

DOC0946R IRmadilloEx User Manual

Model Number: ASM0627-09-E-Cx-O-Gx-D3x

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1. SAFETY

“**WARNING**” refers to situations that could result in **personal injury**.

“**CAUTION**” refers to situations that could result in **equipment damage**.

Failure to follow the requirements below may lead to dangerous situations.





1.1. General safety

	WARNING	The spectrometer weighs ~18 kg; handle with care
	CAUTION	Do not operate outside the range of environmental or analyte conditions specified on the product label
	CAUTION	The probe is NOT a carry handle
	CAUTION	Do not open the spectrometer; it contains no user-serviceable parts

1.2. Lifting instructions

Lift the device using the lip around the lid or with hands underneath the base. Do not use the probe as a carry handle; this could cause damage. Users should risk assess manual handling and use lifting equipment if necessary.

1.3. Electrical safety

	WARNING	The electrical mains cable must be earthed and should include a 5A fuse with a means of isolating both live and neutral; obey local electrical safety codes
	WARNING	An additional earth connection is provided on the enclosure chassis using an M6 screw; use if required by local codes
	WARNING	Never disconnect the mains power connector when energised
	CAUTION	Residual current protection or ground fault interrupter devices are recommended

1.4. Pressure and temperature limits

The maximum pressure and temperature (ambient and analyte) limits for the device vary depending on the model and mechanical interface. Refer to the product label to confirm the limits.

Do not exceed the pressure limits on the product label as this could be dangerous and will invalidate the warranty. If in doubt, contact Keit for advice before installing the spectrometer.

1.5. Operating environment limits



The spectrometer is thermally stabilised and designed to operate indoors or outdoors under a variety of conditions and environments. Avoiding exposure to direct sunlight will help maintain this thermal stability.

Table 1 – Atmospheric requirements for electrical safety

Parameters	Value	Units
Pollution degree of intended environment	4	
Maximum installation altitude	3000	metres

Pollution degree of the environment refers to the level of contamination that the exterior of the device can cope with. Pollution degree 4 means that continuous conductivity from conductive dust, rain or other wet conditions will not cause *electrical safety* to be compromised.

Consideration should also be given to ventilation of the surrounding area when the system is being purged.

	CAUTION	Purging the device with dry nitrogen is recommended for optimum performance (Note: maximum inlet pressure of 1 barg with a flow rate 0.5 to 2 litre/min).
	WARNING	When purging with nitrogen, ensure there is adequate ventilation to prevent asphyxiation; an oxygen sensor is recommended.

1.6. Specific conditions of use

1.6.1. IRmadilloEx Spectrometer, certificate: IECEx CML 22.0082X

- i. The media to be monitored must be in an area where dust particles are excluded.
- ii. The probe must be mounted so it is protected from impact.
- iii. Models with external parts manufactured from light metals can be an ignition source due to impact or friction sparks. On equipment fitted with a probe of material 'TI' (titanium), this shall be considered during installation, particularly in zone 0 locations.
- iv. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.
- v. It is the responsibility of the manufacturer, installer and end user to ensure chemical compatibility between the process analyte and all wetted materials. Consult manufacturer before installation in a process.
- vi. The main enclosure shall not be opened. The flamepaths of the main enclosure shall not be repaired.

1.6.2. Passed on from the CMP Cable Gland certificate: IECEx CML 18.0182X

- i. The glands when used for terminating braided cables are only suitable for fixed installations.
- ii. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.
- iii. When assembled for fitting to flexible conduit, the conduit shall be effectively clamped to prevent twisting and pulling.
- iv. Instrument design confirms conformity with this condition.

1.6.3. Passed on from Hawke Cable Gland certificate: IECEx CML 19.0045X

- i. Instrument design confirms conformity with this condition.
- ii. It is the responsibility of the manufacturer to confirm conformity with this condition.
- iii. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.

1.6.4. Passed on from FibreEx Fibre Optic Connector Certificate: IECEx BAS 16.0032X certificate: IECEx CML 19.0045X

- i. The protective caps shall be fitted immediately following separation.
- ii. Instrument design confirms conformity with this condition.
- iii. It is the responsibility of the manufacturer to confirm conformity with this condition.
- iv. It is the responsibility of the manufacturer to confirm conformity with this condition.
- v. It is the responsibility of the manufacturer to confirm conformity with this condition.

1.6.5. Passed on from CMP 737 Thread Reducer certificate: IECEx CML 18.0177X

- i. It is the responsibility of the manufacturer to confirm conformity with this condition.
- ii. Instrument design confirms conformity with this condition.
- iii. It is the responsibility of the manufacturer to confirm conformity with this condition.
- iv. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.
- v. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.
- vi. Does not apply to model number ASM0627-09-E-Cx-O-Gx-D3x.

1.6.6. Passed on from Redapt BD-U Breather certification: IECEx ITS 16.0014X

- i. Instrument design confirms conformity with this condition.
- ii. It is the responsibility of the manufacturer to confirm conformity with this condition.
- iii. It is the responsibility of the manufacturer to confirm conformity with this condition.
- iv. Instrument design confirms conformity with this condition.
- v. It is the responsibility of the manufacturer to confirm conformity with this condition.
- vi. It is the responsibility of the manufacturer to confirm conformity with this condition.

The Ex-certified version of this product (ASM0627-09-E-Cx-O-Gx-D3x) was assessed against the following standards for hazardous environments:

IEC60079-0 Explosive Atmospheres – Equipment General Requirements

IEC60079-1 Explosive Atmospheres – Equipment protection by flameproof enclosures

IEC60079-26 Explosive Atmospheres – Equipment with EPL Ga

In addition, IEC60079-28 Explosive Atmospheres – Protection of equipment using optical radiation was considered but the equipment is not in the scope of this standard because (ref section 1, part 5) it has an enclosure that fully contains the optical radiation and provides IP6X protection in accordance with IEC60529 Degrees of protection provided by enclosures (IP code).

Furthermore, elements of IEC60079-31 Explosive Atmospheres – Equipment dust ignition protection by enclosure have been applied to preclude optical absorbers from entering the probe.

In accordance with IEC60079-26, the rigid dip probe achieves EPL Ga and can be inserted into zone 0 environments while the main instrument achieves EPL Gb for use in zone 1. The user should be aware that creating an opening in a zone 0 environment may lead to the release

of flammable gas and flame entrance. EPL Ga is achieved for the dip probe since it is an enclosure providing protection against dust ignition.

1.7. Product marking

The device is certified for installation in explosive gas atmospheres and uses a flameproof enclosure for protection. It is marked with its certification coding.

1.7.1. Pressure and temperature limits

The maximum pressure and temperature (ambient and analyte) limits for the device vary depending on the model. Refer to the product label to confirm the limits. Do not exceed the pressure limits on the product label as this could be dangerous and will invalidate the warranty. If in doubt, contact Keit for advice before installing the spectrometer.

1.7.2. Partition walls

The minimum partition wall thickness is 1 mm.

The material of the partition wall is given by the final part of the model number as follows:

Code	Probe Material
[blank]	Hastelloy
TI	Titanium
IN	Inconel
SS	Stainless Steel
TA	Tantalum

2. HOW TO POWER, PURGE AND CONNECT THE IRMADILLOEX

2.1. Powering the IRmadilloEx

**NOTE****See Section 1 Safety prior to attempting installation.**

The spectrometer is normally supplied with a blunt-cut mains cable to be wired into your electrical supply. The instrument requires single-phase mains input and must be connected to a permanent earth (grounding) connection. A 5A fuse should be fitted in the live/hot supply connection.

The power supply needs to be fitted with a means of isolating both live and neutral by fitting a disconnecting switch or using a suitable circuit breaker that meets the requirements of IEC 60947-1 and IEC 60947-3. The switch must be located within easy reach of the instrument and must be marked as the disconnection device for the equipment. The disconnection device must not interrupt the earth connection.

The spectrometer is designed to operate over a wide range of voltages shown below in Table 2 - IRmadilloEx power specifications. If you plan to operate the spectrometer outside of these ranges, contact Keit for advice before powering up the instrument.

Table 2 - IRmadilloEx power specifications

Parameters	Value	Units
AC input voltage	100-240	V
AC input frequency	50/60	Hz
Mains supply fluctuations (% of Nominal Value)	±10	%
Power consumption	110 (max)	W
Overvoltage Category	CAT II	

2.1.1. Uninterruptible power supply (UPS)

To ensure a reliable supply of power to the IRmadilloEx, we strongly recommend use of an uninterruptible power supply (UPS). Contact support@keit.co.uk for further information.

If you are unable to use a UPS, you may find that the system fails to start correctly following a power cut. In this situation, Keit recommends power cycling **first** the IRmadilloEx and **then** the controller.

2.1.2. Power cable

The power cable for the IRmadilloEx is a permanently connected flying lead passed through a cable gland; this is located at the rear of the spectrometer. The gland and cable must be sufficiently protected from loading and twisting. The cable should ideally be routed above ground to avoid accidental damage.

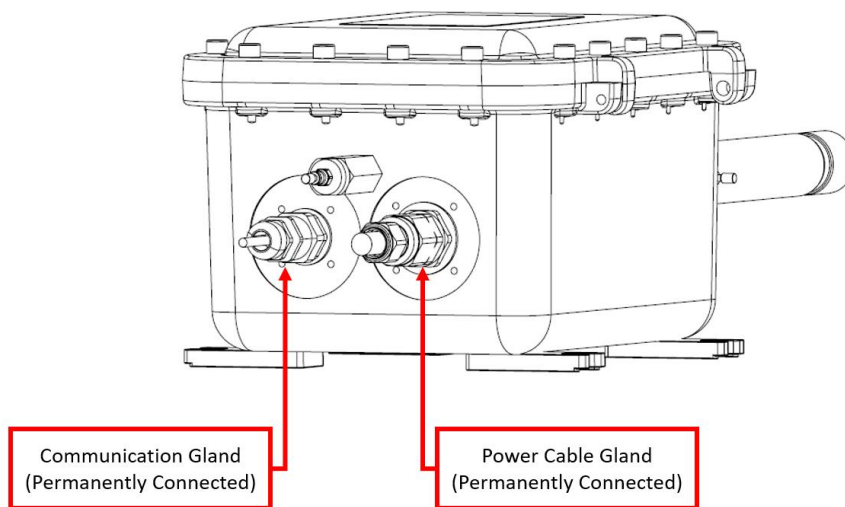


Figure 1: Power and communication gland locations

The spectrometer body has an M6 earth attachment point below the probe. This can be used where local codes require it in addition to earthing through the power supply cable. Please identify and adhere to any applicable local standards.



WARNING

Failure to properly earth the spectrometer may cause serious injury or death.

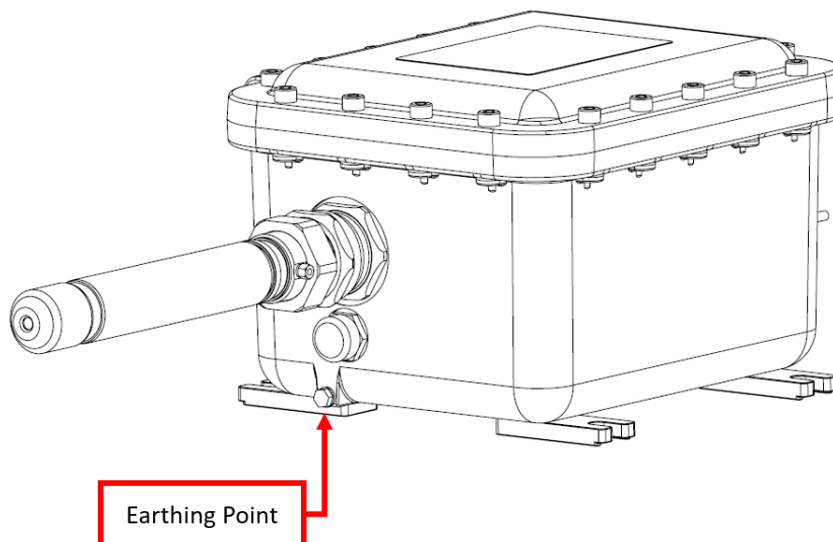


Figure 2: Earthing point for ASM0627-09

2.2. Purging the IRmadilloEx

The IRmadilloEx spectrometer is designed to be continuously purged. This eliminates any interference in operation caused by changing levels of water vapour and carbon dioxide (CO₂) within the instrument, both of which interact strongly with infrared (IR) light.

The IRmadilloEx is fitted with purge inlets on the probe and spectrometer body. The Inlets are shipped with blanking plugs that need to be removed before use. There are breathers on both the probe and spectrometer body.

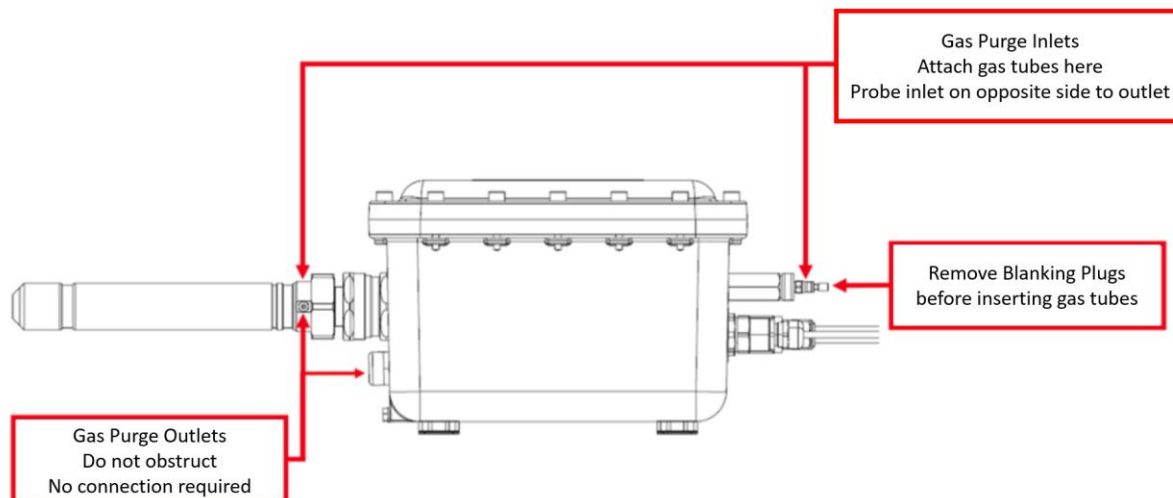



Figure 3: Purge inlet and outlet locations on ASM0627-09

The ideal purge gas is dry nitrogen. Alternatively, dry air from a purge gas generator can be used. The output from this purge gas generator should have a minimum quality according to ISO8573-1:2010 of Class 1:2:1 (dust:water:oil) or better. Keit can recommend suitable generators that achieve this outlet air quality; contact support@keit.co.uk. Purge gas generators may include an internal compressor or use factory-supplied compressed air with a minimum quality of Class 4:4:4 (dust:water:oil).

 NOTE	<p>All FTIR spectrometers are very sensitive to water vapour and carbon dioxide. Even in well-controlled environments, e.g., laboratories, environmental changes can be large enough to cause significant changes in the spectrum. We STRONGLY recommend purging the instrument at all times.</p>
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To purge the instrument:



- Remove the blanking plugs from the gas purge inlets on the instrument probe and body; these are push fit connectors.
- Connect either a 4mm or 5/32" diameter stainless steel or PTFE hose to the purge inlet ports.
- Ensure the gas tubes are connected to a suitable gas supply via a flow meter (we recommend 2 adjustable flow meter per instrument, one for the probe inlet and one for the body of the instrument)
- Adjust the total flow to 0.5 - 2 litres per minute (The pressure drop through the unit is <1 barg).
- Do not turn off the purge during normal operation; this will impact the instrument's performance.
- If the purge tubing is disconnected, the blanking plugs must be fitted to the inlet connections on the probe and body to maintain the IP rating and exclude dust.

The IRmadilloEx requires a stabilisation period of >12 hours once powered on and purging has started. This is to allow the internal components to reach a stable temperature and

complete purging. Once fully purged the instrument is very robust against changes in ambient conditions, provided the purge gas supply is maintained.

2.3. How to connect data communications

Like the power cable, the IRmadilloEx is supplied with a permanently connected flying lead for communication that is passed through a cable gland. You must ensure that the cables are sufficiently protected from loading and twisting. The cable should ideally be routed above ground to avoid accidental damage.

	NOTE	Ensure the mains and data communication cable connectors are dry prior to mating.
	NOTE	Keep the dust caps fitted on connectors when not in use. Never leave an exposed connector.

Model numbers of the form ASM0627-xx-E-x-x-G-xx have the Hawke FibreEx in-line connector for use in explosive atmospheres. The flying lead from the IRmadilloEx mates with the supplied extension cable.

2.3.1. Connecting the Hawke FibreEx in-line connector

- Unscrew the cap on the end of the connector.
- Align the key on the connector with the keyways in the corresponding connector
- Mate the two connectors together
- Rotate the shell secure and complete the connection
- Check that the green and orange lights on the controller are present (Figure 6)

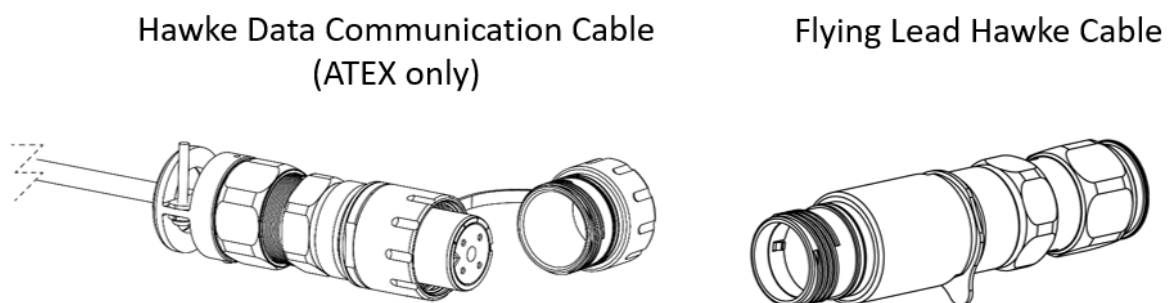


Figure 4 Hawke in-line plug and socket

The extension cable is terminated with a Souriau UTS-LC in-line plug.



Figure 5 Souriau in-line plug

2.3.2. Connecting the fibre data communication cable to the controller

- Remove the dust cap from the data communication cable.
- Carefully match up the data communication cable with the corresponding port on the back of the controller.
- Tighten the locking nut. This will make a secure connection.
- Check that the green and orange lights on the controller are present (see image).

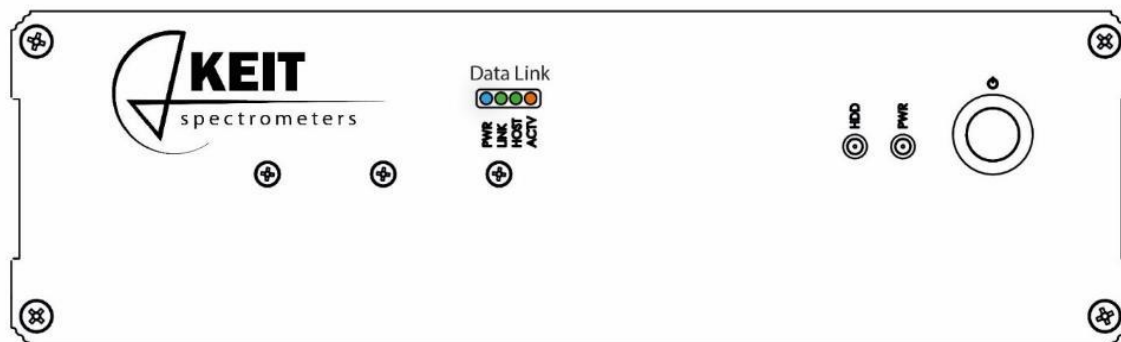



Figure 6: Front panel of Keit controller

	NOTE	Protect the data communication fibre from stress and tight bends (< 80mm bend radius not allowed!). Tight bends cause a stress at the glass surface and increase the probability of fracture.
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2.4. Checking for warnings and checking the probe is clean

When you have connected to the powered-on IRmadilloEx the KeitSpec application should load automatically (within 3 minutes). It is important to confirm that the system is working without errors: information on IRmadilloEx warnings and errors can be found in *DOC0893 KeitSpec Software User Manual*, section 1, *Getting Started*.

Once the system is set up without errors, the probe tip must be cleaned, and a background spectrum must be taken before insertion into the vessel or pipe. If the probe is guaranteed clean, the factory background scan shipped with the instrument – and saved to the desktop of the controller – can be used. Cleanliness of the probe tip is important to performance; if you suspect fouling or scale build-up, perform a clean appropriate to your environment.

2.4.1. Cleaning instructions

Rinse the ATR element with a suitable solvent. The choice of solvent will depend on your process. You may fully immerse the ATR in solvent if needed. The following are suitable:

- Water
- Acetone
- Alcohols
- Surfactant solutions
- Alkanes (hexane, cyclohexane etc...)
- Ethers

Once exposed to a suitable solvent, wipe the ATR with a clean cloth. The metal tube of the probe can also be cleaned by wiping with a cloth.

For hard-to-remove fouling (such as biofilms or dried-on chemicals) Keit recommends an oxidative acid clean. First, clean the ATR using the methods outlined above, then perform the following: Souriau in-line plug

- If you have purchased one, place the PTFE sample cell on the end of the probe and fill with ~4ml of 1 M nitric acid solution. If you have not purchased one then please contact support@keit.co.uk for further information.
- Leave to soak for 1 hr
- Carefully remove the acid using a pipette and fill the sample cell with water
- Remove the water using a pipette
- Remove the sample cell and rinse the ATR again with water
- Carefully wipe the ATR with a cloth

It may be necessary to repeat the cleaning steps again if the contaminant has only been partially removed.

In some cases, it may be necessary to perform an alkali clean on the probe. First clean the ATR using the methods outline above, then perform the following:

- Place the PTFE sample cell on the end of the probe and fill with ~4ml of 1 M sodium hydroxide solution
- Leave to soak for 1 hr
- Carefully remove the alkali using a pipette and fill the sample cell with water
- Remove the water using a pipette
- Remove the sample cell and rinse the ATR again with water
- Carefully wipe the ATR with a cloth

It may be necessary to repeat the cleaning steps again if the contaminant has only been partially removed.

2.4.2. Recognising if the probe is clean

When looking to see if the instrument is clean, the primary area of interest within the spectrum is between 800 and 1800 cm^{-1} . This section of the absorbance plot should maintain a relatively flat line with no consistently repeating peaks. Cleaning Mode can be used to see the effects of the cleaning process in real time – see *DOC0893 KeitSpec Software User Manual, Section 2, The Spectrometer Tab*.

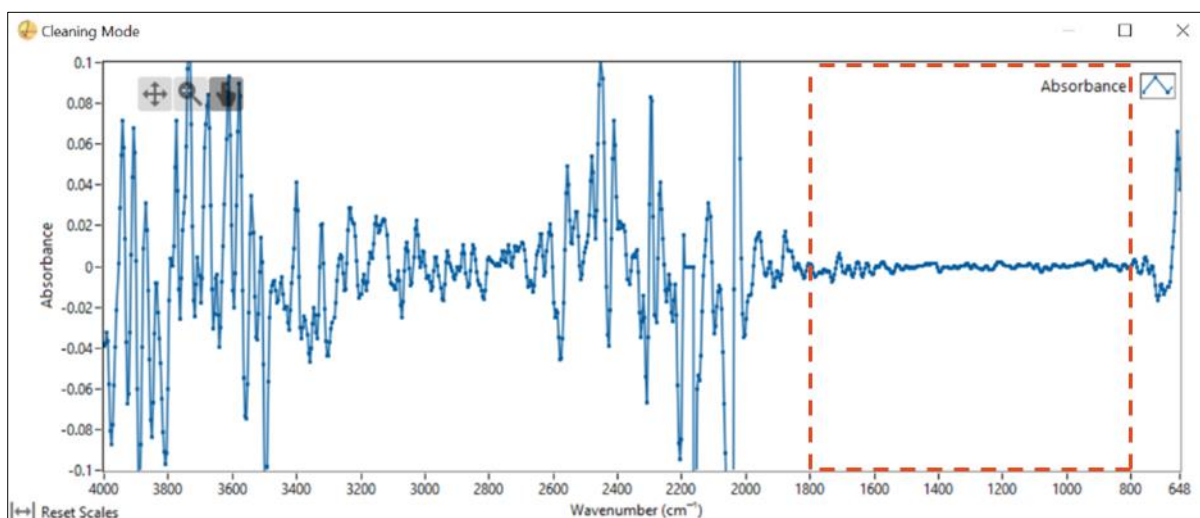


Figure 7: A clean probe showing no significant peaks within the 800 to 1800 cm^{-1} region.

Several sharp peaks in the region 800-1800 cm^{-1} indicate that the probe has not been cleaned properly.

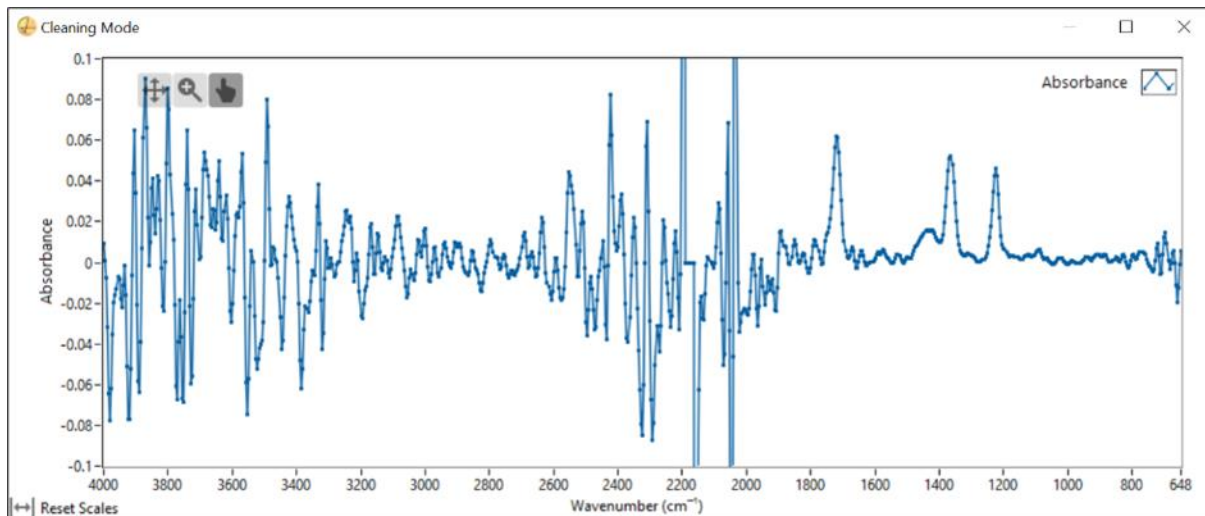


Figure 8: Sharp spikes within the region indicating an unclean probe

A peak at 1400 cm^{-1} indicates that there is some water on the probe. This could indicate poor purge quality.

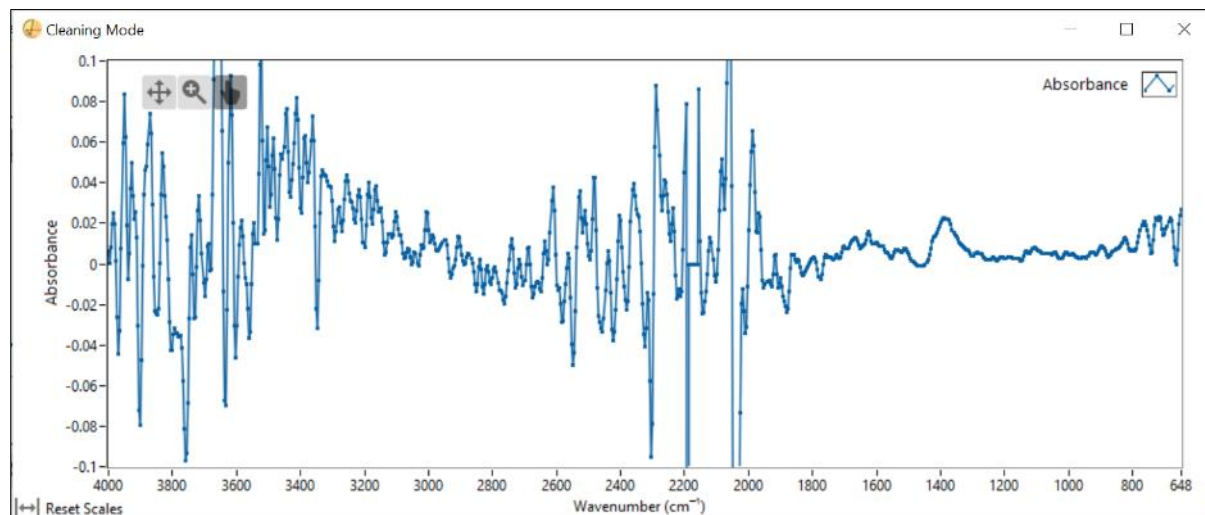


Figure 9: Peak indicating the water in the spectrum

A negative peak indicates that although the probe is clean now, it was not clean when the background was taken. Another background must be taken before any spectra can be measured.

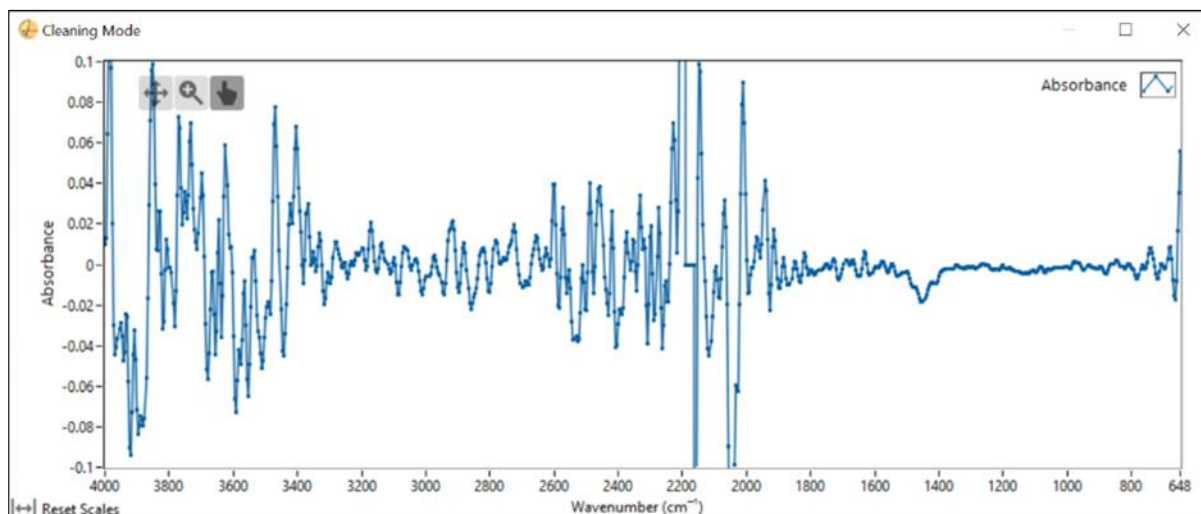


Figure 10: Negative peaks indicating the background was taken when the probe was unclean or not fully purged.

2.5. Taking a background

FTIR requires the collection of a background spectrum (also called a reference or baseline scan) before any absorption scans can be performed. This must be performed before the probe is inserted into the reaction/process of interest. The process for collecting a reference scan can be found in *DOC0893 KeitSpec Software User Manual, Section 1, Getting Started*.

2.6. Installation best practice

Having cleaned the probe and taken a background spectrum, the IRmadilloEx is ready to be inserted into the reaction/process of interest.

Probe installation is unique for each application. Safe installation of the probe into the process is the responsibility of the user and should be assessed by a suitably trained person.

Please refer to the interface drawings of your probe and mounting system for further guidance. If you have not been provided with interface drawings, please contact support@keit.co.uk.

To ensure success with installs, it is important to consider the following requirements:

- The IRmadilloEx needs to be suitably supported. The weight of the instrument is ~18 kg, and it must be supported using the mounting points at the base, either through a custom stand or using a Keit Cradle. The probe should not be used to support the instrument.
- The body of the IRmadilloEx should not be placed in direct sunlight or near a heat source. The instrument has internal temperature control, but this rating is limited and model dependant. Direct heat sources can force the instrument beyond its operating range and cause damage.
- The IRmadilloEx must be axially restrained when in the flow. Pressure on the probe will cause the system to move if not properly restrained along the probe's axis.

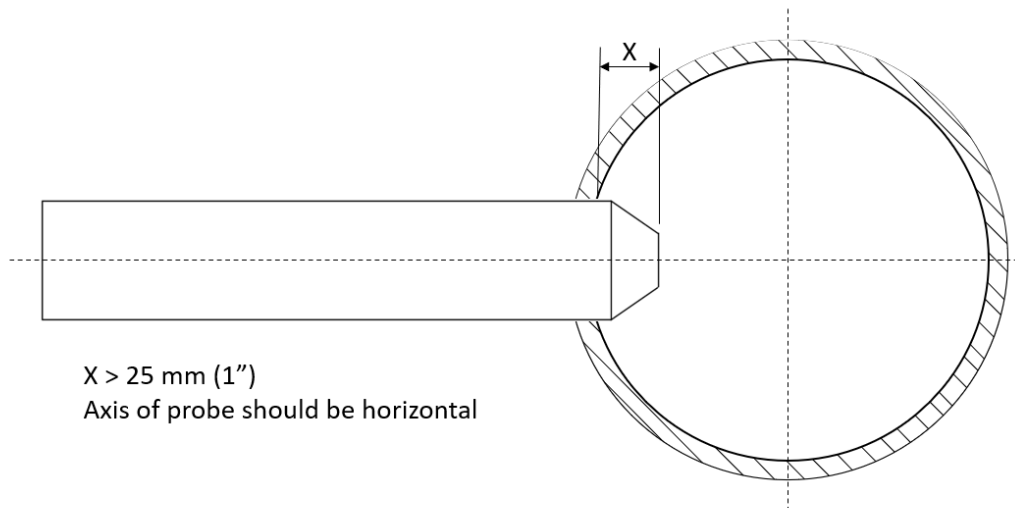


Figure 11: Probe immersion depth in pipework

- The central axis of the probe must be in line with the centre of the pipework.
- The probe must be aligned correctly with the port in which it is placed. It should not be forced or bent into place as this will cause damage to the instrument.
- The nominal position of the probe end from the internal pipe wall is $> 25 \text{ mm (1")}$.
- The IRmadilloEx must be exposed to the flow when in operation. The probe tip must be positioned in the flow within the pipeline or vessel to perform correctly; turbulent flow is desired. If the tip is held in stagnant chemistry, building representative chemometric models will not be possible.
- It is preferable to mount the IRmadilloEx with the probe positioned horizontally. Mounting the IRmadilloEx with the probe pointing downwards risks the formation of bubbles on the ATR element, and prevents the ATR from coming into full contact with the analyte to correctly analyse the process liquid.
- Similarly, avoid mounting the IRmadilloEx with the probe pointing upwards. If there are any suspended solids in the mixture, there is a risk of these solids settling on the probe tip, which may result in the spectra not being representative of the process liquid.
- The IRmadilloEx body should not be placed directly in caustic or acidic environments. The body is made from aluminium and will break down.
- To calibrate the IRmadillo, it is necessary to take samples from your process to analyse offline. The sampling point should be close to the IRmadillo's installation location to ensure that the sample that is taken is representative of the process fluid that is being measured by the IRmadillo at that time. See DOC0926 Offline sampling for IRmadillo calibration for more information on sampling.

2.7. Avoiding fouling

The diamond window at the tip of the probe must be in contact with process fluid in order to give a measurement. Even a thin layer of scaling or fouling will prevent the IRmadillo from being able to 'see' the process fluid.

To minimise the risk of fouling of the diamond window, we recommend taking the following steps during installation:

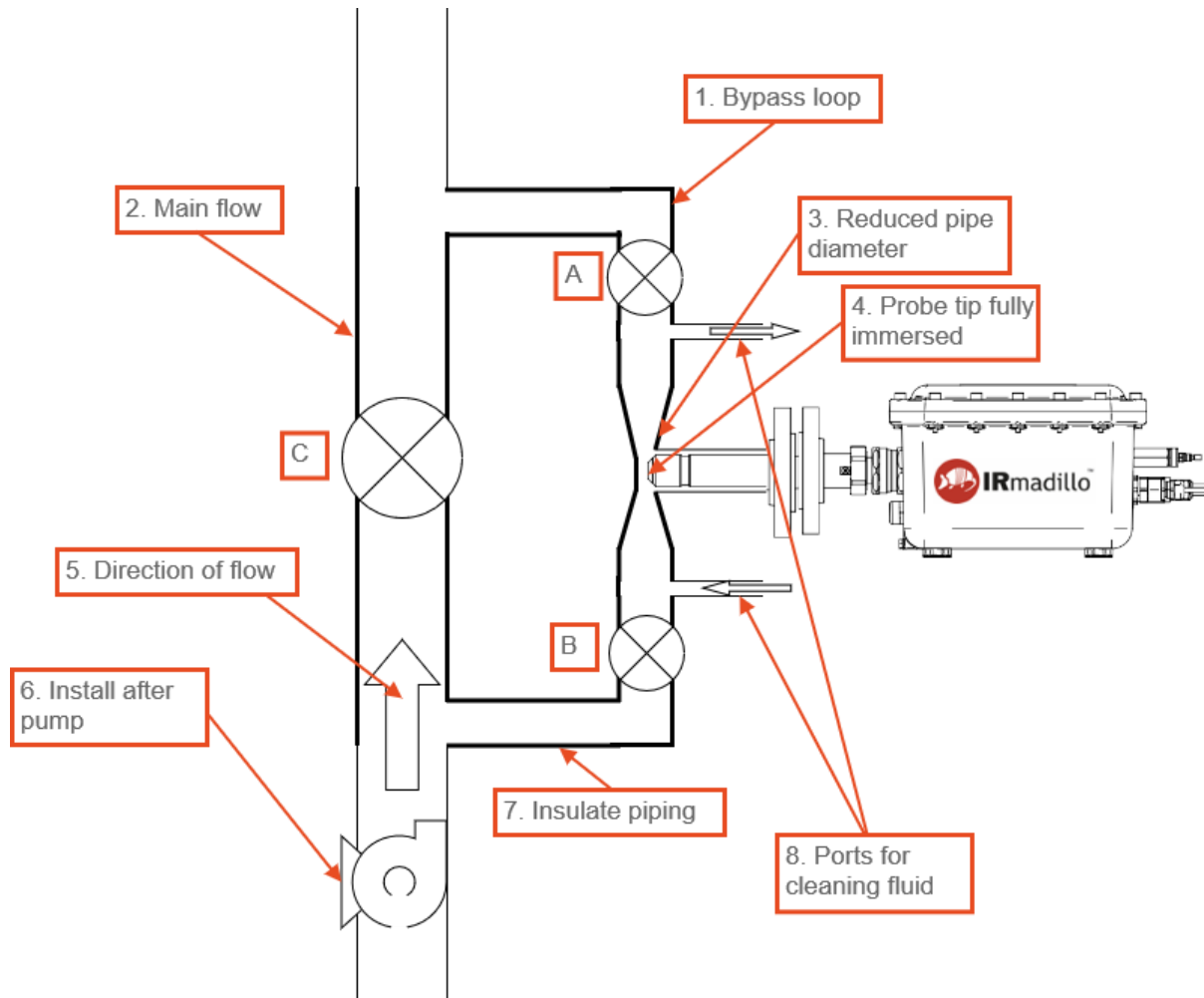


Figure 12: Installing the IRmadillo in a fouling environment

1. Particularly for continuous processes, install the IRmadillo in a bypass loop which can be isolated using valves A and B. This makes it easy to retract the IRmadillo for manual cleaning if required without the need to interrupt the process flow.
2. Direct the flow through the IRmadillo's bypass loop by blocking or restricting the 'main' flow unless the bypass loop is to be isolated (valve C). Alternatively, this may be achieved by mounting in a pump bypass loop (offtake from pump discharge and return to pump suction).
3. Maximise the flow velocity past the IRmadillo by installing in a reduced-diameter section of the pipe. The minimum flow velocity should be 1.5 m/s (5 ft/s) unless there is a risk of abrasion. If so contact Keit to discuss installation.
4. Install the IRmadillo so that the probe tip is fully in the flow. We recommend putting the probe tip as close to the centre of the pipe as possible.

5. The direction of flow should be vertically upwards. This both minimises the risk of air bubbles becoming trapped around the probe tip, and reduces the risk of settling of any sediment that is present.
6. To increase the pressure, install the IRmadillo after a pump. Higher pressure minimises the risk of sedimentation and bubbles.
7. Where possible, install the IRmadillo at a location where the process conditions are less prone to fouling. Depending on your process chemistry, this may be achieved by choosing a high temperature location and using heat tracing and insulation to avoid localised cooling. Higher process temperatures often maximise the solubility of potential fouling substances.
8. Fit ports either side of the IRmadillo's install point to allow clean-in-place or flushing with a suitable cleaning fluid.

3. MAINTENANCE

There are no user-serviceable parts inside the IRmadilloEx. Please contact Keit or our local agent to arrange service or repair. Service should only be performed by suitably trained engineers.

Probe accessories may contain O-rings, which we recommend replacing annually or, where worn or damaged, more frequently. See Section 5 Accessories for more information on accessories.

3.1. Service and support contacts

Website: www.keit.co.uk

Postal address: Keit Ltd.
Unit 4, Zephyr Building
Eighth Street, Harwell Campus
Didcot
Oxfordshire
OX11 0RL
United Kingdom

Telephone number: +44 (0) 1235 431260

Support email: support@keit.co.uk

3.2. Maintenance & support programme (MSP)

The MSP is for those customers who purchase an IRmadilloEx and want the assurance that their instrument will receive regular system maintenance to operate smoothly and uninterrupted. The service package provides a comprehensive set of health checks, upgrades and remote support to keep the IRmadilloEx functioning at the highest level.

It is desirable for Keit to have remote access to the Spectrometer User account on the controller in order to provide remote support. If this is not possible, issues may require the system to be returned to Keit for diagnosis..

For more information about our maintenance & support programme contact Keit using enquiries@keit.co.uk.

3.3. Spectrum health

The spectrum can be used as a good indication of the health of the instrument.

3.3.1. Use at high temperature

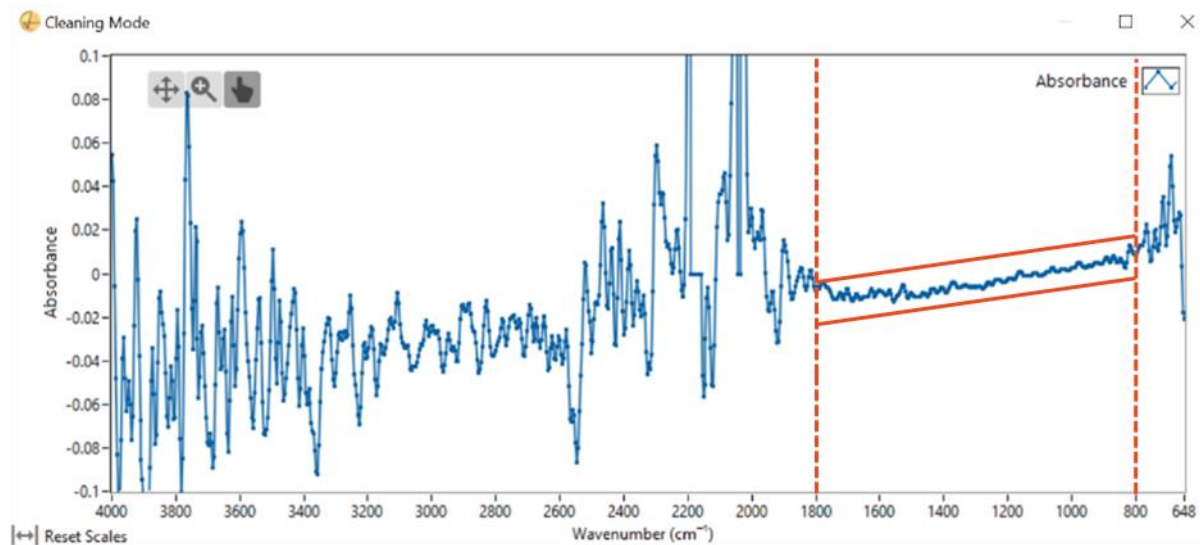


Figure 13: Probe is heated causing the spectrum to tilt

In Figure 13, the spectrum is tilted, with positive absorbance at lower wavenumbers and negative absorbance at high wavenumbers and the spectrum is not flat in the region 800-1800 cm^{-1} . This indicates that the probe tip is at a higher temperature now than it was when the background was taken. This may cause chemometric models to give incorrect results unless the model uses an appropriate pre-treatment to remove the effect. Any model built by Keit will have this taken into account.

3.3.2. Emitter ageing

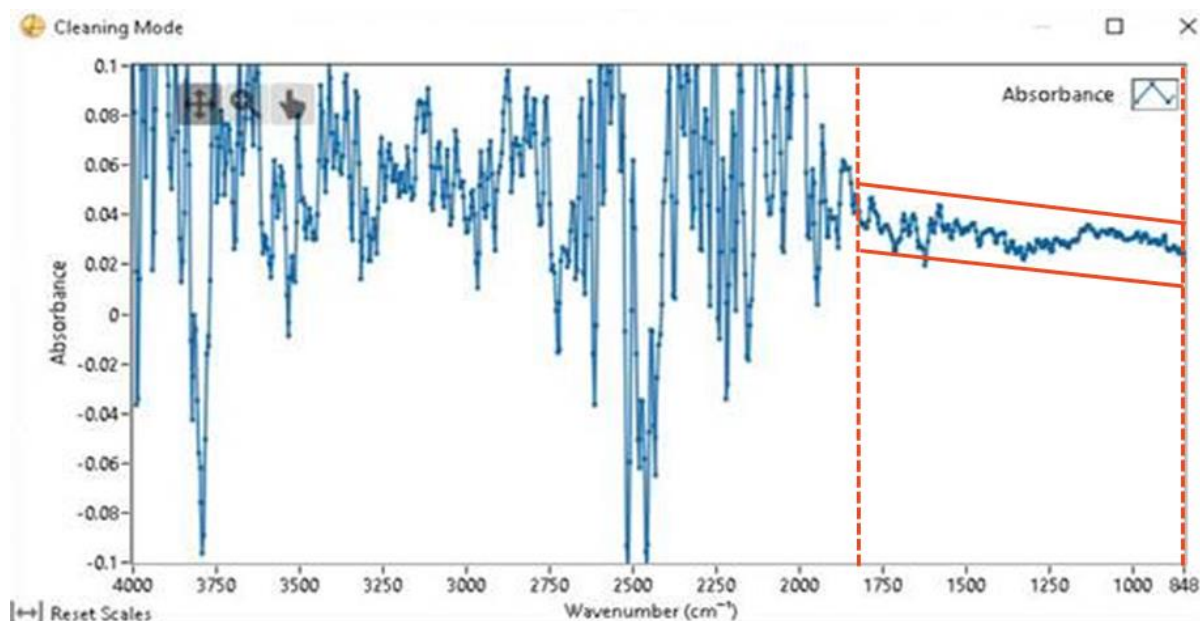


Figure 14: Spectrum is tilted showing signs of emitter ageing

The infrared emitter in the probe is expected to age over its lifetime. The results of this can be seen in Figure 14: the spectrum is tilted; the absorbance is positive across the whole spectrum;

and the spectrum is not flat in the region 800-1800 cm^{-1} (contrast with Figure 7, above). If evidence of emitter ageing is seen, it may be required to take a new background scan to remove this effect – contact Keit for advice.

3.4. Remote health check

Keit can perform an annual examination of your system’s health data remotely to determine if any servicing needs to be carried out. This includes review of internal diagnostics for warnings and errors, component performance for signs of premature ageing, and evaluation of background reference spectra history for signs of operator error or progressive damage.

Remote health checks are offered annually as a part of our MSP.



3.5. Cleaning the fibre optic data cable connectors

Once installed and in normal operation there should be no need to clean the fibre optic connectors. If the instrument needs to be moved so the connectors are disconnected, it is recommended that the connectors are cleaned before being re-connected.

The fibre connectors are cleaned with a cleaning pen as shown below.



Figure 15: Fibre-cleaning pen

	NOTE:	Keep the dust caps on connectors and fibres when not in use. Never leave an exposed fibre connector.
	NOTE:	Protect the fibre from stress and tight bends (< 30mm bend radius not allowed!). Tight bends cause a stress at the glass surface and increase the probability of fracture.

3.5.1. Cleaning the Souriau fibre-optic connectors

Disconnect the connector plug from the back of the controller by gently turning the locknut anti-clockwise as shown below. Do not force it. Forcibly turning any other part of the assembly may break the connector.



Figure 16: Disconnecting Souriau connectors

To clean the female socket, remove the covers from the tip of the cleaning pen and press it into both female ports until it clicks.

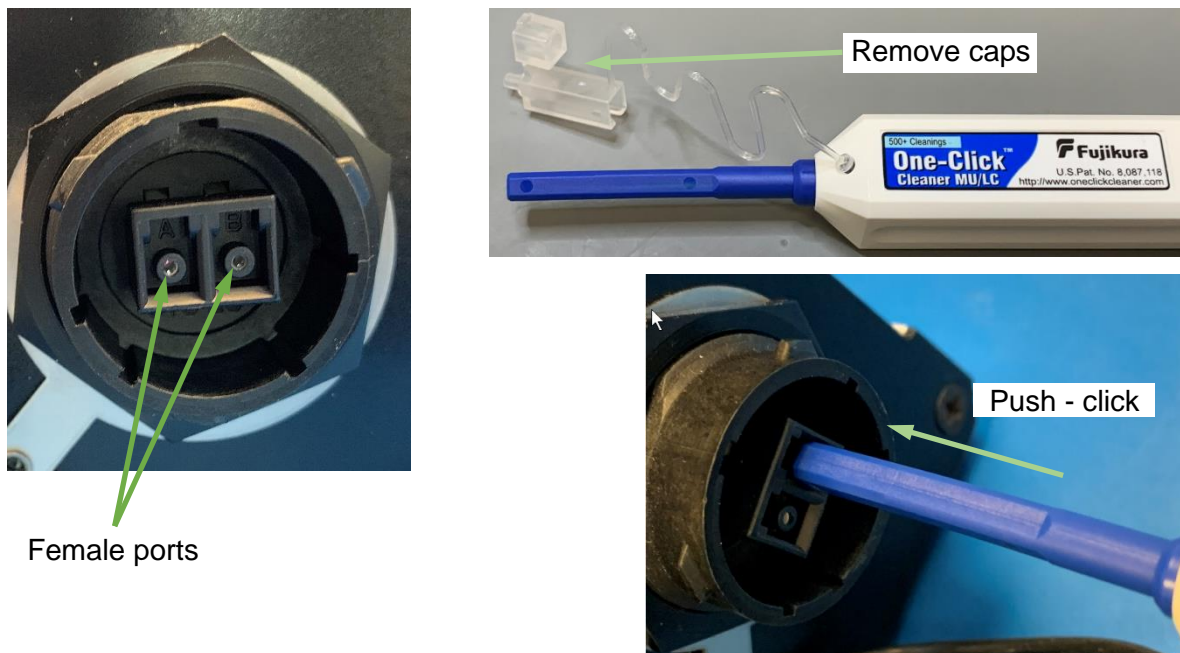


Figure 17: Using the fibre-cleaning pen on the Souriau socket

Cleaning the male plug is similar. The transparent cap remains fitted to the cleaning pen. The pen fits over each of the two male fibre ferrules and is aligned by the transparent cover. Push and click once on each ferrule.

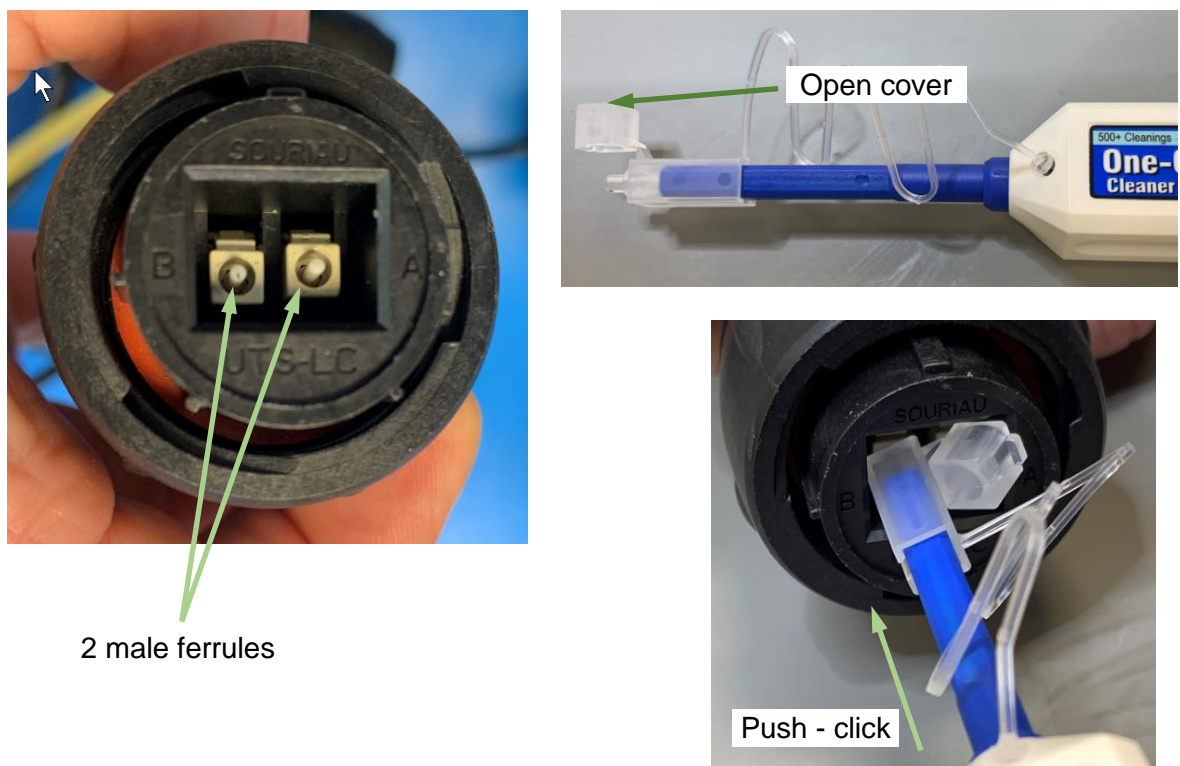


Figure 18: Using the fibre-cleaning pen to the Souriau plug

Once both halves of the connector have been cleaned then they can be reconnected. Align the keyways and turn the locknut clockwise until a distinct click is heard.



Figure 19: Reconnecting the Souriau connectors

4. COMPONENTS

This section contains general information about the IRmadilloEx spectrometer, such as the constituent components and internal controller specifications.

4.1. IRmadilloEx spectrometer

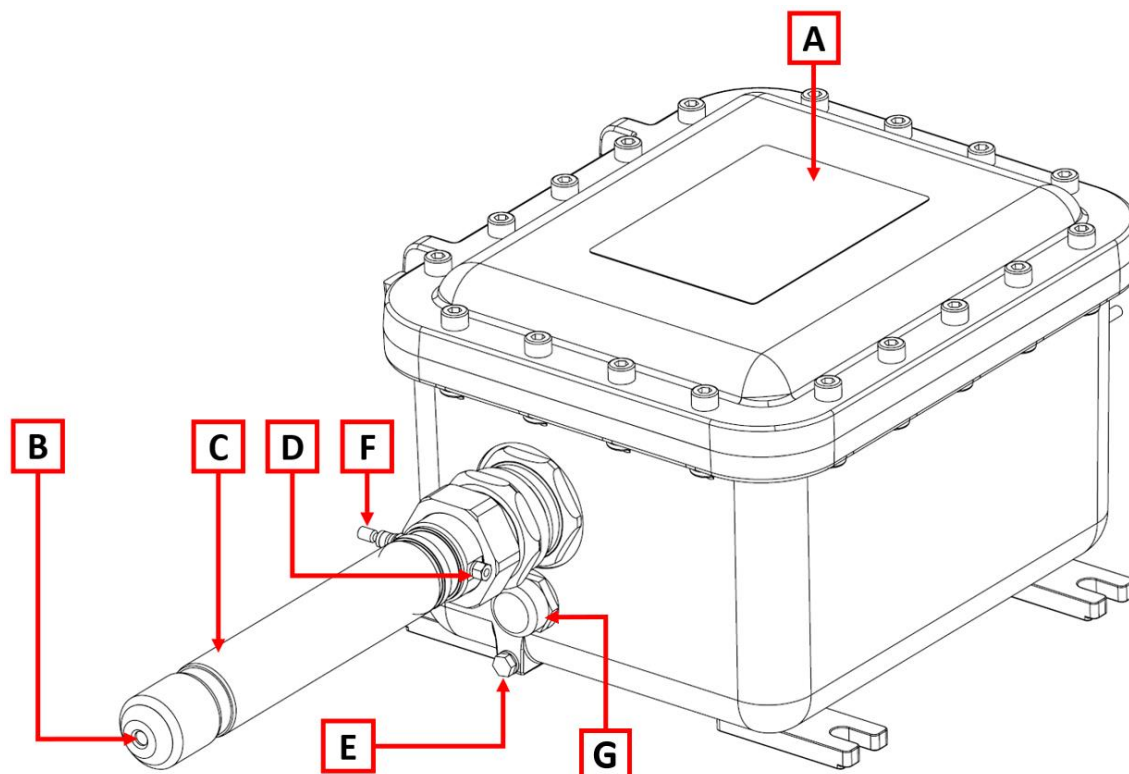


Figure 20: ASM0627-09-E front and top of the instrument

(A) Product label

The product label specifies the model of instrument with permissible environmental and analyte operating conditions, along with applicable certification. Particular attention should be given to the rated pressure and temperature limits.

(B) ATR element

The diamond ATR element is located at the end of the probe.

(C) Probe

The probe is designed to be installed directly into a reaction vessel or pipe and is made of a corrosion-resistant metal.

(D) Probe (gas) purge outlet

Allows purge gas to escape the probe. There is a single outlet located on the probe for all purge gas to escape.

(E) Earthing point

The spectrometer body has an M6 earth attachment point below the probe. This can be used where local codes require it in addition to earthing through the power supply cable.


(F) Probe Purge inlet

The probe purge inlet is used to purge the probe only. The connection is a 4mm or 5/32" Legris push-fit fitting typically fitted with a blanking plug that will need to be removed to allow connections. Rigid or fixed piping may be used if the fitting is compatible and mechanical stress is avoided.

(G) Body (gas) purge outlet

Allows purge gas to escape the spectrometer body. There is a single outlet located beneath the probe for purge gas to escape.

More detail on how to purge the instrument is given in Section 2.2, *Purging the IRmadilloEx*.

	WARNING	Failure to properly earth the spectrometer may cause serious injury or death.
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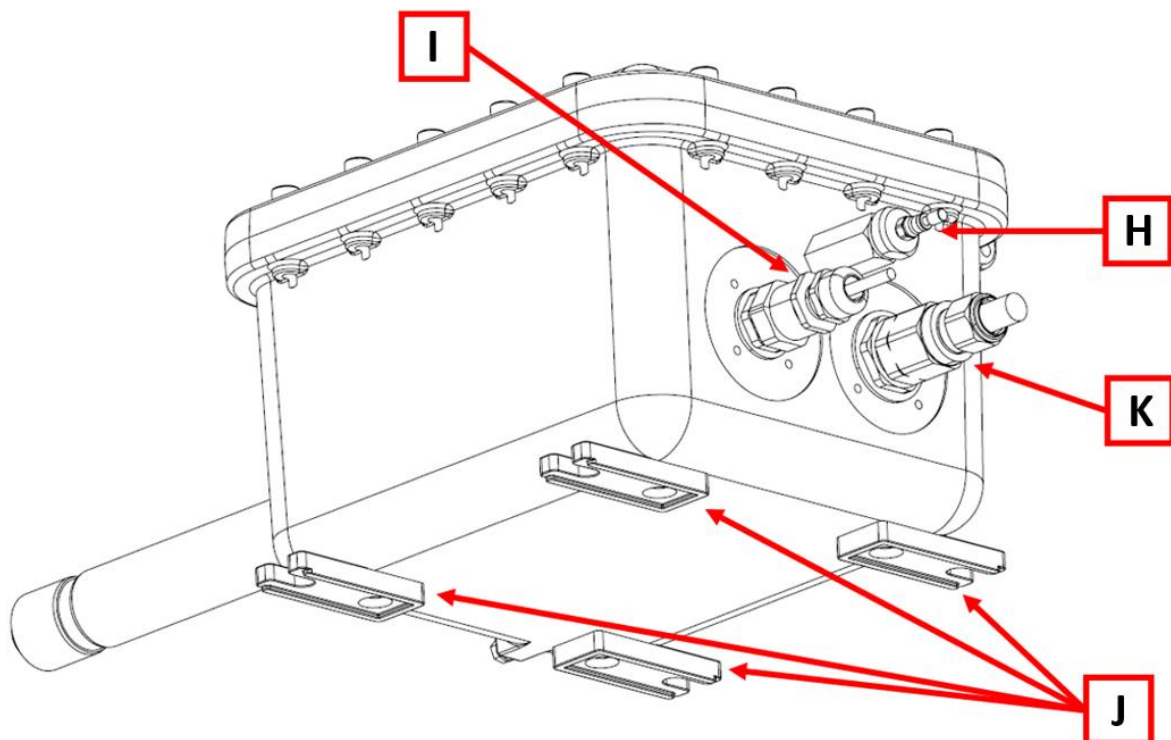


Figure 21: ASM0627-09-E back and base of the instrument

(H) Body Purge inlet

The spectrometer purge inlet is used to purge the spectrometer body. The connection is a Legris push-fit fitting typically fitted with a blanking plug that will need to be removed to allow connections. Rigid or fixed piping may be used if the fitting is compatible and mechanical stress is avoided.

More detail on how to purge the instrument is given in Section 2.2, *Purging the IRmadilloEx*.

(I) Communication gland

This is the connection from the spectrometer to the controller. More detail on how to connect using the cables is given in section 2.3, *How to connect data communications*. The spectrometer is configured to accept a fibre-optic data cable and is fitted with a cable gland.

(J) Mounting holes

The spectrometer must be supported using the four M8 mounting holes in its base. Optional feet are provided (shown attached in Figure 21).

(K) Power cable gland

This is the mains power connection to the spectrometer. More detail on how to connect power to the spectrometer can be found in Section 2.1, *Powering the IRmadilloEx*.

4.2. Controller specifications

Table 3 - Specifications of the IRmadilloEx controller

Category	Specification
Controller	The controller has been optimised for the rugged operation of the IRmadilloEx spectrometer; it is not a general-purpose personal computer. Keit does not recommend the installation of additional software; changes to the configuration may affect performance and reliability.
User accounts	There are two user accounts, one with system administrator privileges and a second 'standard' user. The standard user account starts automatically and is the default account for the KeitSpec software application. The system administrator account is provided to make changes to the operating system configuration and install additional software, if required. If providing Keit remote access to the controller, the connection should be to the 'standard' Spectrometer user account.
Windows updates	The controller is running Windows 10 LTSC with automatic updates disabled by default. The local administrator should choose when/if to update the operating system. A strategy will be required to manage updates, particularly if the controller is connected to a network.
Anti-virus	There is no anti-virus installed. The controller should only be connected to internal, protected networks. Install your preferred anti-virus if required

For detailed information on the controller, see Appendix 1: *Controller Specifications*.

4.3. Storage conditions

When installed with purge and power, the IRmadilloEx can thermally control its internal temperatures up to the limit specified on the product label. However, if the system is to be stored before its use Keit recommends an air-conditioned environment. The environment must be non-condensing, with a relative humidity below 95%. The IRmadilloEx or storage container should also be out of direct sunlight.

**WARNING**

Storing the IRmadilloEx unpowered and unpurged in unsuitable conditions can cause damage to the instrument. If in doubt, please consult with Keit

In contrast, the controller must be both stored and operated in a safe, non-hazardous environment. Keit recommends an air-conditioned environment, which is non-condensing and has a relative humidity below 90%. See Appendix 1: *Controller Specifications* for more information.

**WARNING**

Storing or operating the IRmadilloEx's controller in unsuitable conditions can cause damage. If in doubt, please consult with Keit

5. ACCESSORIES

5.1. Sample cell - ASM1398


WARNING
Not Ex certified

The sample cell is a ~5ml vessel attached at the end of the probe for performing manual sample analysis or used as part of a probe cleaning procedure. It is fixed in place using a tri clamp that locates over the rear of the sample cell and two semi-circular collars that fit around the probe. Ensure that the C-pieces make good contact with the probe and that the pins are seated inside their corresponding holes then use the clamp to fit the cell to the probe, clamping against the C-pieces. The clamp does not need to be tightened with significant force, we recommend to tighten the thumbscrew until resistance is felt + 1 turn. For volatile substances it is recommended to keep the stopper/cap in place during use.

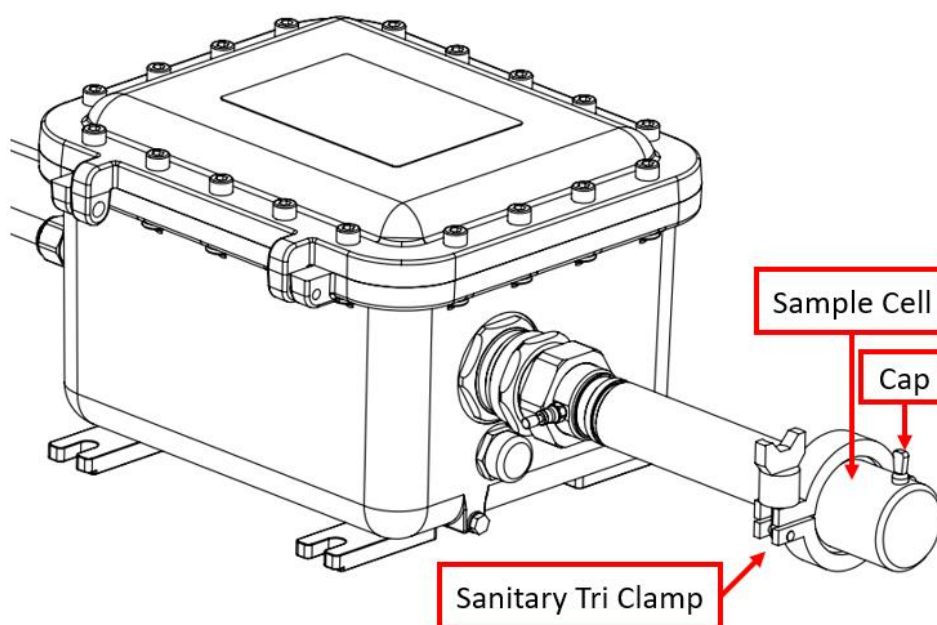


Figure 22: Sample cell fitted to IRmadilloEx probe



5.1.1. Maintenance

Inspect the O-ring regularly and replace if it has visually degraded, whether through swelling or other damage; use plastic forceps to remove the O-ring. This is particularly important if the chemistry that you are analysing is known to cause swelling of the O-ring elastomer. In any case, replace O-rings annually. Also inspect the clamp and C-pieces for any signs of degradation, cracks, or damage. If the clamp and/or the C-pieces shows signs of significant wear, do not re-fit them and contact support@keit.co.uk for advice. For O-ring specifications please see document "Flow cells and sample cell for ASM0627-xx-x-Cx-O-Gx-D3x (Non-ATEX Certified).pdf"

5.1.2. Cleaning

The sample cell may be cleaned using standard laboratory cleaning practices, as appropriate for your reaction. Also ensure the ATR element has been thoroughly cleaned and dried before use of the sample cell.

5.2. Flow cells

	WARNING	Not Ex certified.
	WARNING	Test for leaks after installation with non-hazardous chemistry before resuming normal operations.

The flow cell assemblies contain a pressure vessel and have been designed to withstand the analyte conditions that are specified on your product label. For detailed technical drawings, contact Keit.

5.2.1. High flow cell - ASM1392

The high flow cell can be secured to the end of the probe for continuous analysis of your process. The flow cell is fitted with two $\frac{3}{4}$ " NPT ports on opposing sides, in order to accommodate a high flow rate offshoot pipe from the main process, passing the liquid in front of the ATR. This is an alternative to installing the IRmadilloEx into a main pipeline.

It is fixed in place using a tri clamp that locates over the rear of the flow cell and two semi-circular collars that fit around the probe. Ensure that the C-pieces make good contact with the probe and that the pins are seated inside their corresponding holes then use the clamp to fit the cell to the probe, clamping against the C-pieces. The clamp does not need to be tightened with significant force, we recommend to tighten the thumbscrew until resistance is felt + 1 turn. The flow cell can be rotated through 360° to accommodate the user's installation. Please ensure that the flow through the cell is turbulent.

Maintenance and inspection method: Visually check that all O-rings inside the cell have not perished. They should show no signs of swelling, tearing, or degradation. For O-ring specifications please see document "Flow cells and sample cell for ASM0627-xx-x-Cx-O-Gx-D3x (Non-ATEX Certified).pdf". Also inspect the clamp and C-pieces for any signs of degradation, cracks, or damage. If the clamp and/or the C-pieces show signs of significant wear, do not re-fit them. Contact support@keit.co.uk for advice.

Do not use impact (e.g. a hammer) to separate components if the probe becomes stuck in the flow cell.

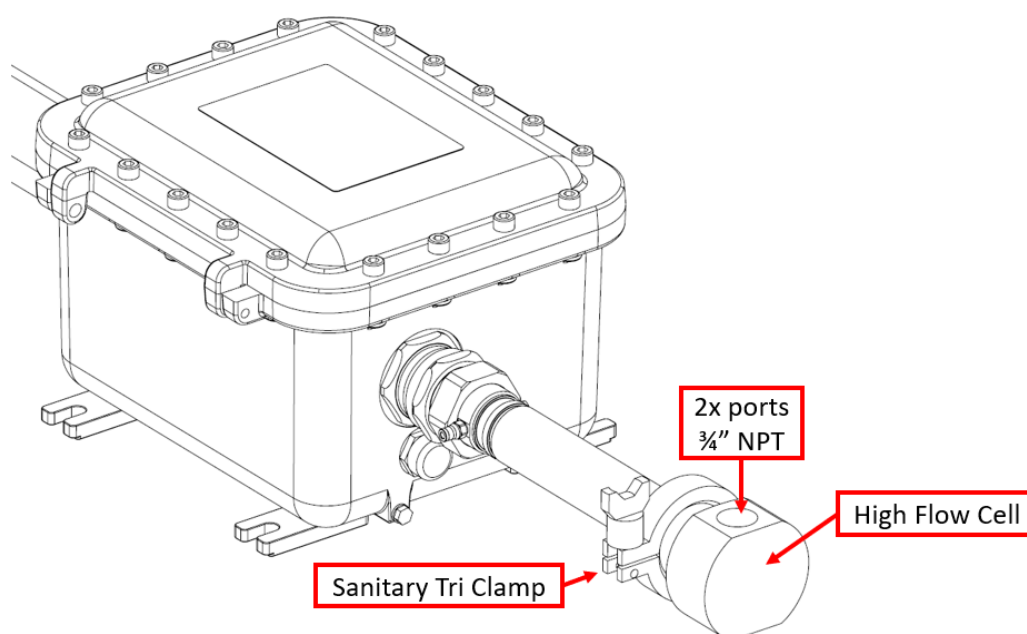


Figure 23: High flow cell fitted to IRmadilloEx probe
Table 4 – Specifications and safety limits (high flow cell)

Parameter	High Flow Cell
Pressure	Refer to high flow cell marking
Analyte Temperature	Refer to high flow cell marking
Body Material	Corrosion-resistant metal
O-ring Seal	FFKM (Kalrez)
Port Size	3/4" NPT
Cell Internal Volume	~27 ml
Intended Use	Only for use with ASM0627-09-E-Cx-O-Gx-D3x
Fluid Group	1
Minimum Inspection Frequency	Annual

5.2.2. Low flow cell - ASM1222

The low flow cell that can be secured to the end of the probe for continuous analysis of your process. The flow cell is equipped with two 1/16" NPT fittings to attach pipelines too, or it can be assembled with two 1/4" Swagelok nuts attached to a short section of pipe on opposing sides.. It is designed to force liquid past the ATR and is primarily used for lab work where flow rate and volume are low.

It is fixed in place using a tri clamp that locates over the rear of the flow cell and two semi-circular collars 'C-pieces' that fit around the probe. Ensure that the C-pieces make good contact with the probe and that the pins are seated inside their corresponding holes. Slide the flow cell over the probe so the O-ring is in contact with the end of the probe. Then use the clamp to secure the C-pieces and cell. The clamp does not need to be tightened with significant force, we recommend to tighten the thumbscrew until resistance is felt + 1 turn. The flow cell can be rotated through 360° to accommodate the user's installation. The cell should be checked for leaks prior to running hazardous chemistry through it.

Maintenance and inspection method: Visually check that all O-rings inside the cell have not perished. They should show no signs of swelling, tearing, or degradation. For O-ring specifications please see document "Flow cells and sample cell for ASM0627-xx-x-Cx-O-Gx-D3x (Non-ATEX Certified).pdf". Also inspect the clamp and C-pieces for any signs of degradation, cracks, or damage. If the clamp and/or the C-pieces shows signs of significant wear, do not re-fit them. Contact support@keit.co.uk for advice..

Do not use impact (e.g. a hammer) to separate components if the probe becomes stuck in the flow cell.

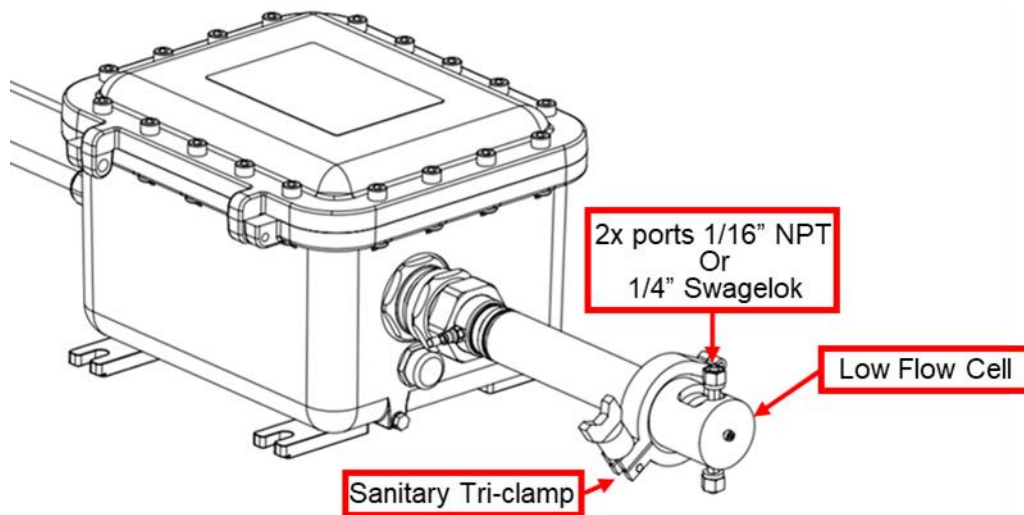


Figure 24: Low flow cell fitted to IRmadilloEx probe

Table 5 - Specifications and safety limits (low flow cell)

Parameter	Low Flow Cell
Pressure	Refer to low flow cell marking
Analyte Temperature	Refer to low flow cell marking
Body Material	Corrosion-resistant metal
O-ring Seal	FFKM (Kalrez)
Port Size	1/16" NPT or 1/4" Swagelok
Cell Internal Volume	~0.8 ml
Intended Use	Only for use with ASM0627-09-E-Cx-O-Gx-D3x
Fluid Group	1
Minimum Inspection Frequency	Annual

5.3. Welded Hub For Lap Joint Flange

A version of the IRmadilloEx is available to allow connection to process pipework with an ANSI/ASME B16.5 (other options available on request) compliant flange. A hub is welded to the wall of the probe and a compatible lap-joint flange is mounted between the hub and spectrometer body to permit clamping to process pipework. For technical drawings, contact Keit at support@keit.co.uk.

It is important to follow these instructions completely to ensure safe use of the flanged probe.

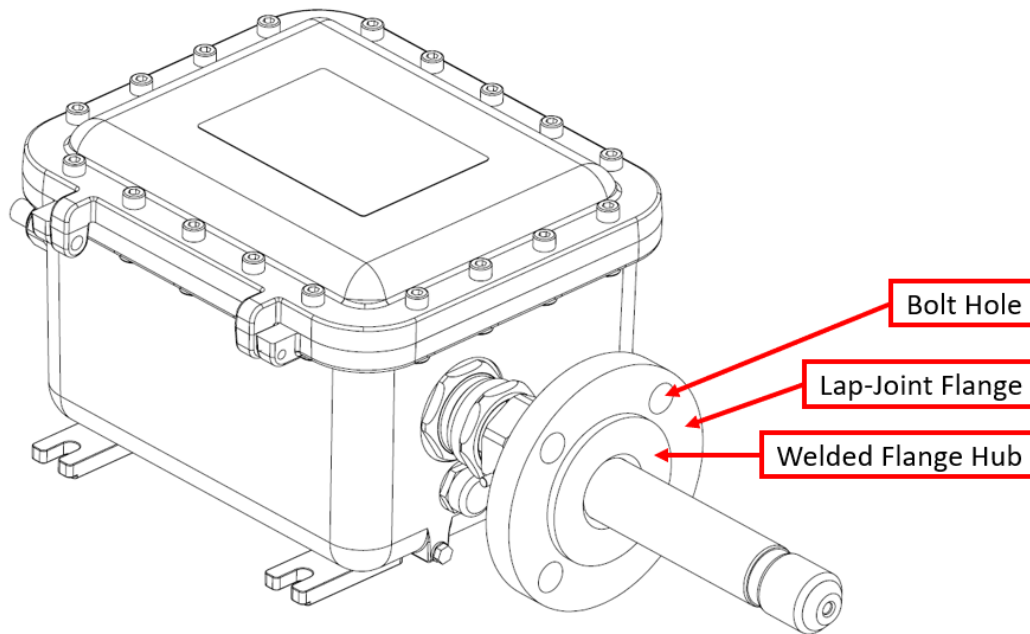


Figure 25: Welded hub for lap joint flange

5.3.1. Safety




 WARNING	<p>The flange and hub form a seal with the process pipework and as such are safety critical to prevent an accidental discharge of the process media. Keit recommends regular inspection of the integrity of the welds on the front and rear in line with local safety procedures.</p>
 CAUTION	<p>The spectrometer weighs ~18kg. The flange must not be used to support the instrument on process pipework. Doing so risks damage to the spectrometer and excess stress on the piping system.</p>
 WARNING	<p>Pipe flanges' permitted working pressures are temperature dependent in accordance with the relevant standard (ANSI/ASME B16.5 or EN 1092-1).</p>

Table 6 - Specifications and safety limits (welded flange probe)

Parameter	Welded Flange Probe
Pressure	This is limited by the ASME B16.5-2020 Pipe Flanges and Flanged Fittings Standard. Pressure derated with temperature.
Analyte Temperature	Refer to IRmadilloEx product label
Probe Body Material	Hastelloy C276
Welded-Hub Material	Hastelloy C276
Lap-Joint Flange Material	Hastelloy C276 or stainless steel
Gasket Material	Customer supplied. Material must be to specification of standard ANSI B16.21 or EN equivalent
Port Size	Nominal pipe size: 2 inches

5.3.2. Installation

The sealing face on the probe requires a gasket to mate against the flange on the process pipework. The gasket material must be chosen to be compatible with the pressure and temperature range of the process media and must be chemically compatible.

	WARNING	Choice of gasket material must be appropriate for the chemistry and process being used.
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The probe body and hub are manufactured from Hastelloy as standard, which is resistant to many aggressive chemicals. **However, you are advised to check with Keit before installing on a new process.**

Before beginning installation, ensure that the gasket is in good condition and that the sealing faces are not scratched or dented.

Support the spectrometer on a suitable mounting frame that aligns the probe with the flange port that it will be fitted to. Avoid applying stress to the probe, weld, or flange by ensuring that the sealing face of the hub sits flush against the gasket and sealing face of the mating flange before fitting any mounting bolts to the flange.

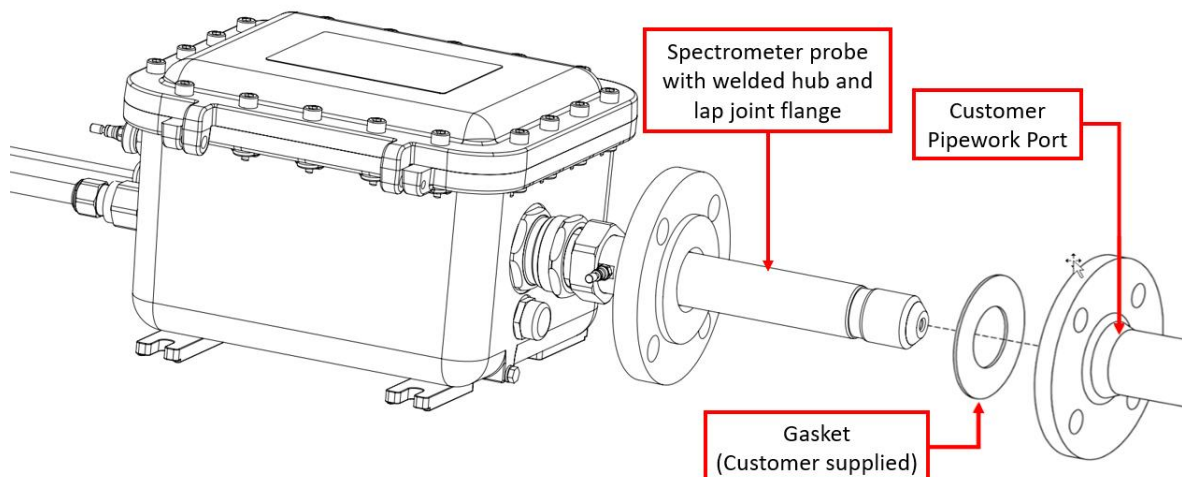


Figure 26: Fitting a flanged probe to process pipework

Once the spectrometer is aligned with the port, fit appropriate bolts as specified in the relevant standard, and tighten in stages in the order shown below.

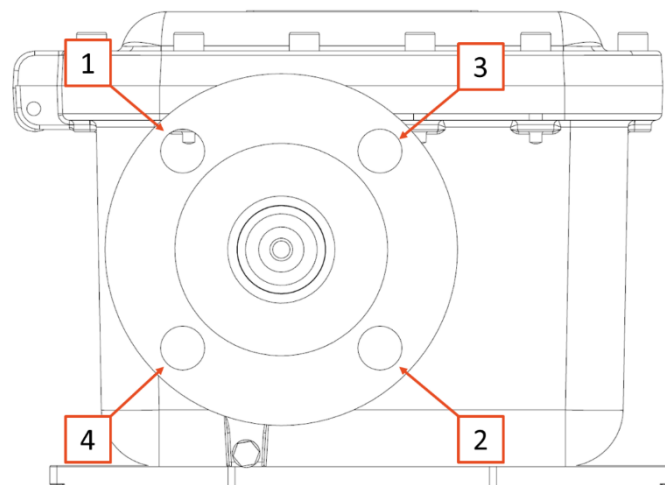


Figure 27: Front view of lap-joint flange, hub and bolt holes. Tighten bolts in steps in order 1-2-3-4 to ensure even compression of the gasket

Ensure that the bolts are sufficiently tight to prevent a leak from your pipework.

5.3.3. Maintenance

Keit recommends regular inspection of the integrity of the welds on the front and rear in line with local safety procedures.

Inspection of the sealing weld will require removal of the flange and spectrometer from the pressure vessel and can be completed as part of regular inspection/maintenance of the spectrometer and pipework.

Do not use impact (e.g. a hammer) to separate components if the gasket becomes stuck to the flange and hub.

The lap-joint flange may be manufactured from Hastelloy or stainless steel. Care should be exercised to ensure that it is not corroded by aggressive chemicals during maintenance or installation.

5.4. Inclined Stand - ASM0916



WARNING

Not Ex certified

The inclined stand is designed for using the spectrometer as a bench top instrument for offline sampling. Angled at 35°, the probe can be positioned into beakers or other vessels for ease of use. It can also be configured for two heights to give added flexibility in how it is used.

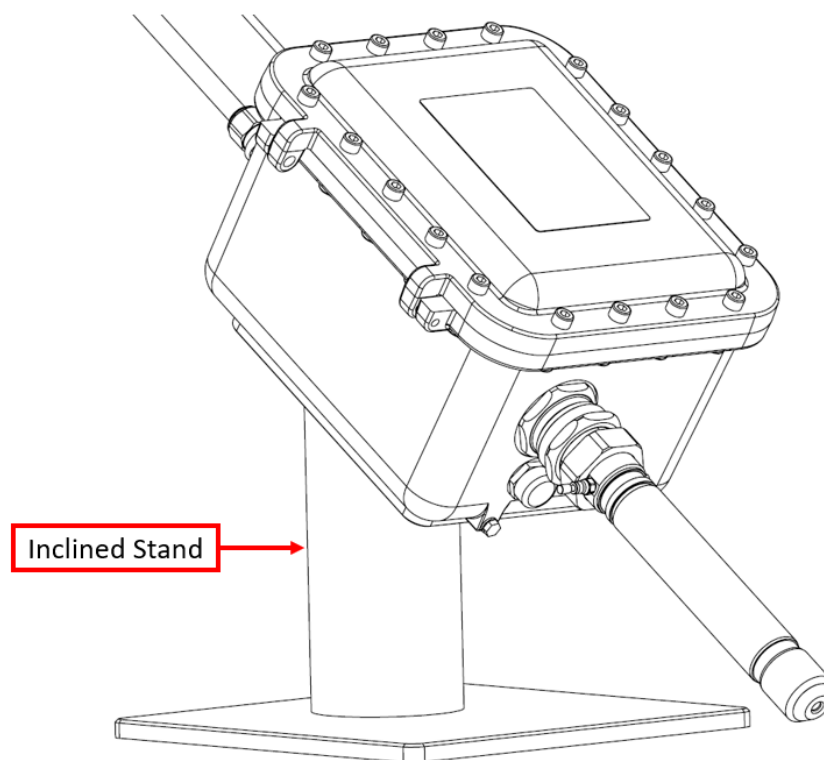


Figure 28: IRmadilloEx on an inclined stand

5.4.1. Safety



WARNING

The spectrometer and inclined stand assembly weighs ~24kg. Use caution when handling to avoid injury.

5.4.2. Installation

Assemble the inclined stand to the desired height; two positions are possible. For technical drawings, contact Keit at support@keit.co.uk.

To install the inclined stand to the instrument, carefully roll the spectrometer over such that the mounting holes are pointed upward, the instrument should be disconnected from power coms and purge to avoid damage to the cables or twisting.

Position the inclined stand over the mounting points such that the mounting plate lines up with the instrument. The spectrometer is located with 4 screws through the corners of the stand into the mounting holes on the spectrometer.

Return the instrument to the correct orientation and connect the purge, the power cable, and communications cable/s.

6. TROUBLESHOOTING

If you encounter any issues either during installation or during use of the IRmadilloEx please contact Keit (support@keit.co.uk).

Below are some examples of issues that may be experienced with potential solutions to the problem.

Table 7 – Troubleshooting guide

Issue	Cause	Potential Solution
Software cannot connect to spectrometer	No power to spectrometer	Check mains power connection
	Fibre-optic link issue	Check integrity of the fibre-optic link, remake the fibre-optic connections or clean the fibre-optic connectors
Insensitive to analyte changes	ATR element not in sample	Ensure ATR element is properly immersed in sample to be analysed
Noise in spectra that doesn't disappear with longer sampling times	Background scan taken with insufficient averaging	Experiment with increased background scan acquisition time
Negative peaks in spectrum	Background scan taken with a dirty probe	Clean ATR element and take a new background scan.
Signal too noisy	Insufficient averaging	Experiment with increased averaging
Low / No signal	Instrument warming up	Allow the instrument to warm up for several minutes before checking raw spectrum. Recommended to allow 12 hr to fully warm up before use.
	Switch on from a very low or a high temperature	Allow to warm up for 12 hr before checking raw spectrum. It will take time to stabilise the internal temperature and you must wait for this to occur.
	Thermal shutdown activated operation outside of specification.	Contact Keit for advice on resetting the instrument
Appearance of unexplained features (characteristically seen at 1600 – 1700 cm⁻¹)	Water vapour present in instrument	Check that your purge gas specification is suitable and that your gas supply is free flowing with no blockages
		Check that any purge tubing is stainless steel or PTFE

Issue	Cause	Potential Solution
Unrepeatable measurements	Damage to ATR element	Contact Keit
	Contamination of ATR element	Clean the probe. See Section 2.4 Checking for warnings and checking the probe is clean
	Dip probe misaligned by inappropriate use	Contact Keit
	Analyte temperature changes	Some cross sensitivity is expected

APPENDIX 1: Controller Specifications

Physical details

Parameter / Feature	Description
Dimensions	See drawings below Optional mounting adaptors are available to fit a 2u 19" rack.
Operating Environment	The controller must be operated in a safe, non-hazardous environment. <ul style="list-style-type: none"> • T_{ambient}: 0°C to 50°C • Relative humidity: 5% to 90% at 25°C
Monitor Resolution	The recommended monitor resolution is 1280 x 1045 pixels or higher.
Mains Power	90 to 264 Volts AC, 47 to 63Hz Power consumption 20W (internal power supply rated to 60W)
Communications Link	Data communications between controller and spectrometer are through a multimode duplex fibre-optic lead with dual LC connectors available from Keit. The maximum possible length is determined by the fibre optic cable type used: Type OM1 (62.5/125µm): max length 275m



Depth

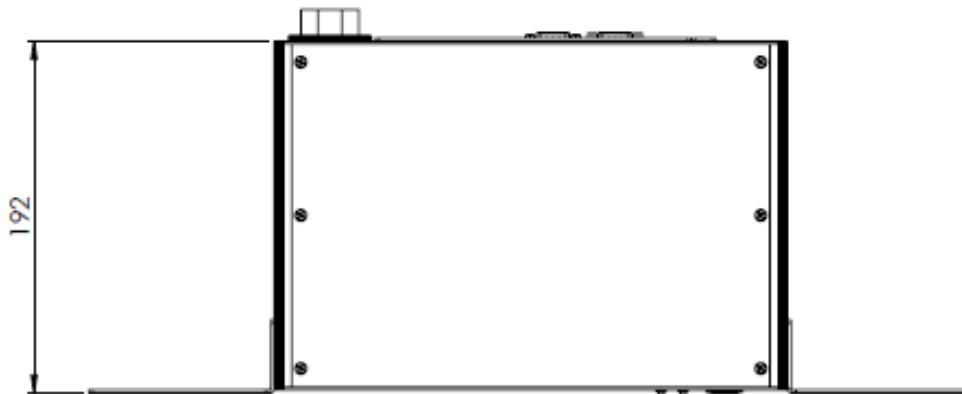


Figure 29 Plan view

Front panel

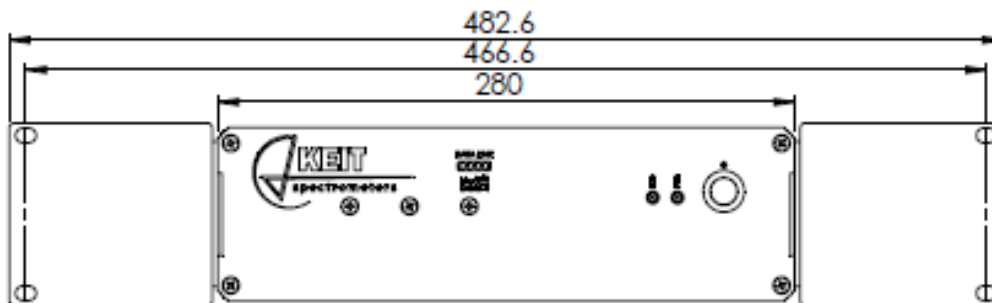


Figure 30 Front panel view

Indicator Label	Function
HDD	Hard Disk Drive active
PWR	Power ON
DATA LINK: PWR	LED blue when power is ON LED off when no power supplied
DATA LINK: LINK	LED green when fibre-optic link is established between controller and fibre-optic converter
DATA LINK: HOST	LED green (continuous) when fibre-optic converter is recognised by the controller LED green (blinking) when in suspend state
DATA LINK: ACTV	LED amber (flashing) when data transmission is active between fibre-optic converter and spectrometer LED off when in suspend mode

Rear panel

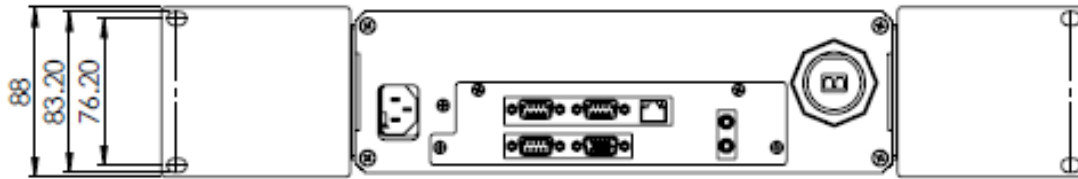


Figure 31 Rear panel view with blanking plate in position

Connections available:

- HMI: 1x VGA, 1x HDMI, PS2 keyboard, PS2 Mouse, Mic-in & Line-out
- USB:4 (2 x USB3.0, 2 x USB2.0)
- Networking: 2 x Gigabit LAN / Ethernet
- Serial Data: 3 x RS232/422/485 COM ports
- Mains Power

A removable blanking plate (shown in Figure 3) is fitted as standard with 4 retaining fasteners. This is to prevent tampering with 1 x Ethernet, 4 x USB, 2 x PS2 and HDMI ports.

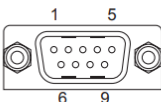
Information for Fibre Optic Patch Panel

The fibre-optic connectors are LC connectors manufactured by Souriau. If you wish to make a patch panel then a duplicate set of these will be required:

Existing Jam Nut Receptacle on rear of controller	UTS718LCN
New Required Plug	UTS6-JC18LCN

Wiring Pin Out for COM Ports

The COM ports are terminated with standard 9-way male D-sub Connector Plugs. The COM ports are configured in the BIOS by default to RS485 (RS232 and RS422 is available if required).

	Pin	RS232	RS422	RS485
	1	DCD	TX-	RTX-
	2	RXD	RX+	N/A
	3	TXD	TX+	RTX+
	4	DTR	RX-	N/A
	5	GND	GND	GND
	6	DSR	N/A	N/A
	7	RTS	N/A	N/A
	8	CTS	N/A	N/A
9	COM1: +5V/+12V/+5VSB COM2, 3: +5V/+12V	COM1: +5V/+12V/+5VSB COM2, 3: +5V/+12V	COM1: +5V/+12V/+5VSB COM2, 3: +5V/+12V	