTALLATION section. Information on cleaning or servicing the cell can be found under MAINTENANCE. It is *not* recommended that the user attempt a realignment of the main cell optics without first consulting with CIC Photonics personnel regarding the sensitivity of the adjustments required and the equipment necessary to ensure that the correct pathlength is achieved.

2.0 INSTALLATION

2.1 INSTALLING THE CELL

Your Pathfinder-EN will be baseplated for the spectrometer specified at the time the cell was ordered. The baseplate will either be a CIC Photonics unit with provisions for a number of different spectrometer benches or, in the case of most Nicolet, Bomem or Bruker benches, it may be outfitted with a baseplate from the spectrometer manufacturer. In either case the baseplate mounting provisions ought to allow registration and hold-down of the cell unit into the spectrometer sample compartment.

The cell will be oriented such that the gas port at the base of the cell faces outward toward the front of the bench. In some cases there will be alignment pins to register the cell into the correct position with respect to the beam centerline. There will also often be provisions for tying the cell rigidly down into the sample compartment. The hardware necessary for this purpose will have been included with the tool and hardware complement shipped with your unit and will vary depending on the type of spectrometer. If you cannot find the hardware or the cell does not seem to fit correctly into the bench call us for further assistance before proceeding further.

Once the cell is in place, inspect the relative positions of the beam passages on the sides of the sample compartment and the purge couplings (if ordered) to verify that they line up with each other as they should. If your unit does not have the purge couplings, verify that the two internal transfer optic mirrors line up with the beam line.

2.2 Alignment to Spectrometer

For safe shipping, the Pathfinder is set at approximately an 11-meter pathlength which places the pivoting object mirrors against a hard stop. Before using, unlock the pathlength dial and set it to the 10.0-meter per the calibration chart. You should immediately see energy through the cell. Compare the energy through the cell with the open beam energy by measuring a spectrum through the cell and ratioing to the open beam. If the energy is greater than or equal to 20% in regions of the spectrum where there are no atmospheric absorptions, no further alignment will be necessary. If you see less energy than this, the output pick-off mirror should be adjusted first. **If adjusted at all, the input pick-off mirror should only be repositioned slightly as calibration of the path dial can be compromised if it is adjusted too far.**

The 1/4-20 screws adjust the tilt of the mirrors, and the 6-32 set screws adjust the rotation. Allen keys are provided to adjust these screws. Each adjustment is independent. Only small adjustments will be necessary. Adjust each of the four adjusters, first for the output mirror, until an energy maximum is reached. Monitor the energy signal on your spectrometer as you adjust these mirrors. Note: It is important to make very small adjustments of these mirrors, especially on the input side. In many cases, no adjustment will be needed. In any case, only a fraction of a turn of the screw should be made while looking for improved energy throughput**. Large adjustments can throw the cell out of alignment, since these mirrors in part control the number of internal beam reflections.**

2.3 PLUMBING THE CELL

In a standard Pathfinder-EN the main gas fittings feeding and returning samples to and from the cell will be 1/4” VCR. One VCR fitting is located on top of the cell and one near the base of the cell. We recommend using the base VCR as the gas inlet and the top VCR as the outlet. Both fittings have a standard VCR gland and a female nut, and the connections you supply should be 1/4” VCR with a male nut. Install a VCR gasket onto one gland or the other for each connection. We prefer gaskets with retainers that hold the gasket in place while assembling the joint, but loose gaskets can be set on top of the gland and then will center as the female nut is raised. You will need 3/4” and 5/8” wrenches to make the connections. Tighten the joint to finger-tight. Mark the positions of the two halves of the fitting with a line. Then hold the male nut stationary and tighten the female nut 1/8 turn past finger-tight for 316 or nickel gaskets, or 1/4 turn past finger-tight for copper or aluminum gaskets. **Note**: Excessive over-tightening will damage the sealing beads and may cause system leakage.

There are many different ways to configure your plumbing system but a few guidelines may be helpful in order to get the best results with the cell. Isolation valves should be placed as close to the cell in both the inlet and return lines. Lines may be heated to help prevent moisture retention on the internal surfaces. Lines may be coiled adjacent to connections to allow freedom of motion when making or breaking connections. If a vacuum system is used to aid in clearing the cell of samples or contaminants it should be placed as close to the cell as is feasible, preferably with a straight-line passage from the cell to the pump inlet. **A pressure relief valve should be installed in one of the cell lines and plumbed to an approved vent or scrubber if hazardous gases are present or if elevated pressures are used. Note**: For more information on safety precautions and procedures see the SAFETY section.

2.4 PLUMBING THE PURGE COUPLINGS (if supplied)

The purge couplings should be extended by sliding them outward until the sealing gasket makes good contact with the sides of the sample compartment. The gaskets should be compressed slightly to ensure intimate contact and an effective seal. While each seal is in compression, tighten the small thumb screws in the ring to hold the assembly in place. This is often a cumbersome task alone and you may need a second pair of hands to simultaneously hold the assembly in place while the screws are tightened. The goal is to establish a sealed volume for the beam to pass through. The better this environment is sealed, the dryer it can be made and in turn the better results you will achieve in collecting spectra.

The fittings on the purge couplings are 1/4" Swagelok. You can use any common metal or polypropylene tubing to supply purge gas but in general stainless steel will be the optimal choice as the internal surfaces will be smoother and will retain less moisture than plastic tubing. It makes no difference which side is used as inlet but the exit should also be plumbed away from the system to prevent back-migration of moisture into the purge volume which will occur even against a positive flow. Purge flow rates will be discussed in detail in the OPERATION section, but you should be able to supply flows of at least 10 liters/min. to both the purge and to the cell for ‘reasonable’ dry down times. Heating the purge lines will further shorten the dry-down time.

3.0 OPERATION

3.1 CELL PREPARATION

Once the cell has been installed and the various gas lines plumbed you are ready to begin conditioning the cell. The optimal cell environment for most purposes is as dry as possible and stable at some temperature above ambient. More information on heating the cell follows in the next subsection. The purge gas used will determine how effectively the cell can be dried. In general nitrogen is used for this purpose as it is one of the least expensive gases available, is inert, can be dried with commercial dryers and has usually already been supplied to the laboratory either from tanks on a manifold or from a liquid nitrogen Dewar.

The higher the flow rate of purge gas the faster the cell will come to equilibrium at some partial pressure of moisture. This state of equilibrium is a balance between the amount of latent moisture in the purge gas, the rate of adsorption of moisture onto the internal surfaces of the cell and the rate at which moisture desorbs off the walls back into the purge flow. In general, depending on the flow rate of purge gas and the temperature of the cell, drying will take from a few hours to a few days to reach equilibrium. At equilibrium, assuming the system is adequately leak-tight, moisture levels are likely to be in the 10 to 100 ppb levels. To reach this level of dryness within a 24 hour period will require purge flow rates of 5 to 10 liters/min. and a cell temperature at or above 100 °C.

Note: When measuring the moisture level inside the cell by applying a known extinction coefficient and Beer's law, one must consider that at these flow rates the system is primarily measuring the condition of the purge gas, not necessarily accounting for the condition of the cell walls. Although your cell may not be at equilibrium your measurements can show low moisture levels. In order to check the condition of the cell environment itself, isolate the cell by valves and measure under static conditions. This will give a more realistic value for the level of moisture in the cell and can also be used as a leak-check method. When the cell is sealed off, some moisture will leave the internal surfaces and bring the internal volume and internal surfaces into equilibrium. The higher the temperature of the cell, the smaller the amount of moisture will have remained on the walls and the dryer the equilibrium level will be. But if there is a leak in the system, instead of coming to a point of equilibrium, the moisture level within the cell will continue to rise, even if the cell is at positive pressure, until eventually the humidity in the cell equals that of its surroundings. This process might take quite some time, particularly if the leak is small, (less than 10E-7 cc/second), But leaks of this magnitude are intolerable if one wishes to operate near the limit of detection at moisture levels below 100 ppb, or is dealing with toxic gases.

Remember, however, that if your measurements are on samples flowing through the cell at some given rate, the important factor is the equilibrium state of the cell environment at that rate of gas exchange; and it may differ from that under static conditions. Also bear in mind that different gases may interact with the moisture on the cell walls to differing degrees. For example, a cell at equilibrium with nitrogen flowing at a given rate will undergo a rise in moisture level when HBr is introduced because the more corrosive agent will tend to “strip” moisture off the walls and seek a different equilibrium point.

3.2 CELL HEATING

The Pathfinder-EN is equipped with a heating system comprised of two heating circuits. The main heaters are sheet heater elements affixed to the outer surface of the cell body and together they supply 400 W. A supplementary rod heater is embedded in the bottom flange and provides an additional 400 W. A two-channel controller is required to run the two heating circuits. CIC Photonics offers such a controller, and if you have purchased this unit it will have been tuned to your cell prior to shipment. In order to get the system running, all you need to do is turn the power on and set the desired temperature in the lower display. Detailed instructions on the operation of the controller may be found in Appendix B. Following is a brief summary of these setup and operating parameters that is adequate for resetting some of the parameters during the course of your work or if for some reason the unit reverts to the factory defaults.

CHANGING CONTROLLER PARAMETERS

Be sure the Pacesetter controller is plugged in and the power is on. Press and hold both arrow keys on one controller simultaneously. The letters “LOC” should appear on the green display. By using the up or down arrow keys set the value, which appears on the red display, at “0”. Press the M key and the next parameter will appear on the green display. You should see the letters “In”. Set this value using the arrow keys until the letter “H” appears. By continuing in the same fashion, set the following values:

Parameter	Channel 1 (base heaters)	Channel 2 (body heater)
CF	C	C
rL	0	0
rH	200	200
Ot1	ht	ht
HSC	3	3
Ot2	no	no
rP	on	on
rt	180	350
PL	100	100
dSP	nor	nor

The next time you push the M key you should see temperatures in both displays. The following setting of the Operation parameters must be performed with a thermocouple and heaters attached to the unit. Press the M key. The letters “Pb1” will appear. Set the value at 0 using the arrow keys. Press the M key again and using the same method as above set the unit for the following values:

Parameter	Value
CAL	0
Aut	2

The “Aut” parameter sets the unit to Autotune mode. In this mode the controller will gauge the thermal load required to heat the system at a given rate and also gauge how well insulated the system is by monitoring how quickly the system cools when power is removed. Your system should already have been tuned prior to shipment but it may be repeatedly re-tuned, for example if the insulation is changed, ambient conditions change, or gas flowrates are varied thereby changing the cooling rate internally.

After the controller has been programmed, you can simply set the desired cell temperature with the arrow keys. For more detailed information on the additional functions and features of these controllers please consult the controller manual in Appendix B. If you have questions about the operation of the controllers please feel free to call us for technical support at (505) 343-1489 or Watlow at (507) 454-5300.

3.3 BACKGROUND MEASUREMENTS

For those systems equipped with the purge couplings, background measurements may be made either by removing the cell from the sample compartment or by evacuating the cell between measurements.

3.4 CHANGING THE PATHLENGTH

The Pathfinder pathlength dial is calibrated in terms of actual pathlength, see calibration chart at the beginning of this manual for your specific Pathfinder. At the minimum setting on the dial, the beam traverses the cell twice. This translates to 0.4 meter pathlength (on the analog dial, the remainder digits are represented on the dial itself, and the integer digits are displayed on a changing wheel above the dial). The next setting is for 1.2 meters, and so on. The cell is shipped in a “locked” position at a setting above the 10-meter position. Because of alignment differences between spectrometers, peak energy may be shifted slightly (but only slightly) from the calibrated dial readings. For maximum performance, dial in the pathlength you desire, then adjust slightly to maximize energy.

4.0 MAINTENANCE

As with most instruments, the Pathfinder-EN should be regularly maintained in order to operate as its optimal level of performance. For White cells this means taking care to avoid misaligning the optical elements, keeping the internal surfaces clean, monitoring the condition of the seals, and periodic inspection and recalibration. With the possible exception of recalibration all these operations can be carried out by the user, including fine alignment of the system to the bench and replacement of the windows. The following set of maintenance guidelines gives basic information about performing these operations. We will be happy to support you in doing this maintenance yourself, or, if you feel more comfortable, we can do the work in our facility freeing up your time for other priorities. Either way, our goal is to ensure that this instrument continues to provide the best possible level of performance for many years to come.

4.1 REPLACING WINDOWS

The windows provide the primary interface between the internal sample volume and the rest of your system. It is of the utmost importance that they remain optimally transmissive through the spectral region important to your measurements, and further that they continue to provide adequate containment of the sample volume over time, particularly if you are dealing with toxic or potentially harmful agents.

There are two windows in your gas cell, one at the entrance and a second at the exit of the beam to the cell volume. Both are mounted to the bottom of the cell body, and both are easily accessible for inspection or replacement if necessary. The standard windows shipped with the Pathfinder-EN are potassium bromide (KBr), a soft and hygroscopic material with good transmission characteristics. Other materials are available including BaF2, CaF_2, ZnSe, and AgCl, all of which have their own advantages and disadvantages. Hygroscopic materials tend to degrade with exposure to moisture. It is, therefore, imperative that these optics are maintained in a desiccated or purged environment if they are to perform satisfactorily over the long term. At some point it may become necessary or desirable to change the windows, either to replace windows which have degraded or to use a more suitable material for a given application. The following lists steps by which the windows can be replaced in systems with a purge/reference enclosure. If your system is not configured this way please consult CIC Photonics technical support at (505) 343-1489 for further assistance.

1. Check that the system is at ambient pressure.

2. Disconnect main gas inlet lines and heater cables.

3. If the cell is equipped with purge couplings, remove them next.

4. Set the cell down on its side such that the window ports are accessible. Take care not to over-bend heater cables as the cell is laid down.

5. Inspect the windows for obvious fogging, fractures or other defects. If you are simply inspecting the condition of the windows and decide not to replace them, reassemble the cell in the reverse order as above.

6. To replace the windows, insert the rectangular-shaped blade tool into the slots of the retaining rings holding each of the windows in place. As the rings are unscrewed and removed the windows can tip out of position and fall, so be careful. If the windows are not readily removed, try using a piece of scotch tape smoothed onto the outer surface as a handle to pull them gently out of their recesses. In some cases there will have been some adhesion between the windows and the O-rings. In such a case you may need to insert a fine bladed screw driver at the edge of the window and apply a small amount of force to dislodge the window. **Note**: Most IR materials are very fragile and this operation can easily damage the window. If you intend to save the windows for future use take great care in applying force with any tool directly to the window.

7. This is a good opportunity to replace the window seals. Two spare window Viton O-rings are included in the tool complement for the Pathfinder-EN. If you have already used them we will be happy to supply you with additional O-rings, in the standard Viton material, at modest cost. (Kalrez O-rings are more expensive.) Simply call technical support and we'll ship them asap. If you prefer to obtain them locally, the industry standard designation is 2-014 Viton.

8. To install the new windows, inspect the O-rings for *any* foreign material and clean them with acetone or ethanol. Clean the bottoms of the O-ring grooves with the same solvent and a cotton swab. Take care that you don't leave any fibers behind; even one small cotton fiber can create an unacceptable leak path.

9. Place the O-ring into the groove at the bottom of the recess. Place the new window into the recess taking care to touch only the sides of the optic and that the O-ring doesn't slip out of place during the process.

10. Replace the retaining ring and loosely install the screws. Holding the ring firmly against the window, tighten the three screws progressively such that the compression of the O-ring is uniform. Continue this process until the screws get noticeably harder to turn, then *stop*. **Note**: Over-tightening the screws or tightening them non-uniformly can cause the window to fracture.

11. Inspect the O-rings through the windows. It should be evident that there is a flattened sealing region where the O-ring and window interface. Check for fractures of the window. Fractures will most likely be planar and parallel to the axis of the window. Sometimes one needs to look at the window from different angles to see them. If none are apparent then proceed. If there is a fracture, repeat the procedure with a new window.

12. Replace the cell on the purge enclosure taking care to align the pins as appropriate. Replace the purge top plate screws and tighten.

13. Reconnect gas lines and heater connectors. Be sure to use new VCR gaskets.

14. Take sample and background measurements to confirm that throughput has, if anything, increased. Begin reconditioning of the cell with dry purge, heat, etc.

4.2 INSPECTION OF THE CELL

Periodic inspection of the internal surfaces of the gas cell body as well as the optical elements is recommended on a regular basis. What this means for your particular cell will depend on the type of materials to which the cell is exposed, the temperature at which that exposure occurs, the presence of protective plating or coatings on the cell components, the time in service, etc. For most applications where the samples are inert and no performance problems are apparent, inspection on a yearly basis is probably adequate. If corrosives are present and the cell is in constant use, regular inspection on a monthly or quarterly basis is advised.

CIC Photonics has provided services doing inspection, replacing seals, realigning, and even repolishing the optical elements as necessary since we began building gas cells in 1990. If you prefer for us to do this work, it is a simple matter to arrange for return of the cell. Service for our existing customers always takes priority.

An initial inspection of the Pathfinder's interior and mirror surfaces can only be accomplished by removing the cell's top plate. We recommend that you contact our Technical Support before doing so (505-343-1489).

In pristine condition, the gold coatings on the mirrors are very uniform. Any corrosion or staining present will be highly dependent on the nature of cell use and the agents to which it was exposed, and so it is difficult to define criteria by which to assess damage. If there is any visible non-uniformity on the surfaces, but throughput has not diminished substantially, the question becomes one of whether corrosion of the internal components is contaminating the cell environment and affecting spectral measurements. If throughput has dropped as a result of the deterioration of internal components, the cell ought to be returned for inspection and any necessary service. Many cells operate for years without exhibiting appreciable deterioration; but it is highly dependent on the nature of use.

We recommend that you monitor the energy throughput of your gas cell from day one on a monthly basis and keep a written record. Once the throughput drops below 75% of its original level, you need to be concerned about possible chemical degradation of the mirror surfaces. At that point, call Technical Support for assistance.

4.3 DISASSEMBLY

Disassembly of the Pathfinder-EN by the user is discouraged. Removal of the top plate is okay for a cursory inspection, but to do any substantive cleaning requires, at the minimum, removing the entire objective mirror sub-assembly. Doing so will likely require a re-alignment of the White cell mirror system.

4.4 CLEANING THE CELL (only by experienced personnel)

Note: Some cleaning of the gas cell can be accomplished without opening up the cell except for the gas ports. If you suspect that a film or powder has simply deposited on the mirrors, rather than the gold surfaces being chemically degraded, the interior of the cell can be flushed with warm isopropyl alcohol. Pour the alcohol into one of the gas ports, swish it around and then dump it out. Repeat this several times until the discharged alcohol is clean. Then dry out the cell with a purge gas and try it out.

In order to clean the cell you will need:

- Lint-free cleaning rags
- Micro-fiber optical cloths
- Acetone or isopropyl alcohol
- Clean low pressure compressed air

We normally use acetone for all of the cleaning operations on the cell. Wet a cleaning rag with solvent and wipe down the interior non-optical surfaces periodically inspecting the rag for residue. If the rag shows signs of material removed from the surfaces, change rags until there is no observable residue. It will probably work best to work on the interior in sections so as not to skip areas.

> **CAUTION**: The gold coating on the mirror surfaces is extremely fragile and can easily be scratched, even by incidental contact with a soft cloth. Be sure to avoid *any* contact with the mirrors while cleaning the other internal surfaces.

Examine the objective mirrors. In our experience they normally stay cleaner than the rectangular field mirror because of their downward orientation in the cell. More contaminants seem to settle on the field mirror which faces upward during normal operation.

If the objectives appear to be clean except for some small particulate matter, first try blowing air on the surfaces from a clean source, (“canned air” or pure nitrogen from a tank work the best) or just flushing the mirror surface with solvent. If this doesn’t do it, wet an optical cloth with solvent, give it a quick shake to remove any large droplet of solvent, then very gently use it to remove the particulate. Less damage to the mirror will occur if the cloth is simply brought into contact and then removed than if the cloth actually wipes across the surface. If this doesn’t work you may want to leave the contamination in place rather than risk damaging the mirror.

The same technique should then be used with the field mirror. First try blowing off any particles and/or flushing the surface with solvent. Then, if necessary, try cleaning a small test area on an edge near one of the narrow ends of the mirror. This is a portion of the mirror that isn’t used by the beams as they pass through the cell. Again, use a wet optical cloth and touch the surface. Examine the swab for residue or particulate. Cleaning the entire mirror by this method will be a slow process requiring patience if the mirror surface is to remain undamaged. (If small scratches are introduced you should not assume the mirror is ruined, particularly if the scratches fall out of the active regions on the mirror).

If you need guidance or have questions during the cleaning process please don’t hesitate to call Technical Support (505) 343-1489.

After the internal surfaces have been cleaned, reassemble the cell in the reverse order Once the system is reassembled you will want to check the alignment.

5.0 ALIGNMENT

There are two levels of cell alignment. This procedure covers the fine alignment of the cell to optimize its alignment to a particular spectrometer bench. In addition there is the primary alignment of the cell mirrors themselves to create the classic procession of paths through the White cell. The primary alignment requires specific tools and experience in White cell alignment. For more information regarding the primary alignment procedure please call for Technical Support (505) 343-1489.

Every spectrometer bench will have a unique alignment, although benches from a given manufacturer may have consistent nominal specifications for beam height and position. In order to maximize the performance of the Pathfinder-EN for use with a particular bench, the transfer mirrors can be positioned to ensure the optimal launching of the beam into the cell and the optimal redirection of the beam as it exits the cell towards the detector. The following procedure can be used at any time to "tweak" the alignment for optimal energy throughput.

1. Set the spectrometer software to "alignment mode" or that mode in which a readout of detector voltage is monitored real-time. This is not initiating a self-alignment of the bench itself, but rather finding a readout of the energy the detector sees.

2. Place the Pathfinder gas cell in the spectrometer compartment and make note of the throughput voltage indicated on the spectrometer.

3. One may now optimize the pointing accuracy of the **output** transfer mirror. The screw that has a black nylon head controls Y-axis pointing, The other screw controls X-axis.

4. Small increments of adjustment should be made while monitoring the throughput voltage for a max value. After maximizing one axis, the other axis must be checked and optimized in an iterative fashion.

5. **We recommend that the user NOT adjust the input transfer mirror without FIRST consulting our Technical Support.** Then, at some risk, the input mirror may be similarly aligned for maximum energy throughput but remember that small changes on the input side are in a sense magnified by all the subsequent reflections within the cell. Adjustments on the input side may feel somewhat more sensitive. Again, align for maximum energy.
6. Now return to the output mirror and again maximize energy. If you wish, you may lock the adjustments but we find that in general the positions of the mirrors are constant and the locks really aren't required.

6.0 SAFETY

As with many complex systems there are a number of potential hazards when dealing with a gas cell. We have tried to anticipate these hazards in the design of the system so as to make its operation straight-forward and safe. But there is no substitute for common sense, particularly when using equipment that may be at temperatures high enough to burn, pressures high enough to cause injury if the system is installed incorrectly or operated recklessly, or when dealing with potentially toxic chemicals, laser sources, etc. Please remember that you are the front line of defense against workplace accidents: always wear protective equipment as may be required in your facility, follow all standard safety practices and procedures as defined by your internal safety personnel, and *use common sense* when working around potentially hazardous equipment.

Below are a few simple guidelines for the safe operation of our gas cell. We do not represent this list as a comprehensive safety manual nor as a complete list of all considerations in operating the cell, but following these guidelines will help ensure that your time spent working with our product is safe and productive.

- Always test the integrity of the system for leaks with an inert gas prior to charging the system with a toxic or hazardous gas.

- If testing toxic or hazardous gases follow all applicable safety standards requiring the use of toxic gas monitoring sensors, proper disposal of waste samples, and adequate ventilation in the vicinity of the cell.

- Check the temperature of the cell with the controller readout prior to beginning any service work on the cell *or the attached gas lines* as they may be as hot as 200 °C.

- Always double check that the system is at ambient pressure prior to initiating any service, especially opening *any* sealed joint.

- Never sight directly down the beam path of the spectrometer. Both the IR beam and any alignment laser may be of sufficient power to cause eye injury. Follow all manufacturer’s safety guidelines for the spectrometer bench.

- Never defeat any safety interlock or pressure relief device.

- Before attempting any operation with the cell for which the outcome is questionable regarding safety, please consult our technical assistance personnel for guidance.

- Use common sense.

7.0 LEAK TESTING AND CORROSIVE GAS RECOMMENDATIONS

Prior to shipment of our gas cells, we leak test with helium using a Varian Model 938-41 Helium Leak Detector. The cell is pressurized to approximately 25-30 psig with helium and the detector is then used to “sniff” the entire assembly. The detector’s sensitivity for helium is 1.0 x 10(-8) cc/sec.

Although we rarely experience any leaks developing in shipment, it is recommended that you perform your own leak test upon receipt of the cell, particularly if hazardous gasses or pressures will be encountered in the cell’s operation. The gas cells are not ultra high vacuum instruments, and though very tight assemblies can be achieved, do not expect them to pass leak tests of 10(-7) cc/sec or better.

If you ordered your gas cell for corrosive gas applications, it was probably provided with Kalrez O-rings, metal seals or Teflon-encapsulated Viton O-rings. Be aware that some of these materials will degrade over extended exposures to various corrosive gases, particularly at elevated temperatures. Under such conditions we recommend that you leak test your gas cell on a regular basis.

If you are working at elevated pressures and/or with toxic gases you should observe normal safety precautions for protecting operating personnel. It is recommended that the gas cells and associated manifolds be isolated as is practical in some manner from personnel, such as by using fume hoods, separately flushed enclosures, shields, etc.

We do offer diagnostic, cleaning and repair services for the gas cells, at which time we can replace or upgrade the seals. Please call us at 800-635-3051 if we can be of assistance.

8.0 List of Parts

The items listed below make up the Pathfinder-EN assembly. Note that some parts require factory installation, and are not user serviceable. Also, this list refers to the heated version of the Pathfinder-EN and may change as improvements become available. This list is subject to change at any time without notice.

Cell Body Assembly			
	37-20-ENCB	1	Enhanced cell body
	V37-Dial	1	Vernier dial
Machined Parts			
	37-20-11	2	window retainer
	37-20-02	1	top plate
	37-02-02	1	objective mount
	37-02-03	2	objective pivot
	37-20-07	1	objective bracket
	37-20-03	1	bottom plate
	37-02-09	1	path bracket
	37-02-11	1	path screw
	37-02-12	1	path dial
	37-02-14	1	path block
	37-02-15	2	pivot
	37-05-01	2	mirror mount
	37-05-02	2	spring mount
	37-05-03	2	mount shaft
	37-05-04	2	adjuster screw
	37-05-05	2	collar
	37-20-05	3	field mirror positioning screw
	37-20-06	2	field mirror locking screw
Mirror Section			
	37-01-03	2	small pickoff mirror
	37-01-10	1	field mirror
	37-02-01	2	objective mirror
Heater Section			
	H37-S-110	1	sheet heater, 400W
	H37-ST-110	1	sheet heater w/thermocouple, 400W
	H37-110BTK	1	cartridge heater, 400W & thermocouple (domestic)
	H37-240BTK	1	cartridge heater, 400W & t-couple(int'l)
Mounting Section			
	Specific to user		

Plumbing

SS-400-1-OR	1	Swagelok O-seal
SS-4CA-50	2	in-line relief valve

Packing Complements

	1	7/64 Allen key
	1	3/16 Allen key
	1	Set of instructions

Hardware — Detailed listing of specific hardware is available upon request

APPENDICES