



gasclam[®]

Continuous Borehole Gas Monitoring System

GasClam V8

USER MANUAL



SALAMANDER
GROUP

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1. Introduction to GasClam®



GasClam is the world's first in-situ continuous borehole gas monitor and logging instrument. It is an invaluable tool for detecting and recording the concentration of a wide range of gases commonly required in monitoring applications, including Methane (CH₄), Carbon Dioxide (CO₂), Oxygen (O₂), Carbon Monoxide (CO), Hydrogen Sulphide (H₂S) and Volatile Organic Compounds (VOC).

In addition to the selected gases, the GasClam also records temperature, barometric pressure and borehole pressure. An optional borehole water level sensor can be fitted to measure fluctuations in the water table should this data be required.

Samples can be taken at programmable intervals, providing an invaluable set of data. The GasClam's default setting is to take a sample every hour, giving it an operational life of approximately one month (using the rechargeable battery packs supplied) which can be extended up to 3 months (using optional proprietary long-life Lithium battery packs).

The GasClam can operate as either a stand-alone logger or real-time monitor linked to data acquisition systems (Telemetry) via an optional modem system or communication cable. Recorded data can be viewed using the GasClam software or exported for analysis to a spreadsheet.

The software is also used to setup the GasClam for logging, including logging intervals, total number of samples, power supply and venting options.

The GasClam itself is built to the highest standards with the outer casing from stainless steel, is intrinsically safe and is certified for use in explosive environments in hazardous zone 1 and conforms to International Protection code IP68.

Salamander Group Ltd recommends that users perform regular bump tests in conjunction with an annual service and calibration, which is provided by the Salamander Group service department or a Salamander Group approved service centre.

In this manual a Warning identifies conditions and actions that pose a hazard to the User or the Unit.



WARNING: Before using the GasClam you must read this and the software manual paying particular attention to the sections covering optimisation of GasClam performance and the effects of water.



WARNING: Do not connect or disconnect any cables in hazardous areas and do not use non-approved equipment in hazardous areas such as laptops, notebooks and mobile phones.



WARNING: For reasons of intrinsic safety, batteries MUST NOT be changed within hazardous areas. Always ensure you are in a safe area before carrying out any type of work on your GasClam.



WARNING: To maintain the Unit's certification and intrinsic safety use ONLY GasClam approved batteries, external power supply junction boxes and spare parts.

2. The GasClam

2.1. Package Contents

When first unpacking take a little time to check and examine the contents of the GasClam package:

- GasClam V5.8 Unit (with sensors and power options fitted – standard 2x Duracell)
- Power option (standard Charger, Power Supply and 2x Ni-MH rechargeable battery packs)
- Instrument Case and Strap
- Serial Communication Cable
- Push-Button Cable
- Allen key (no.5) for battery cover
- Box spanner for Barbs
- Allen key (no.4) for Vent Plug
- Vent Plug Set
- Spare Moisture Filters 2x
- Snorkel Set
- Spare Snorkel Filter
- CD Manual & Software, Calibration Certificate and Warranty

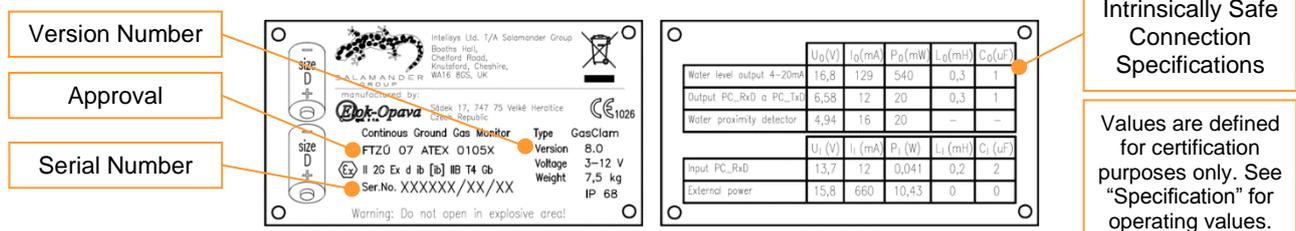


The GasClam is packed for transport with caps on the inlet, outlet and vent barbs, these **black caps** must be removed before the Unit is used. If it is intended to store the Unit for a longer period of time it is recommended to replace the caps on the barbs to stop moisture and dust ingress.

2.2. Parts Description



Identification Plates



Version Number

Approval

Serial Number

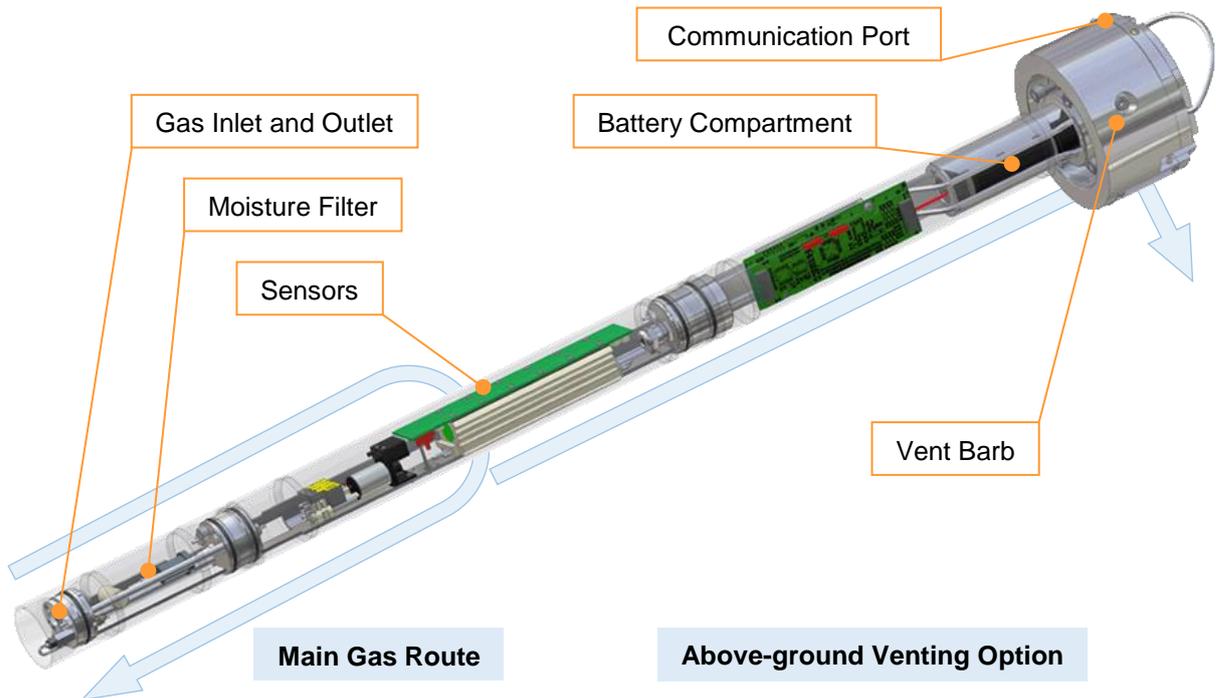
Intrinsically Safe Connection Specifications

Values are defined for certification purposes only. See "Specification" for operating values.

	U_0 (V)	I_0 (mA)	P_0 (mW)	L_0 (mH)	C_0 (μ F)
Water level output 4–20mA	16,8	129	540	0,3	1
Output_PC_Rx0 to PC_Tx0	6,58	12	20	0,3	1
Water proximity detector	4,94	16	20	–	–

	U_i (V)	I_i (mA)	P_i (W)	L_i (mH)	C_i (μ F)
Input_PC_RxD	13,7	12	0,041	0,2	2
External power	15,8	660	10,43	0	0

2.3. How the GasClam Works



When logging is started the GasClam instantly takes its first sample. A click is heard and then the pump starts which takes a sample of air from the borehole. First the pressure and temperature readings are taken. While the pump is on readings from gas flow sensors are taken. The pump then switches off and after a short pause readings from static gas sensors are taken. The whole process takes approximately 2 ½ minutes depending on sensor configuration.

A set of readings is created and stored in non-volatile memory, the number of readings varies with the number of sensors used. This set of readings is one “Sample”. The next sample can be taken after about ½ minute, hence the minimum interval between samples which is the “logging interval” is 3 minutes.

The sampled gas is returned back into the borehole, however if required, a venting system can open a pathway from the borehole to the atmosphere at specified intervals and for specified durations.

2.4. User Accessible Parts



WARNING: To ensure the GasClam’s intrinsic safety DO NOT dismantle or attempt any unauthorised servicing.

The GasClam has only two main User changeable parts: the Moisture Filter which is accessed by unscrewing the black Filter Cover tube (see section “Servicing”) and the batteries which are accessed by removing the Battery Cover Plate (see section “Changing Batteries”).

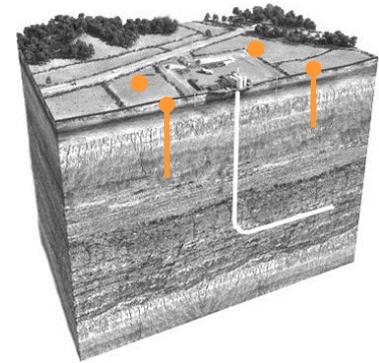


3. Planning Monitoring and Site Preparation

3.1. Number of Units and Site Layout

To achieve the required effectiveness of site monitoring the types of gases (see section “Specification”) and additional parameters including water level that need be monitored should be defined and the GasClam units need to be configured and calibrated accordingly prior to deployment in the field.

Also the number of GasClam units to be used and the location of the boreholes should be planned with consideration to access, ground water and possible flooding.

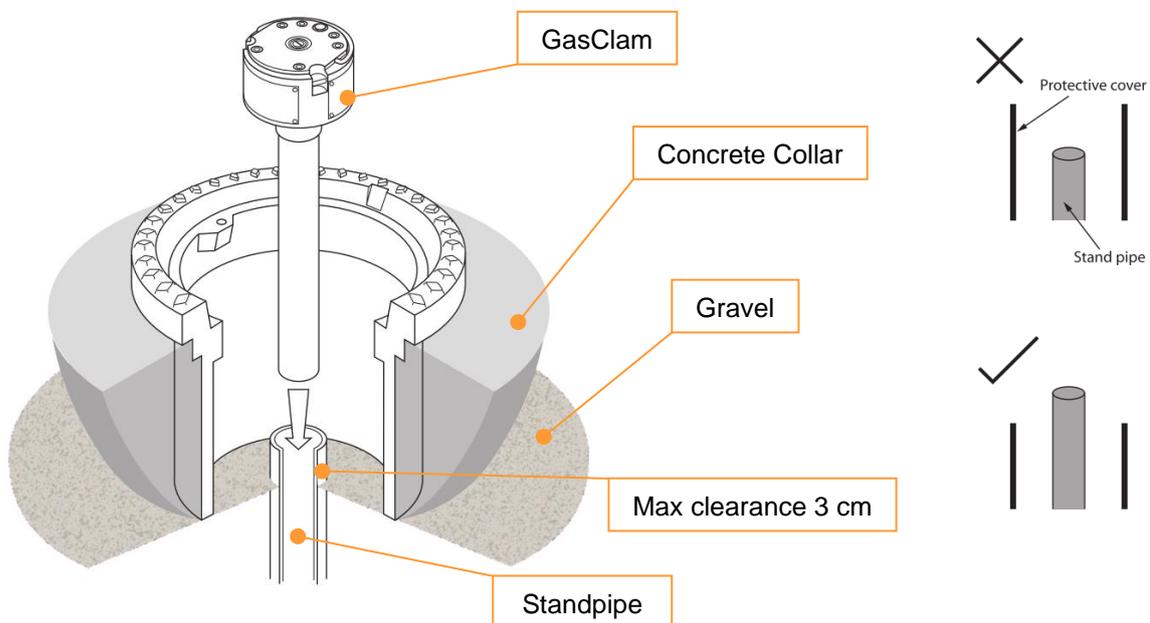


3.2. Hazardous Areas

It is important to define the extent of hazardous areas in accordance with national and local standards and how far these areas extend away from the boreholes where GasClams will be deployed.

3.3. Borehole Headworks

The GasClam is designed to fit in a 50 mm (2”) borehole. The recommended Headworks are 8” Monitoring wells from Stuart Wells (<http://wellservices.stuartgroup.ltd.uk/>) or a similar type and should be installed following the diagram below:



It is important to have the standpipe a maximum of 3 cm above the base of the Headworks, this will ensure the GasClam will fit under the lid of the cover. The Headworks must be concentric to the standpipe for the GasClam to be housed correctly. The standpipe must also be cut square to allow a good seal.

If a protective cover is to be used make sure this ends below the top of the standpipe otherwise the GasClam will not fit correctly.

4. GasClam Configuration and Setup

4.1. Software

Installation

The GasClam software will run on: Windows XP SP 2, Windows 7, Windows 8.0 and 8.1.

The GC software v6.1.5 (or higher) is on the CD (latest version can be provided by your service centre), it includes an installation package with .Net Framework 4 (x86) (downloadable also from the Microsoft website) and a PDF manual. The software needs 45 MB of free space on the hard disk for installation.



WARNING: All connections between the GasClam and a PC and all software settings must be performed outside the hazardous areas.

Function

The software is used to configure the GasClam for logging, downloading logging data, performing analysis and exporting data for more detailed analysis in other programs such as spreadsheets. The software is also used to perform periodic “Bump Test” and “User Calibration”.

The main settings are the logging interval, variable logging interval programme, the number of samples (sample count), the outlet gas venting method and whether a borehole water level sensor is fitted.

To help make data analysis easier the software can set each GasClam a “friendly” name. If more than one GasClam is being used on a monitoring site it is good practice to also label each GasClam so that they are not put in the wrong boreholes.



4.2. Power Supply Options

The GasClam can use 4 approved power sources:

- 2x 1.5 V Alkaline-Manganese Duracell - MN1300 (Alk-Mn) *(logging interval 3 minutes to 24 hours)*
- 2.6 V Nickle Metal Hydride rechargeable battery pack (Ni-MH) *(logging interval 3 minutes to 24 hours)*
- 7.2 V Lithium non-rechargeable battery pack (Li) *(logging interval 15 minutes to 24 hours)*
- 12 V External dc power supply (Ext) *(logging interval 3 minutes to 24 hours)*

The GasClam can operate as either a stand-alone logger or linked to a data acquisition system and the choice of power supply will also depend on cost, the frequency of site visits, the required logging interval, the requirement for online monitoring rather than just logging, the extent of the hazardous area etc.

The Ni-MH battery packs are rechargeable lasting up to a month with a 1-hour logging interval. The Li packs are non-rechargeable primary cells that can last up to 3 months with a 1-hour logging interval. The lifespan of individual types of battery packs depends on the logging interval, GasClam sensor configuration, operating temperature and for rechargeable packs in particular, age and time since they were last charged.

An external power supply is particularly useful if shorter logging intervals are required (sampling up to every 3 minutes) when a battery pack would not last a month and frequent site visits are not feasible. This option is also advantageous if remote monitoring is required either using the optional modem (which can also be powered externally) or external telemetry (see section “External Power”). Note: Moisture Filter life is dependent on logging interval.

The GasClam will automatically select the power source and adjust accordingly (see Software Manual).

4.3. External Power Supply



WARNING: The external power supply and communications can only be designed and installed by persons suitably qualified and trained while adhering to national and local standards and regulations.

A GasClam can be powered by an external power supply using either the optional “External Power and Com Cable” which is 10m long or for longer distances using the optional “Junction Box” and a suitable cable.

Either cable is then connected to the external power supply via barriers which must have the following parameters to maintain intrinsic safety.

External Power Supply Parameters

- Nominal Voltage U_n = 12V DC $\pm 10\%$
- Power Output P_n $\geq 5W$
- Maximum Voltage U_o $\leq 15.6V$
- Capacitance C_o $\geq 600pF + C$ cable
- Impedance L_o $\geq 0.2mH + L$ cable



WARNING: When using an external power supply the GasClam and the EGPRS Modem **MUST NOT** have a battery fitted.

4.4. Remote Data Acquisition (Telemetry)

4.4.1. Stand-alone

If remote access is required to data and GasClam settings for real time telemetry an optional EGPRS Modem can be connected directly to the GasClam Com Port. This forms a stand-alone solution where batteries are required for both the GasClam and the Modem.

4.4.2. Stand-alone with external power

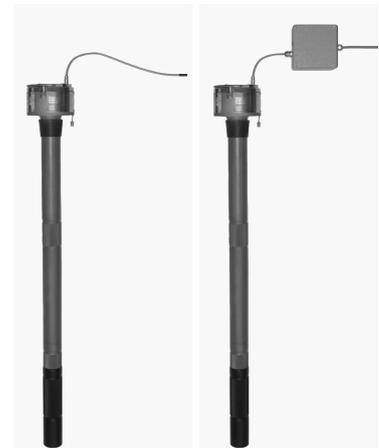
If the stand-alone solution requires monitoring with more frequent logging intervals which would be outside the capability of the battery packs it is also possible to power both the GasClam and EGPRS Modem at the same time via the optional “Junction Box”.

The external power supply and barriers must have the parameters defined above to maintain intrinsic safety.

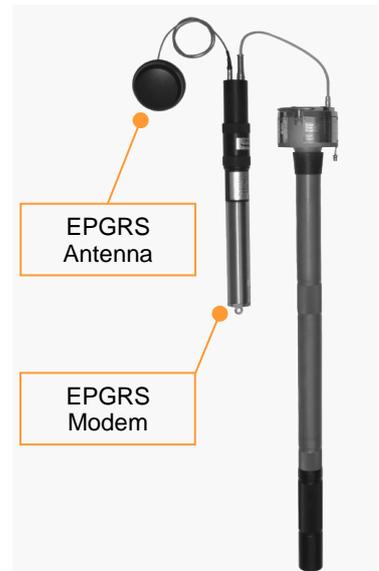
4.4.3. Custom remote data with external power

The optional “External Power and Com Cable” (as above) can also be used to access logging data or change GasClam settings from outside the hazardous area. Cable length is 10m which is the maximum guaranteed distance for the GasClam RS232 interface.

For further details concerning external power supplies, the EGPRS Modem and remote data acquisition please contact your local supplier or Salamander.



GasClams without batteries



EGPRS Antenna

EGPRS Modem



4.5. Battery Life and Sample Count

The battery life and the number of samples taken will depend on the battery type, the operating temperature, humidity and the logging interval.

All batteries will have reduced maximum lifespans at low temperatures.

Power Supply	Voltage [V]	Capacity [Ah]	Operating range [°C]	Maximum Number of Samples for Logging Interval ⁽¹⁾			Nominal Battery Life in days for Interval ⁽²⁾	
				5 min	15 min	1 hour	15 min	1 hour
Alkaline Duracell 2x	3.0	13.5	0 – 50	197	963	963	8	32
Ni-MH Rechargeable	2.6	9.5	0 – 40	680	666	666	5	23
Li Long Life	7.2	19.0	0 – 50	na	2937	2937	24	98

The average number of samples for each logging interval is shown (1). This value can vary depending on operating temperature, the number and type of gas sensors fitted in the GasClam and the state of the filters. These values are for temperatures at 20 °C with the maximum number of sensors and clean filters.

The “Nominal Battery Life” (2) is a conservative calculation of the number of days a battery will last under “nominal” conditions (battery is fully charged at the start of logging, operating temperature is 20 °C, the filters are clean) and using all the sensors. This value is 80% of the average value for 15min and 1 hour logging intervals. Other factors such as relative humidity can also affect the battery lifespan (see below).

4.5.1. Alkaline Batteries

The GasClam is fitted with Alkaline batteries for initial testing and checks. However, for normal field work it is recommended to use either the Ni-MH rechargeable or Li long-life battery packs. The Duracell batteries can be stored in the instrument case as a reserve and can be used when the rechargeable battery has not been charged and the GasClam must be deployed immediately. Alkaline batteries have a long “shelf life” but do not use after the date shown on the battery. Short logging intervals will reduce the maximum number of samples taken.

4.5.2. Ni-MH Rechargeable

The Ni-MH rechargeable battery packs should be fully charged using the charger provided (see instructions) and used for logging as soon as possible. Rechargeable batteries do not have a long “shelf life” as they will self-discharge over time.

This also means that battery life is not proportional with an increase in logging interval, e.g. if the logging interval is increased from 1 hour to 12 hours the nominal battery life will not increase 12 times to 276 days (9 months). The NiMH batteries self-discharge at a rate of 15% - 20% per month.

To obtain the maximum working life from the Ni-MH battery packs it is recommended that they are always first fully discharged and then charged using the charger provided (see Charger instructions). Also Ni-MH battery packs should be charged at least once every 6 months even if they are not being used.

4.5.3. Li Long-Life

The Long-life battery pack will last up to 3 months at an hourly logging interval. Only the Li battery pack has a restriction on the minimum logging interval that can be used and that is 15 minutes.

The Li battery pack has a built-in fuse to maintain intrinsic safety and if the GasClam is switched on/off rapidly using the Push-button cable in rare cases this can cause the fuse to blow. If the GasClam does not react with a Li battery pack first check the battery using a voltmeter.

Adhere to the conditions of use and safety instructions enclosed with the Li battery packs.

4.6. The Effects of Temperature and Humidity on Sample Count

To ensure that the gas sample is dry before measurement by the CH₄ and CO₂ sensors a Moisture Filter is fitted in the GasClam. Over time this will hydrate and its ability to remove moisture will decrease. If moisture is not successfully removed, concentration readings can be affected. The amount of samples that can be taken will depend on temperature and humidity. The table below shows how many samples can be taken at 90% Relative Humidity (RH) at different temperatures (90% RH is assumed to be worst case).

Temperature °C	1°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	38°C
Samples at 90% RH	3455	2620	1850	1320	950	700	520	390	330

Typically, temperatures in a borehole will not go below 3°C and will not exceed 15°C however, this will depend on installation. If the GasClam is used above ground then temperatures can vary more widely.

The Ni-MH rechargeable battery on the GasClam lasts approximately 670 samples. To ensure the GasClam does not take more samples than the filters capacity use the table above to set the sample count (see Software “Setup”), e.g. if the borehole is at 30°C set the sample number to less than 520.

It is unlikely that RH in a borehole will exceed 90% all the time and to help assess how to manage the filter after the first installation there is an indicator system. The indicators work differently below 30°C and above 30°C (see section “Servicing”).

4.7. Temperatures Below 0°C

If the temperature drops below 0°C and there is high humidity the valves in the GasClam may freeze and prevent correct sampling and a pump error will be flagged. This will not damage the GasClam; when temperature rises above 0°C it will function correctly (see section “Fault Finding”).

Typically the GasClam is installed in boreholes below the ground and the GasClam will not go below 0°C due to ground heat. If the GasClam is installed above the ground, insulation or a heater will be needed to prevent freezing. If you are unsure about your GasClam installation contact your local supplier.

4.8. The Effects of Water on a GasClam

The GasClam is designed to:

- measure gas concentrations,
- measure borehole and atmospheric pressure,
- allow a venting pathway between the borehole and atmosphere,
- the GasClam software enables a selection of venting options.

To measure gas concentrations the gas must be dry and measurements of atmospheric pressure should not include the pressure of overlying water. As the GasClam can be in a position liable to flooding from above (flooded Headworks) and below (borehole water level) it is necessary to:

- carrying out simple preventive and remedial maintenance and
- being aware of the limitations of data gathered under flood conditions.

4.9. How the GasClam Prevents Water Entering From Below

To prevent water entering the GasClam from below a water proximity sensor is situated below the gas inlet. If water rises up the borehole and comes into contact with the proximity sensor the GasClam will pause logging. When water level drops GasClam will resume logging after 1 hour.

To prevent water from reaching the gas inlet barb and flooding the GasClam, the Filter Cover creates an air pocket at the base of the GasClam (Always check to see if the cover is not damaged or cracked as this could then let water in).

The air pocket should stop water from reaching the gas inlet for at least 7 days when the GasClam is completely submerged with 20 cm of water above its head. If the GasClam is immersed for longer, the User must check to ensure water has not reached the inlet barb before restarting the GasClam. If the User suspects that water may have reached the gas inlet they must contact their local service centre.



NOTE: The water proximity sensor works on the principle of conductivity and when water comes into contact with the sensor it completes the circuit switching off the GasClam. If a non-conducting fluid, such as oil, is floating on top of the water in a borehole the water proximity sensor will not detect it and therefore it can be sucked into the GasClam.

4.10. How the GasClam Prevents Water Entering From Above

To prevent water reaching the vent pathway the Snorkel Set should always be attached to the Vent Barb. The open end tube should be supported so it is located at the top of the Headworks to reduce the chance of water ingress.

In locations where the Headworks are likely to be flooded the Vent Barb must be replaced with the Vent Plug. The supplied box spanner is used to remove the Vent Barb and the supplied Alan key (no.4) used to insert the Vent Plug and washer.

If the Vent Plug is inserted it should be configured in the software (see software "Setup"). Atmospheric pressure will not be recorded in this mode.



4.11. Optimising GasClam Performance

Read the 'Cross sensitivities and sensor performance' section to understand how each gas is detected and the implication of environmental conditions on their detection.

Understand the implication on sampling and bump testing if a 5% CO₂ sensor is installed (see section "Technical Specification").

Periodically (on a monthly basis) the GasClam should be removed from the borehole if installed for long periods and checked (see section "Site Visit").

If conditions of 85% RH and 40°C have persisted for more than 10 days the H₂S, CO and O₂ sensors may need to be reconditioned (see section "Service").

The GasClam software (see Software Manual) offers a selection of venting options during logging.



5. Start Monitoring

5.1. Changing Batteries



WARNING: For reasons of intrinsic safety, batteries MUST NOT be changed within hazardous areas. Always ensure you are in a safe area before carrying out any type of work on your GasClam.



WARNING: To maintain the Unit's certification and intrinsic safety use ONLY GasClam approved batteries.

The battery compartment is accessed by loosening the four (no.5) Allen key bolts on the Battery Cover Plate – *note that the bolts do not unscrew completely, they remain with the plate.*

To replace batteries follow the instructions below:

- 1) First clamp the Battery Cover Plate so that the spring under the plate does not exert unequal force on the bolts ensuring that bolts loosen smoothly without forcing the thread.

This can be done by clamping the plate with the thumb on the “GasClam” logo and the rest of the fingers under the head.

- 2) Loosen the bolts first by applying force on the long end of the Allen key in a cross pattern (1,2,3,4).
- 3) When the bolts are loose and while still clamping the Battery Cover Plate unscrew fully.
- 4) To remove the batteries tilt the GasClam until they slide out.
- 5) Replace with only GasClam approved batteries positive terminal facing DOWN into the GasClam.
- 6) Check the integrity of the O-ring, if damaged it MUST be replaced. The O-ring should be checked every time the batteries are replaced.
- 7) When the O-ring is resting on the battery compartment push the cover plate down evenly to ensure it travels down square. This will prevent damage to the O-ring.

The cover plate must sit flush with the head of the GasClam otherwise the intrinsic safety of the unit will be compromised.

- 8) Again clamp the plate with the thumb on the “GasClam” logo and the rest of the fingers under the head.
- 9) First tighten the bolts by hand taking care that the bolts tighten smoothly without crossing the threads.
- 10) When the bolts are finger tight use the Allen Key, alternate between the bolts in a cross pattern (1,2,3,4) applying moderate force on the short end of the Allen Key.
- 11) Repeat this several times tightening the bolts in a cross pattern.
- 12) When the bolts are tight repeat one more time applying moderate force on the long end of the Allen key.



If this procedure is not followed carefully, damage to the O-ring may be caused compromising the intrinsic safety of the Unit.



WARNING: Do not connect or disconnect any cables in hazardous areas and do not use non-approved equipment in hazardous areas such as laptops, notebooks and mobile phones.

5.2. Connecting the GasClam to a PC

Whilst the GasClam is outside the hazardous area it can be programmed using a computer with the GasClam software (see Software Manual). This is done using the Serial Communication Cable (supplied) and an RS232-USB converter (not supplied).

- 1) Remove the cap from the Com Port on the GasClam. Carefully connect the Serial Communication Cable ensuring that the two red dots are aligned, then push for a firm click.
- 2) Connect the Serial Communication Cable to the RS232 converter and connect to the USB port of the computer (the RS232 convert will need to install drivers the first time it is connected to the computer).
- 3) Start the GasClam software either using the desktop icon or from the start menu.



5.3. Check Voltages and Settings

The GasClam will automatically detect the power source when it is first inserted and adjust accordingly (after a see Software Manual).

After new batteries have been inserted check in the “Home” window that the appropriate power source has been selected by the GasClam in the line “Power Source” and that “Power Status” meter is showing the correct voltage:

Alkaline Duracell: New above **3 V**.

Ni-MH rechargeable: Fully recharged **2.5 – 2.7 V**.

Li Long-life: New battery pack **7.0 – 7.2 V**.

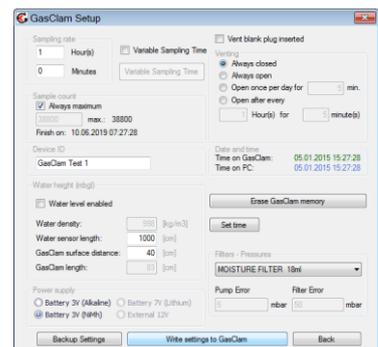
After ensuring that the battery type and voltage corresponds with the newly fitted batteries, proceed to set up the GasClam for the monitoring application (and specific borehole) by clicking on the “Setup” button in the “Home” window.

In the “Setup” window first check that the time and date are correct, that if a water level sensor is fitted it is selected, that the correct venting option is selected and then add a friendly name for the GasClam. After configuring the GasClam then setup the logging intervals and sample counts required. When finished, write the setup to the GasClam.

Check the settings in the “Home” window then run one test sample. Afterwards check that the status is “Sleeping”. Switch off the software, disconnect the Serial Communication Cable and replace the Com Port Cap on the GasClam.

Check that the black Barb Caps have been removed.

The GasClam is ready for deployment.



5.4. Installing the GasClam in a Borehole

Using the Lifting Handle carefully lower the GasClam into the borehole and check that it sits in the standpipe smoothly with the Rubber Collar forming a good seal.

Ensure that either a Snorkel Set or the Vent Plug is fitted.

If a water level sensor is to be used first hook it and then connect it to the GasClam outside the hazardous area. Take the GasClam with the water level sensor to the borehole. First lower the sensor and then the GasClam again ensuring a good fit with the Rubber Collar and the standpipe (see water level sensor instructions).



5.5. Turning the GasClam On

The only way to manually start the GasClam when it has been deployed is to use the supplied **Push-Button Cable**. It connects to the Com Port on the head of the GasClam in the same way as the Serial Communication Cable.

It is intrinsically safe and is the **ONLY** piece of equipment that can be connected and disconnected from the Unit in a hazardous area.

To start the GasClam, hold the button down for two seconds, the red LED will flash rapidly indicating the GasClam has started logging and is currently sampling.

After sampling has finished (approximately 3 minutes) the red LED flashes intermittently indicating that the GasClam is Logging but between Samples.

To stop the GasClam, press the button for two seconds, the red LED will stop flashing indicating that the GasClam is "Sleeping".

The Push-Button cable can also be used to perform occasional checks of the state of the GasClam without the need to take the Unit out of the borehole.



No flashing	Sleeping / Off
Rapid flash	Sampling
Intermittent flash	Logging on

It is recommended that when a GasClam is deployed and logging is first started to check that the LED starts to flash rapidly indicating that sampling has started and then to wait until the LED starts to flash intermittently indicating that the first sample has finished before disconnecting the Push-Button Cable.

Alternatively

Alternatively if using the optional modem installed next to and connected to the GasClam, logging is started and stopped automatically remotely via the modem.

Or remotely from outside the hazardous area using the approved external connector cable with appropriate barriers. This is usually installed in conjunction with an external power supply also with appropriate barriers (see section External Power).

5.6. Leaving the Site

When leaving a borehole check that:

- 1) the Snorkel Set is fitted correctly and above the flood level,
- 2) the Com Port Cap is fitted to prevent dust in the socket,
- 3) the Headworks cover has been securely fitted.

6. Site Visits



WARNING: Do not connect or disconnect any cables in the hazardous area and do not use non-approved equipment in the hazardous area such as laptops, notebooks and mobile phones.



WARNING: Before removing the GasClam from the field it must be run at least once (purged) in a non-hazardous atmosphere to clear any hazardous gasses from the unit.

6.1. Regular Checks

It is recommended that at least once a month (or sooner depending on the power option and logging interval) the GasClam is safely removed from the borehole and inspected outside the hazardous area in a dry location. When removed:

- Inspect the GasClam for any signs of wear and tear (especially the Filter Cover Tube).
- Check for signs of water ingress prior to purging the unit (see section “Effects of Flooding”).
- If there are no signs of water ingress, purge the unit.
- Download and backup the logging data.
- Check the data for any faults (see Software Manual) and if required take appropriate action.
- Change batteries if required and check the integrity of the battery O-ring.
- Check and change the Moisture Filter if required (see section “Service”).
- Perform a Bump Test on the sensor channels if required (see Software Manual).

Note: If conditions of 85% and higher RH and +40°C are expected to have persisted for more than 10 days the H₂S, CO and O₂ sensors may need to be reconditioned (see section “Specification”).

6.2. Data Retrieval

Manual Download

Remove the GasClam from the borehole using the Lifting Handel. Take the GasClam outside the hazardous area.

Under no circumstances take or connect a laptop to the GasClam in a hazardous area!

Place the GasClam on a clean dry surface and wipe the head around the Com Port Cap if dirty. Connect the GasClam to the PC using procedure previously described.

Download the data using the software as described in the Software Manual. Sampling will cease when the GasClam logging memory is full. Ensure memory is cleared for extended sampling once logging data has been checked, validated and backed-up.

Automatic Telemetry

If the optional modem or external power source is used with data then site visits are not required to download data. However it is best practice to visit the site every month to ensure that the unit and the systems is in good working order.



6.3. Leaving the Site

When leaving the site after a regular visit, check as before. If leaving the site after monitoring is complete ensure that the borehole is secured safely and not open.

7. Calibration, Servicing and Storage

7.1. Unit Calibration and Service

To ensure correct and accurate operation it is recommended that the GasClam should be recalibrated and serviced every 12 months (or sooner depending on the logging interval and sensor configuration). The GasClam is ATEX certified for use in potentially explosive areas, therefore it must only be serviced and fully calibrated by an authorised GasClam service centre. Failure to do so will invalidate the warranty and may invalidate the certification.

A single point user calibration is available by using the software (see Software Manual).

7.2. Storing the GasClam when Not In Use

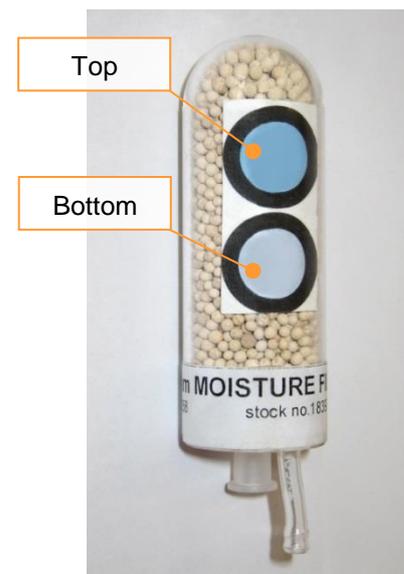
When the GasClam is not in use it should be cleaned thoroughly, run for several cycles in clean preferably dry air, the batteries removed and placed in the instrument case. If it is intended to store the Unit for a longer period it is recommended to replace the caps on the barbs to stop moisture and dust ingress. When storing for a longer period (more than 3 month) the GasClam should be fitted with 2x 1.5 V Alkaline-Manganese Duracell - MN1300 (Alk-Mn) batteries to ensure the functionality of the electronics

7.3. Filter Management

Below 30°C the bottom indicator turns pink after approximately 40% of filter life and the top turns pink after 50% of filter life. For 15°C and 90% RH, the indicators will change in accordance to the table below. Above 30°C and high humidity the indicators on the Moisture Filter correspond to less samples.

Environmental conditions	Max number of samples	Bottom indicator turns pink after: [samples]	Top indicator turns pink after: [samples]
15°C - 90% RH	1320	490	730
38°C - 98% RH	300	240	360

To assess if the filter needs to be replaced when the batteries are changed inspect the filter indicators. If both indicators are blue, the filter does not have to be replaced. The table below shows what actions to take depending on the state of the top and bottom indicators with respect to temperature and humidity.



Bottom indicator	Top indicator	Action at 15°C - 90% RH	Action at 38°C - 98% RH
Blue	Blue	Don't replace	Don't replace
Pink	Blue	Don't replace (probably need to replace next time)	<u>Replace</u>
Pink	Pink	<u>Replace</u> Check GasClam for signs of moisture in the unit. Contact local service centre if any signs of moisture within the GasClam or tubing.	<u>Replace</u> Check GasClam for signs of moisture in the unit. Contact local service centre if there are any signs of moisture within the GasClam or tubing. If sampling in the same borehole again reduce the total number of samples taken so both indicators do not turn pink.

If both indicators turn pink after 1 battery life (670 samples) contact your local supplier for sampling advice.

7.4. Inspecting and Replacing the Moisture Filter



WARNING: The GasClam must never be operated without the Moisture Filter.

To inspect the Moisture Filter follow the instructions below:

- 1) Place the GasClam on a table with the head down.
- 2) Carefully unscrew the black plastic Filter Cover using both hands placed on the knurled sections for better grip.
- 3) Check the colour of the indicators.
- 4) Check the sealing O-rings, if damaged replace immediately.
- 5) If the result is ok then screw the Filter Cover back on.

To replace the Moisture Filter follow the instructions below:

- 1) Place the GasClam on a table with the head down.
- 2) Carefully unscrew the black plastic Filter Cover.
- 3) Using both hands, put the thumbs beneath the filter and push it up and out of the connecting barb and nozzle.
- 4) Leaning the new filter to right and first connect the tube (Tygon) to the barb.
- 5) Push the tube firmly down on the barb.
- 6) Lean the filter back upright making sure the other inlet sits down on the nozzle.
- 7) Push the filter completely down firmly from the top.
- 8) Run the “Leak Test” from the software to check that the system is correctly sealed.
- 9) Check the sealing O-rings, if damaged replace immediately.
- 10) If the result is ok then screw the Filter Cover back on.



7.5. User Serviceable Parts

7.5.1. Battery compartment O–ring:

When changing the batteries always inspect the O-ring on the Battery Cover Plate, if there is any sign of damage replace.

7.5.2. Moisture Filter

The GasClam must never be operated without a Moisture Filter! Follow the advice regarding Moisture Filter management and the instructions on how to change the filter.

7.5.3. Filter Compartment O–rings:

When inspecting the Moisture Filter check O-ring 1 and 2, if there are any signs of damage replace the corresponding O-ring immediately.

7.5.4. Snorkel

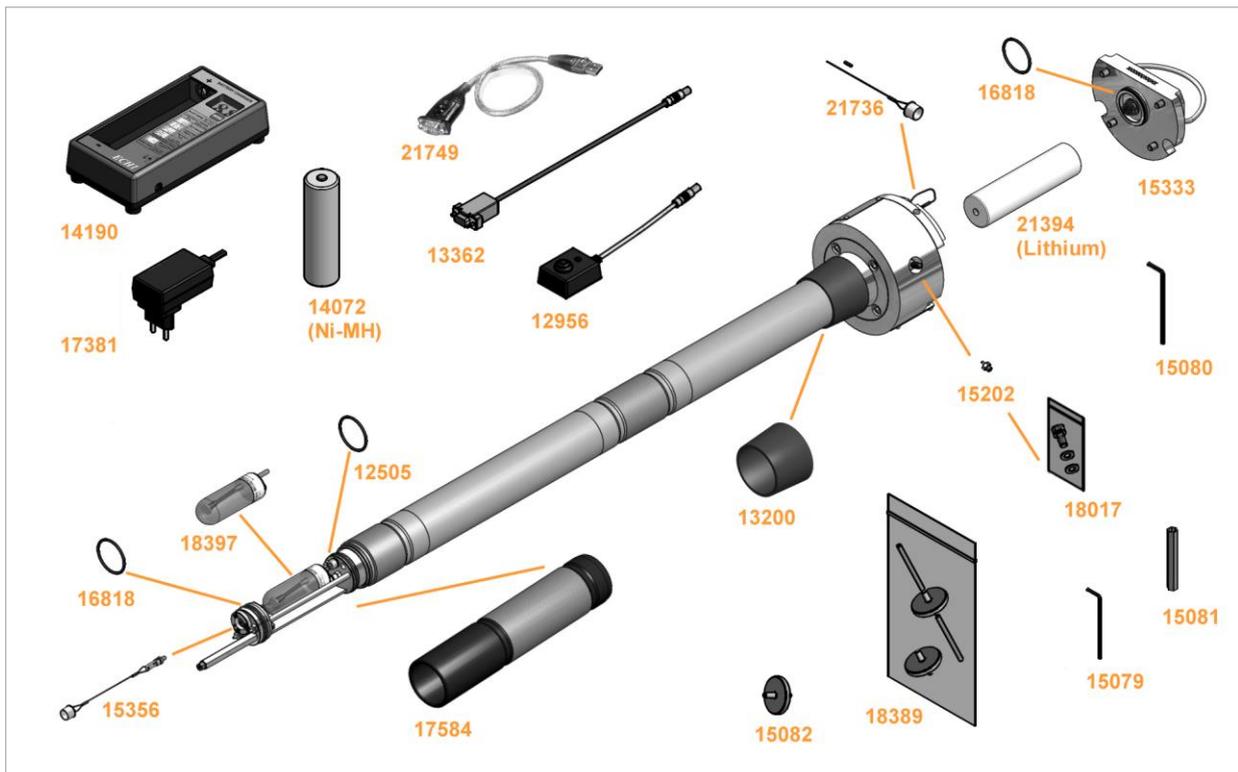
The snorkel should be checked regularly, if there is any damage replace immediately.

7.5.5. Rubber Collar

Inspect the collar regularly, if there is any signs of damage replace immediately.

7.6. User Spare Parts

Item	Part no.	Description
1	13362	Serial Communication Cable (2m)
2	12956	Push-Button Cable (1m)
3	13200	Rubber Collar
4	18397	Moisture Filter (18ml)
5	18389	Snorkel Set
6	15082	Snorkel Filter
7	18017	Vent Plug Set
8	15202	Barb (Vent, Inlet and Outlet)
9	14072	Battery Pack NiMH L1X2 (2.4V - Rechargeable)
10	14190	Battery Charger ECH 1.1
11	17381	Battery Charger Power Supply
12	21394	Battery Pack Lithium Primary Li72-190F
13	17584	Moisture Filter Cover (Plastic)
14	21736	Communication Port Cap and Lanyard
15	15356	Water Level Sensor Cap and Lanyard
16	16181	O-Ring 1 and O-Ring Battery Cover (∅ 032 x 2 mm)
17	12505	O-Ring 2 (∅ 033 x 2 mm)
18	15333	Battery Cover Plate (Complete)
19	15080	Allen Key no.5 (Battery Cover)
20	15081	Box Spanner no.7 (Vent Barb)
21	15079	Allen key no.4 (Vent Plug)
22	21749	ATEN – USB-RS232 Converter



8. Fault Finding

8.1. Software

The primary fault finding tool is the “Error Log” which can be checked after downloading a set of logging data and the “Error Box” in the software’s home window (see Software Manual).

8.2. The Effects of Flooding on Data and the GasClam

When the GasClam unit is not taking any samples it has a protection rating of IP68, however immersion will effect data and may require subsequent corrective action.

These effects and requirements will differ whether immersed from above (flooded Headworks) or from below (rise in borehole water level) see table below:

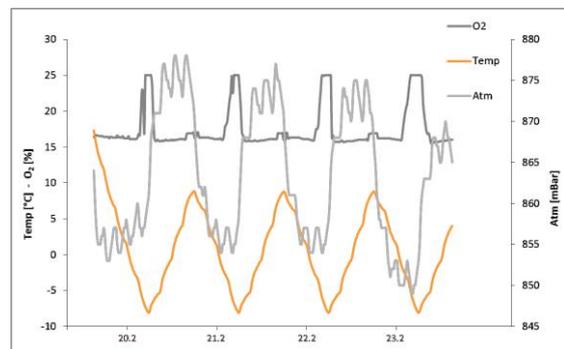
Flooded Headworks		Remedial Action	Preventive Maintenance
Effects on data	Should Vent breather be submerged: <ul style="list-style-type: none"> • Atmospheric pressure readings will be incorrect. • Scheduled venting will be ineffective. 	To replace lost atmospheric data use borehole pressure as an approximate replacement or use data from another source.	If the chamber is known to flood, or is already full of water: <ul style="list-style-type: none"> • Choose another chamber. • Or replace the Snorkel with a Vent Plug.
Effects on GasClam	If submerged for an extended period the vent pipe may become flooded. The vent breather may become clogged by dirty water.	When the GasClam is visited check data and call the service centre if atmospheric pressure looks strange, they will advise.	If chamber is liable to flooding: <ul style="list-style-type: none"> • Replace Snorkel Filter each visit. • Position the Snorkel at a higher location.
Flooded Borehole		Remedial Action	Preventive Maintenance
Effects on data	Should water reach the base of the Unit the inflow and outflow valves will close, no samples will be taken: <ul style="list-style-type: none"> • Borehole pressure readings will be incorrect. • Gas concentration readings will be incorrect. 	Data points for the set logging interval will be marked when samples have not been taken.	If borehole water level is known to be high or is already full of water: <ul style="list-style-type: none"> • Choose another chamber. • Or extend the borehole above ground level.
Effects on GasClam	Should water reach the base of the GasClam the water proximity (flooding) sensor will react and the inflow and outflow valves will close and no samples will be taken. A flooding error will be flagged up in the software.	None	Every time a GasClam is removed from a borehole the inlet barb should be checked to see if a water droplet is on it. If so dry with a cloth. If there is any chance that water may have entered the inlet contact your local service centre and DO NOT start or purge the GasClam.

8.3. Potential Problems when GasClam used Below 0°C

If the temperature of the body of the GasClam drops below 0°C and there is high humidity the valves inside may freeze and prevent correct sampling. This will not damage the GasClam and when temperatures rise above 0°C it will function correctly.

Another indication that the valves have frozen is that the O₂ sensor will go off scale either positively or negatively and the atmospheric pressure reading will also dramatically increase.

The graph illustrates a cycle between -10 and 10 °C at 98% RH. When the temperature reaches -5°C O₂ goes off scale positively and atmospheric pressure increases by 20 mBar. When temperature rises the valve thaws and O₂ concentrations are correct.



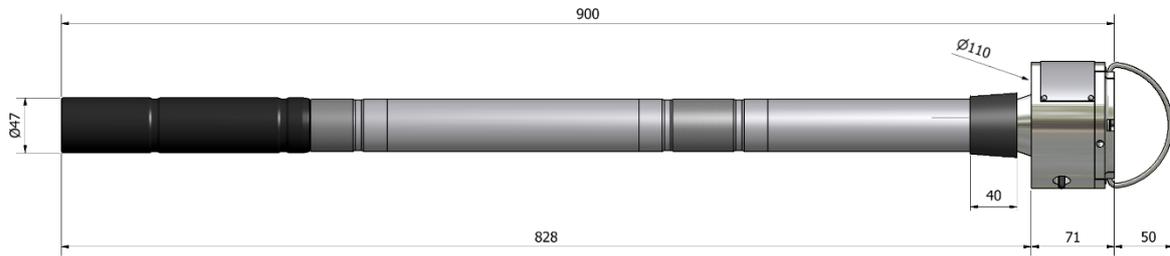
9. Technical Specification

9.1. General Specification

GasClam	V8
Material	Outer case and frame: High Quality Stainless Steel. Filter Cover: PP plastic
Weight	7.5 kg (16.8 lb)
Dimensions	Overall length 90 cm, head \varnothing 11 cm
Ingress Protection	IP 68 (continuous submersion, 20 cm above the GasClam head for 7 days)
Working Environment	0 to +40 °C (32 to 104 °F) RH up to 95%
Storage Environment	+5 to +25 °C dry conditions
Power Supply Options	2x 1.5 V Alkaline-Manganese Duracell - MN1300 (Alk-Mn) – LR20 2.6 V Nickle Metal Hydride rechargeable battery pack (Ni-MH) – L1X2 7.2 V Lithium primary battery pack (Li) – Li72-190F 12 V External dc power supply (Ext) – 12V dc \pm 10% max 660 mA
Power Consumption	Sampling max 300 mA @ 12V Sleep 60 μ A @ 12V
Logging Interval	3 minutes to 24 hours (Lithium battery packs 15 minutes to 24 hours)
Internal Memory	Maximum 30,000 date/time stamped sample set, depending on configuration If errors are recorded maximum memory is reduced to 15,000 sample sets
Internal Memory Mode	Sampling will stop when the memory is full.
Date and Time	Internal clock
Sensors	5x gas sensors (plugin), 2x pressure, 1x temperature (built-in), water level (optional)
Communication	RS232 – 115200 baud
Configuration and Setup	GasClam Software v6.1.5
Approvals	CE, EMC
ATEX	-20 °C to +50 °C Alkaline batteries -10 °C to + 40 °C Ni-MH rechargeable battery pack -20 °C to +50 °C Li Long-life battery pack -20 °C to +50 °C External
Protection	II 2G Ex d ib [ib] IIB T4 Gb
Certificate number	FTZU 07 ATEX 0105 X
IECEX (Pending)	-20 °C to +50 °C Alkaline batteries -10 °C to + 40 °C Ni-MH rechargeable battery pack
Protection	Ex d ib [ib] IIB T4 Gb
Certificate Number	IECEX FTZU 09.0026
CSA C US (Pending)	-20 °C to +50 °C Alkaline batteries -10 °C to + 40 °C Ni-MH rechargeable battery pack
Protection	Class 1, Zone 1, Ex d ib IIB, T4 Class I, Zone I, AEx d ib IIB, T4
Certificate Number	2320892
Patent	European and Worldwide Patent granted

9.2. Dimensions

The main dimensions of the GasClam are show below (mm):



9.3. Built-in Sensors

Sensor	Type	Range	Resolution
Barometric Pressure	Piezoelectric	800 - 1250 mBar	1 mBar
Borehole Pressure	Piezoelectric	800 - 1250 mBar	1 mBar
Temperature	Internal Chip	-20 to +50 °C (-4 to 122 °F)	0.1°C (1°F)
Water depth (optional)	Piezoelectric	0 - 27 m	0.01 m

9.4. Gas Sensor Specifications

Position	Sensor	Type	Range	Resolution	Accuracy	Linearity
5	CO ₂	Infrared	0 - 100 %	1% above 50% 0.5% below 50%	± 2% FSD	± 2% FSD or 10% reading
5	CO ₂	Infrared	0 - 5%	-	-	-
4	CH ₄	Infrared	0 - 100 %	1% above 50% 0.5% below 50%	± 2% FSD	± 2% FSD or 10% reading
4	CH ₄		0 - 5%	-	-	-
3	O ₂	Electrochem	0 - 25 %	0.10%	± 5% of reading ± 1 digit	<1% O ₂ deviations @ 10% O ₂
2	CO	Electrochem	0 - 2000 ppm	1 ppm	<± 3ppm at 0 ± 5% at 250 ppm ± 10% full scale	± 5% 0 - 500ppm ± 10% full scale
2	H ₂ S	Electrochem	0 - 100 ppm	1 ppm	<± 1 ppm at 0 ± 2.5% at 50 ppm	± 5%
2	Dual CO	Electrochem	0 - 500 ppm	1 ppm	<± 3ppm at 0 ± 3% at 250 ppm	Linear at 0 and 400 ppm Error at full scale <15 ppm
	H ₂ S	Electrochem	0 - 200 ppm	1 ppm	<± 1 ppm at 0 ± 2% at 100 ppm	Linear at 0 and 100 ppm Error at full scale 0 to ± 4ppm
1	VOC	PID	0 - 6000 ppm	1 ppm	± 5% of reading ± 1 digit	± 5% to 100 ppm

Note: Specifications obtained under laboratory conditions of gas flow, temperature and humidity. Field performance is dependent on the correct installation procedures being followed, environmental conditions, frequent sensor cleaning and regular calibration. Some of the sensors have cross sensitivity, for more information contact your local supplier. Details are subject to change without notice.

9.5. Cross sensitivities and Sensor Performance:

9.5.1. 100% Carbon Dioxide (CO₂)

Carbon Dioxide is measured using an infrared sensor tuned to C=O. There are no other gasses commonly found in the subsurface that absorb infrared radiation at this wavelength, so the reading will not typically suffer from cross sensitivity.

9.5.2. 5% Carbon Dioxide (CO₂)

When sampling concentrations up to 5% the sensor will read 90% of the real value after one sample (typically this will be within error of the sensor). For example, if you are sampling every hour and the real concentration changes from 0% – 2.5% in 1 hour (which is unlikely) the sensor will read approximately 2.25%. In reality if low concentrations are present they will change much more gradually i.e.:

- Sample 1 Real concentration 0.0 Measured 0.000
- Sample 2 Real concentration 0.1 Measured 0.090 (within error)
- Sample 3 Real concentration 0.3 Measured 0.279 (within error)
- Sample 4 Real concentration 0.8 Measured 0.750 (within error)

When concentration decreases the reading will also be 90% of the real value after 1 sample. Below are examples when 4.7% CO₂ has been sampled and how the sensor/filter clears down in air.

- Sample 1 4.701 4.738 4.671
- Sample 2 0.326 0.29 0.468
- Sample 3 0.071 0.037 0.042

9.5.3. Methane (CH₄)

Methane is measured using an infrared detector tuned to C-H bonds. The sensor is calibrated using certified methane calibration gas and will give accurate readings providing no other C-H compounds are present. If additional hydrocarbons are present they will contribute to the reading.

9.5.4. Oxygen (O₂)

The oxygen sensor is a Galvanic sensor and very specific. It has a little cross sensitivity with CO₂, 5 % CO₂ only causes a 0.1% change in reading. Humidity has a small effect on output, between 0 % to 95% RH the % O₂ change is < 0.7 %. The sensor can work between 5 - 95 % RH continuously and 0 - 99% short term.

9.5.5. Single Carbon Monoxide (CO)

The Single CO sensor has a filter to reduce the cross sensitivity with H₂S, NO₂, NO and SO₂, the following are the filter capacities for the given gases:

- H₂S 250,000 ppm - hours
- NO₂ 600,000 ppm - hours
- NO 20,000 ppm - hours
- SO₂ 300,000 ppm - hours

50 ppm NO will read < 5 ppm

400 ppm H₂ @ 20°C will read < 60 ppm

400 ppm C₂H₂ will read < 25

9.5.6. Single Hydrogen Sulphide (H₂S)

The cross sensitivities with these gases are:

- 5 ppm NO₂ will read approximately -1 ppm on the H₂S Channel
- 50 ppm NO will read < 5 ppm on the H₂S Channel
- 20 ppm SO₂ will read < 4 ppm on the H₂S channel
- 400 ppm CO will read < 4 ppm on the H₂S channel
- 10 ppm Cl₂ will read < -25 ppm on the H₂S channel

9.5.7. Dual CO / H₂S Sensor

The CO and H₂S sensors are electrochemical sensors and suffer from cross sensitivity to other gases that may be found in the subsurface. The carbon monoxide sensor suffers in particular from the cross sensitivity with H₂S, H₂ and NO.

The cross sensitivities with these gases are:

- 15 ppm H₂S will read < 6 ppm on the CO channel
- 35 ppm NO will read < 0.1 ppm on the CO channel
- 100 ppm H₂ will read approx. 20 ppm on the CO channel

The hydrogen sulphide sensor is especially cross sensitive to the following:

- 5 ppm NO₂ will read approximately -1 ppm on the H₂S Channel
- 35 ppm NO will read < 1 ppm on the H₂S Channel
- 5 ppm SO₂ will read < 1 ppm on the H₂S channel
- 300 ppm CO will read < 6 ppm on the H₂S channel

If the sensors have been exposed to gases they are cross sensitive for long periods it may take some time for the sensors to recover. The sensors can be checked after exposure to these gases by setting the GasClam to sample every 5 minutes in clean air and the concentrations should return to zero and stabilise. If you suspect a cross sensitivity problem please contact your supplier for further advice.

9.5.8. Additional CO / H₂S sensor performance information

If the GasClam is located in a zero oxygen environment for longer than 24 hours the CO and H₂S sensor performance may be hindered. To return the channels to optimal performance the sensor needs to be left exposed to an oxygenated environment for the same length of time as it was deprived of oxygen for.

Above 85% RH and 40°C a maximum continuous exposure of 10 days is recommended. Where such exposure occurs the sensor will recover normal electrolyte volumes when allowed to rest at lower % RH and temperature for several days.

If very accurate CO or H₂S measurements are required it is recommended that a single CO or H₂S sensor is used.

9.5.9. Volatile Organic Compounds (VOC)

The VOC sensor is a mini photo ionisation detector (PID) and is sensitive to any VOCs that have an ionisation potential less than 10.6 eV. The sensitivity of the sensor depends on the VOC present. The sensor is calibrated to isobutylene and its response to other VOCs can be calculated using that compounds response factor. A response factor is a number, which relates the PID response to a particular VOC, to the PID response from the calibration gas (normally isobutylene). If the response of a PID to a particular VOC is eight times smaller than it is for the same concentration of isobutylene, then the response factor would be 8. Similarly, if the response factor for a particular VOC is 0.5, the response is twice that for isobutylene at the same concentration.

Concentrations greater than 4% CH₄ and CO₂ will attenuate the response of the PID sensor.

Some VOCs after ionisation may stick to the PID lamp reducing the amount of ultraviolet light available for future measurements. Before each PID measurement is made the lamp is turned on for 30s to burn the residual VOCs off. However, some VOCs may be more persistent and not completely removed, if this happens the PID response will decrease. To recondition the lamp, set the GasClam to sample every 3 minutes and run for 1 hour in clean air, then perform a bump test. If the sensor has not completely recovered try reconditioning for longer. If this does not work contact your local service centre.

10. Warranty and Compliance

10.1. Warranty

Standard warranty is 1 year.

10.2. WEEE Compliance

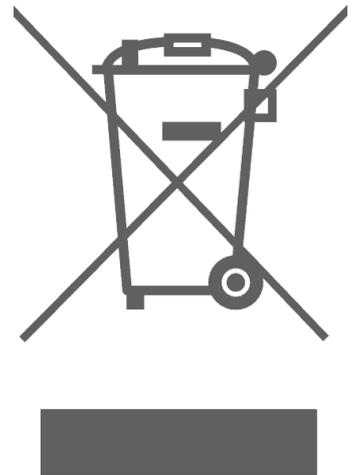
The wheelie bin symbol displayed on equipment supplied by Intelisys Limited trading as Salamander Group, signifies that the apparatus must not be disposed of through the normal municipal waste stream, but through a registered recycling scheme.

The Waste Electrical and Electronic Equipment directive (WEEE) makes producers responsible from the 1st July 2007 to meeting their obligations, with the fundamental aim of reducing the environmental impact of electrical and electronic equipment at the end of its operational life.

Salamander Group is now registered with the Environmental Agency as a producer and has joined a recycling scheme provider who will manage and report on our electrical waste on the company's behalf.

Our Producer Registration Number is "WEE/BG4835XV".

When your instrument is at the end of its life, please contact the Salamander Group sales team, who will advise you on the next step in order to help us meet our WEEE obligations.



10.3. Declaration of Conformity

EU DECLARATION OF CONFORMITY

According to Decision No 768/2008/ES of the European Parliament and of the Council

Landfill gas monitor type GasClam

The manufacturer stated below declares that the characteristics of the product meet the required technical standards, directives and specification and that it conforms to the respective European Union harmonisation standards. Furthermore the manufacturer declares the product to be safe whilst adhering to the conditions for its correct installation, maintenance and use. This declaration of conformity is issued under the sole responsibility of the manufacturer.

Manufacturer:

Elok - Opava spol. s r.o., Sádek 17, 747 75, Velké Heraltice

Notification of quality assurance:

FTZÚ 02 ATEX Q 025

Product description:

The Landfill gas monitor is used for monitoring gas released from bore holes in landfill sites. After recording the necessary number of samples the data is transfer to a PC using a serial cable, where it is then processed.

Autorized person:

FTZÚ, AO 210, OSTRAVA-RADVANICE, IN - 00577880

Notified person:

CE 1026

Certificate number:

FTZÚ 07 ATEX 0105X

Type of protection:

Ex II 2G Ex d ib [ib] IIB T4 Gb

Conformity assessment procedure:

The product's conformity was assessed with respect to the following requirements:
 – ATEX Directive 2014/34/EU, EMC Directive 2014/30/EU.
 – it was compared with the submitted documentation
 – issued on fundamentals of declaration of conformity of the producer
 – it was tested according standards

List of standards:

EN 60079-0:2012, EN 60079-1:2007, EN 60079-11:2012

List of technical regulations:

02600,NKO

Date and Place of Issue: Authorised representative:

20. 04. 2016 in Sádek Ing. Jiří Klein




Sádek 17, 747 75 Velké Heraltice
 IČO: 46576525, DIČ: CZ46576525
 Tel.: 553 663 930-3, Fax: 553 663 948-9



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 Approved by: Malchárek Josef

Created on: 20. 04. 2016
 Approved on: 20. 04. 2016

Doc. No. / Rev.: POS20160012/E0
 State: Released

Elok-Opava spol. s r.o.

www.elok.cz

Page 1 of 1

NOTES:

CONTACT	Supplier / Service Centre
<p>Salamander Group 2 Cricklade Court Old Town Swindon Wiltshire SN1 3EY United Kingdom</p> <p>Tel: +44 (0)7969 980 294 Email: info@salamander-group.co.uk Web: www.gasclam.com</p>	

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