Cyclone™ Series
Heatable Long Pathlength Gas Cells

User Manual

2I-24102-11

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USER MANUAL - CONTENTS

1. Introduction

Thank you for purchasing a Specac Product.

The Cyclone™ Series gas cells are a range of long pathlength gas cells available as C2 (P/N GS24102), C5 (P/N GS24105), C10 (P/N GS24110) and C20 (P/N GS24120) versions for the measurement of gases/vapours at unit ppm levels of their concentration by IR transmission spectroscopy.

The pathlength ranges for each gas cell variant are:

Cyclone™ C2 cell is from 0.5m to 2.5m in 0.5m steps.
Cyclone™ C5 cell is from 1.0m to 8.0m in 1.0m steps.
Cyclone™ C10 cell is from 2.1m to 10.6m in 1.06m steps.
Cyclone™ C20 cell is from 2.0m to 20.0m in 2.0m steps.

As standard, the range of Cyclone™ gas cells (C2, C5, C10 and C20) can be supplied with the following options:

- A borosilicate glass (**G**) body capable for use up to 14.7psi pressure or nickel coated aluminium metal (**M**) body capable for use up to 125psi pressure.

- KBr (**K**), CaF2 (**C**) or ZnSe (**Z**) windows to be used in the glass bodied cells and CaF2 (**C**) or ZnSe (**Z**) windows in the metal bodied cells.

- Fixed (**F**) or Adjustable (**A**) pathlengths on the mirror carriage frame.

- Viton (**V**) or Kalrez (**X**) O-ring seals.

- Fitting of a low (**L**) pressure gauge kit to glass bodied cells only and low (**L**) or high (**H**) pressure gauge kit to metal bodied cells.

With the addition of the Cyclone™ gas cells own version of dedicated heating jacket and controller system, the Cyclone™ gas cell can be operated to a temperature of 200°C for measurement of gases/vapours. (**Note***: The C20 gas cell size* ***cannot*** *be heated*.)

Common to **all** the Cyclone™ Gas Cells are the following features:

- Nickel coated aluminium internal hardware.
- Protected coated gold mirrors.
- Purgeable interface optics.
- Benchmark™ baseplate compatibility.
- Push on type gas inlet and outlet fittings with switchable valves.
- Compatibility with the laser alignment accessory (P/N GS24500).

The actual part number of the Cyclone™ gas cell received refers to the configuration of the gas cell from the optional components fitted, related to the coded lettering suffix to the cells individual number.

Hence, a cell with P/N GS24105GCAV identifies a Cyclone™ C5 size cell with glass body, CaF2 windows, adjustable pathlength, Viton O-ring seals and no pressure gauge fitted as supplied.

Another example would be P/N GS24110MZFXH which identifies a Cyclone™ C10 size cell with metal body, ZnSe windows, fixed pathlength, Kalrez O-ring seals and fitted with a high pressure gauge kit as supplied.

Please also note the part number configuration of the Cyclone™ gas cell supplied **does not** refer to a specific FTIR spectrometer system into which the gas cell can be installed. Installation of the gas cell into a spectrometer is via the use of a specific Benchmark™ baseplate that is installed into the spectrometer first. (See page 15.) The Benchmark™ baseplate for a specific make and model of spectrometer should be requested at the time of ordering of a specific configuration of Cyclone™ gas cell and it will be supplied with the gas cell.

2. Safety Considerations

With use of any spectroscopic accessory that involves the study of a wide range of chemical samples, the associated risk in handling may mostly be attributed to the specific sample type to be handled itself. As far as it possible you should follow a procedure for safe handling and containment of the type of sample to be used.

With respect to safety of use specifically for the Cyclone™ long pathlength, heatable gas cells, apart from taking necessary precautions when heating the gas cell to elevated temperatures, different window materials can be used for containment of a specific gaseous/vapour type within either a glass or nickel coated aluminium body for the gas cell itself. As standard, KBr, CaF_2 and ZnSe windows are the three window materials of choice that can be used.

Caution: *Out of these three different window types, ZnSe is the most potentially hazardous material with respect to toxicity risk in use and handling.*

KBr and CaF_2 window materials can be considered relatively safe to use, although these materials may be harmful to the body if ingested in significant quantity. The general rule when working with **any** window/crystal material (and sample) **is to always wear gloves and safety gear** (e.g. safety spectacles) when handling to obviate the risk of contact with the skin.

Provided with each choice of window material that can be fitted for use in the Cyclone™ gas cell is a window material safety data sheet for the specific material itself that can be consulted for safe handling. A copy of each of these datasheets can also be found in this User Instruction Manual in the **Notes On Cleaning** Section found on pages 64 to 67.

Hazardous Samples

Any Cyclone™ C20 gas cell with a metal body must not be used above 91 psi a (5.3 bar g) when using a hazardous sample.

Definition of a Hazardous Sample

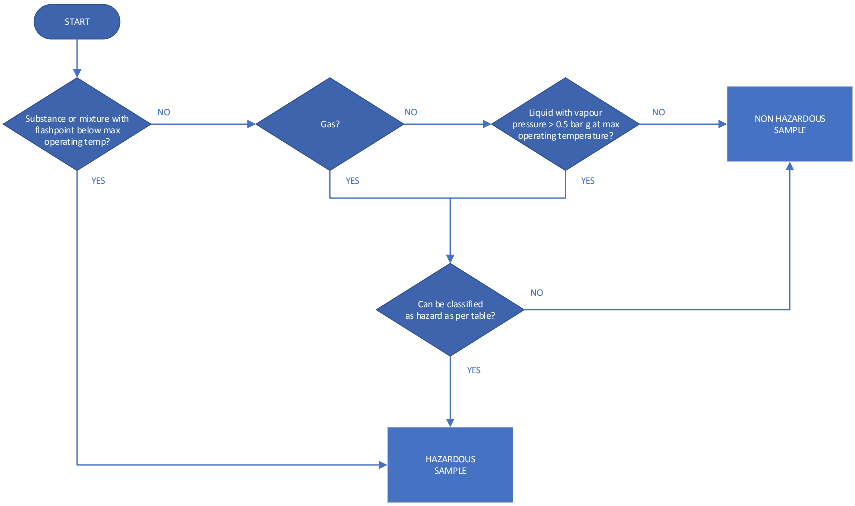
A hazardous sample is defined as a gas (or liquid with a vapour pressure > 0.5 bar g at maximum operating temperature), with a hazard classification shown in the table below or any substance or mixture whose flashpoint is below maximum operating temperature**.**

The following table defines hazard classification as per Regulation (EC) No 1272/2008. (Applicable Hazard Statement Codes given for reference.)

Hazard Class and Category	Hazard Statement Codes
Unstable explosives or explosives of divisions 1.1, 1.2, 1.3, 1.4 and 1.5	H200, H201, H203, H204, H205
Flammable gases, category 1 and 2	H220, H221
Oxidising gases, category 1	H270
Flammable liquids, category 1, 2 and 3*	H224, H225, H226*
Flammable solids category 1 and 2	H228
Self-reactive substances and mixtures type A to F, or organic peroxides type A to F	H240, H241, H242
Pyrophoric liquids or solids, category 1	H250
Substances and mixtures which in contact with water emit flammable gases, category 1, 2 and 3	H260, H261
Oxidising liquids or solids, category 1, 2 and 3	H271, H272
Acute oral toxicity, category 1 and 2	H300
Acute dermal toxicity, category 1 and 2	H310

* Where flashpoint is below max operating temperature.

The following flow chart can help to identify whether a sample is defined as hazardous, in relation to the hazard classification table.



3. Specifications of Cyclone™ Gas Cells

The Cyclone™ gas cells are supplied as C2, C5, C10 and C20 versions for their overall size in terms of volume of cell and the pathlengths achievable in the size of cell. The smallest volume is for the C2 cell and the largest volume is for the C20 cell. The shortest pathlength that can be set is 0.5 meters with the C2 Cell and the longest pathlength that can be set is 20.0 meters with the C20 gas cell.

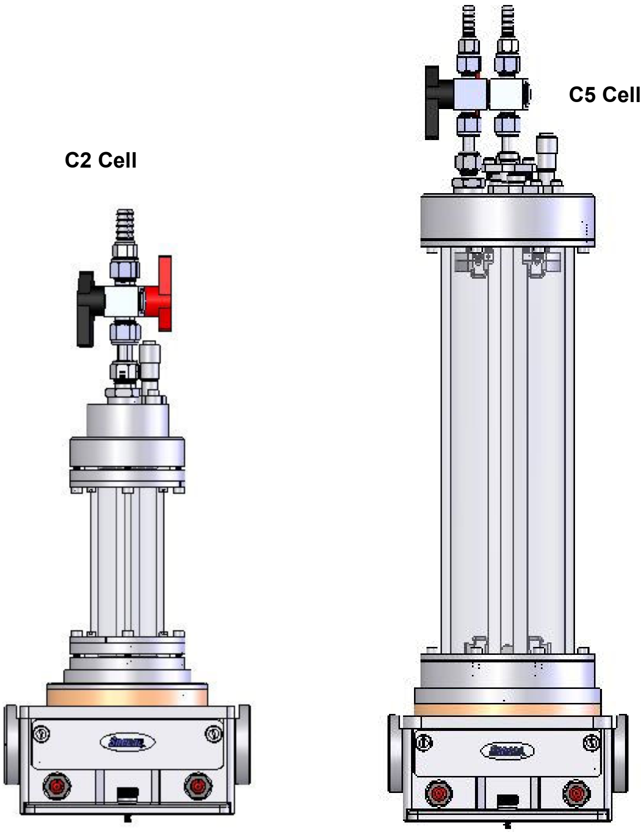


Fig 1. Front View of Cyclone™ Gas Cells, C2 and C5 Versions Comparison for Their Relative Sizes/Dimensions

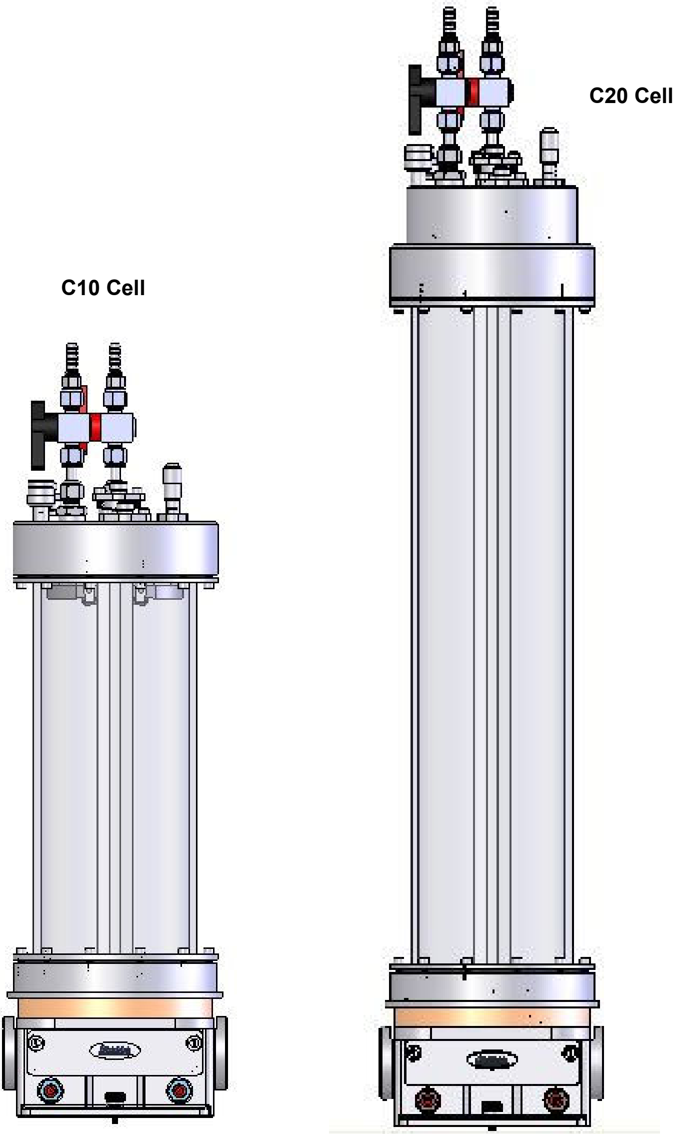


Fig 2. Front View of Cyclone™ Gas Cells, C10 and C20 Versions Comparison for Their Relative Sizes/Dimensions

Dimensions of the Cyclone™ Gas Cells

	Overall Height	Height from optical unit top surface	Top of cell diameter	Cell body diameter	Width at optical unit
C2 Cell	*384mm*	*314mm*	*73mm*	*46.5mm*	*153mm*
C5 Cell	*536mm*	*466mm*	*114mm*	*86.5mm*	*153mm*
C10 Cell	*540mm*	*470mm*	*142.5mm*	*113.2mm*	*153mm*
C20 Cell	*782mm*	*712mm*	*142.5mm*	*113.2mm*	*153mm*

Volume to Pathlength Options in the Cyclone™ Gas Cells

	Base Pathlength	Volume	Pathlength Range
C2 Cell	*12.5 cm*	*0.19 liters*	*0.5 to 2.5m (in 0.5m steps)*
C5 Cell	*25.0 cm*	*1.33 liters*	*1 to 8m (in 1.0m steps)*
C10 Cell	*26.4 cm*	*2.60 liters*	*2.1 to 10.6m (in 1.056m steps)*
C20 Cell	*50.0 cm*	*4.30 liters*	*2.0 to 20.0m (in 2.0m steps)*

“Base Pathlength” is defined as the distance between the two objective mirrors at the top and the “T “shaped field mirror at the base of the Cyclone™ gas cell on the mirror carriage frame. The pathlength for the Cyclone™ gas cell can be provided as “fixed” for the mirrors on the frame, e.g. at a fixed 5 meters pathlength for the C5 cell, or as an adjustable pathlength option cell, whereby you have the facility to alter the pathlength manually for the full range of 1 to 8 meters in 1meter steps. (i.e. 1m, 2m, 3m, 4m, 5m, 6m, 7m and 8m for the C5 cell.)

Vacuum Testing

All Cyclone™ gas cells have been rated to a vacuum of $3x10^{-3}$ Torr ($4x10^{-3}$ mbar). The leak rates of the cells are typically:

C2 Cell $6.4x10^{-5}$ Torr liters / Sec ($8.5x10^{-5}$ mbar liters / sec)
C5 Cell $2.3x10^{-5}$ Torr liters / Sec ($3.0x10^{-5}$ mbar liters / sec)
C10 Cell $3.0x10^{-5}$ Torr liters / Sec ($4.0x10^{-5}$ mbar liters / sec)
C20 Cell $3.0x10^{-5}$ Torr liters / Sec ($4.0x10^{-5}$ mbar liters / sec)

1 Torr = 1.333 mbar

4. Checklist

On receipt of your Cyclone™ Gas Cell please check that the following have been supplied:

- Cyclone™ Gas Cell configured with specified body (glass or metal) option, windows option, fixed or adjustable pathlength option (micrometer fitted) and Viton or Kalrez seals option.
- Fitting of a low or high pressure gauge kit P/N G24160 (if ordered).
- Set of Allen Keys:
  Allen Key 2.0 mm A/F for transfer mirror spring (tilt) adjustment.
  Allen Key 2.5 mm A/F for objective mirror (tilt) adjustment.
  Allen Key 3.0 mm A/F for cell/optical unit attachment, transfer mirror radial adjustment, micrometer clamp plate and blanking plug plate.
- Benchmark™ baseplate specifically for your spectrometer.
- Desiccant end caps P/N GS24150 (if ordered) for transfer optical unit.
- Purge bellows P/N GS10707 (if ordered) for transfer optical unit.
- An Essential Spares Kit of parts (P/N GS24103 for Cyclone™ C2 Cells and P/N GS24106 for Cyclone™ C5, C10 and C20 Cells).
- Benchmark™ baseplate installation guide instruction manual.
- Spectral throughput trace for configured gas cell.
- Micrometer alignment tool (Adjustable (**A**) pathlength cells only).

Carefully remove the gas cell and all other parts from their packaging. The Cyclone™ gas cell supplied will be vacuum wrapped in an aluminium/silver foil bag to prevent any moisture or dust etc, affecting the optics (windows and mirrors) during transportation. Remove the foil bag by carefully cutting at the base of the gas cell and sliding up and away over the Cyclone™ gas cell itself. By cutting the bag carefully, if desired it may be possible to use the foil bag for recovering the gas cell when stored away in its carry case when not in use.

5. Optical Layout of the Cyclone™ Cells

The optical layout of the Cyclone™ gas cells is shown in Fig 2. The infrared beam is reflected within the cell by the 'White' three mirror cell system (as devised by J.U. White in 1942). This system gives multiple passing in increments of 4 passes. The three mirror surfaces are all spherical, each with the same radius of curvature. The radius is determined from the base pathlength of the cell. Fig 2. shows the basic set of a minimum of 4 passes within a Cyclone™ gas cell which completes a beam passage through the gas cell. A combination of the base pathlength multiplied by the number of passes through the gas cell determines the pathlength.

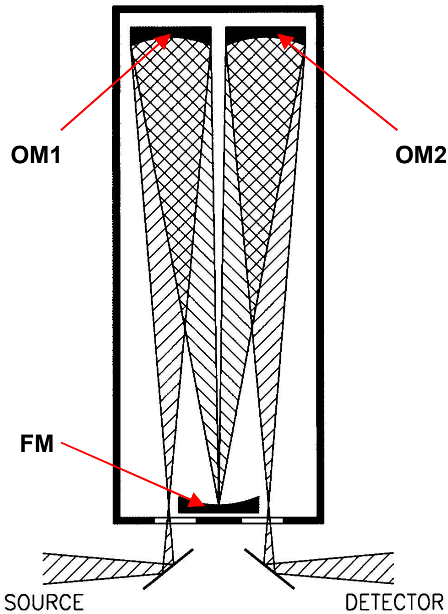


Fig 2: Optical Layout of Cyclone™ Cells

The radiation from the source is deflected via the transfer optics input mirror through the cell aperture window into the gas cell. From there, the diverging beam passes to the first objective mirror (**OM1**) which then focuses an image onto the "T" shaped field mirror (**FM**). The beam is returned, diverging to the second objective mirror (**OM2**) which in turn directs it out of the cell to the transfer optics output mirror and on to the detector, or back to the field mirror (**FM**) for additional multipassing. (See Section 6) In order to see the beam passes in a Cyclone™ gas cell it can be mounted on a visible light source such as the laser alignment accessory (P/N GS24500).

6. Multipassing of Spectral Beam of Light

When there are more than 4 passes of the beam in the gas cell, the images will line up on the field mirror in 2 rows, as shown in Figs 3 and 4. The actual pathlength of the gas cell will be the number of passes of the beam multiplied by the base pathlength. (e.g. 12 passes of the C5 gas cell is equivalent to 12 x 25cm = 3 meters.)

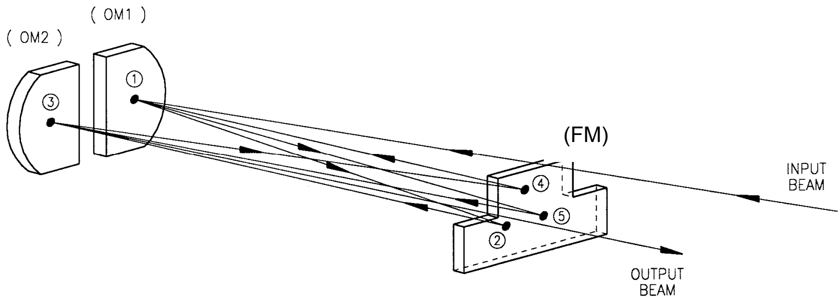


Fig 3: The sequence of the beam passes for the spots is: Input, (1), (2), (3), (4), (1), (5), (3), output. There have been 8 passes in this system. This sequence is the same for both left to right (LR) and right to left (RL)

To achieve multipassing the beam is directed off the second objective mirror (**OM2**) onto the field mirror (**FM**), on a similar level as the incoming beam. The closer the fourth image is placed to the incoming beam, the more passes there will be in the optical system.

The Cyclone™ gas cells have been specified for their pathlength ranges and light beam passes as follows:

C2 Cell – pathlength range of 0.5 to 2.5 meters - 4 to 20 passes.
C5 Cell – pathlength range of 1.0 to 8.0 meters - 4 to 32 passes.
C10 Cell – pathlength range of 2.1 to 10.6 meters - 8 to 40 passes.
C20 Cell – pathlength range of 2.0 to 20.0 meters - 4 to 40 passes.

Fig 4. represents the pattern of light spot images on the "T" shaped field mirror (**FM**) as seen from above. In Fig 4. there are 7 spots on the **FM**. The combination of spots in this pattern corresponds to 16 passes in the gas cell.

The number of passes of the light beam though the Cyclone™ gas cell can be calculated either by:

1. Counting the number of spots on the **FM**, multiplying by 2 and adding 2, for example, for seven spots (7 x 2) + 2 = 16.

2. Counting the number of spots on the widest part of the 'T' shaped **FM** and multiplying by 4, for example, 4 x 4 = 16.

As the number of passes (and spots) increase, the spots in the rows get closer together.

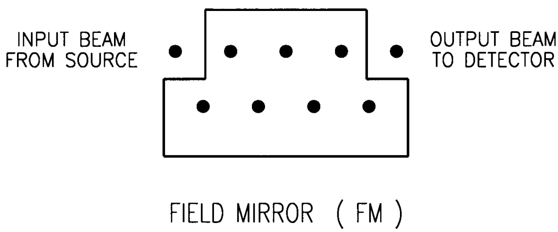


Fig 4: Light Spot Images on Field Mirror (FM)

7. Installation and Alignment in a Spectrometer

The Cyclone™ gas cell is supplied with its own transfer optical unit assembly (**1**). This mounts directly to any Benchmark™ baseplate by location of the optical unit onto the pillars and /or location studs of the baseplate and securing into position by tightening of the central thumbscrew (**2**). (See Fig 5.) This way of installation means that the Cyclone™ gas cell can be used in any FTIR spectrometer fitted with an appropriate Benchmark™ baseplate.

For installation of the Benchmark™ baseplate supplied for your spectrometer please refer to the separate Benchmark™ baseplate installation guide instruction manual supplied with the gas cell. Once the Benchmark™ baseplate is installed, the Cyclone™ gas cell can be mounted to the baseplate.

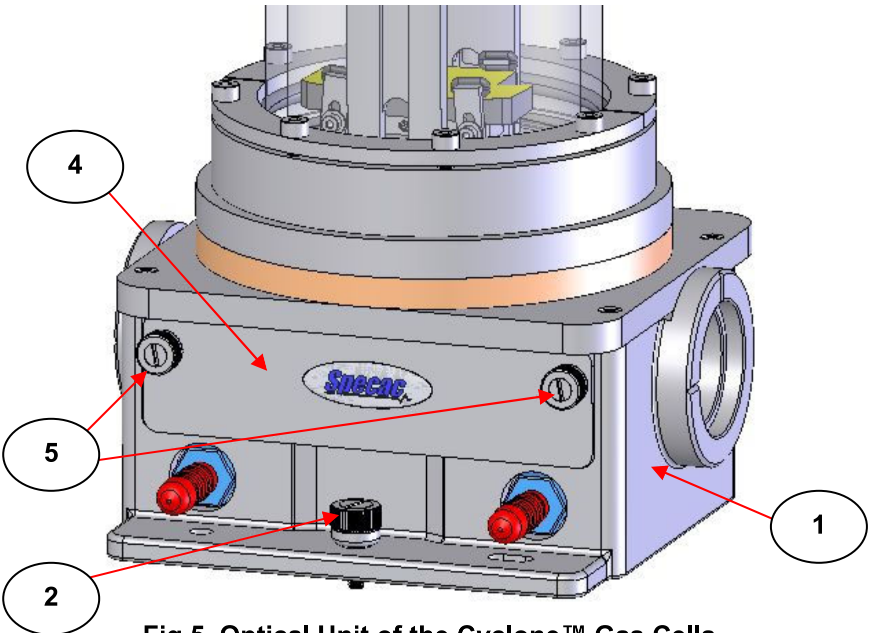


Fig 5. Optical Unit of the Cyclone™ Gas Cells (Optical unit used with C5 Type of Cell)

Note: *Due to the larger size of the Cyclone™ C10 and C20 cells, and also, the size of the heating jackets, some spectrometers with small sample compartments may not be able to accommodate these particular Cyclone™ Cell variants. (See Compatibility Guide Section 14).*

The configured Cyclone™ gas cell is factory aligned before despatch for a throughput performance, but for optimum performance it will require fine alignment tuning in the specific spectrometer into which it is to be installed and used. Alignment is achieved by adjusting the mirrors (**3**) in the optical unit (**1**). To gain access to the mirrors remove the optical units cover plate (**4**) by unscrewing the two cover plate thumbscrews (**5**). (See Fig 5.)

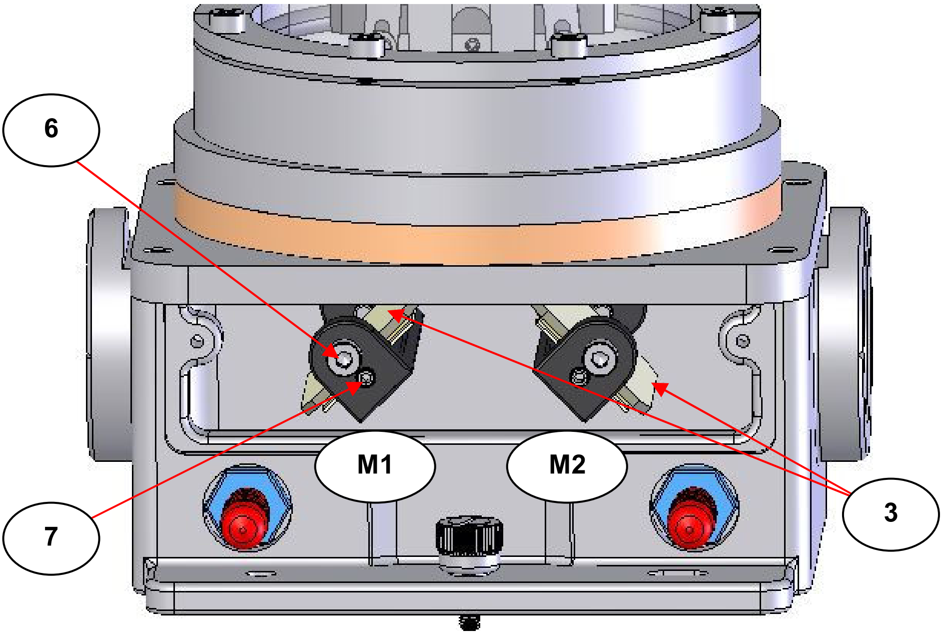


Fig 6. Cyclone™ Gas Cell Optical Unit with Cover Plate Removed

The transfer optical unit (**1**) is a simple system of two mirrors to deflect the source beam into and collect from the gas cell, and then to deflect it to the detector. Fig 6. shows the optical unit (**1**) with cover plate (**4**) removed and the internal mirrors (**3**) on their adjustable mirror carriage assemblies (**M1** and **M2**). The mirror carriage assemblies have two screw fixings. The M4 x 5mm cap head screw (**6**) is used to rotate the mirror (**3**) surface. The M4 x 12mm grubscrew with cone point (**7**) is used to tilt the mirror (**3**) surface.

For an alignment procedure the actual configuration of the build of Cyclone™ gas cell for the infrared beam direction through the sample compartment determines which mirror carriage assembly (**M1** or **M2**) becomes the output mirror (**3**). Looking from the front of the spectrometer the source of light to detector can pass from a left to right (**LR**) or right to left (**RL**) direction. From Fig 6. for use in a spectrometer with **LR** beam direction, **M2** becomes the output mirror (**3**). For a **RL** beam direction **M1** becomes the output mirror (**3**).

Important Note: *For the Cyclone™ gas cell build itself, for **LR** (source to detector) optical systems the field mirror (**FM**) in the gas cell will be oriented such that it appears as an inverted 'T' when the gas cell has been installed in the spectrometer and viewed from the front or above. For **RL** optical systems the field mirror (**FM**) will be oriented as an upright 'T' when viewed from the same position. (See Fig 7.) This ensures that the micrometer adjustment screw for adjustable pathlength cells will be operating the output objective mirror OM2. (See adjustable pathlength option in Section 11, page 57).*

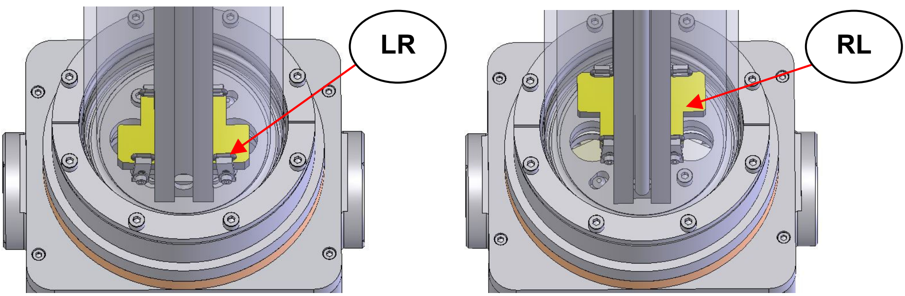


Fig 7. Orientation of FM for (LR) or (RL) Beam Direction

When installing either a pre-aligned fixed (**F**) pathlength or adjustable (**A**) pathlength Cyclone™ gas cell into the spectrometer for the first time you should get some signal throughput registering at the detector.

Note: *For a typical alignment procedure, as follows, we have used the **RL** beam orientation as an example with **M1** becoming the output mirror.*

Using any appropriate beam energy monitoring signal from the FTIR spectrometer itself adjust the **M1** output mirror (**3**) initially, **only,** for rotation turning screw (**6**) clockwise or anticlockwise. You may see an improvement in the overall signal at the detector from rotation of the mirror in either direction. If you move away from a peak maximum throughput reading by clockwise rotation, stop and slowly rotate the screw (**6**) in the opposite direction. When a peak maximum throughput reading has been reached, leave the mirror (**3**) at the rotated setting.

Now, adjust the **M1** output mirror (**3**) for its angle of tilt by turning the grubscrew (**7**) clockwise or anticlockwise and observe the throughput signal reading. Similarly, if by clockwise rotation the peak maximum reduces, then rotate the screw (**7**) in the opposite direction.

When you have an optimum peak reading for the pathlength setting of your Cyclone™ gas cell in your spectrometer system, from adjustment of the **output mirror M1 alone**, the gas cell can be considered correctly aligned. However, you may be able to slightly improve the overall throughput by slight adjustment of the **input mirror M2** now, by similar rotation and tilt adjustments of this mirror (**3**) by the screws (**6**) and (**7**) respectively.

Important: *When making any adjustment to either the **M1** (output) or **M2** (input) mirror (**3**) complete the action by bringing back to an optimum peak signal reading before moving to the **other** mirror (**3**) for further adjustment.*

If you do alter the setting of the input mirror **M2** slightly from an alignment procedure, it may then be necessary to readjust the output mirror **M1** again for rotation and tilt to get a fine "balance" for the mirror (**3**) settings in the optical unit (**1**) alone.

Specific Information on Cyclone™ Gas Cell Alignment of All Mirrors (M1, M2, FM, OM1 and OM2)

To check for the mirror alignment of any fixed (**F**) pathlength version of Cyclone™ gas cell, but most especially for adjustable (**A**) pathlength configured cells, Specac thoroughly recommends use of the laser alignment accessory (P/N GS24500). This accessory provides a coherent, visible source of red light to assist in any initial cell alignment for **ALL** mirrors used in the Cyclone gas cell (**M1**, **M2**, **FM**, **OM1** and **OM2**) before the cell is placed into a spectrometer sample compartment for fine tuning against the spectrometers source and detection system. For general alignment, as shown by our example for a **RL** beam instrument, it is usually only necessary to adjust the **M1** (output) and **M2** (input) mirrors (**3**) in the optical unit (**1**) rather than require any adjustment of the mirrors (**FM**, **OM1** and **OM2**) inside the gas cell body to achieve the correct alignment. However, if alignment cannot be achieved, then the mirrors inside the gas cell body (**FM**, **OM1** and **OM2**) may be at an incorrect setting.

Taking a C10 Cyclone™ gas cell as an example, irrespective of whether it is a fixed (**F**) or adjustable (**A**) pathlength configured cell, it will be factory aligned and set to a pathlength of 10.56 meters (40 passes of the beam through the cell). For a correctly aligned fixed (**F**) or adjustable (**A**) pathlength cell the T shaped field mirror **FM** will show a line of 10 spots of light on the longest part of the T shaped **FM**, with 19 spots of light in total arranged as two parallel lines from side to side across the **FM**. (See example of 16 beam passes for Fig 4, page 12).

If for any reason the objective mirrors (**OM1** (input) and **OM2** (output)) at the top of the cell become detached from their spring setting, then the pattern of light spots on the **FM** will not be observed. Therefore, no amount of adjustment for correct alignment of the **M1** (output) and **M2** (input) mirrors (**3**) in the optical unit (**1**), will enable any light throughput. The objective mirrors (**OM1** and **OM2**) must be checked and remounted correctly in their spring setting. This is not a tricky job, but it does involve removal of the outer glass (**G**) or metal (**M**) cylinder body of the gas cell to gain access to the mirrors for resetting. It is therefore crucial to establish a pattern of light spots on the **FM** to verify that the internal mirrors **OM1** and **OM2** are set correctly.

For adjustable (**A**) pathlength cells, if the **OM2** has been adjusted via the micrometer screw for a **different** pathlength from the standard factory setting, it is necessary to establish some pattern of light spots on the **FM** to calculate for a set pathlength. Any slight misalignment either side of the next sequence of spots (the next corresponding sequence of 4 beam passes through the cell) means there will be no passage of light through the cell and consequently no light will reach the output mirror (**M1** or **M2** – depending on beam direction) of the optical unit (**1**).

Therefore, for alignment of a fixed (**F**) pathlength Cyclone™ gas cell using the laser alignment accessory, mount the Cyclone™ gas cell on the alignment accessory such that the laser source will enter the optics box from the same beam direction as the spectrometer system. (**LR** or **RL)**. Rotate and/or tilt the input mirror (**3**) to direct a beam of light up to the input objective mirror (**OM1**) at the top of the gas cell. If both objective mirrors (**OM1** (input) and **OM2** (output)) are in alignment, then a pattern of spots corresponding to a specific pathlength setting are seen on the bottom T shaped **FM**. The final beam pass through the cell will be directed past the **FM** to the output mirror (**3**) in the optical unit (**1**). This mirror (**3**) can then be rotated and/or tilted to direct the beam of light to the target cross on the laser alignment accessory. The Cyclone™ gas cell can then be placed into the spectrometer for fine tuning and maximising of the beam signal throughput using the final **output** mirror (**3**) in the optical unit (**1**) to direct to the spectrometers detector.

For alignment of an adjustable (**A**) pathlength cell on the laser alignment accessory, mount the Cyclone™ gas cell on the alignment accessory such that the laser source will enter the optical unit (**1**) from the same beam direction as the spectrometer system. (**LR** or **RL)**. If **NO** light spots are seen on the **FM** when the beam of input light from the laser alignment accessory is directed to **OM1**, then adjust **OM2** by movement of the micrometer adjustment screw until a pattern of light spots is obtained. (For any pattern of light spots to be achieved with an adjustable (**A**) cell, it is assumed that **OM1** and **OM2** are correctly set in their mirror mountings.) When a specific beam pass sequence has been established from the spot pattern, the final beam pass through the cell will be directed past the **FM** to the output mirror (**3**) in the optical unit (**1**). This mirror (**3**) can then be rotated and/or tilted to direct the beam of light to the target cross on the laser alignment accessory. The Cyclone™ gas cell can then be placed into the spectrometer and the **output** mirror (**3**) **ONLY** of the optical unit (**1**) may need to be adjusted to peak up the signal for the pathlength selected.

Important: *Only when a throughput and alignment of all the cell mirrors have been established in the way as described, should the micrometer be adjusted to change the position of the **OM2** and hence the pathlength of the cell. Subsequent altering of the **OM2** mirror position for a different pathlength should not alter the overall alignment of the cell from this point.*

Change of Beam Direction

The Cyclone™ gas cell is easily adapted if you need to operate it in a spectrometer system with a different beam direction (**LR** or **RL** source to detector) to that of your current spectrometer. Follow the instructions to separate the gas cell body from the optical unit (**1**) in Section 9, page 34 of this manual (Cyclone™ Gas Cell Windows), for either the C2 or C5, C10 and C20 cells. (It is a slightly different procedure for the different size of cells). Then refit the gas cell to the optical unit (**1**) with the appropriate number of M4 fixing screws after rotating the cell body through 180º. The T shaped **FM** will now be in the opposite direction as viewed from the front of the optical unit (**1**). (See examples as Fig 7, page 17). In this way, a cell that was suitable for a **RL** beam direction can be used in a **LR** spectrometer system, or vice-versa.

Features on the Optical Unit

There are features on the optical unit (**1**) of the Cyclone™ gas cell that allow it to be operated in a purged environment (i.e. filling the optical unit with N_2 (Nitrogen) gas), if using a spectrometer with sealed optics.

At the front of the optical unit (**1**), there are two purge port fittings (**8**). For non-purged operation, the protective rubber sealing covers are kept in position to cap off these flow ports, but to purge, the rubber seal covers are removed by pulling them off from the barbed ended purge port fittings. With their removal flexible purge tubing (silicone rubber) can be connected in place to the barbed tubing connections. One of the ports (**8**) acts as an inlet and the other as an outlet for gas flow. (See Fig 8.). The cover plate (**4**) is not removed to purge the optical unit.

When appropriate tubing is connected, establish a flow of N_2 gas to purge the optical unit (**1**) free of any residual atmospheric conditions (air, water vapour, excess CO_2 etc). Purging the optical unit (**1**) with N_2 gas can help in low level measurements of CO_2 vapour within a gaseous species inside the gas cell itself.

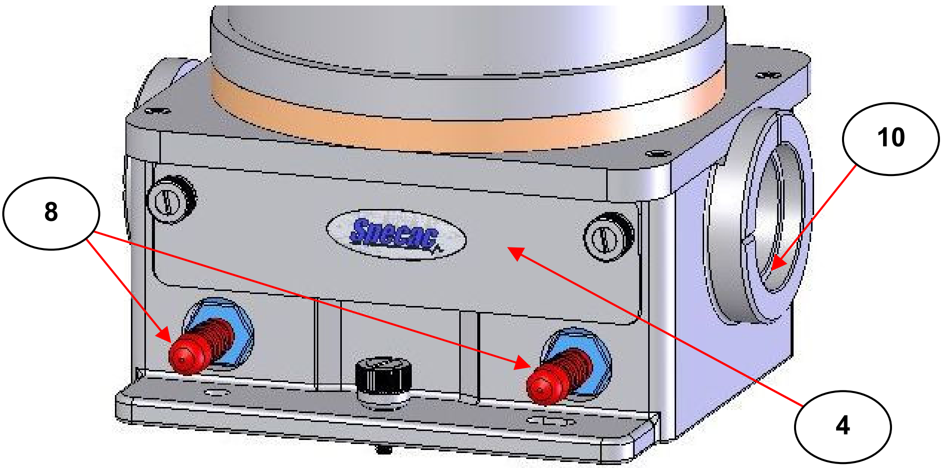


Fig 8. Purge Ports on Optical Unit of Cyclone™ Gas Cells

To allow the optical unit (**1**) to be purged efficiently when the Cyclone™ gas cell is installed into the sample compartment of a spectrometer, it is necessary to fit the flexible purge bellows (**9**) that are supplied as Specac P/N GS10707 to the optical unit (**1**).

Note: *It is recommended that purge bellows (**9**) are fitted during use to help stabilize the instrument background, even if the accessory is not being purged.*

Fitting Purge Bellows (P/N GS10707) to the Optical Unit

The purge bellows (**9**) push fit over the circular aperture ports (**10**) at each end of the optical unit (**1**). (See Fig 8.) The purge bellows (**9**) may need to be cut to a shorter length for a better fit within the sample compartment when fitted to the optical unit (**1**).

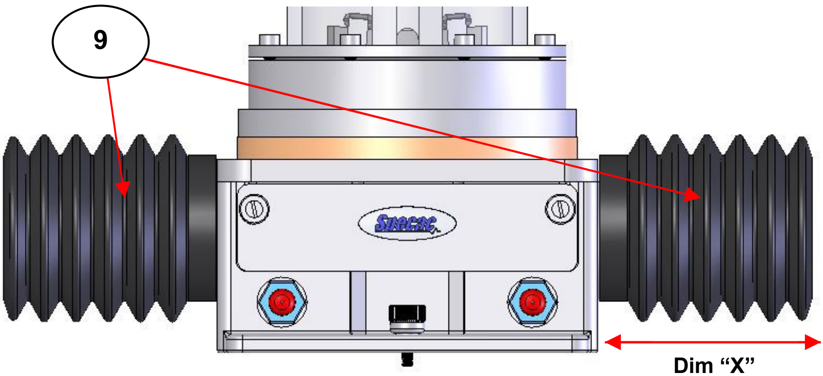


Fig 9. Purge Bellows (9) Fitted to Cyclone™ Optical Unit (1)

With the Benchmark™ base plate secured, and Cyclone™ gas cell installed correctly into position on the Benchmark™ baseplate, measure the approximate distance between the spectrometer side walls from the source and detector ports and the flat end surface of the optical unit (**1**) (Dimension 'X' – see Fig 9).

Using a sharp razor blade, take care to cut lengths of the flexible purge bellows (**9**) which are equivalent to the measured length (**X**) plus an additional 10 mm for each purge bellow.

Tip: *It is easier to cut the purge bellow (**9**) between the hard ridges.*

Unscrew the fixing thumb screw (**2**) and remove the Cyclone™ gas cell away from the Benchmark™ baseplate and from the sample compartment.

Fit the flexible purge bellows (**9**) over both circular aperture ports (**10**) (as seen at Fig 9.) and compress sufficiently to enable the gas cell and purge bellow assembly to fit back into the spectrometer on the Benchmark™ baseplate.

Ensure the purge bellows (**9**) are not obstructing the beam and then tighten the fixing thumb screw (**2**) to secure the Cyclone™ gas cell optical unit (**1**) back onto the Benchmark™ base plate.

Desiccator Storage Caps

For storage of a Cyclone™ gas cell a set of desiccator storage caps (P/N GS24150) can be fitted over the circular aperture ports (**10**) to keep the internal conditions of the optical unit (**1**) dry and moisture free. The purge ports fittings (**8**) must be sealed with their rubber covers and the front cover plate (**4**) must also not be removed.

One of the desiccator caps (**11**) is simply a cover. The other cap (**12**) contains a desiccant material which will maintain a dry atmosphere within the optical unit (**1**). This in turn will preserve the life, especially of KBr windows if fitted in a cell. When still active as a desiccant, the cap (**12**) face will be blue in colour. When pink in colour, the desiccant has been exhausted. The desiccant can be reactivated by placing the cap (**12**) in an oven at 120°C for four hours.

Fig 10. Desiccator Storage Caps P/N GS24150

8. Cyclone™ Gas Cell Bodies

The Cyclone™ gas cell bodies are supplied in borosilicate glass (**G**) or nickel coated aluminum (**M**).

The borosilicate glass (**G**) bodied cell should show much less absorption of acidic vapors than a metal (**M**) bodied cell to minimise any potential future contamination (memory effects) of such residual vapours in the gas cell. However, choice of the Cyclone™ gas cell body may depend upon the pressure of the gas to be analysed.

The pressure rating of a (**G**) cell is lower than that for an (**M**) cell.
(**G**) Cyclone™ gas cells are rated to 14.7 psi.
(**M**) Cyclone™ gas cells are rated to 125 psi.

Safety Note:

*KBr (**K**) windows **should not** be used in (**M**) gas cells as they will break at the elevated pressures obtainable with these types of cells. For safety reasons (**M**) gas cells are supplied with CaF2 (**C**) or ZnSe (**Z**) windows only*.

Top of Gas Cell Bodies – Fittings and Features

At the top of both types of (**G**) or (**M**) gas cells bodies, there are some common fittings and features. The top areas of the C5, C10 and C20 gas cells are very similar in design, but there are slight differences for the C2 gas cell, being that it is physically much smaller in diameter size compared to the other gas cells. (See Fig 11. for comparison between C2 and a C5 size cyclone™ gas cell.)

Inlet and Outlet Gas Flow Tubes

Common to the range of Cyclone™ gas cells are inlet (**13**) and outlet (**14**) gas flow tubes in stainless steel material. These gas flow tubes are finished at the top of the gas cell with their own stainless steel on/off valve taps (**15** – inlet, **16** –outlet) that have “barbed” hose type connections (**17**) for fitting of 1/4" O.D. (or 6mm O.D.) flexible gas tubing. However, the barbed hose type connections (**17**) can be removed by undoing their fixing nut (**18**) and replacing with 1/4” stainless steel tubing with olive/ferrule and nut connections for alternative plumbing to an (inlet) gas supply and (outlet) gas flow or vacuum pump facility.

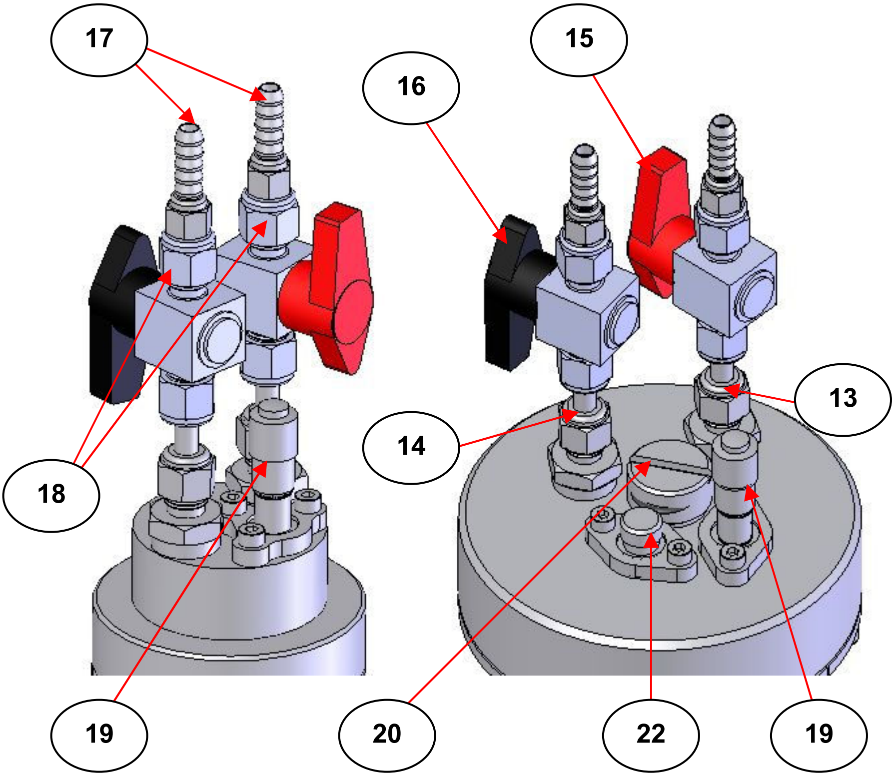


Fig 11. Comparison of Cyclone™ C2 (Left) and C5 (Right) Gas Cells for Top Fittings

The inlet tube (**13**) and its valve (**15**) can be easily distinguished from the outlet tube (**14**) and its valve (**16**). The inlet valve (**15**) tap is red and the outlet valve (**16**) tap is black in colour. The taps themselves are turned to an “on” position for gas flow and the direction of the arrow point on the tap indicates the direction of flow. The inlet tube (**13**) passes all the way down the inside of the gas cell (in the grooved recess of the mirror carriage frame support) to exit at the base of the gas cell. The outlet tube (**14**) is shorter in length and gases flow in from the gas cell at the top. In this way a gas cell is filled from the bottom to the top to enable complete filling of the gas cell for either static or flow measurement purposes.

The Cyclone™ gas cell can be operated in a **flow through mode** for vapour measurement with both valves (**15)** and (**16**) open.

To operate the Cyclone™ gas cell in a **static mode** for vapour measurement, allow the gas to fill the cell via the inlet tube (**13**) with both valves (**15**) and (**16**) open. To seal the gas in the gas cell, cease the flow of the gas by closing the outlet valve (**16**) and then the inlet valve (**15**) as soon as possible after.

Adjustable Pathlength Micrometer Adjustment Screw (19)

In Fig 11. both the Cyclone™ C2 and C5 gas cells have been shown if they are configured as adjustable (**A**) pathlength gas cells, rather than a fixed (**F**) pathlength gas cell. A micrometer adjustment screw (**19**) will be fitted to allow for alteration of the **OM2** mirror for a multipassing event.

If the Cyclone™ gas cell is a fixed (**F**) pathlength cell, the micrometer adjustment screw (**19**) at this position on the top surface of the gas cell is replaced by a blanking plug. (Please refer to Section 11, page 57 in this instruction manual for more details regarding adjustable (**A**) pathlength cells and the fitting of a micrometer adjustment screw).

"**Eye Spy" Inspection Hole (20)**

On Cyclone C5, C10 and C20 gas cells only (the C2 cell is too small to accommodate this part), at the centre of the cell top plate there is an "Eye-Spy" blanking plug (**20**) which can be removed to allow you to see into the cell from above and view the lower **FM**.

The blanking plug (**20**) is removed by using a large, flat bladed screwdriver located in the central top slot and is turned anticlockwise. The blanking plug has a sealing O-ring (**21**) which is fitted to the plug itself. When retightening the blanking plug (**20**) back into position, ensure that this O-ring seal (**22**) is suitable for use. (See Fig 12.)

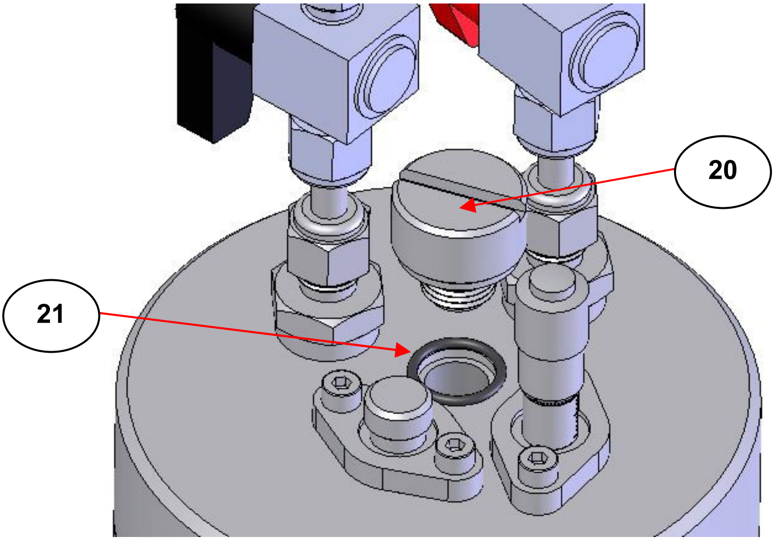


Fig 12. Eye-Spy Blanking Plug Removed and Sealing O-Ring

The “Eye-Spy” hole is a useful feature for alignment purposes when using a metal (**M**) bodied cell or a metal (**M**) or glass (**G**) bodied cell with the Cyclone™ gas cells own specific heating jacket in position.

A metal (**M**) body or the heating jacket itself that surrounds either a (**G**) or (**M**) bodied gas cell, means that the surface of the lower **FM** in the gas cell cannot be seen. By looking through the Eye-Spy hole, it allows the pattern of light spots on the **FM** to be visualized when carrying out an alignment procedure, particularly if using a source of coherent light such as that obtainable with the laser alignment accessory P/N GS24500. (See Multipassing, pages 13 and 14 and Specific Alignment, pages 19 and 20).

Cover Plate and Plug for OM2 "Tilt" Angle Adjustment (22)

On Cyclone C5, C10 and C20 gas cells only (the C2 cell is too small to accommodate this part), there is cover plate and blanking plug (**22**) over the mechanism that is used to adjust the "tilt" angle of the **OM2**. A correct tilt angle for the **OM2** establishes a **parallel** line pattern of spots on the **FM**. (See Multipassing pages 13 and 14.) This tilt angle will be factory set for both (**F**) and (**A**) type cells. In normal use this setting will never need to be adjusted, but if for any reason a parallel line pattern of light spots is not being observed, then it is possible that the **OM2** requires realignment by adjustment for its tilt angle.

The procedure to do this is as follows. (See Fig 13.)

Note: *It is highly recommended that this alignment procedure is carried out with the laser alignment accessory (P/N GS24500)*

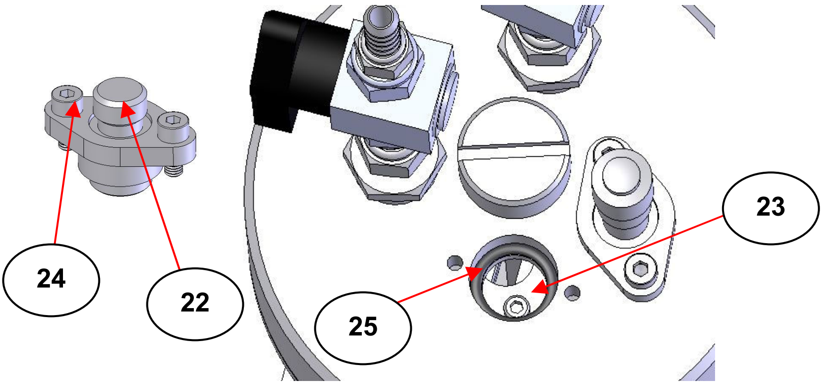


Fig 13. Above View of OM2 Tilt Adjustment Screw (23) with Cover Plug Assembly (22) Removed

Place the Cyclone™ gas cell on the laser alignment accessory to obtain a coherent light pattern of spots on the **FM** corresponding to the pathlength set on the gas cell. (If using an (**M**) bodied cell you can observe the spot pattern on the **FM** through the Eye-Spy hole (**20**).)

Remove the cover plug assembly (**22**) to access the M3 x 12mm mirror adjustment screw (**23**) by undoing the two fixing M4 x 10mm screw bolts (**24**) and pulling the plug (**22**) up out of its location hole. (The cover plugs own sealing O-ring (**25**) may be retained in the hole or come away with the plug (**22**) when it is removed.) If you have a fixed (**F**) pathlength gas cell, then a pattern of spots should be seen on the mirror, albeit that the two lines are not parallel to each other. If you have an adjustable (**A**) pathlength cell, then you may need to adjust the micrometer screw (**19**) to produce a number of spots on the **FM**. When a pattern of spots is seen turn the tilt mirror adjustment screw (**23**) either clockwise or anticlockwise with an Allen key to bring the rows of light spots parallel to each other. When parallel, replace the blanking plug assembly (**20**) over the adjustment screw (**23**), checking that the O-ring (**25**) is OK to use for sealing.

Pressure Gauge Kits (P/N GS24160)

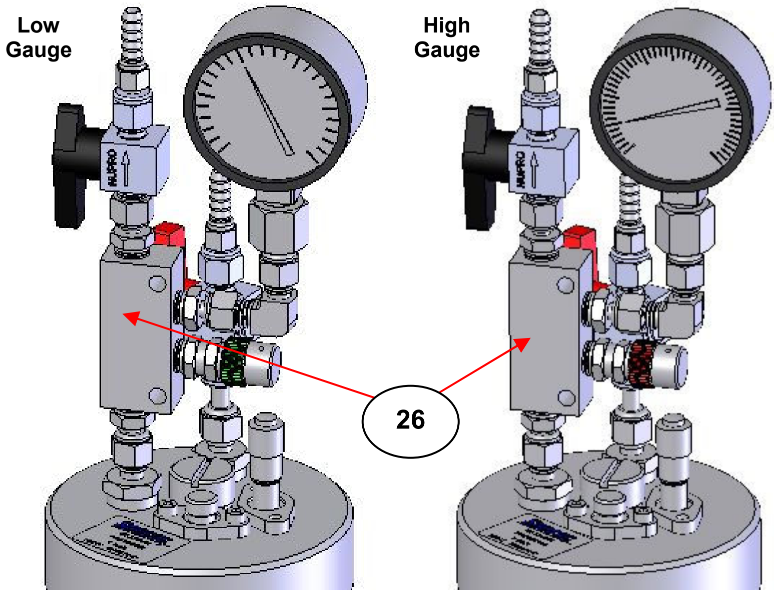


Fig 14. Low and High Pressure Gauge Kits fitted to Cyclone™ Cell

For the range of Cyclone™ gas cell variants a low (**L**) or high (**H**) pressure gauge kit (P/N GS24160) can be fitted for measurement of the gas pressure within the gas cell environment. The pressure gauge kit of parts (**26**) can be purchased separately for fitting to a Cyclone™ gas cell, or these parts may have already been configured and fitted to the gas cell that has been ordered and supplied. (An (**L**) or an (**H**) letter is included in the part number of the Cyclone™ gas cell ordered.) Either the (**L**) or (**H**) pressure gauge kit of parts (**26**) is fitted between the top of the outlet gas flow tube (**14**) and the outlet on/off valve (**16**). The (**L**) pressure gauge is rated up to a maximum operating pressure of 14.7psi, whereas the (**H**) pressure gauge is rated up to 125psi.

(**G**) bodied gas cells can only have (**L**) pressure gauge kits (**26**) fitted, but (**M**) bodied cells rated to a higher pressure capability can be fitted with either (**L**) or (**H**) pressure gauge kits.

Gas Line Connections to the Cyclone™ Gas Cell for Safe Operation When Using a Heating Jacket

Whenever raising the temperature for an operation of the Cyclone™ C2, C5 or C10 variants of gas cell by use of its corresponding, matched Heating Jacket System, it is highly recommended to have **a pressure safety device** plumbed into a gas line connection that is made to the **outlet** gas tube (**14**).

The low (**L**) or high (**H**) pressure gauge kit of parts (P/N GS24160) ideally should be fitted to the Cyclone™ gas cell to facilitate the inclusion of a pressure gauge indicator along with an over-pressure event safety line that can be vented to a safe place of containment (e.g. a fume hood). On the body of the pressure gauge (**26**) there is a corresponding set pressure relief valve assembly fitting beneath the low (**L**) or (**H**) pressure gauge as fitted. Specac suggest and advise that this set pressure relief valve is re-sited to a safe containment area such as a fume hood by fitting an additional and appropriate length of stainless steel tubing between the pressure gauge body and the pressure relief valve. (See schematic Fig 15.)

Inclusion of such a pressure safety device with associated gas line connectivity is needed to vent away any potential excess build-up of the pressure in the gas cell chamber area (specifically for a **fixed volume** state of the gas cell – non-flowing experiments) when elevated temperatures from ambient conditions are established from use of the Cyclone™ gas cells own Heating Jacket System. (Please see User Instruction Manual 2I-24302-6 regarding the Heating Jacket System.) Any excess pressure conditions subjected to the gaseous environment created from heating a gas in a fixed volume (e.g. a hot and potentially toxic environment), can be safely diverted away from the gas cell chamber itself to prevent any accidental damage to the windows that have been fitted and/or compromising of the seals as fitted. Failure of the seals and window components under excess pressure risks a release of any gas conditions into the sample compartment of the spectrometer being used and increases the risk to any operator.

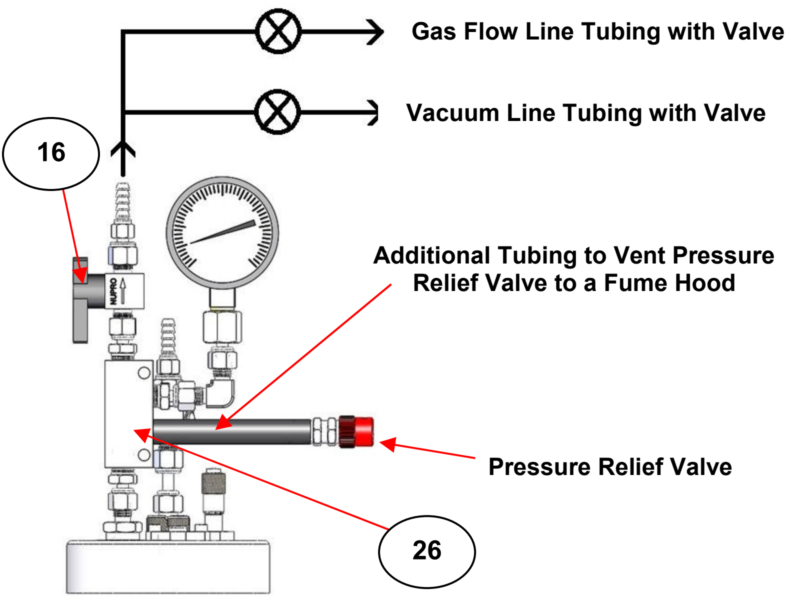


Fig 15. Schematic for Suggested Safety, Vacuum and Flow Gas Line Connectivity for Safe Operation of Cyclone™ Gas Cells

As shown in the schematic at Fig 15**,** along with the consideration for safety in operation for any potential over-pressure events, suggested gas line connections have been made from the outlet valve tap connection (**16**) to separate vacuum and flow lines with their own on/off valve taps. Both the safety over pressure line and additional flow line are routed to terminate in a safe containment area such as a fume hood. Any exhaust port(s) from a vacuum pumping system for the vacuum line should also ideally be routed to vent off the gas to a safe area too, such as a fume hood environment.

From connection in this way of these gas lines to a Cyclone™ gas cell and particularly if the gas cell is to be heated, the safety over pressure line at the pressure gauge kit of parts (**26**) as fitted is “open” all the time (no on/off tap/valve is incorporated in the safety line), if the gas cell is to be used in a static or flow mode of operation for gas conditions or if there is a need to evacuate the gas cell using a vacuum pump line.

Depending upon the circumstances of operation needed for the Cyclone™ gas cell (at ambient or elevated temperature conditions), the valve taps on the outlet valve (**16**), vacuum line and flow line can be opened or closed accordingly to control the pressure and allow for safe operation of the equipment. The setting of the valve taps as open or shut can be tabulated as follows for specific experimental conditions with regards as to which line is operable.

Gas Cell Operating Condition	Outlet Valve Assembly (16)	Valve on Flow Line	Valve on Vacuum Line
Over Pressure Monitoring	**Open or Shut**	**Open or Shut**	**Open or Shut**
Gas Flow	**Open**	**Open**	**Shut**
Vacuum	**Open**	**Shut**	**Open**

9. Cyclone™ Gas Cell Windows

KBr (**K**), CaF2 (**C**) or ZnSe (**Z**) windows are used as standard in the Cyclone™ gas cells. (Other window materials may be supplied if specially requested by contacting Specac.)

For the C2 size cell there is **one** window used at the base of the gas cell to allow for an input beam of light from the optical units **input** mirror (**3**) to reach the **OM1** and for an output beam of light from the **OM2** to pass through to the optical units **output** mirror (**3**).

For the C5, C10 and C20 size cells there are **two** windows used at the base of the gas cell. One window allows for an input beam of light from the optical units **input** mirror (**3**) to reach the **OM1** and the other window allows for an output beam of light from the **OM2** to pass through to the optical units **output** mirror (**3**).

The "nominal" window dimensions for each gas cell are shown in the following table.

Gas Cell	**KBr Window P/N GS24153**	**CaF2 Window P/N GS24155**	**ZnSe Window P/N GS24154**
Cyclone™ C2 P/N GS24102	47.5mm dia x 10.0mm thick (1)	47.5mm dia x 7.5mm thick (1)	47.5mm dia x 7.5mm thick (1)
Cyclone™ C5 P/N GS24105	29.0mm dia x 6.0mm thick (2)	29.0mm dia x 4.0mm thick (2)	29.0mm dia x 4.0mm thick (2)
Cyclone™ C10 P/N GS24110	29.0mm dia x 6.0mm thick (2)	29.0mm dia x 4.0mm thick (2)	29.0mm dia x 4.0mm thick (2)
Cyclone™ C20 P/N GS24120	29.0mm dia x 6.0mm thick (2)	29.0mm dia x 4.0mm thick (2)	29.0mm dia x 4.0mm thick (2)

The windows are sealed into position by use of an O-ring, PTFE gasket and clamp ring assembly. It may be necessary to gain access to the windows to:
1) Change them in the gas cell for a different window material.
2) Replace the windows because they have become damaged.
3) Clean the windows because they have become contaminated.
The procedure to gain access is similar for **all** the gas cells but there are differences between the C2 size cell and the other cell sizes.

Window Access for Cyclone™ C2 Cell

This procedure is followed for both (**G**) and (**M**) version body gas cells. Specac recommend the wearing of gloves to prevent touching the window material and causing contamination when handling.

Separating the C2 Cell from its Optical Unit

Remove the four M4 x 10mm cap head screws (**27**) that hold the Cyclone™ C2 gas cells bottom flange plate fitting to the optical unit (**1**). (See Fig 16.)

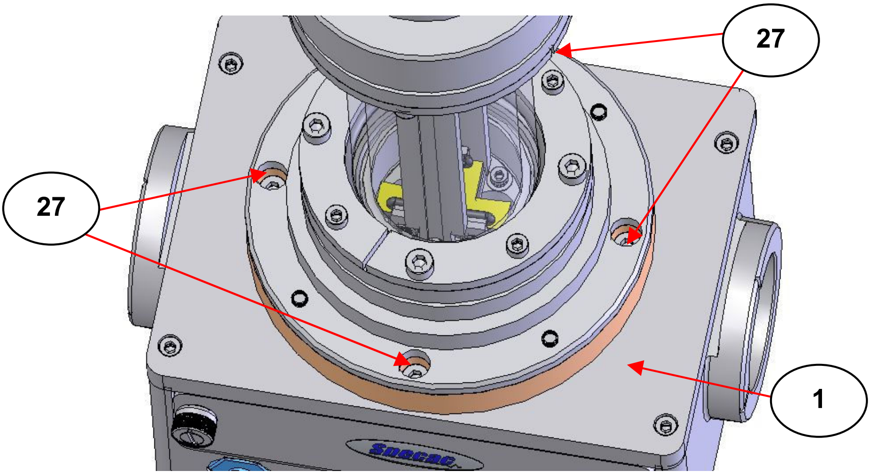


Fig 16. Cyclone™ C2 Bottom Flange Plate Screw Fixings

Separate the top gas cell assembly from the transfer optical unit (**1**) by carefully pulling the gas cell up and away.

Note: *At this stage the Cyclone™ C2 gas cell complete upper assembly can be rotated through 180º and then reattached to the optical unit (**1**) by retightening of the fixing screws (**27**) for reconfiguration of the gas cell for a change of beam direction – **LR** or **RL** (See Change Of Beam Direction, page 21.)*

Window Removal

With the top gas cell assembly of parts separated from the optical unit (**1**) access can be gained to the single window assembly at the base of the C2 gas cell. (See Fig 17.)

Note: *For dismantling and rebuilding of the window assembly of parts it is important that the Cyclone™ C2 gas cell body is held as vertically as possible with the window end of the gas cell uppermost for the components to fit and align correctly.*

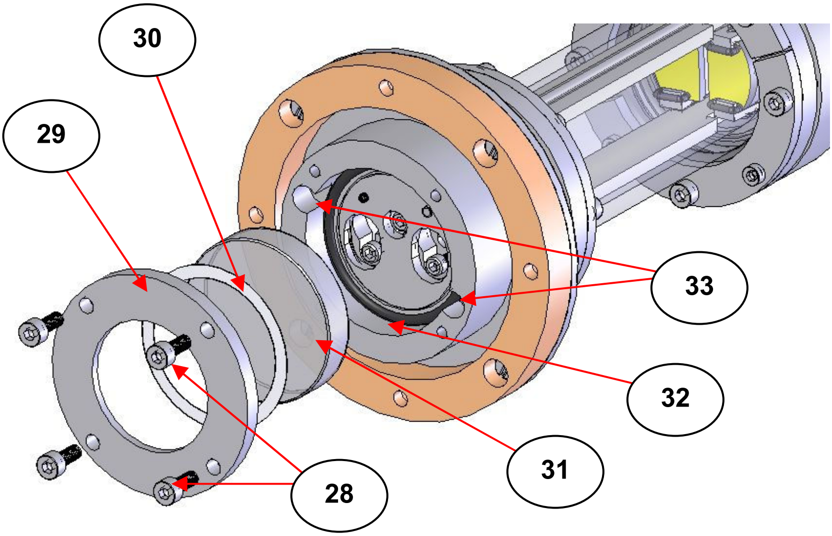


Fig 17. Window Assembly of Parts Separated at the Base of the Cyclone™ C2 Gas Cell

On the underside of the gas cell unscrew anticlockwise the four M4 x 10mm cap head screws (**28**) that holds the window flange clamp plate (**29**) in position. Remove the clamp plate (**29**) to reveal the protective PTFE washer (**30**) held between the clamp plate and the window (**31**). Set the four cap head screws (**28**), clamp plate (**29**) and PTFE washer (**30**) parts carefully to one side.

Beneath the window (**31**) is a sealing O-ring (**32**). The window (**31**) may be quite securely fixed to the O-ring (**32**) and so to assist in the window removal, there are a couple of access grooves (**33**) whereby a small screwdriver or suitable tool can be inserted. The tool used can then be **very carefully** pressed against the side edge of the window, to apply a force to help in the windows release from the O-ring (**32**).

When the window (**31**) is removed, the O-ring (**32**) may be stuck to the window and so will be removed too, or it may still be retained in its recess and must be prised carefully out of the gas cell. Check the condition of both the window (**31**) and the sealing O-ring (**32**) and replace with new components if necessary when reassembling.

Fitting of a new window material, or the same window after it has been cleaned, is the reverse procedure to dismantling of the parts. Having placed the O-ring (**32**) back into its recess, holding the gas cell vertically, carefully fit the window (**31**) into place. Now carefully position the PTFE washer (**30**) and then the clamp plate (**29**) centrally (and the correct way up – see detail below) over the PTFE washer (**30**), making sure the screw holes of the clamp plate (**29**) are aligned with their location holes in the base of the gas cell. Fit and tighten the four M4 screws (**28**) into position by turning them in sequence as follows.

Screw (28) Tightness for Window (31) Fitting and Sealing

For specific refitting of the window (**31**) into position, tighten all four screws (**28**) initially to finger tightness, ensuring that the clamp plate (**29**) is level and that there is a uniform gap all the way around the circumference between the clamp plate (**29**) and base of the gas cell. Proceed to tighten each screw (**28**) for a quarter clockwise turn (one at a time) in a "cross diagonal" configuration to ensure evenness of fit of the window assembly components for sufficient sealing.

Increasingly, with each quarter turn, the screws (**28**) will become more difficult to tighten.

Warning: *Be careful not to overtighten the screws (**28**) to avoid damage to the window (**31**).*

Window Flange Clamp Plate (29) Detail

For **all** Cyclone™ gas cells (C2, C5, C10 and C20), KBr (**K**) windows are thicker than their CaF2 (**C**) or ZnSe (**Z**) window material equivalent(s).

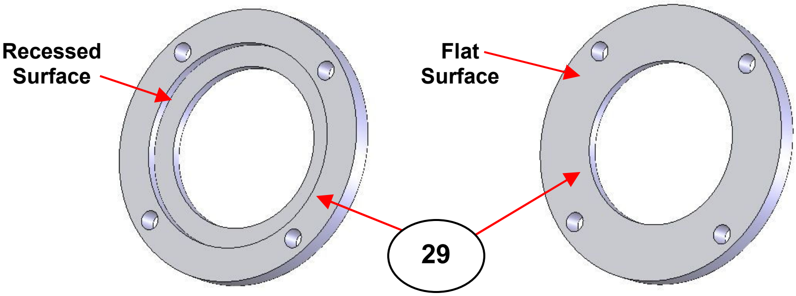


Fig 18. Cyclone™ C2 Window Flange Clamp Plate

The window clamp plate (**29**) for the C2 size gas cell has two different surfaces. (See Fig 18.) One side is recessed and the other side is flat. In the construction of the window assembly of parts seen at Fig 17, the flat surface for the clamp plate (**29**) is seen to be on the outermost side. This means that for this shown sequence of assembly of parts, the **recessed** surface of the clamp plate (**29**) is in contact with the PTFE washer (**30**) for clamping and sealing a thicker KBr (**K**) window (**31**) into position. If a thinner CaF2 (**C**) or ZnSe (**Z**) window (**31**) is being clamped into position, then the **flat** surface of the clamp plate (**29**) must be in contact with the PTFE gasket (**30**).

Note: ***Recessed*** *surface in contact with* ***thicker (K)*** *window.*
Flat *surface in contact with* ***thinner (Z)*** *and* ***(C)*** *window.*

Therefore, when refitting a window into position, ensure that the clamp plate (**29**) is located the right way up for the specific window thickness.

Warning: *The clamp plate (**29**) could crush a thicker KBr window when tightening, if replaced the wrong way up.*

Window Access for Cyclone™ C5, C10 and C20 Cells

This procedure is followed for both (**G**) and (**M**) version body C5, C10 and C20 gas cells. There are slight differences in construction of the C5 gas cell to the C10 and C20 versions, but essentially, the procedure for window access is the same for all three sizes of gas cells. Specac recommend the wearing of gloves to prevent touching the window material and causing contamination when handling.

Separating the C5 Gas Cell from its Optical Unit

The C5 gas cell is secured to the transfer optical unit (**1**) by four M4 x 8mm screws (**34**) located on the underside of the optical unit top plate. (See Figs 19 and 20.) Two of the four screws (**34**) at the rear of the optical unit (**1**) are readily accessible, but the other two screws (**34**) at the front of the optical unit (**1**) require removal of the optical unit's front cover plate (**4**) to gain access.

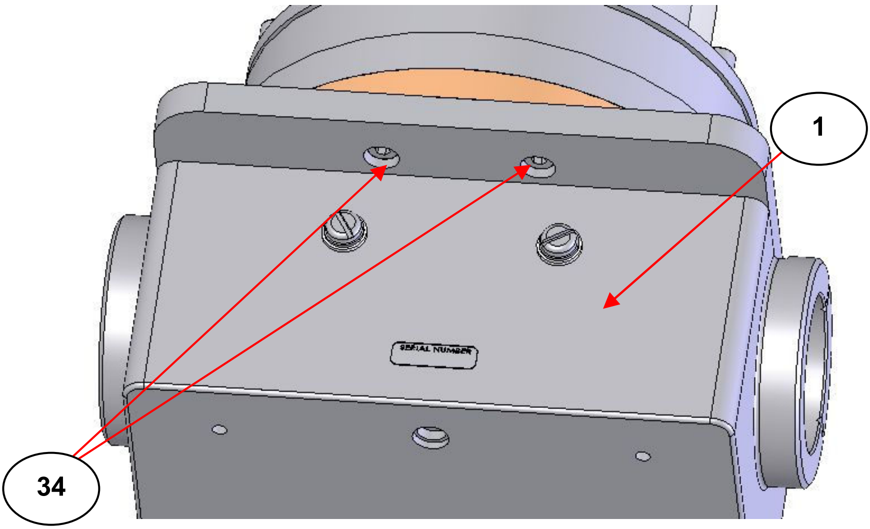


Fig 19. Rear View of Cyclone™ C5 Gas Cell Showing Fixing Screws (34) for Gas Cell to the Optical Unit (1)

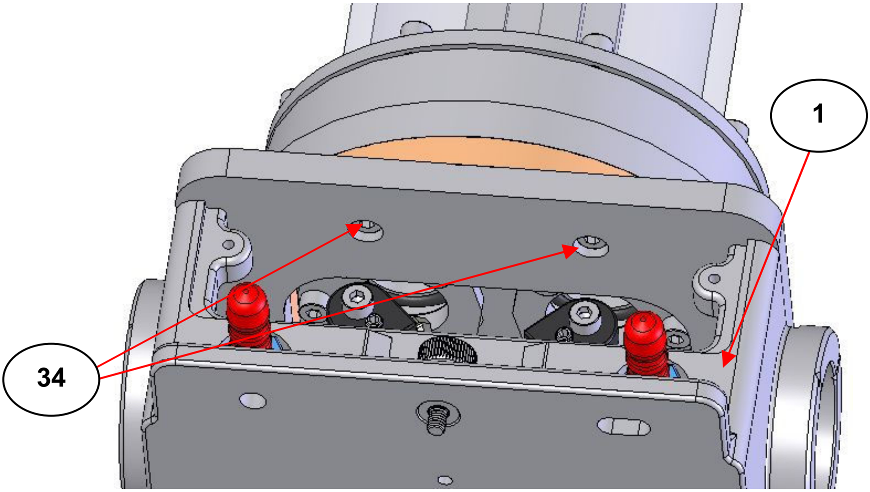


Fig 20. Front View of Cyclone™ C5 Gas Cell Showing Fixing Screws (34) to the Optical Unit (1) - Front Cover Plate (4) Removed

To carry out the procedure for unscrewing of the four screws (**34**) it is recommended to have the gas cell lying on its front, on a secure level workbench surface, to undo the rear screws and then turned over to lay on its back to undo the front screws. When the four screws (**34**) have been removed the gas cell can be separated from the optical unit. (See Fig 21 for resulting gas cell assembly).

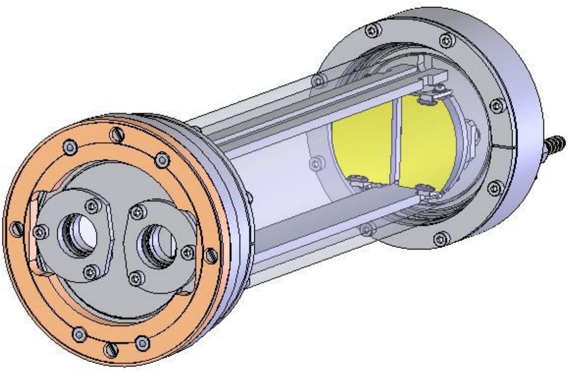


Fig 21. Bottom View of C5 Gas Cell Separated from Optical Unit

Separating the C10 and C20 Gas Cell from their Optical Units

The procedure to separate the C10 and C20 gas cells from their optical units is the same as for the C5 size gas cell, except that the two front fixing screws (**34**) of the four are accessible **without** the need to remove the front cover plate (**4**). (See Fig 22.)

Note: *Fixing screws (**34**) are M4 x 12mm size for C10 and C20 cells.*

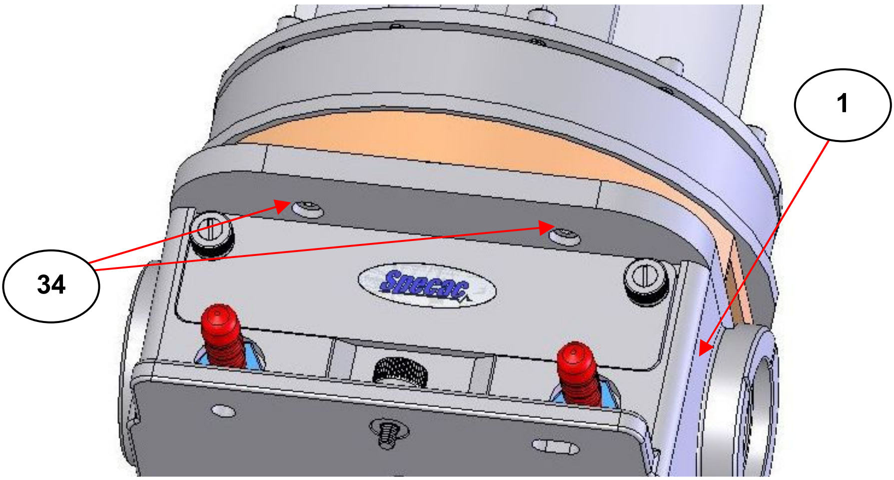


Fig 22. Front View of Cyclone™ C10 and C20 Gas Cells Showing Fixing Screws (34) to the Optical Unit (1)

For separation of a C10 or C20 gas cell from the optical unit (**1**) please follow the instructions for the C5 cell on pages 39 and 40.

Window Removal from C5, C10 and C20 Gas Cells

Window removal from the Cyclone™ C5, C10 and C20 gas cells is very similar to the procedure followed for the C2 size cell but with some slight differences to the parts themselves. Cyclone™ C5, C10 and C20 gas cells have two window assemblies of parts (that take smaller diameter windows), whereas the C2 cell has a larger single window assembly of parts. The window clamp plate (**35**) for C5, C10 and C20 cells is smaller and has three M4 x 10mm fixing screws (**36**) instead of the four M4 x 10mm fixing screws M4 x 10mm (**28**) used for the window flange clamp plate (**29**) of the C2 cell.

Note: *For the purposes of explanation, Figs 23, 24 and 25 show the C5 cell which are representative of the C10 and C20 cells too.*

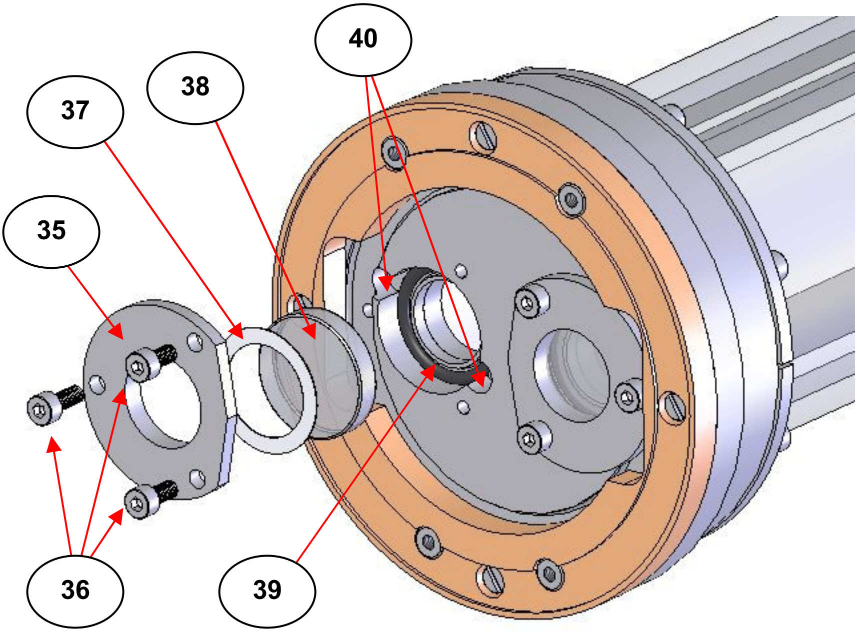


Fig 23. Window Assembly of Parts Separated at the Base of the Cyclone™ C5 Gas Cell

On the underside of the gas cell unscrew anticlockwise the three M4 x 10mm cap head screws (**36**) that hold the window flange clamp plate (**35**) in position. Remove the clamp plate (**36**) to reveal the protective PTFE washer (**37**) held between the clamp plate and the window (**38**). Set the three cap head screws (**36**), clamp plate (**35**) and PTFE washer (**37**) parts carefully to one side.

Beneath the window (**38**) is a sealing O-ring (**39**). The window (**38**) may be quite securely fixed to the O-ring (**39**) and so to assist in the window removal, there are a couple of access grooves (**40**) whereby a small screwdriver or suitable tool can be inserted. The tool used can then be **very carefully** pressed against the side edge of the window, to apply a force to help in the windows release from the O-ring (**39**).

When the window (**38**) is removed, the O-ring (**39**) may be stuck to the window and so will be removed too, or it may still be retained in its recess and must be prised carefully out of the gas cell. Check the condition of both the window (**38**) and the sealing O-ring (**39**) and replace with new components if necessary when reassembling.

Fitting of a new window material, or the same window after it has been cleaned, is the reverse procedure to dismantling of the parts. Having placed the O-ring (**39**) back into its recess, holding the gas cell vertically, carefully fit the window (**38**) into place. Now carefully position the PTFE washer (**37**) and then the clamp plate (**35**) centrally (and the correct way up – see detail below) over the PTFE washer (**37**), making sure the screw holes of the clamp plate (**35**) are aligned with their location holes in the base of the gas cell. Fit and tighten the three M4 screws (**36**) into position by turning them in sequence as follows.

Screw (36) Tightness for Window (38) Fitting and Sealing

For specific refitting of the window (**38**) into position, tighten all three screws (**36**) initially to finger tightness, ensuring that the clamp plate (**35**) is level and that there is a uniform gap all the way around the circumference between the clamp plate (**35**) and base of the gas cell. Proceed to tighten each screw (**36**) for a quarter clockwise turn (one at a time in rotation configuration – screw 1, screw 2, screw 3, etc) to ensure evenness of fit of the window assembly components for sufficient sealing.

Increasingly, with each quarter turn, the screws (**36**) will become more difficult to tighten.

Warning: *Be careful not to overtighten the screws (**36**) to avoid damage to the window (**38**).*

Window Flange Clamp Plate (35) Detail

For **all** Cyclone™ gas cells (C2, C5, C10 and C20), KBr (**K**) windows are thicker than their CaF2 (**C**) or ZnSe (**Z**) window material equivalent(s).

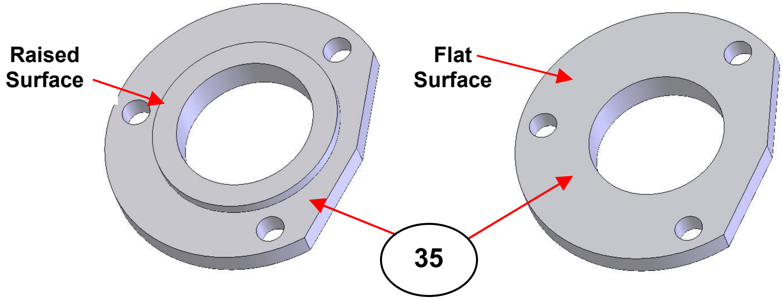


Fig 24. Cyclone™ C5 Window Flange Clamp Plate

The window clamp plate (**35**) for the C5, C10 and C20 size gas cells has two different surfaces. (See Fig 24.) One side has a raised surface and the other side is flat. (This is different to the C2 window clamp plate (**29**) – see page 33). In the construction of the window assembly of parts seen at Fig 23, the flat surface for the clamp plate (**35**) is seen to be on the outermost side. This means that for this shown sequence of assembly of parts, the **raised** surface of the clamp plate (**35**) is in contact with the PTFE washer (**37**) for clamping and sealing a thinner CaF2 (**C**) or ZnSe (**Z**) window (**38**) into position. If a thicker KBr (**K**) window (**38**) is being clamped into position, then the **flat** surface of the clamp plate (**35**) must be in contact with the PTFE gasket (**37**).

Note: ***Raised*** *surface in contact with* ***thinner (Z)*** *and* ***(C)*** *windows.*
Flat *surface in contact with* ***thicker (K)*** *windows.*

Therefore, when refitting a window into position, ensure that the clamp plate (**35**) is located the right way up for the specific window thickness.

Warning: *The clamp plate (**35**) could crush a thicker KBr window when tightening, if replaced the wrong way up.*

Beam Direction Change for C5, C10 and C20 Cells

The Cyclone™ C5, C10 and C20 gas cells differ from the Cyclone™ C2 gas cell for a rebuild procedure if wishing to transfer the gas cell for use from one spectrometer to another with a different beam direction through the sample compartment from source to detector. (**LR**) or (**RL**)

As explained on page 35 for the C2 cell, once the C2 cell has been separated from its optical unit (**1**), the C2 body assembly can be rotated through 180° orientation and be affixed to the optical unit (**1**) to allow the gas cell to be operated in an opposite beam direction spectrometer. However, for the C5, C10 and C20 gas cells, the procedure for separation of the gas cell from its optical unit (**1**) must be carried out (as would be adopted to gain access to the windows), but at this stage further modification of parts at the base of the gas cell is required to allow for operation of the gas cell in an opposite beam direction spectrometer to the existing configuration of build.

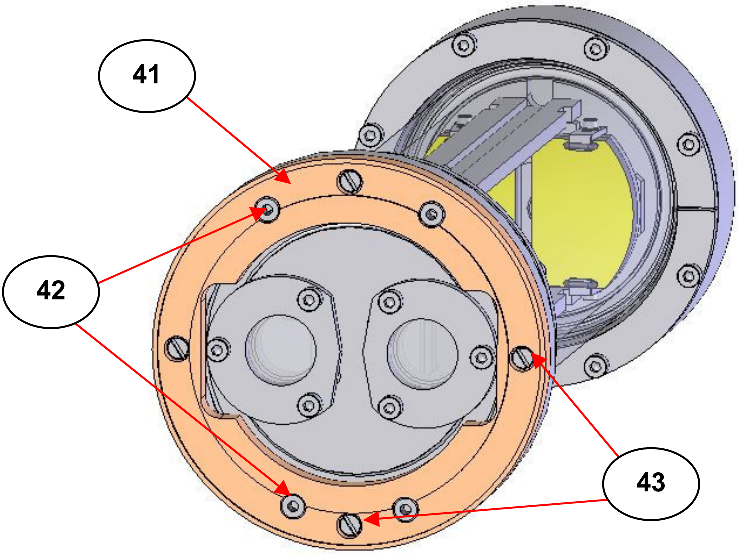


Fig 25. Underside View of C5 Cell Separated from Optical Unit (1) and with Windows Sealed in Position

When the Cyclone™ C5, C10 or C20 gas cell has been separated from its optical unit (**1**), lay the gas cell on its side on a flat work bench to gain access to the underside of the cell where the window assemblies are fitted. (See Fig 25.)

At the base of the gas cell there is a PEEK retaining ring (**41**). In the PEEK ring (**41**) there are four captive retaining nuts (**42**) for the four M4 x 8mm (C5) or M4 x 12mm (C10 and C20) screws (**34**) that hold the gas cell body assembly to the optical unit (**1**). These four nuts (**42**) are in a specific configuration within the circumference of the PEEK ring, such that with the gas cell orientated as shown in Fig 25, the top two retaining nuts (**42**) are further apart than the lower two retaining nuts. This pattern of retaining nut (**42**) locations on the PEEK ring (**41**) matches the pattern of four holes on the top surface of the separated optical unit (**1**) and determines the gas cell for use in one of the specific light beam directions. (**LR** or **RL**).

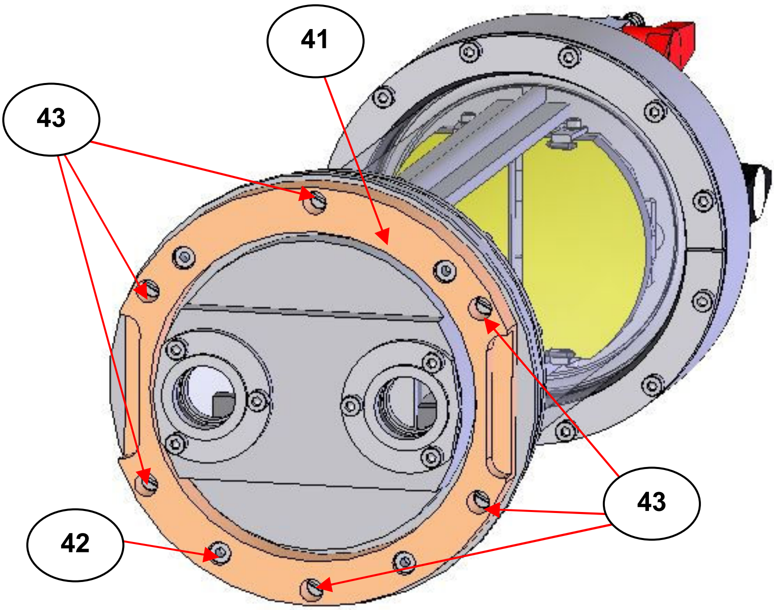


Fig 26. Underside View of C10 Cell Separated from Optical Unit (1) and with Windows Sealed in Position

Additionally, on the PEEK ring (**41**) there are **four** slot head M4 x 10mm screws (**43**) on a C5 Cell and **six** slot head M4 x10mm screws (**43**) on C10and C20 cells. (See Fig 26). To convert the gas cell for use in an **LR** beam direction spectrometer from **RL** (or vice versa), undo the four/six slot head screws (**43**) that will allow for separation of the PEEK ring (**41**) from the base of the gas cell body assembly. When the PEEK ring is separated, rotate the PEEK ring through 180° and then re-secure it back to the base of the gas cell body by tightening the four/six slot head screws (**43**) back into position. The pattern of four retaining nuts (**42**) on the PEEK ring will be inverted. When the gas cell body assembly is reattached through the pattern of holes on the top surface of the optical unit (**1**) using the four M4 x10mm fixing screws (**34**), the gas cell will have been converted to use within an opposite beam direction spectrometer.

10. Mirrors and Mirror Carriage Frames

All Cyclone™ gas cells are provided with gold coated mirror surfaces on quartz glass supports for the **OM1**, **OM2** and **FM** mirrors. (Page 12.) The mirrors themselves are fitted to the nickel coated aluminium mirror carriage frame on individual support mounts for **OM1**, **OM2** and **FM** via the use of O-rings and support clips. No adhesives are used for construction of the mirrors on the mirror carriage frame. In this way the mirrors are easily adjustable for change of pathlength and there is no risk of sample vapour contamination within the gas cell environment. The design also allows for thermal expansion of the mirror components to keep the gas cell correctly aligned when operated with the Cyclone™ gas cells own specific heating jacket and controlling system, up to 200°C temperature maximums. The gold mirror surfaces also have an antireflection protective coating and offer typically 98% reflectance performance (at 2000cm^{-1}).

Mirror Cleaning and Mirror Frame Replacement

To clean the mirrors or replace the mirror carriage frame assembly, the following procedure should be adopted. There is a slightly different procedure for the C2 size cell, whereas the C5, C10 and C20 size cells are all similar.

C2 Gas Cell Outer Cylinder (G) or (M) Body Removal

To gain access to the mirror frame assembly inside the gas cell, the outer surrounding gas cylinder (**44**) of a (**G**) or (**M**) body cell is removed. For the C2 size cell this is achieved by unscrewing and removing the four lower M4 x 20mmscrews (**45**) **only** to the lower flange ring clamp plate (**46**) that holds the gas cylinder in position. (**Do not** undo the M3 x 10mm screws (**47**) on the ring clamp plate (**46**)). (See Fig 26.) Lift off vertically the C2 gas cell outer cylinder assembly (**44**) away from the optical unit (**1**) and mirror carriage frame (**48**). It is possible the cylinder assembly (**44**) may be stuck to the lower sealing O-ring (**49**) within the gas cell chamber, but by careful manipulation of the cylinder assembly (slight rocking and twisting of this assembly against the lower sealing O-ring), it can be lifted up and away. You will be left with two separate assemblies of parts as seen at Fig 28.

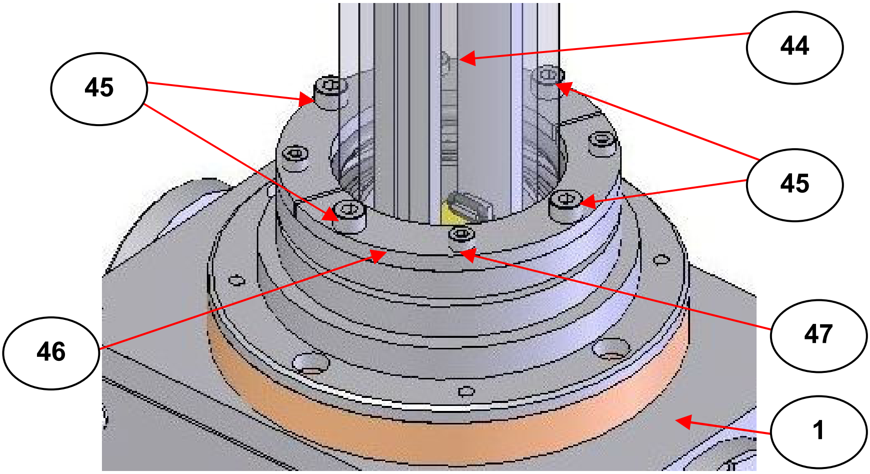


Fig 27. C2 Gas Cell Outer Cylinder (G) or (M) Assembly Removal

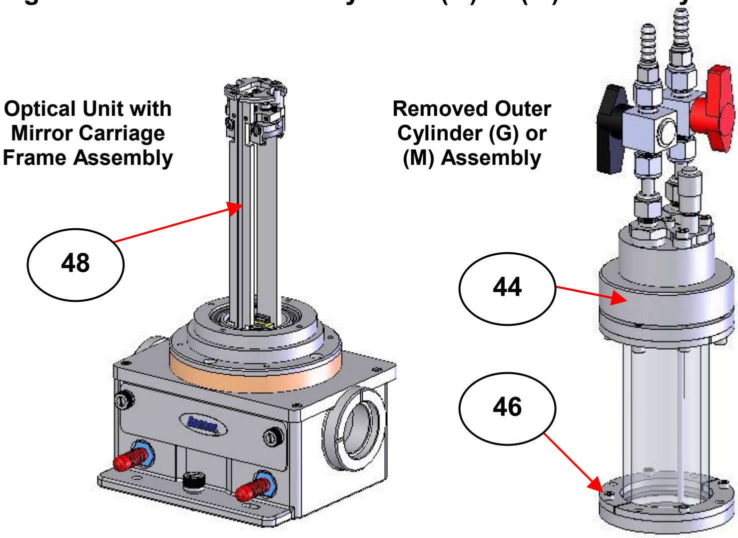


Fig 28. C2 Gas Cell Outer Cylinder Removed from Optical Unit

When the cylinder assembly (**44**) has been removed from the Optical Unit assembly of parts, access can be gained to remove the mirror carriage frame assembly (**48**). The mirror carriage frame assembly is held in place by a single M2.5 x 10mm screw and spring washer (**50**). Remove the screw and spring washer (**50**) by unscrewing anticlockwise and carefully pull the mirror carriage frame assembly (**48**) up and away from the base of the cell. (See Fig 29.) (The lower sealing O-ring (**49**) can also be seen more easily in Fig 29.)

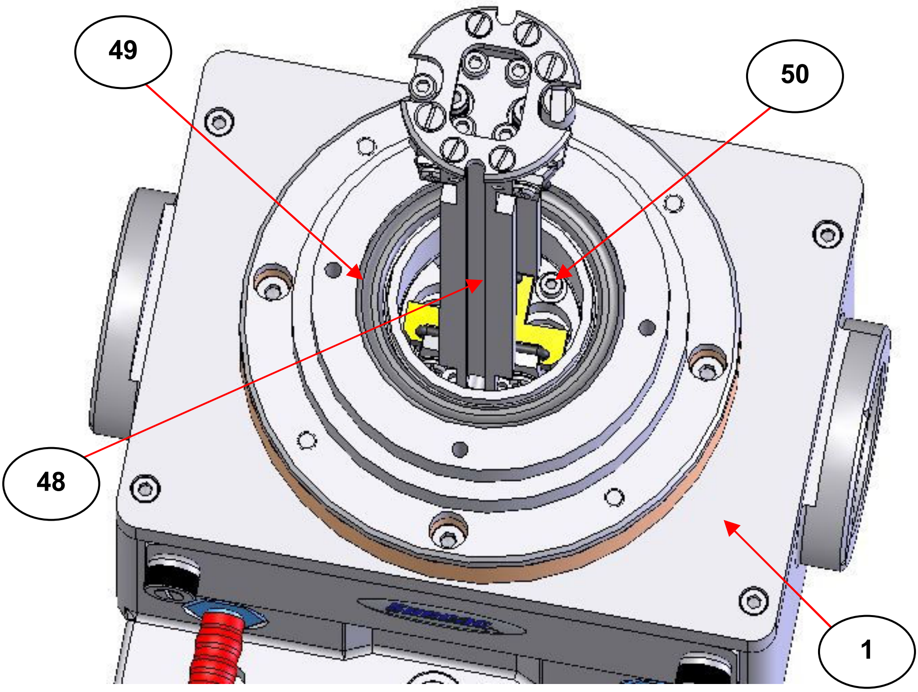


Fig 29. C2 Cell Mirror Carriage Frame Assembly Fixing Screw (50)

With removal of the mirror carriage frame assembly (**48**) for easier access, the frame and mirrors can be cleaned using suitable solvents and cleaning materials. Care must be taken when cleaning the gold mirrored surfaces. Only **very fine lens tissue** should be used to avoid abrasion and consequent possible loss of signal throughput.

The removed Cyclone™ C2 gas cell mirror carriage assembly (**48**) is shown in a little more detail for the mirrors and components as Fig 30.

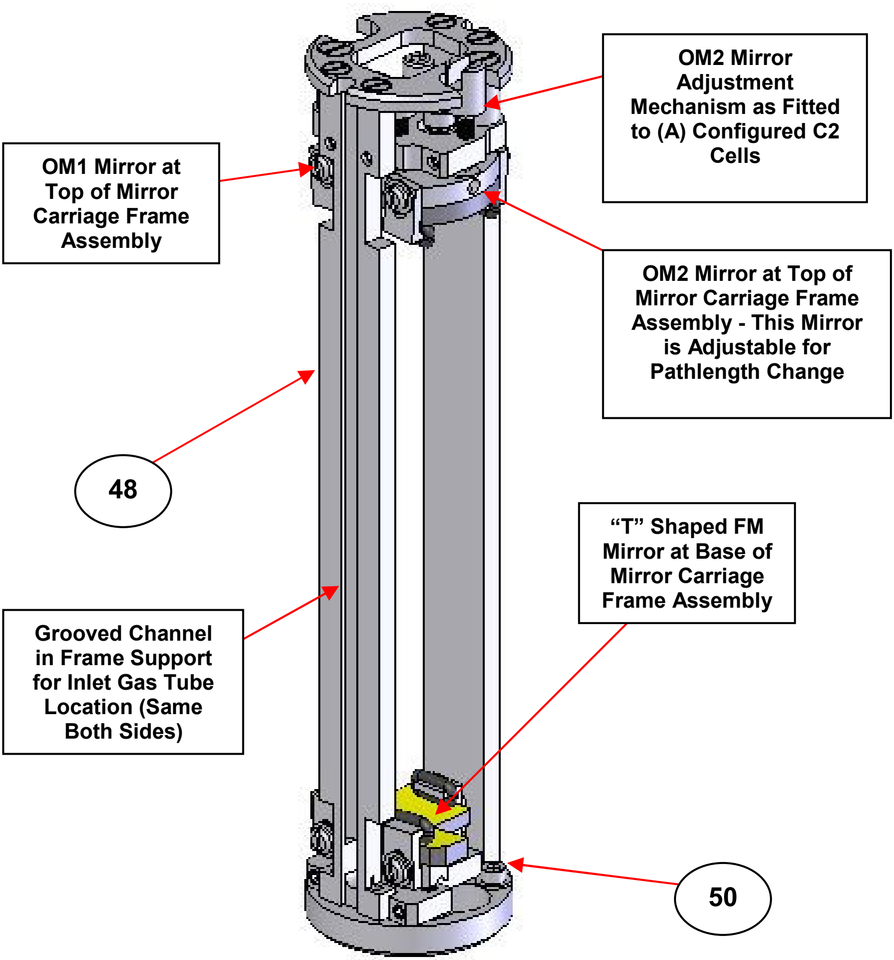


Fig 30. C2 Cell Mirror Carriage Frame Assembly Detail

Reassembly of Mirror Carriage Frame and Outer Cylinder Assembly – C2 Cell Only

Refit the mirror carriage frame assembly (**48**) back into position to the base of the cell securing with the M2.5 x 10mm screw and spring washer (**50**). (See Fig 29.)

Before refitting of the outer cylinder assembly (**44**) check that the lower sealing O-ring (**49**) is in a good and suitable condition. Take the outer cylinder assembly (**44**) and place over the mirror carriage frame (**48**) now secured to the optical unit (**1**) in the same orientation as it was removed. It is essential that the long gas inlet tube (**13**) inside the outer cylinder assembly locates correctly with the grooved channel in the mirror carriage frame and that if an adjustable pathlength (**A**) version of gas cell is being used, that the micrometer adjustment screw (**19**) underside tab relocates with the slot in the **OM2** mirror adjustment mechanism. (See both details on Fig 30.)

Lower the outer cylinder assembly (**44**) into position ensuring it sits correctly over the lower O-ring seal (**49**). Slide the lower flange ring clamp plate (**46**) down to the base of the cylinder assembly and align the M4 screw holes with the holes at the base of the cell.

Note: *For (**G**) body gas cells the flange ring clamp plate (**46**) covers a **second** sealing O-ring (**49**) which creates the gas tight seal when compressed against the (**G**) body. For (**M**) body gas cells there is **no** second O-ring (**49**) used to create the seal, as the (**M**) body seals against the O-ring (**49**) retained in the base of the gas cell.*

Proceed to retighten the four M4 x 20mm screws (**45**) into position to pull the flange ring clamp plate (**46**) tight to seal the O-ring(s) (**49**) against the (**G**) or (**M**) cylinder body. Ensure when tightening the M4 screws (**45**) that there is an even and level gap all the way around the circumference of the ring clamp plate (**46**) and between the base fitting of the cell, such the cylinder assembly (**44**) is tightened correctly back in position.

C5, C10 and C20 Gas Cell Outer Cylinder (G) or (M) Body Removal

For removal of the outer cylinder (**G**) or (**M**) body of C5, C10 and C20 gas cells, figures for the C5 gas cell have been used as an example. The procedure to adopt is the same as that described for the Cyclone™ C2 gas cell (See pages 48 and 49.)

Specifically, to gain access to the mirror frame assembly inside the gas cell, the outer surrounding gas cylinder (**51**) of a (**G**) or (**M**) body cell is removed. For the C5 size cell this is achieved by unscrewing and removing the **eight** lower M4 x 16mm screws (**52**) to the lower flange clamp ring plate (**53**) that holds the gas cylinder in position. For the C10 and C20 size cells there are **twelve** lower M4 x 16mm screws (**52**) to unscrew and remove from the lower flange ring clamp plate (**53**). See Fig 31.

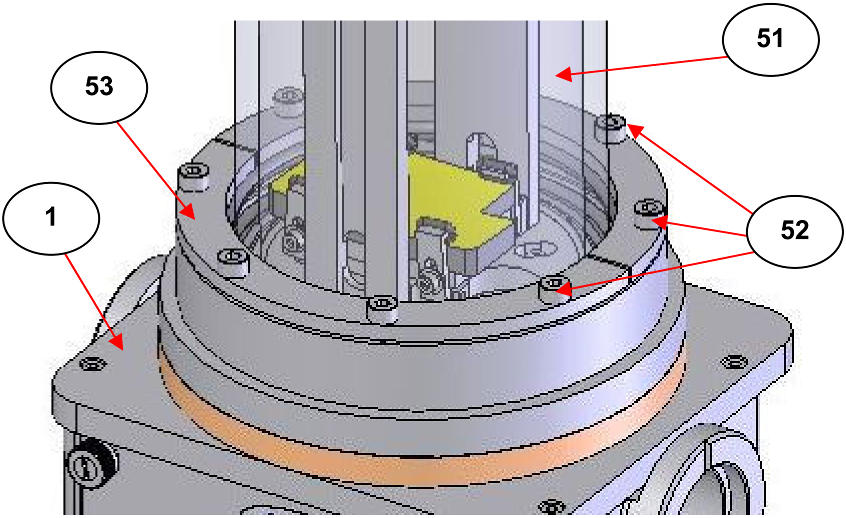


Fig 31. C5 Gas Cell Outer Cylinder (G) or (M) Assembly Removal

When the cylinder assembly (**51**) has been removed from the Optical Unit assembly of parts, access can be gained to remove the mirror carriage frame assembly (**54**). The mirror carriage frame assembly is held in place by a single M4 x 12mm screw (**55**). Remove the screw

(**55**) by unscrewing anticlockwise and carefully pull the mirror carriage frame assembly (**54**) up and away from the base of the cell. (See Fig 32.) The lower sealing O-ring (**56**) for the C5 cell can also be seen in Fig 32. Fig 33. shows the C5 cell outer body cylinder assembly (**51**) when removed from the optical unit.

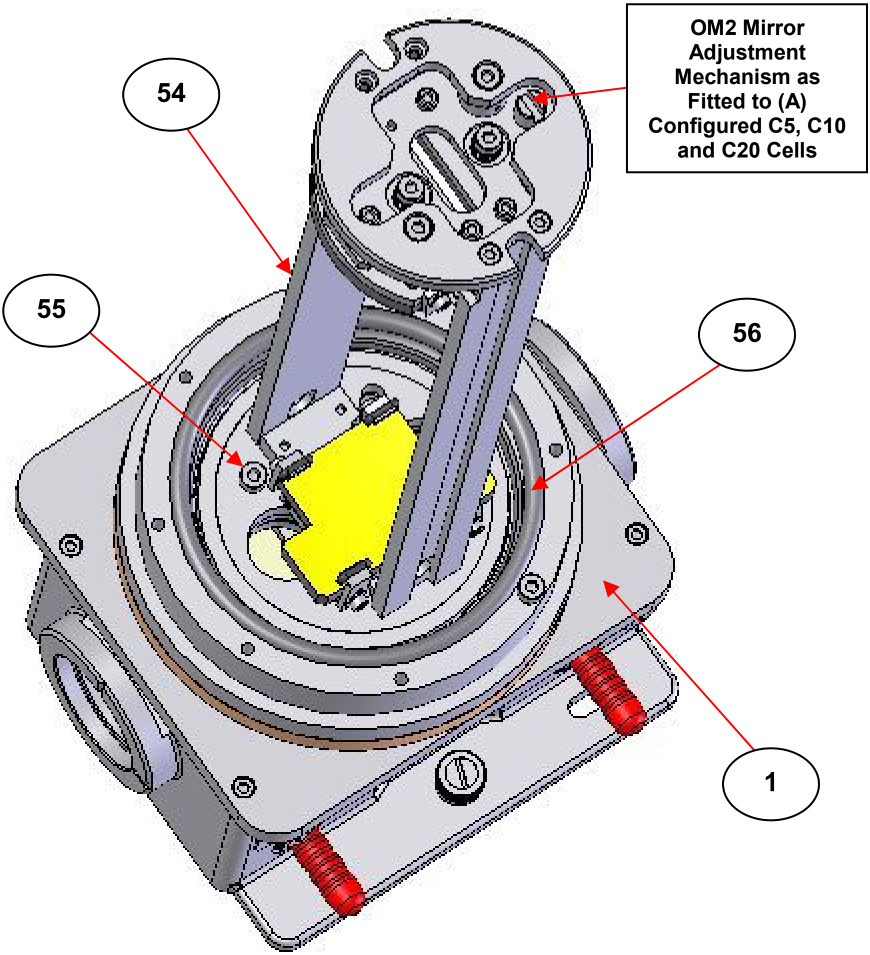


Fig 32. C5 Cell Mirror Carriage Frame Assembly Fixing Screw (55)

With removal of the mirror carriage frame assembly (**54**) for easier access, the frame and mirrors can be cleaned using suitable solvents and cleaning materials. Care must be taken when cleaning the gold mirrored surfaces. Only **very fine lens tissue** should be used to avoid abrasion and consequent possible loss of signal throughput.

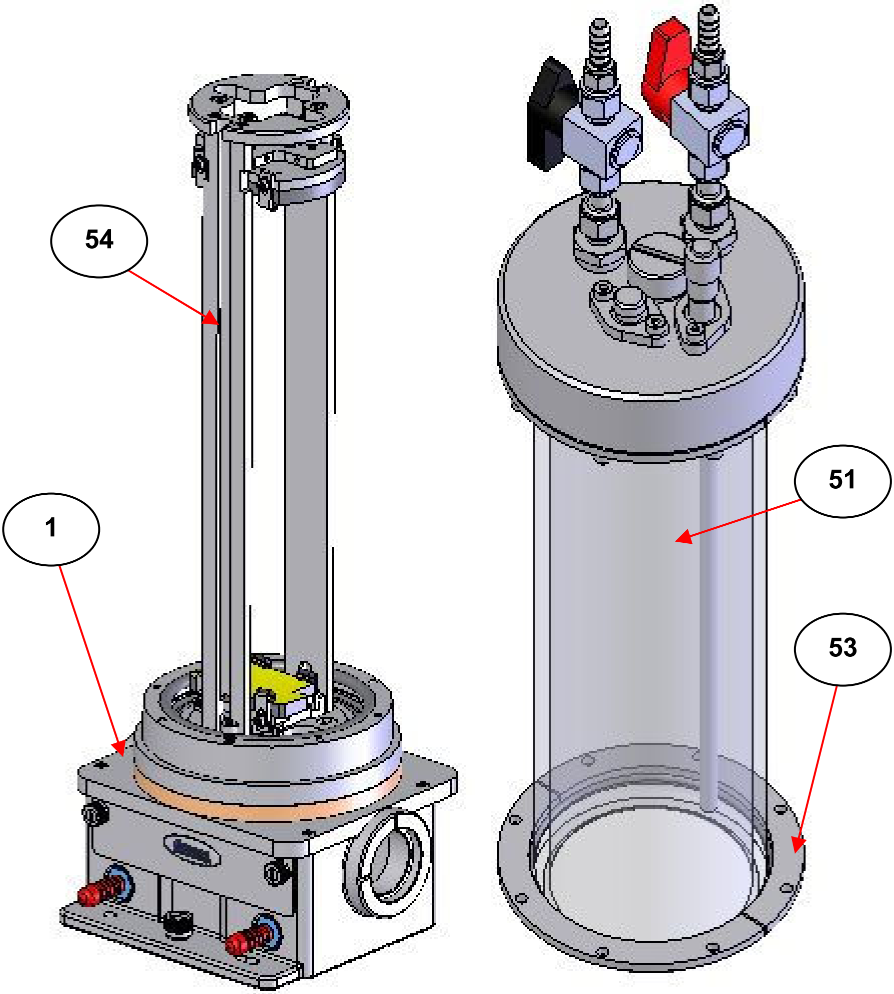


Fig 33. C5 Gas Cell Outer Cylinder Removed from Optical Unit

Reassembly of Mirror Carriage Frame and Outer Cylinder Assembly – C5, C10 and C20 Cells

Refit the mirror carriage frame assembly (**54**) back into position to the base of the cell securing with the M4 x 12mm screw (**55**). (See Fig 32.)

Before refitting of the outer cylinder assembly (**51**) check that the lower sealing O-ring (**56**) is in a good and suitable condition. Take the outer cylinder assembly (**51**) and place over the mirror carriage frame (**54**) now secured to the optical unit (**1**) in the same orientation as it was removed. It is essential that the long gas inlet tube (**13**) inside the outer cylinder assembly locates correctly with the grooved channel in the mirror carriage frame and that if an adjustable pathlength (**A**) version of gas cell is being used, that the micrometer adjustment screw (**19**) underside tab relocates with the slot in the **OM2** mirror adjustment mechanism. (See details on Fig 32.)

Lower the outer cylinder assembly (**51**) into position ensuring it sits correctly over the lower O-ring seal (**56**). Slide the lower flange ring clamp plate (**53**) down to the base of the cylinder assembly and align the M4 screw holes with the holes at the base of the cell.

Note: *For (**G**) body gas cells the flange ring clamp plate (**53**) covers a **second** sealing O-ring (**56**) which creates the gas tight seal when compressed against the (**G**) body. For (**M**) body gas cells there is **no** second O-ring (**56**) used to create the seal, as the (**M**) body seals against the O-ring (**56**) retained in the base of the gas cell.*

Proceed to retighten the eight or twelve M4 x 16mm screws (**52**) into position to pull the ring clamp plate (**53**) tight to seal the O-ring(s) (**49**) against the (**G**) or (**M**) cylinder body. Ensure when tightening the M4 screws (**52**) that there is an even and level gap all the way around the circumference of the ring clamp plate (**53**) and between the base fitting of the cell, such the cylinder assembly (**51**) is tightened correctly back in position.

11. Micrometer Screw Adjustment Mechanism for Adjustable (A) Cyclone™ Cells

The range of Cyclone™ gas cells can be provided as Fixed (**F**) or Adjustable (**A**) pathlength cells. For (**A**) configured cells the Cyclone™ gas cell is fitted as standard with a micrometer screw (**19**) device and an adjustment mechanism of parts at the top of the mirror carriage frame assemblies (**48** and **54**) to allow for adjustment of the **OM2**.

For removal of the outer cylinder body assemblies (**44** or **51**) to gain access to the internal mirror carriage frame (**48** or **54**), although the procedure as described in Section 9) works for both Fixed (**F**) and Adjustable (**A**) Cells, for refitting of the body assemblies to the optical unit (**1**) it may be easier to **remove** the adjustable pathlength micrometer screw (**19**) parts from the top of an Adjustable (**A**) gas cell. (See Fig 34. of a C5 gas cell as an example for **all** (A) gas cells.)

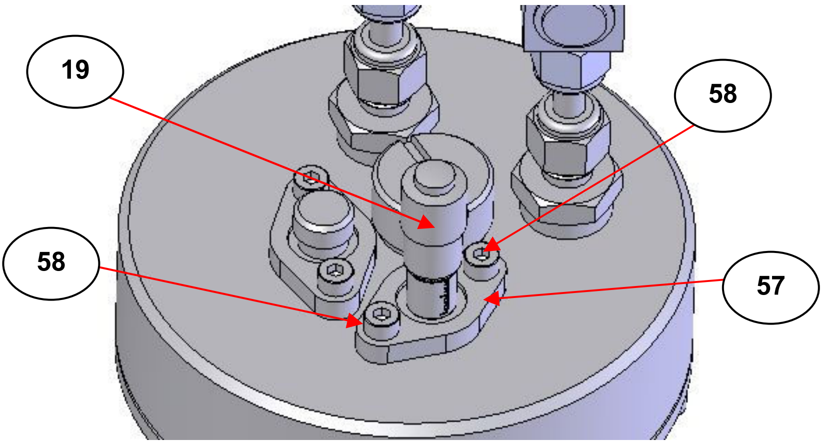


Fig 34. Micrometer Adjustment Screw Parts for Removal

The micrometer adjustment screw (**19**) is held in place by a clamping plate (**57**), which is in turn fixed in place by two M4 x 10mm screws

(**58**). (There are three M4 x 10mm screws (**58**) used to hold the clamp plate (**57**) for a Cyclone™ C2 (**A**) type cell.)

Note: *Before undoing the clamp plate screws (**58**), it is **recommended** that the micrometer screw (**19**) setting, which is read from the Vernier scale on the screw, is recorded for the **actual pathlength** that has been set on the Cyclone™ Cell itself. This value can be confirmed or re-applied to the micrometer screw (**19**) when it is repositioned into the top of the gas cell during reassembly.*

Remove the micrometer clamp plate screws (**58**) and pull up on the micrometer screw (**19**) to lift it and the clamp plate (**57**) away from the top of the gas cell. There is a sealing O-ring (**59**) for the micrometer screw (**19**) which may be retained in the recess hole or it may come away with the micrometer screw when removed. (See Fig 35.).

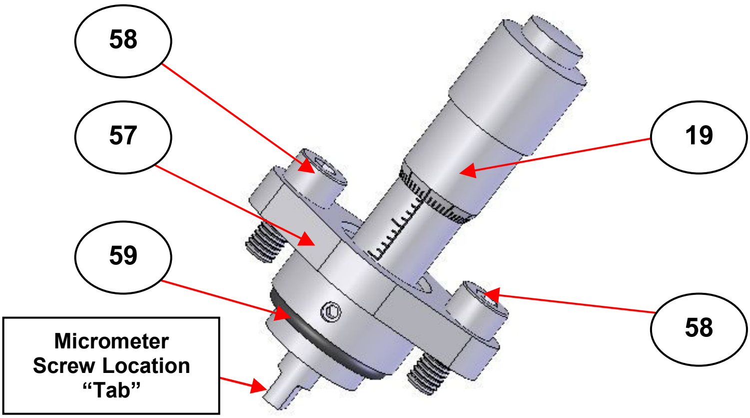


Fig 35. Micrometer Adjustment Screw Parts of C5, C10 and C20 (A) Type Cells

Keep the micrometer adjustment screw assembly of parts safe after removal, whilst you may be cleaning the mirror carriage frame assembly or attempting to reconfigure the gas cell for use in an opposite beam direction spectrometer system.

Refitting the Micrometer Adjustment Screw (19) Assembly

A special location tool (**60**) is provided with Adjustable (**A**) pathlength Cyclone™ gas cells to help in the correct and "square" refitting of the outer cylinder (**G**) or (**M**) body assemblies (**44** or **51**) to the optical unit (**1**) when the micrometer adjustment screw assembly has been removed from the gas cell body. (See Fig 36.)

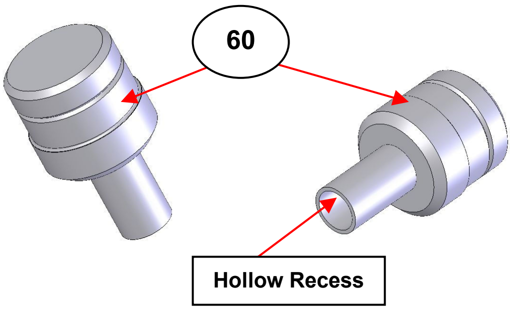


Fig 36. Location Tool for (A) Cells Outer Cylinder Body Refitting

When refitting an (**A**) type gas cell (**G**) or (**M**) outer cylinder assembly to the optical unit (**1**), the following procedure is recommended.

Lower the outer cylinder assembly (**44** or **51**) over the mirror carriage frame assembly (**48** or **54**) and onto the optical unit (**1**) in the same orientation as removed. The long input gas flow tube (**13**) locates into a groove on the mirror carriage frame. You should ensure that the **OM2** slot screw adjustment mechanism is centralized to the micrometer adjustment screws (**19**) mounting hole. This might require slight lateral movement of the outer cylinder assembly in its position, when resting on the lower sealing O-ring (**49** or **56**), until the parts line up.

Place the special location tool (**60**) into the micrometer screw hole recess such that the recessed hollow of the tool (**60**) fits over the OM2 slot screw adjustment mechanism and the whole tool (**60**) part slips smoothly into the hole. Ideally, check that the location tool (**60**) is free to be rotated easily by hand within the recess hole to ensure that a correct position for the outer cylinder assembly has been established. It is important when re-clamping the outer cylinder assembly to the optical unit via the fixing screws for the lower flange clamping plate that this “centralized position” for the outer cylinder assembly does not alter. A smooth operation for rotation of the micrometer screw adjustment mechanism depends upon the correct position of the micrometer adjustment screws (**19**) tab into the **OM2** slot screw mechanism at the top of the mirror carriage frame assembly.

Tighten the M4 x 20mm (C2 cell) or M4 x16mm (C5, C10 and C20 cells) clamp ring screws, evenly and alternately in rotation, to pull down on the lower flange plate clamp ring whilst ensuring that the location tool (**60**) still moves freely up and down and rotationally within the micrometer adjustment screw recess hole. Continue tightening the clamp ring screws until the outer cylinder assembly is firmly fixed back to the optical unit (**1**) for correct sealing with the lower O-ring (**49** or **56**).

Remove the location tool (**60**) and re-fit the micrometer screw and clamp plate assembly (**19** and **57**) to the top of the gas cell ensuring that the O-ring (**59**) is in position and is suitable to use. Make sure the micrometer screw location “tab” part (see Fig 35.) engages with the **OM2** slot screw adjustment mechanism and rotates freely without binding.

Note: *It may be a requirement that the depth of the micrometer screw at the “tab” part is adjusted to between 1.5 to 2.0mm shorter than has been set from the Vernier reading taken before its removal. To reduce the depth, turn the micrometer screw anticlockwise for 1.5 to 2.0 complete rotations and read the new setting from the Vernier scales. This adjustment in the micrometer screw depth setting may be necessary to ensure smooth operation of the screw if the mirror frame expands due to different temperature settings. If possible, try to keep your micrometer setting value the same as the reference value when supplied. See Test Certificate.*

Micrometer Adjustment

When an Adjustable (**A**) type Cyclone™ gas cell is supplied from new the micrometer adjustment screw (**19**) will be set with a specific micrometer reading from the Vernier scale. This value reading is found on the Test Certificate supplied and relates to the following pathlengths as **set** on each of the different cell variants for performance testing when supplied as new.

Cyclone™ C2 Cell is set to 2.0 m pathlength. (Range 0.5 to 2.5 m).
Cyclone™ C5 Cell is set to 5.0 m pathlength. (Range 1.0 to 8.0 m).
Cyclone™ C10 Cell is set to 10.0 m pathlength. (Range 2.0 to 10.6 m).
Cyclone™ C20 Cell is set to 20.0 m pathlength. (Range 2.0 to 20.0 m).

The micrometer value reading is used as the gas cells own **reference point** for setting of the OM2 mirror for the factory set pathlength.

Note: *If the mirror carriage frame is removed for any reason then it is recommended that a note is made of the micrometer setting value for the pathlength position that may be set on an (**A**) type cell at that time. When reassembling an (**A**) type cell the micrometer screw (**19**) must be replaced in the same position to maintain the reference scale values to adjust for different pathlengths. (See reassembly of cells on* pages 52 and 56).

The micrometer reading value set for the (**A**) type cell supplied is designated as “X” in the following tables. Adjustment figures for the range of movement on the micrometer screw (**19**) to vary the pathlength over the range obtainable for each gas cell type are typically as follows. To **decrease** the pathlength setting on a gas cell the value of X **increases** with respect to the movement of the micrometer screw (**19**) by turning it **anticlockwise.** To **increase** the pathlength setting on a gas cell the value of X **decreases** with respect to the movement of the micrometer screw (**19**) by turning it **clockwise.**

For Cyclone™ C2 (**A**) Cells

No. of Passes	4	8	12	16	20
Pathlength (m)	0.5	1.0	1.5	2.0	2.5
Movement of Micrometer in mm	X +0.70	X +0.23	X +0.07	X	X -0.05

For Cyclone™ C5 (**A**) Cells

No. of Passes	4	8	12	16	20	24	28	32
Pathlength (m)	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Movement of Micrometer in mm	X +1.29	X +0.48	X +0.21	X +0.08	X	X -0.05	X -0.09	X -0.12

For Cyclone™ C10 (**A**) Cells

No. of Passes	8	12	16	20	24	28	32	36	40
Pathlength (m)	2.11	3.17	4.22	5.28	6.34	7.40	8.45	9.50	10.56
Movement of Micrometer in mm	X + 1.56	X + 0.92	X + 0.58	X + 0.42	X + 0.26	X + 0.17	X + 0.10	X + 0.04	X

For Cyclone™ C20 (**A**) Cells

No. of Passes	4	8	12	16	20	24	28	32	36	40
Pathlength (m)	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
Movement of Micrometer in mm	X + 1.42	X + 0.78	X + 0.46	X + 0.29	X + 0.21	X + 0.13	X + 0.09	X + 0.05	X + 0.02	X

These adjustment figures can also be used for (**A**) type cells when they are being heated up to 200ºC using their own heating jacket and controller system. (Note, C20 size cell cannot be heated.) Although initial adjustment of the transfer optical unit (**1**) **output** mirror (**3**) may be required to “peak up” the signal through the cell at a temperature above ambient, an appropriate pathlength can be selected for the cell by use of the adjustment figures from the reference setting.

Note: *As stated these figures are a typical guide for an alternative pathlength setting on an (**A**) type cell **if not** using the Laser Alignment Accessory P/N GS24500 as a reference, visible light source for a multipassing spot pattern on the FM.*

12. Cleaning/Care of Cyclone™ Gas Cells

After use of the Cyclone™ gas cell it is recommended that the following procedures are adopted to properly care for the accessory.

1. Flush the cell with dry N_2 (Nitrogen) gas to remove any residual contaminants. If heated gases have been analyzed this will help to remove any condensed vapor on the components of the cell. If the gas cell has been operated at a temperature above ambient/room temperature, then it is recommended to flush through with N_2 gas whilst the gas cell is cooling down to room temperature before storage. N_2 gas can be flowed through if both the inlet (**15**) and outlet (**16**) valve taps are open and the valve tap to a flow line from any recommended gas line connectivity has been adopted. (See schematic Fig 15, page 30.)

2. If any parts such as the gas cell body or mirrors require cleaning then suitable solvents may be water, methanol, ethanol and acetone. When cleaning any of the mirrors (in the gas cell and in the optical unit) **always** use a very gentle soft lens tissue moistened with a suitable solvent and dab at the surfaces rather than wiping to minimize the risk of scratching and abrasion to the mirror surfaces.

3. If they are available, fit the desiccator storage caps P/N GS24150 to the transfer optical unit (**1**). (See page 22). These prevent moisture and dust from contaminating the windows on the gas cell and mirrors in the optical unit (**1**) whilst being stored.

4. Place the Cyclone™ gas cell back into its protective carry case or into a dry storage cabinet such as the Specacabinet P/N GS19100.

By following these procedures the gas cell will be ready for quick and easy installation the next time it is to be used.

Notes On Cleaning

When cleaning any removed **window material** being used in the Cyclone™ gas cell, it is **very important to take care** to avoid damage to the window materials**.** As also mentioned in the Safety Considerations (Section 2, page 5), of the three standard window materials supplied that can be fitted in the gas cell, ZnSe is potentially the most hazardous in terms of risk of toxicity if it makes contact with the skin.

Note: ***Always wear gloves to protect yourself and the window material.***

Solvents such as water, methanol, acetone, hexane, chloroform etc are suitable to use for cleaning purposes, but avoid use of any solvents that are "wet" or contain trace amounts of water, as KBr window materials will be damaged. CaF_2 and ZnSe window materials are generally chemically tolerant of a wide range of aqueous based solvents or solutions for cleaning purposes, but only sample solutions that fall within the pH range of pH4 to pH11 are tolerated by the ZnSe window material. Stronger acidic or basic solutions if introduced will irreparably damage any ZnSe windows that are fitted.

Caution! *If in doubt that your solvent for cleaning may be damaging to the window material being used with the Cyclone™ gas cell, always try to test a fragment of the window material type, if possible, with the chemical first.*

When wiping away any solid (condensed) residues (if present) on the window surfaces, use a very soft lens tissue moistened with the appropriate solvent to avoid scratches being caused on the surface of the window material. Scratches and blemishes to the window surface will result in poor light throughput for the transmission technique (more risk of light scatter) and an overall degradation in the Cyclone™ gas cell performance.

Datasheet for Potassium Bromide (KBr) Material

General

Medium for making Potassium Bromide pellets for IR spectroscopy.
When fused together as a solid can be polished and used as a transmission window material. Hygroscopic material similar to Sodium Chloride (NaCl).
Soluble in water, glycerine and alcohols. Slightly soluble in ether.
Fairly good resistance to mechanical and thermal shock.
Molecular formula: KBr.
Chemical Abstracts Service (CAS) No: 7758-02-3.

Physical Data

Appearance: Odourless, white or colourless crystalline solid.
Melting point: 730°C.
Boiling point: 1380°C.
Vapour pressure: 1mm Hg at 795°C.
Specific gravity: 2.75 g cm^{-3}.
Solubility in water: 53.48g/100g at 0°C.
Hardness: 6 Kg/mm^2.
Refractive Index: 1.54 (at 2000cm-1 - wavenumbers).
Spectroscopic transmission range: 43,500 to 400 cm-1 (wavenumbers).

Stability

Stable. Incompatible with strong oxidising agents, strong acids, bromine trifluoride and bromine trichloride.

Toxicology

Harmful if ingested in large amounts, if inhaled, or if in repeated contact with the skin.

Personal Protection

Always wear safety spectacles and gloves when handling the powder or window material.
Allow for adequate ventilation.

Storage

Keep powder or windows stored in a cool, dry container.

Datasheet for Calcium Fluoride (CaF_2) Material

General

Known as Calcium Fluoride, Calcium Difluoride, Fluorspar or Irtran 3.
When powder is fused together, is used as a transmission window material.
Insoluble in water, resists most acids and alkalis. Is soluble in ammonium salts.
Its high mechanical strength makes it particularly useful for high pressure work.
Brittle material sensitive to mechanical and thermal shock. Does not fog.
Molecular formula: CaF_2.
Chemical Abstracts Service (CAS) No: 7789-75-5.

Physical Data

Appearance: Odourless, white or colourless crystalline solid.
Melting point: 1360°C.
Boiling point: 2500°C.
Solubility in water: 0.0017g/100g at 0°C.
Hardness: 158 Kg/mm^2.
Refractive Index: 1.40 (at 2000cm-1 - wavenumbers).
Spectroscopic transmission range: 77,000 * to 900 cm-1 (wavenumbers).

Stability

Stable.Incompatible with acids.

Toxicology

Harmful if ingested in large amounts, if inhaled, or if in repeated contact with the skin.

Personal Protection

Always wear safety spectacles and gloves when handling the powder or window material.
Allow for adequate ventilation.

Storage

Keep powder or windows stored in a cool, dry container.
(* UV Grade material required for this range limit.)

Datasheet for Zinc Selenide (ZnSe) Material

General

Toxic and hard yellow coloured crystalline powder when fused together as a solid can be used as a transmission window material or as a crystal material for attenuated total reflectance (ATR) FTIR spectroscopy.
Insoluble in water, but attacked by strong acids and bases. (pH range 4 to 11 tolerant).
Organic solvents have no effect.
Fairly brittle as a window material and sensitive to thermal and mechanical shock.
Molecular formula: ZnSe
Chemical Abstracts Service (CAS) No: 1315-09-9.

Physical Data

Appearance: Yellow crystals, granular powder or amber coloured window material
Melting point: 1515°C at 1.8 atmospheres. (26.5psi)
Solubility in water: 0g/100g at 0°C.
Hardness: 120 Kg/mm^2.
Refractive Index: 2.43 (at 2000cm-1 - wavenumbers).
Spectroscopic transmission range: 20,000 to 500 cm-1 (wavenumbers).

Stability

Stable. Reacts with acids to give highly toxic hydrogen selenide. May be air and moisture sensitive. Incompatible with strong acids, strong bases and strong oxidising agents.

Toxicology


Toxic if small amounts are inhaled or swallowed. In stomach toxic hydrogen selenide (H2Se) is liberated. Skin and eye irritant. Danger of cumulative effects from frequent handling without protection.

Personal Protection

Always wear safety spectacles and gloves when handling the powder or window material. Allow for good ventilation.

Storage

Keep powder or windows stored in a cool, dry container, with appropriate safety labelling.

13. Spares for Cyclone™ Gas Cells

GS24106 Essential Spares Kit for Cyclone™ C2 Gas Cell.

GS24107 Essential Spares Kit for Cyclone™ C5 and C10 Gas Cells.

GS24150 Pair of Desiccator Storage Caps for transfer optic ports of all Cyclone™ Cells.

GS24152 Series Gold mirrors on frame for Cyclone™ Gas Cells. (Specify C2, C5, C10 or C20 gas cell)

GS24153 KBr (**K**) Windows for Cyclone™ Gas Cells. (Specify C2, C5, C10 or C20 gas cell)

GS24154 ZnSe (**Z**) Windows for Cyclone™ Gas Cells. (Specify C2, C5, C10 or C20 gas cell)

GS24155 CaF2 (**C**) Windows for Cyclone™ Gas Cells. (Specify C2, C5, C10 or C20 gas cell)

GS24160 Cyclone™ and Tornado™ Long Pathlength gas cell pressure gauge kit. (Specify either low or high pressure gauge)

GS24302 Heating Jacket and Controller for C2 Cyclone™ Cells. (Specify 220v or 110v)

GS24305 Heating Jacket and Controller for C5 Cyclone™ Cells. (Specify 220v or 110v)

GS24310 Heating Jacket and Controller for C10 Cyclone™ Cells. (Specify 220v or 110v)

GS24500 Laser Alignment Accessory (for use with all Benchmark™ mounted accessories).

14. Compatibility Guide

This guide shows which Cyclone™ gas cell and respective heating jacket can be used within a range of spectrometer sample compartments. Key: FWJ - Fits (and also) With Jacket. FNJ – Fits but No Jacket. DNF – Does Not Fit.

FTIR Instrument	C2 Cell P/N GS24102	C5 Cell P/N GS24105	C10 Cell P/N GS24110	C20 Cell P/N GS24120
Bomem M100	FWJ	FWJ	FWJ	FNJ
Bomem MB100	FWJ	FWJ	FWJ	FNJ
Bruker IFS66	FWJ	FWJ	FWJ	FNJ
Bruker Tensor, Vertex, Vector Instruments	FWJ	FWJ	FWJ	FNJ
Agilent Instruments	FWJ	FWJ	FWJ Close at rear	FNJ Close at rear
Mattson Genesis	FWJ	FWJ	FWJ Close at sides	FNJ Close at sides
Mattson Galaxy	FWJ	FWJ	FWJ Close at sides	FNJ Close at sides
Midac	FWJ	FWJ	FWJ	FNJ
Nicolet 500, Avatar, Nexus, iS10, iS50 Instruments	FWJ	FWJ	FWJ Close at sides	FNJ Close at sides
Nicolet iS5	FWJ	FNJ	FNJ	FNJ
Perkin Elmer 2000 (GX)	FWJ	FWJ	FWJ Close at sides	FNJ Close at sides
Perkin Elmer Spectrum One, 100, 400, Frontier Instruments	FWJ	FWJ	FWJ Close at sides	FNJ Close at sides
Perkin Elmer Spectrum Two	FWJ	FWJ	DNF	DNF
Jasco 400/600V, 5000/7000 Instruments	FWJ	FWJ	FNJ	FNJ
Shimadzu 8400, Prestige 21, IRAffinity, Tracer Instruments	FWJ	FWJ	FNJ	FNJ

Part Description for "Bubble" Numbered Items

(**1**) Optical unit for Cyclone™ gas cell.
(**2**) Fixing thumbscrew of optical unit.
(**3**) Mirrors in optical unit.
(**4**) Optical unit cover plate.
(**5**) Fixing screw for cover plate.
(**6**) M4 x 5mm cap head screw to rotate mirror surface.
(**7**) M4 X 12mm grub screw to tilt mirror surface.
(**8**) Optical unit purge port fitting.
(**9**) Purge bellows.
(**10**) Circular aperture port on optical unit.
(**11**) Desiccator storage cap.
(**12**) Desiccator storage cap with desiccant.
(**13**) Inlet gas flow tube.
(**14**) Outlet gas flow tube.
(**15**) Inlet tube on/off valve fitting.
(**16**) Outlet tube on/off valve fitting.
(**17**) On/off valve "barbed" hose connection fitting.
(**18**) On/off valve "barbed" hose connection fitting locking nut.
(**19**) Adjustable (**A**) pathlength micrometer screw.
(**20**) "Eye Spy" blanking plug.
(**21**) "Eye Spy" blanking plug O-ring.
(**22**) OM2 tilt adjustment blanking plug.
(**23**) OM2 tilt adjustment screw (M3 x 12mm).
(**24**) OM2 tilt adjustment blanking plug fixing screw (Cap head M4 x 10mm).
(**25**) OM2 tilt adjustment blanking plug O-ring.
(**26**) Low and High pressure gauge kit of parts.
(**27**) Cyclone™ C2 gas cell body bottom flange plate fixing screw (Cap head M4 x 10mm).
(**28**) Cyclone™ C2 gas cell window flange clamp plate fixing screw (Cap head M4 x 10mm).
(**29**) Cyclone™ C2 gas cell window flange clamp plate.
(**30**) Cyclone™ C2 gas cell PTFE gasket for window assembly.
(**31**) Cyclone™ C2 gas cell window.
(**32**) Cyclone™ C2 gas cell sealing O-ring for window assembly.

(**33**) Cyclone™ C2 gas cell window access grooves.
(**34**) Cyclone™ C5, C10, C20 gas cell body flange clamp plate fixing screw (Cap head M4 x 8mm and M4 x 12mm).
(**35**) Cyclone™ C5, C10, C20 gas cell window flange clamp plate.
(**36**) Cyclone™ C5, C10, C20 gas cell window flange clamp plate fixing screw (M4 x 10mm).
(**37**) Cyclone™ C5, C10, C20 gas cell PTFE gasket for window assembly.
(**38**) Cyclone™ C5, C10, C20 gas cell window.
(**39**) Cyclone™ C5, C10, C20 gas cell sealing O-ring for window assembly.
(**40**) Cyclone™ C5, C10, C20 gas cell window access grooves.
(**41**) PEEK retaining ring.
(**42**) Retaining nuts for flange clamp plate fixing screws (**34**).
(**43**) PEEK ring retaining screws (Slot head M4 x 10mm).
(**44**) Cyclone™ C2 gas cell (**G**) or (**M**) outer body cylinder.
(**45**) Cyclone™ C2 gas cell lower flange clamp plate ring fixing screw (Cap head M4 x 20mm).
(**46**) Cyclone™ C2 gas cell lower flange ring clamp plate.
(**47**) Cyclone™ C2 gas cell lower flange ring clamp plate fixing screw (Cap head M3 x 10mm).
(**48**) Cyclone™ C2 gas cell mirror carriage frame.
(**49**) Cyclone™ C2 gas cell lower sealing O-ring for cylinder assembly.
(**50**) Cyclone™ C2 gas cell mirror carriage frame fixing screw (Cap head M2.5 x 10mm).
(**51**) Cyclone™ C5 gas cell (**G**) or (**M**) outer body cylinder.
(**52**) Cyclone™ C5 gas cell lower flange ring clamp plate fixing screw (Cap head M4 x 16mm).
(**53**) Cyclone™ C5 gas cell lower flange ring clamp plate.
(**54**) Cyclone™ C5 gas cell mirror carriage frame.
(**55**) Cyclone™ C5 gas cell mirror carriage frame fixing screw (Cap head M4 x 12mm).
(**56**) Cyclone™ C5 gas cell lower sealing O-ring for cylinder assembly.
(**57**) Micrometer adjustment screw clamp plate.
(**58**) Micrometer adjustment screw clamp plate fixing screw (Cap head M4 x 10mm).
(**59**) Micrometer adjustment screw sealing O-ring.
(**60**) Adjustable (**A**) pathlength cell body location tool.

Notes for Use of Cyclone™ Gas Cells

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