BOREAL LASER INC.

GasFinder FC

Operation Manual

OP1
Remote Head

OP3
Remote Head

GasFinderFC

V1 Duct Probe

Retros

Menu ver. 1.10.c **Part No. NDC-200004-D**

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BOREAL LASER INC.

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GasFinder2	NDC-200023-A
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GasFinderMC-1	NDC-200005-c
GasFinderAB	NDC-200006-B
GasFinderMC	NDC-200010-C
GasFinderMC-1	NDC-200020-B
GasFinderPT	NDC-200021-B
GasFinder2 for Multiple Path Monitoring	NDC-200025-A

User Manuals:

GasViewOP	NDC-200022-B
GasViewMC	NDC-200013-B
GasMap	NDC-200007-A

Accessory Manuals:

4-20mA Module	NDC-200014-A
RF Barrier Module	NDC-200027-A
DCR Module	NDC-200016-A
Diagnostic and Troubleshooting Kit	NDC-200026

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Before operating the system, please read this manual fully to obtain the best results from your product. The lightning flash with arrowhead inside the triangle, is intended to alert the user to the presence of un-insulated dangerous voltage within the products enclosure that may be of sufficient magnitude to constitute a risk of electrical shock to persons.

CAUTION: TO PREVENT THE RISK OF ELECTRIC SHOCK, DO NOT REMOVE COVER (OR BACK). NO USER-SERVICEABLE PARTS INSIDE. REFER SERVICING TO QUALIFIED SERVICE PERSONNEL ONLY.

SAFETY INSTRUCTION:

Please read all the instructions herein.
Please heed all safety warnings.
Please retain this manual for future reference.
Please install in accordance with these instructions.

Note that if the equipment is used in a manner not specified in the manual, the protection provided by the equipment may be impaired.

Removal of the equipment cover will void any warranty.

WARNING

TO REDUCE THE RISK OF ELECTRIC SHOCK:

- Do to expose this equipment to rain or moisture.
- Do not use the unit near water, and do not immerse in any liquid or pour any liquid on the unit.
- Servicing is required when the unit has been damaged in any way, such as the power-supply cord or plug is damaged, liquid has been spilled or objects have fallen into the unit, the unit has been exposed to rain or moisture, does not operate normally, or has been dropped.
- Refer all servicing to qualified personnel only. The unit contains no user servicable parts.

Disclaimer
Boreal Laser Inc. assumes no liability or responsibility for issues or harm resulting from the use of this equipment.

BOREAL LASER INC.

GasFinderFC

OPERATION MANUAL

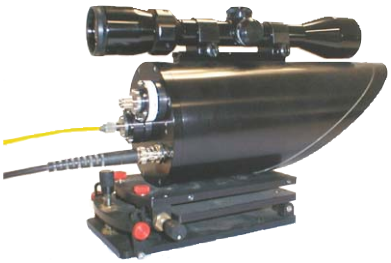
Contents

Section 1. System Description 1.1
Specifications 1.3
GasFinderFC 1.3
OP1 Open Path Transceiver (Remote Head) 1.3
OP3 Open Path Transceiver (Remote Head) 1.3
V1 Duct Tranceiver (Duct Probe) 1.3
Certification 1.4
Labels 1.4
Safety Concerns 1.4
Section 2. Pre-Installation Checks 2.1
GasFinderFC, Remote Heads, Retroreflectors Duct Probes 2.1
Tools and Equipment 2.2
Equipment Check 2.2
Section 3. Installation 3.1
GasFinderFC 3.1
Retroreflectors 3.1
Light Values 3.1
Condensation 3.3
Transceivers (Remote Heads) 3.4
OP1 Remote Head 3.4
OP3 Remote Head 3.5
Optical Alignment 3.7
Adjusting the Aiming Scope 3.8
V1 Duct probe 3.9
Cable Connections 3.10
Fibreoptic 3.10
Coaxial 3.11
Data 3.12
Power 3.12
Section 4. Data Input/Output 4.1
DB15 Connector 4.1
Serial Communications 4.2
Data String Specification 4.2
Debug String Specification 4.3
Date and Time fields 4.3
Data Transmission 4.4
Downloading Data 4.5
HyperTerminal 4.5
4-20mA 4.6

Section 5. Operating Instructions 5.1
Start Up 5.1
Menu Details 5.3
Main Menus 5.3
System Menus 5.6
Password Protected Menus 5.8
Section 6. Maintenance 6.1
GasFinderFC 6.1
Remote Heads & Duct Probes 6.1
Cables 6.1
Retroreflectors 6.2
Section 7. Troubleshooting 7.1
Array Transfers 7.3
Stability of Support Structures 7.4
Types of Supports 7.5
Alignment Procedures for a Moving Building 7.6
Centering Cross Hairs 7.7
Section 8. The Basics of Laser Gas Detection 8.1
Tuneable Diode Laser 8.1
Absorption Lines 8.1
Gas Detection with a Laser 8.2
Retroreflectors 8.3
Glossary of Common Terms and Abbreviations. 8.4
Section 9. Appendices 9.1
Appendix A — Menu Structure 9.1
Appendix B — Status Codes 9.3
Appendix C — Explanation of ppmm 9.4
Appendix D — Explanation of R2 ..... 9.5
Appendix E — Conversion from ppm to mg/nm3 ..... 9.7
Appendix F — Log to Memory 9.8
Appendix G — Calibration 9.10
Appendix H — Pre-Ship Settings 9.11
Appendix I — Accessories 9.12
Appendix J — Cable Compensation 9.13
Appendix K — 2-Way Serial Communication 9.14
Section 10. Drawings 10.1
1. GasFinderFC Interconnection – JB0512FC-A 10.1
2. GasFinderFC Dimensions – JB0125MC-A 10.2
3. OP1 Remote Head Dimensions – BOR 02110-J 10.3
4. OP3 Remote Head Dimensions – JB 0930 RH-B 10.4
5. V1 Duct Probe General – DP-D-V1-001 ..... 10.5
6. V1 Duct Probe Dimensions – DP-D-V1-002 ..... 10.6
7. V1 Duct Probe Connections – DP-D-V1-003 ..... 10.7
8. OP3 SS Enclosure Dimensions – BOR 02910 ..... 10.8
9. OP3 SS Tilting Joint Dimensions – BOR 02915 ..... 10.9

OP1 Remote Head

2 OP1 Remote Heads



OP3 Remote Head

2 OP3 Remote Heads
in stainless steel enclosures

V1 Duct Probe

GasFinderFC
mounted in cabinet

MANUFACTURER'S WARRANTY

COMMITMENT TO CUSTOMER SATISFACTION

Boreal Laser is committed to working closely with customers to define gas detection solutions that Boreal Laser can deliver and that meet customer requirements. However, very rarely, unforeseen circumstances relating to a specific installation may prevent a Boreal Laser solution from meeting all customer expectations.

Boreal Laser will make every reasonable effort to work with the customer to modify an installation to meet requirements for up to 12 months after installation. Should these efforts fail, Boreal Laser will negotiate with the client for the removal and return of Boreal supplied equipment. Refunds will be arranged on a case-by-case basis depending upon the specific circumstances. As a guideline, Boreal will provide a full refund less 10% re-stocking charge on Boreal Laser manufactured items. Refunds will typically not apply to the following: installation specific items such as cabling and mechanical mounting structures; non-recurring engineering charges associated with the specific project; technical support expenses (labor and travel related costs) invoiced during the course of the project.

STANDARD WARRANTY

Boreal Laser provides a standard warranty with all Boreal Laser manufactured GasFinder2, GasFinderFC, GasFinderMC, GasFinderAB and GasFinderPT laser gas detector products. The warranty covers the GasFinder laser analyzers plus Boreal Laser manufactured items supplied with the GasFinder laser analyzers such as: battery packs; power supplies; x-y mounts; open path transceiver heads; duct probes; external gas sample response cells; 4-20mA modules; RF Barrier modules; dry contact relay modules. The standard warranty does not cover items manufactured by third parties and supplied as components of a system, such as: cables; reflector elements; enclosures; scanning mounts; meteorological instruments; etc.

For items covered by the standard warranty, Boreal Laser guarantees that, during the first 12 months following delivery, there will be no charges for parts or service required to correct:

- Equipment breakdowns
- Equipment malfunctioning
- Repeated or recurring faults or errors in the system.

Instrument shipping and/or travel expenses for on-site service will be charged at cost.

This warranty does not apply to situations whereby system performance has been compromised as a result of customer negligence or abuse or damage resulting from natural disasters.
Boreal Laser provides software upgrades and unlimited telephone and e-mail support free of charge for the lifetime of an installation. Boreal Laser software is provided 'As Is' without any express or implied warranty of any kind. Boreal Laser is not liable for any damages (including, without limitation, lost profits, business interruption, or lost information) arising out of use of or inability to use Boreal Laser software products.

ENHANCED WARRANTY

Boreal Laser can quote Enhanced Warranty on a project specific basis to include some or all of the following:

- Include all non Boreal Laser manufactured items supplied on a specific job.
- Extended warranty if a delay is expected from the time of delivery to the time of installation and commissioning.
- Include a specified number of site visits during the warranty period - highly recommended for development projects.
- Extended warranty on GasFinder systems beyond the standard 12 month period.

PROCEDURES FOR RETURNING A UNIT TO BOREAL LASER

Contact Boreal Laser Inc. at support@boreal-laser.com or +1 (780) 488-5173 to request a Return Material Authorization (RMA) number and any other specific shipping details; please provide extended warranty registration number if applicable.

Important Instructions for Return Shipments:

Send all returns with RMA# clearly marked on outside of container and/or shipping label to:

Boreal Laser Inc.
Service Department - [RMA #xxxx]
12846 – 146 Street NW
Edmonton AB T5L 2H7
CANADA

Indicate ***'Equipment being returned to manufacturer for service'*** and indicate a value for customs of $500.

Section 1. System Description

Boreal Laser's patented (US Patent 5,637,872) TDL (Tunable Diode Laser) fibre coupled monitor measures gas concentration over an open path. The monitoring system consists of an integrated transmitter/receiver, an open path transceiver head or duct probe, and a remote, passive retroreflector array. A fibreoptic cable connects the transmitter to the transceiver head or duct probe. A two-axis instrument mount and an aiming scope or red aiming laser are used to align the remote head with the retroreflector array. The returning laser signal is detected by a photo diode in the remote head or duct probe and sent back to the receiver via a coaxial cable.

The **GasFinderFC** houses the laser diode source, the transmitter and receiver electronics and microcomputer subsystems and has connectors for 12VDC power input, and data I/O. The remote head or probe is connected with fibreoptic and coaxial cables. A schematic representation of the **GasFinderFC** system is shown below in figure 1:

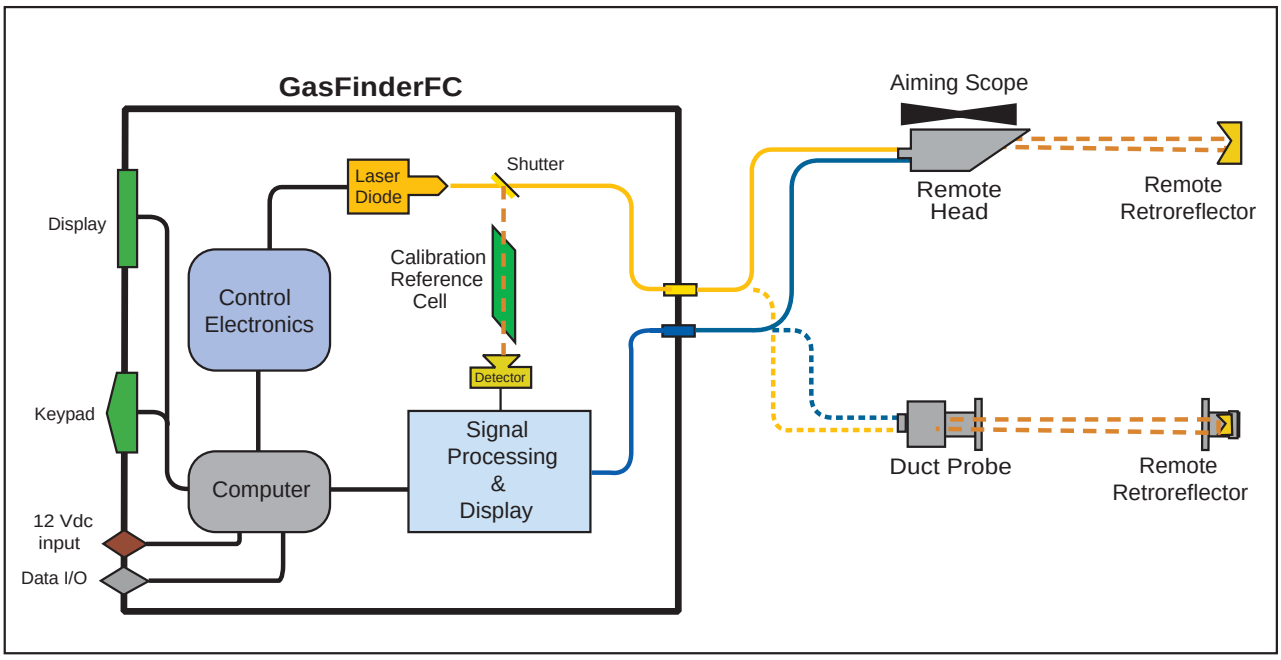


Fig. 1 Schematic representation of GasFinderFC

The laser signal from the **GasFinderFC** is sent through a fibreoptic cable to the remote head or duct probe where it is emitted and propagates through the atmosphere to the retroreflector. It then returns to the cell where it is focused on to a photo diode detector. The detector converts it to an electrical signal which travels through a coaxial cable to the electronics in the **GasFinderFC**. A portion of the laser beam is passed through an on board reference cell to provide a continuous calibration check. These two optical signals are converted into electrical waveforms which the computer processes to determine the actual concentration of gas along the optical path. The computed gas concentration is then displayed on the rear panel of the instrument, and can be transmitted to a computer where the data can be collected, stored, and graphically displayed. For industrial applications a 4-20mA output is also available.

A software program, **GasViewOP** is available which runs on the computer and can be used to alter some of the parameters on the **GasFinderFC**

The three main parts of the equipment are:

- **GasFinderFC, or CCU**
- **Open Path Transceivers** or **Remote Heads** and **Duct Probes**
- **Remote Reflectors, or Retros**

- **GasFinderFC** unit contains the laser diode and electronics and is mounted in a cabinet in a protected area at a fixed location. The front panel contains the power supply connector, I/O connectors and a Liquid Crystal Display (LCD) which displays the gas concentration in ppm/ppmm with an R^2 or Light Value indicator. When required, the display can also show the system parameters which are accessed using a key pad. The rear panel contains the fibreoptic and coaxial connectors. Specifications of the **GasFinderFC** are given on page 1.3. The unit is configured by entering values using a key pad on the front panel or with a computer using **GasViewOP**. These values are described in the **Menu Structure** which contains three subsections:

Main Menu	contains items such as path lengths, units, memory, etc.
System Menu	contains arrays, real time clock, baud rates, etc.
Password Protected Menu	contains calibration values.

Details of the menus are given on pages 5.3 to 5.6 and a flow diagram is shown in Appendix A.

- **Heads** and **Probes** are passive units and require no power.

Remote Head

Duct Probe

- **Retroreflectors** are passive units and reflect the laser signal back to the **Heads** or **Probes**. For short distances (up to 30m), reflective tape can be used. For greater distances corner cube or IMOS retroreflectors should be used. The corner cube retroreflectors allow for alignment tolerance (i.e., they reflect the light straight back to source independent of the angle of the reflector). The sealed enclosures can be provided with hoods, desiccant packs, and in some cases heaters to reduce the effect of rain, condensation or frost. The type of reflector used will depend on the path length, atmospheric conditions such as dust or fog, and the type of laser.

Details of the reflectors are given on page 3.2.

Retro Tapes

Enclosure containing 4 corner cube retro reflectors and a thermostatically controlled heater

Array containing 21 reflectors

Specifications

GasFinderFC

Weight	5.2kg (11.5lbs)
Dimensions (L x W x H)	290 x 195 x 150mm (11.4 x 7.7 x 5.9 inches) See Section 10
Power Requirements	2A @ 12VDC
Operating Temperature Range	-20C to +40C (HF +10C to +40C)
Scan Rate	1 sample / sec
Display	2 x 20 character Liquid Crystal Display
Laser Type	Semiconductor
Laser Output	20mW
Data Output	RS232, serial data, CSV. Optional 4 - 20mA current loop
Baud Rate	.3 / 1..2 / 2.4 / 4.8 / 9.6 / 19.2 / 38.4 / 57.6 / 115.2 / 230.4 kbps.
Cable, Fibre-optic	9/125 micron single mode with FC/APC connectors
Cable, Coaxial	Belden 9880 Ethernet Cable
Patch cord	Belden 89907

Accessories

OP1 Open Path Transceiver (Remote Head)

Weight	3.0kg (6.6 lb)
Dimensions (L x W x H)	315 x 106 x 180mm (12.4 x 4.2 x 7.1ins)
Power Requirements	Nil
Alignment	Open sights, visual laser accessory

OP3 Open Path Transceiver (Remote Head)

Weight	2.0kg (4.4 lb)
Dimensions (L x Diam)	310 x 105mm (12.2 x 4.1ins)
Power Requirements	Nil
Alignment	3/9 x 40 aiming ‘scope, visual laser accessory

OP3 Open Path Transceiver (Remote Head) with Stainless Steel Enclosure

Weight	14.1 kg (31.0 lbs)
Dimensions (L x W x H)	761 x 250 x 385 mm (30.0 x 9.8 x 15.2 inches)

V1 Duct Transceiver (Duct Probe)

Weight	7.5kg (16.5 lb)
Dimensions (L x Diam)	525mm x 75mm flange (20.7 x 3ins)
Purge Air	1bar @ 10 l/m (depending on dust loading)
Alignment	Visual laser accessory

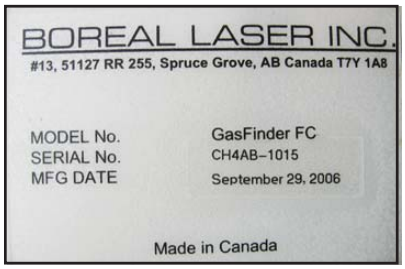
V1 Duct Probe Reflector

Various

Certification

OP3 Head	CSA	Class 1, Division 1, Groups A, B, C and D CSA Encl. Type 3R Exia
	CENELEC	EEx ia IIC T4 LCIE SYST 01.E6049 X

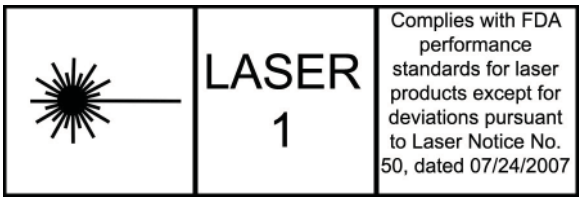
Labels



This label is affixed to the top of the **GasFinderFC** and gives the instrument serial number and manufacturing date.

Safety Concerns

Boreal Laser's **GasFinderFC** contains an invisible (infrared) laser source.
The infrared laser and red aiming lasers conform to Class 1 as per IEC 60825-1 and are eye-safe. They do not require the use of protective eye wear, protective equipment, or outdoor control measures. There is no optical ignition hazard presented by lasers of this type.
There are no user serviceable components contained in apparatus, all units must be returned to factory for repair.



Caution: — The infrared laser output from the **GasFinderFC** has very low power(conforms to Class 1 as per IEC 60825-1) and will not damage eye tissue. However, it is the recommendation of Boreal Laser Inc. that, as with ANY LASER SYSTEM, the user/operator should avoid staring directly into the output aperture of the instrument.
Note that the laser beam is infra-red and is not visible to the eye.

The **GasFinderFC** transceiver unit is not intrinsically safe and is normally located away from a hazardous area.
The retroreflectors are intrinsically safe and can be used in hazardous areas. In hazardous areas, where heaters are required to prevent condensation, they should be of a suitable type.

Section 2. Pre-Installation Checks

GasFinderFC

GasFinderFC in cabinet

A site survey should be undertaken to check the following points:

- **Location:** the **GasFinderFC** may be located in any suitable place. A cabinet is ideal.
- **Power Supply:** a 12VDC power supply should be available
- **Accessibility:** safe access to the front and rear of the **GasFinderFC** should be possible.
- **Size:** if the **GasFinderFC** is used in a cabinet it should be big enough to accommodate any required splice boxes, cable terminations, power supply and output modules.
- **Cables:** cable trays or conduit should be used to support the coaxial and fibreoptic cable between the **GasFinderFC** and the Remote Head or Duct Probe. Do not run cables alongside power cables, especially cables used for Variable Frequency Drives.

Remote Heads

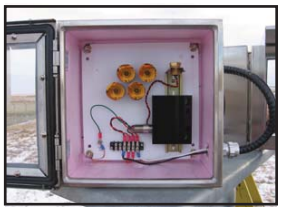
Remote Head locations should be chosen with regard to visibility and limiting paths to 500m for OP3 Remote Heads, and be in areas that are safely accessible for installation and maintenance. Limit cable runs to 750m or an appropriate distance to pull the cable. Dusty locations are to be avoided if possible. The Remote Head mounting can withstand small vibrations and some translational motion but is extremely sensitive to rotational movement. The mounting must be rigid and well braced. Pre-terminated cables can be brought directly into the enclosure, otherwise it is necessary to use a splice box close (1m) to one side and run a patch cord to the Remote Head. Mounting locations outside where sun can strike directly on the mount structure may require insulation to prevent movement due to differential heating.

OP3 Head

2 OP3 heads in SS enclosures

Retroreflectors

Retroreflector locations should be chosen to limit paths to the suitability of the remote head and be in areas that are safely accessible for cleaning when necessary. Dusty locations should be avoided if possible. Steam may pose a problem if it is dense and consistently crosses the path.
If the location is outside and the climate is humid, a rain hood and a heated enclosure may be necessary to prevent condensation on the window. This usually requires an outlet close by to supply power to a heater.
The reflector mounting can tolerate small vibrations and movement, but the reflector enclosure should be attached with the front window perpendicular to the path. There should be no obstructions in the path between the retroreflector and the head.



4 Retroreflectors with heater

Duct Probes

Alignment is made easier if the flanges for the Duct Probes are welded perpendicular to the path axis. Clean air up to 10 litres/min, controlled with a regulator, should be provided for purging the Duct Probe and retro windows. Ducts with a heavy dust load, may require a higher flow rate.

2 Duct Probes with Purge Air and Splice Box

Tools

Required:

- Site-specific personal protective equipment
- Permanent marker or pen
- Set of assorted cable ties
- Socket wrench set
- Small adjustable “crescent” wrench
- Small vise grips
- Phillips, Robertson and Flat Head screwdrivers
- Allen Keys (imperial and metric)
- Coaxial-cable termination tool (Amphenol crimper: ARF1118 with CTL-3 jaws. 0.100D and 0.429D.)
- Wire cutters, wire stripper, linesman’s scissors, pliers
- Knife
- Duct tape
- Electrical tape and self-amalgamating tape
- Label maker or cable markers
- Silicone sealant RTV3145
- Twist drill set and step-bit or hole-saw selection
- Small multimeter
- Ladder and/or man-lift (as appropriate)
- If pre-terminated cables are not used then a cable splicer is required capable of making FC/APC connections.

Optional/Recommended:

- Two-way radios (if permitted)

Equipment Check

Verify that all the equipment on the order sheet has arrived complete and in good condition. Any damage due to shipping should be reported immediately and steps taken to obtain replacement parts.

Order ready for shipment

Section 3. Installation

Safety Issues

Caution : — The laser output from the **GasFinderFC** has very low power (conforms to Class 1 as per IEC 60825-1) and will not damage eye tissue.

However, it is the recommendation of Boreal Laser Inc. that, as with ANY LASER SYSTEM, the user/ operator should avoid staring directly into the output aperture of the instrument. Note that the laser beam is infra-red and is not visible to the eye.

GasFinderFC in enclosure

Tools Required: Electrician's hand tools, set of Allen keys.
The Boreal Laser Inc. fibreoptic test kit is recommended.

The **GasFinderFC** does not usually require installing, however the reflectors, heads and cables will require some installation.

Retroreflectors

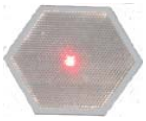
The retroreflector is a vital part of the system and choosing the correct one is necessary for the correct operation of the system. Refer to page 3.2 for details on choosing a reflector. For short paths where reflective tape is used, the tape can be attached to the back of an enclosure which is fitted to a tripod or placed on a wall in any convenient location. The angle of the tape can be adjusted to give an adequate signal return provided this does not degrade the R^2 value.

- Where retroreflectors are used on longer paths, these may be mounted in an enclosure on a tripod, or the enclosure placed in any convenient location.
- Purge air may be required for retros used in ducts.
- Where long paths are measured in metal buildings, the remote head may go out of alignment as a result of solar heating deforming the structure. The preferred solution is to use multiple reflectors. See pge 7.7
- The **GasFinderFC** does not require any changes when different path lengths are measured unless ppm values are needed, in which case the distance must be set and an appropriate reflector used.

Light Values

The type of reflector used will depend on the path length, atmospheric conditions such as dust or fog, and the type of laser. When choosing a reflector, the prime concern should be to keep the returning light level value between the preferred values of 4,000 and 8,000. The range of the value is between 1000 and 16,368. Below 1000 the display will indicate "Low Light". There is no indication that the returning light has exceeded 16,368. When this happens the receiver saturates and the displayed light value could read very low (<200). In this situation the gas concentration readings will be in error and it is also possible to cause damage to the optical components. The light value can be adjusted with the use of different reflectors.

Note: Care should be taken to ensure that the returning light does not exceed 14,000.

Reflector types	Path Length	Description	
Red/White Tape	1–5m	The tape comes in 16m rolls x 50mm wide. The tape is divided into red and silver bands and each have different reflective properties. The tape is adhesive backed and can easily be attached to any smooth, dry surface. It is often stuck to the back or side of a retro enclosure.	
Grey Tape	5–40m	Grey Tape comes in sheets 200 x 300mm. It is adhesive backed and can easily be attached to any smooth, dry surface. It is often stuck to the back of a retro enclosure.	
IMOS plastic 46mm Retro	30–100m	These are multi-faceted IMOS 46mm hexagons. They can be fitted together to make up a large composite array.	
63mm Retro	75 – 150m	This is a gold plated hexagonal retro. It is normally housed in a plastic or steel box with a Lexan window. They can also be fitted together to make up a large composite array.	
IMOS array	50 – 300m	The IMOS array shown is made from 14 single hexagonal retros. They are normaly mounted on a back plate which is placed in a stainless steel or FRP enclosure.	
Up to 6 63mm Retros	75m – 400m	These retros are enclosed in a PVC, RPF or stainless steel enclosure. The number of retros will depend on the type of gas being measured, the path length and atmospheric conditions. The window is normally Lexan but can be changed to a special glass when measuring some gases. For outside use rain hoods and heated enclosures are recommended to prevent condensation.	
Up to 76 63mm Retros	600–750m	76 retros are probably the maximum number that can be economically used as the cost becomes prohibitive as the number of retros increases. At path lengths approaching 750m, maintaining the correct alignment becomes difficult.	

The enclosures will vary in size depending on the number of retros and if internal heating is required. Window materials will depend on the site conditions and the gas to be measured. Lexan is normally supplied but window glass, boro-silicate and sapphire are used under specific circumstances. Contact Boreal Laser Inc. for more information.

Condensation

Condensation on the surface of the window is caused by the window temperature falling below the dew point. This may occur in areas of high humidity or large temperatures differences between day and night. The enclosures are well sealed but condensation can sometimes occur on the inside of the window. Condensation can usually be controlled by the following measures:

Radiation Shield

- Fasten a cover or rain hood over the enclosure to shield the window from the effect of radiation cooling at night. This also prevents rain from striking the window.
- Use a desiccant pack inside the enclosure. This will only prevent condensation on the inside.
- Place a heater in the enclosure. The heater can be 12W to 50W depending on the size of the enclosure and the conditions of operation and is controlled by a thermostat to prevent overheating. The heater raises the temperature of the enclosure and prevents condensation forming either on the inside or the outside of the window. To minimise heat loss the enclosure is insulated. This option requires power to be supplied and there are heaters available for use in hazardous areas.

SS Enclosures with Heaters and Rain Hoods

4 retros and heater in insulated enclosure

Transceivers (Remote Heads, Duct Probes)

There are various types of transceivers to which the **GasFinderFC** can be connected:

- OP1
- OP3
- V1

OP1 Transceiver (Remote Head)
This Remote Head is designed to be used for path lengths up to 50m. It has a weather resistant stainless steel assembly and has an adjustable base. It is mounted with a single 12mm bolt and locking screws if required.

- Mount the Remote Head directly to a galvanised steel plate at least 100mm square. Rotate the unit so that the head is aligned with the reflector. Tighten the 12mm bolt.

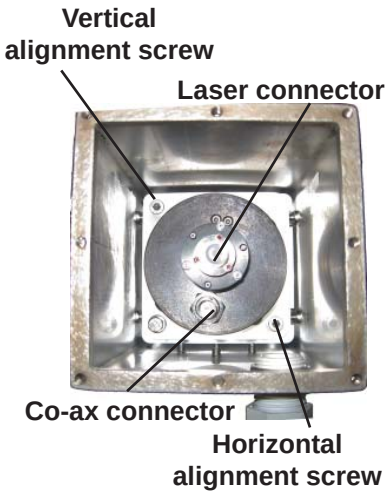
OP1 Head

- Remove the 8 screws from the rear plate.

- Connect a visible laser to the fibreoptic laser connector at the rear of the unit. Align the Remote Head until the red dot appears on the reflector.

- Connect the fibreoptic and coaxial cables to the rear connectors and to the **GasFinderFC** and switch on.

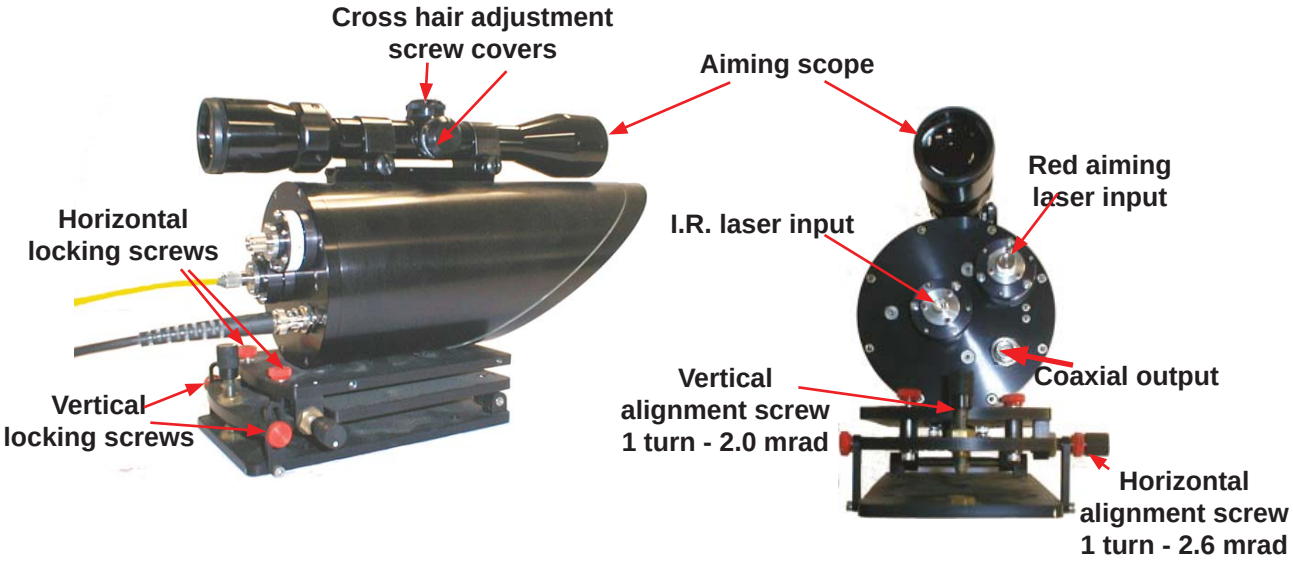
- Make a final alignment adjustment by maximising the light return value. Tighten all the locking screws and secure the cables, making sure that the weight of the cables does not alter the alignment of the Remote Head.



2 OP1 Heads

OP3 Open Path Transceiver (Remote Head)

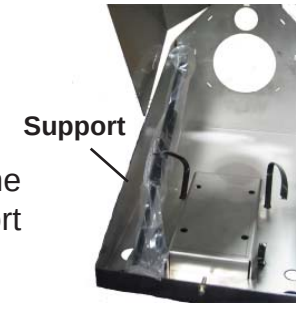
This Remote Head is designed to be used for path lengths up to 750m. It can be fitted in an enclosure and uses an X-Y mount and scope for alignment. It can also be used mounted on a tripod for portable use.



Installing the Mount and the Stainless Steel Enclosure

Caution. care should be taken not to get the fingers trapped between the cover and the sides of the base, especially before the shocks have been connected.

- Remove the enclosure from the packing case, open the cover and remove the base and the nose from inside.

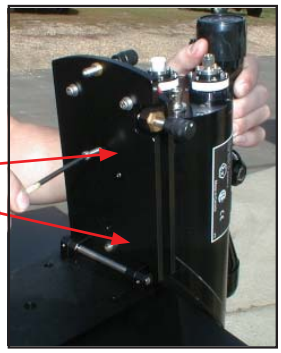


- There is a tubular spring loaded support laying at either side of the base. Remove the plastic bag and attach the front of the support to the front of the cover.

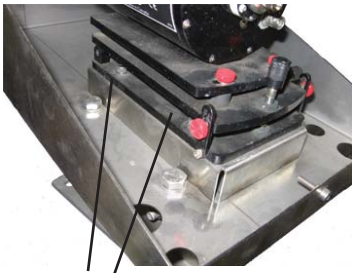
- Attach the nose to the front of the base by inserting the tabs on the nose into the slots and twisting the tabs on the inside.

Front of enclosure Tabs

- Remove the two locking screws for the bottom plate of the XY mount and raise the top two plates.Use the two 8 x 32 x $^{3}/_{4}$" screws to fasten the remote head to the mount.



- Use the four ¼" x 20 x $^{1}/_{2}$" screws to fasten the X-Y mount to the stainless steel bottom plate.



Four ¼" x 20 x $^{1}/_{2}$" screws

- Bolt the base mount to a structurally stable base (see page 7.5), and bolt the stainless steel enclosure with the Remote Head to the base mount. Use the base mount to align it approximately with the retro.

Base mount

- If the aiming scope is not already attached, fasten it to the Remote Head with the large end towards the operator.

Assembled enclosure

Two assembled enclosures mounted on a column

Optical alignment

Once the head is fastened, adjust the two alignment screws on the X-Y mount so that the retroreflector appears in the centre of the cross hairs in the alignment scope. Verify that the entire retroreflector is clearly visible and there are no obstructions in the path.

Ensure that the **GasFinderFC** is switched on and connected to the remote head. Connect the Remote Light Meter (RLM) to the coaxial fitting on the rear of the head. Adjust the X-Y mount with the horizontal and vertical adjustment screws so that the reading on the RLM is as high as possible. Gently tighten the 4 red locking screws on the mount, ensuring that the reading on the RLM does not decrease. Note that the RLM will read about 1/10 the value shown at the **GasFinderFC.** A reading below 200 is an indication that more reflectors are required on that path.
A reading greater than 2000 is an indication that the laser signal may have to be attenuated.

Remote Light Meter

If the retroreflector is not visible in the alignment scope or difficulty is experienced getting a reading on the RLM, connect the visible laser to the fibre connector located above the coaxial connector. Switch on the visible laser. Using the continuous red beam now being emitted from the Remote Head, the mount can be adjusted so that the red beam is reflected back from the retroreflector. Verify that the fibre from the **GasfinderFC** is connected and as soon as the RLM registers a reading, the visible laser use can be discontinued and the RLM used for precise alignment.

Visible Laser and Remote Light Meter

Note: the reflected beam of the visible laser is very bright and should not be observed through the ‘scope.

The red laser output from the aiming laser has very low power (conforms to Class 1 as per IEC 60825-1) and will not damage eye tissue.

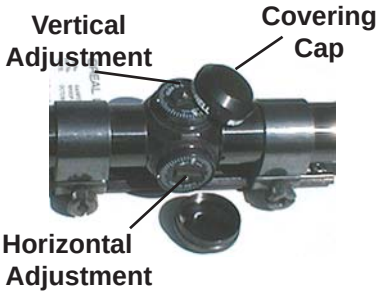
However, it is the recommendation of Boreal Laser Inc. that, as with ANY LASER SYSTEM, the user/ operator should avoid staring directly into the output aperture of the instrument.

Adjusting the Aiming Scope

Cross Hairs

If the cross hairs on the scope do not line up with the centre of the retroreflector, they can be adjusted by unscrewing the covering caps in the centre of the scope and adjusting the rectangular-headed screws underneath.
The factory setting is made so that the cross hairs converge with the laser beam at 100m. Due to the vertical displacement of the scope, the cross hairs will appear above the beam at distances below 100m.

It is better to start by adjusting the mount for maximum signal by maximising the light value reading and then centre the cross hairs in the centre of the Retros by adjusting the cross hairs with the scope adjustment screws. Note that the scope is made for a rifle where the eye is always at a fixed position determined by the stock at a set distance behind the scope. If you are not at the correct distance from the eye-piece, moving the eye laterally will cause the cross hairs to move across the Retro.



- Remove the caps covering the adjustment screws.
- Turn the zoom on the scope to a maximum.
- Focus the eye-piece so the retros are sharp.
- Position your eye so that all the apertures in the scope are concentric and open the full diameter.
- Depending on your eyes, this may be about 6 inches away from the eye-piece. Then the cross hairs intersect on the centre line and will not move laterally.
- Turn the horizontal and vertical screws as necessary to position the cross hairs in the centre of the retro.
- Replace the covers.

Focus and Zoom

The two adjustable rings at the front of the scope can be turned to adjust the focus and zoom. When cold these rings are extremely stiff.
The zoom is used at a minimum when locating the Retro and at a maximum when checking for movement and aligning the cross hairs.
Focus the eye-piece so the Retros are sharp.

When all adjustments to the scope are finished, tighten all the locking screws.

Note: Make sure that these adjustments do not mis-align the system.

V1 Duct Transceiver (Duct Probe)

V1 Duct Probe

The Duct Probe is designed for use across ducts and stacks and consists of a laser emitter and receiver in one unit. The laser beam is targeted on a retroreflector at the opposite side of the duct or stack. In some instances of high gas concentration, the Retro can be replaced by a receiver for single pass operation.
The type of retroreflector usually depends on the particulate loading in the duct and can vary from grey tape to a 62mm retroreflector.

Mounting

Each Duct Probe mounts to a 150 lbs, 3" ANSI flange.
It is important that if the flanges are welded orthogonally to the duct, then both Duct Probe and retro flanges should be mounted at the same height.

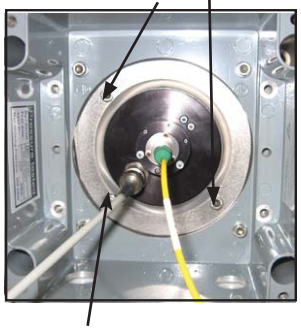
Purge air

Purge air at 1 to 5 l/m will usually prevent dust from settling on the reflector or the window inside the Duct Probe.

Heating

If the Duct Probes are subjected to a temperature lower than that in the ducts they may have to be insulated and heated to prevent condensation forming on the window or the Retro.

Optical Alignment



Remove the opposite port cover plate.
Attach a visible laser to the optical connector in the Duct Probe and adjust the alignment screws so that the red beam is visible in the opposite port. Most ducts have a particulate load and the red laser can easily be seen reflecting off the particles. A piece of white paper placed over the port can assist in centering the beam.
Place the retroreflector in the port and connect a Remote Light Meter (RLM) to the coaxial connector. Remove the Visible Light Meter and connect the fibreoptic cable from the **GasFinderFC** to the Duct Probe. Adjust the alignment screws to obtain maximum signal on the Remote Light Meter. The signal may require attenuating so that proper alignment is possible.
Connect the coaxial cable between the **GasFinderFC** and the Duct Probe.

Attenuation

Variable fibre attenuator

Because of short path lengths it is often necessary to lower the signal strength. This is done by using a variable fibre attenuator which bends the fibre. The light level should not exceed 14,000 at the **GasFinderFC.**

Two Duct Probes with purge air

Two Duct Retros with purge air

Cable connections

Fibreoptic Cables

Caution : the laser output from the control unit has a very low power and will not damage eye tissue. However, as with all laser instruments, it is prudent to avoid looking directly into the laser beam. Note that the laser beam is infra-red and is not visible to the eye.

Tools Required: Electrician's hand tools. The Boreal Laser Inc. Diagnostic and Troubleshooting Kit is recommended.

Cleanliness

It is of paramount importance when dealing with fibre optic cables that clean work practices are followed. The core of a single mode optical fibre is 9 microns in diameter, and a speck of dust can easily block the signal. It is important to clean the connectors before inserting them into the couplings. This is done by holding the end of the connector perpendicular to a clean section of tape and describing a figure of eight movement two or three times. The cleaning tape is held in a dispenser which exposes a new section of tape as needed. Do not use alcohol as it leaves a residue.

Cleaning connectors

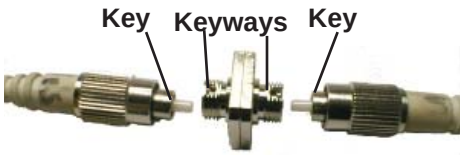
Dignostic and Troubleshooting Kit

The Diagnostic and Troubleshooting Kit contains a Remote Light Meter (RLM), Power Meter, Visible Laser, Infra Red (IR) card, cables and cleaning tape.

Diagnostic and Troubleshooting Kit

Fibreoptic Connections

The fibreoptic couplings are FC/APC and are used to connect two FC/APC fibre connectors. There is a key on the connector barrel to align with the keyway in the coupling. The key and keyway must be engaged in order for the connection to be made correctly.



Coupling & Connectors

Cables

The laser output from the **GasFinderFC** is taken from the FC/APC connector on the rear panel of the instrument. The connection to the Remote Head or Duct Probe is made with a single mode fibre-optic cable which may be a single fibre or a dual fibre, in which one is used as a spare, or via a multi-fibre cable and a splice box.

Splice Box

The fibres can be purchased with the ends pre-terminated or a multi-fibre cable can be spliced to a pre-terminated 'pig tail' on site by a contractor who specialises in fibre-optic FC/APC cable splicing.

Special care is required when installing the cables as too much strain will break them or cause large losses. Cable tray is easier to work with than conduit. Cable ties should be firm but not tight. Any bending should be limited to a 30mm radius. Nylon *Spiwrap* cable protector is very useful for supporting cable and preventing sharp bends.

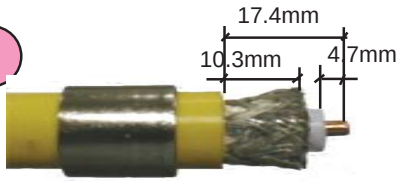
Coaxial Cables

Tools Required: Electrician's hand tools. Amphenol crimper: ARF1118 with CTL-3 jaws. 0.100D and 0.429D.

The returning electrical signal from the remote heads is very small and is susceptible to interference from electrical machinery and radio frequencies. To minimise this interference, a double-shielded coaxial ethernet cable is used. This is a heavy, stiff cable, so a short, flexible 'patch cord' using Belden 89907 cable is used to connect the ethernet cable ends to the **GasFinderFC** and the Remote Head or Probe.

Ethernet Cable Terminations

The Amphenol connector, part # 82-4426-1001, consists of 3 parts: ferrule, centre pin, and body. A crimper (listed above) is required for the assembly. The sequence for the assembly is as follows:

1. 

1. Slide the ferrule onto the cable and strip the jacket, braid and dielectric to the dimensions shown. All cuts should be sharp and square.

Caution. Do not nick the braid, dielectric, or centre conductor. Do not comb out the braid.

2.

2. Insert the pin over the centre conductor so that it butts up against the dielectric. The centre conductor should be visible through the inspection hole in the pin.

3.

3. Use the crimp tool with the 2.5mm(0.1") die cavity. The crimp should be between the inspection hole and the end of the pin.

4.

4. Slide the connector body over the cable so that the inner ferrule slides under the braid. The centre pin will snap into place in the body insulator. Verify that the centre pin is flush with the face of the body.

5.

5. Slide the outer ferrule over the braid and up against the connector body.

6.

6. Crimp the ferrule as shown in #6 using the crimp tool with the10.9mm(0.429") die cavity.

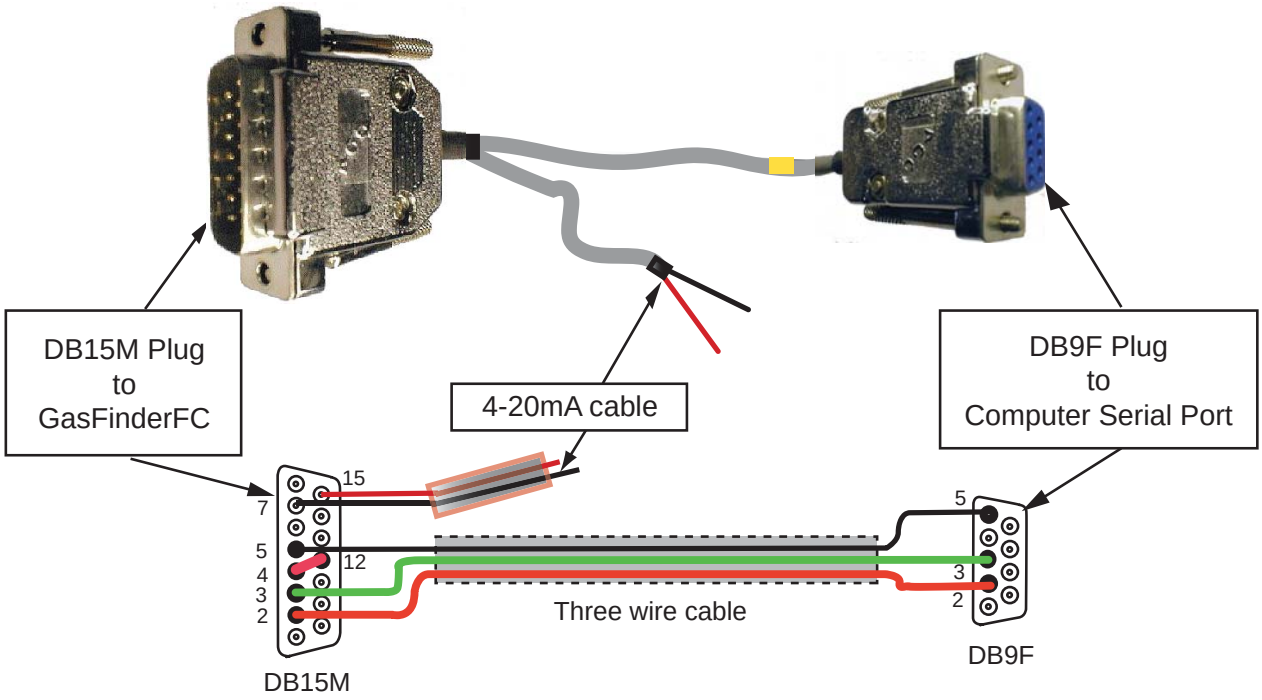
7.

7. Connecting the patch cord to the ethernet cable.

8.

8. Screw the **N** to **BNC** jack into the **N** connector and then twist the **BNC** connector onto the jack.

Data Cable



The data cable carries the RS232 signal from the **GasFinderFC** to an external computer, which stores and displays the data. The cable length should not exceed 30m. If a longer distance is required, other options are available:

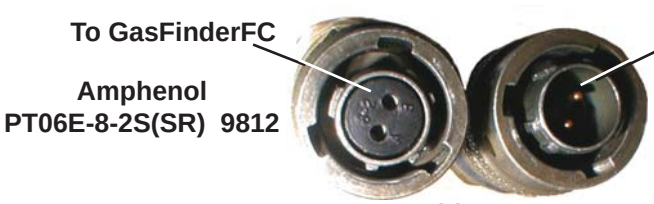
RS485: This allows a twisted pair of wires to carry the data for 200 to 300m.
Fibre-optic modems: These are very small units connected with a multi-mode fibreoptic cable. Distances covered can be many kilometers.
Wireless modems: These are usually spread-spectrum type and can transmit data over distances limited by line of sight.

Cable Connections, Power

The power supply will accept a power from any suitable source. (see specifications page 1.3). A power cord is supplied. If necessary, the plug may be removed and a local plug connected with appropriate pins or the cord wired directly to a circuit breaker or fuse.
A 12v DC cable is connected between the power supply and the **GasFinderFC**.

Power Supply

A 12v battery can be supplied and comes with a cable to connect to the **GasFinderFC**. It also has a battery charger.

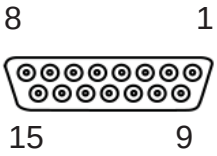


Battery Cable Connectors

12v Battery

Section 4. Data Input/Output

DB15 Connector



Data I/O connector
as viewed on rear panel

Pin	Signal	Pin	Signal
1	n/c	9	PCDSR
2	PCRX	10	PCRTS
3	PCTX	11	PCCTS
4	PCDTR	12	+5Vdc
5	GRD	13	RCVR
6	Ramp	14	Monitor
7	I sink (-)	15	I source (+)
8	n/c		

The DB15F connector on the back of the instrument is a hybrid data I/O connector, combining serial data output (RS-232) and analogue signals useful for examining system performance. The cable details are shown on page 3.10 of this manual.

Signal Description: n/c = no connection

1	n/c		
2	PCRX	Data Receive at PC	Serial output from GasFinderFC
3	PCTX	Data Transmit at PC	Serial input from GasFinderFC
4	PCDTR	Data Terminal Ready	Serial input from GasFinderFC
5	GRD	Signal Ground	Digital / Analogue
6	Ramp	System Timing Clock	Analogue output from GasFinderFC
7	I sink (-)	4-20mA loop return	Analogue output from GasFinderFC
8	n/c		
9	PCDSR	Data Set Ready	not currently implemented
10	PCRTS	Ready to Send	not currently implemented
11	PCCTS	Clear to Send	not currently implemented
12	+5Vdc	System Voltage	Digital / Analogue
13	RCVR	System Signal	Analogue gas level output from GasFinderFC
14	Monitor	System Signal	Analogue light level output from GasFinderFC
15	I source (+)	4-20mA loop source	Analogue output from GasFinderFC

Note: I/O equipment may be connected or disconnected while the system is operating. Caution should be observed that data *may* be compromised during transition.

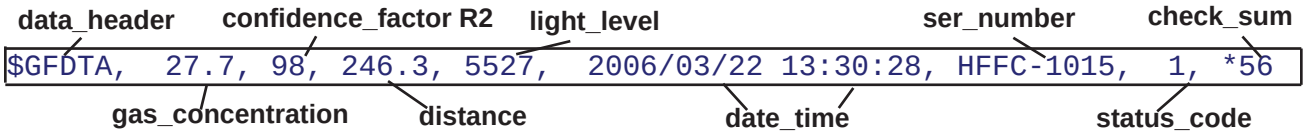
Serial Communications

The **GasFinderFC** will transmit serial data at 300 / 1200 / 2400 / 4800 / 9600/ 19200 / 38400 / 57600 / 115200 / 230400 baud, no parity, 8 bits, one stop bit, (i.e., 9600,N,8,1) after each scan. Two handshaking options are available:

- No Handshaking — Connect pin 4 (PCDTR) to pin 12 (+5Vdc) at the **GasFinderFC** end of the data cable. Data will be sent automatically after every scan. This is the standard configuration of the cable as supplied by Boreal Laser Inc.
- DTR Handshaking — The control computer raises the voltage to +5 Vdc on pin 4 (PCDTR) in order to request a data string. Data are transmitted as an ASCII string and will be sent only when requested by the host computer.

Data String Specification:

$GFDTA



data_header	header designating the type of data	String
gas_concentration	in ppmm (parts per million meter)	Number
confidence_factor,R2	between 0 and 99	Integer
distance	user-set distance to retro in metres	Number
light_level	returning light level	Integer
date_time	current date and time	YYYY/MM/DD hh:mm:ss
ser_number	identification number of the system	String
status_code	code giving system operating status	Integer
check_sum	checks the data stream for errors	String

Field Description	Range	Max. Width (Chars)	Restrictions
data_header	Any	6	
gas_concentration	0 – 99999999	8	
confidence_factor	0 – 99	2	
distance	1 – 9999	4	
light_value	1 – 16384	5	
date_time	Year/Month/Day Hour/Minute/Sec	19	
serial_number	Any	10	
status_code	1 – FFFF	4	
check_sum	0 – FF	2	

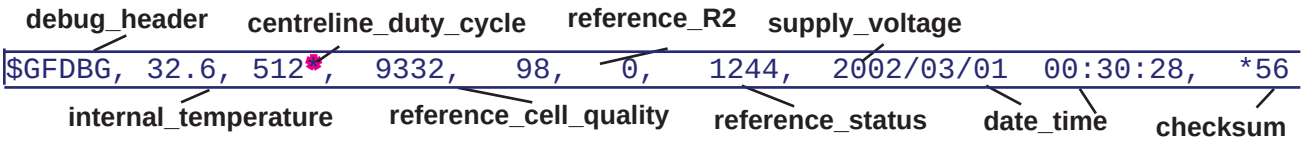
These data strings are comma-delimited (,) and an asterisk (*) signifies end of string.
Each string is terminated by a carriage return and a line feed.
The status codes are described in detail in Appendix B of this manual.

$GFDBG

Periodically, strings containing diagnostic data (**$GFDBG**) are transmitted giving internal details of the GasFinder operation.

The **$GFDBG** string is output whenever the system performs a calibration check.

The format of the **$GFDBG** string is as follows: (* on systems with older software the duty cycle was 128)



Explanation:

debug_header	header designating the type of data	*String*
internal_temperature	internal temperature of GasFinder in degrees C,	*Number*
centreline_duty_cycle	setting to enable array peaks to line up,	*Integer*
reference_cell_quality	reference cell quality as a percentage x 100,	*Integer*
reference_R2	reference cell R2,	*Integer*
reference_status	code giving reference system operating status,	*Integer*
supply_voltage	supply voltage to GasFinder x 100,	*Integer*
date_time	current date and time	*YYYY/MM/DD hh:mm:ss*
checksum	checks the data stream for errors,	*String*

These data are comma-delimited (,) and an asterisk (*) signifies the end of a string. Each string is terminated by a carriage return and a line feed.

Date and Time fields

When data is viewed using **GasViewOP**, the data is a true representation of the raw data from the **GasFinderFC** and the **$GFDTA** and **$GFDBG** strings have a date and time stamp. The time in the $GFDTA string is taken from the **GasFinderFC** internal clock.
When data is downloaded using **GasViewOP**, the file extension is .gvl. The date and time fields are taken from the computer running the **GasViewOP** program. These PC generated date and time fields are inserted into the data in every **$GFXXX** string and will appear in the log file.

When data is viewed using HyperTerminal, the extension is .txt and the data is a true representation of the raw data from the **GasFinderFC** and the **$GFDBG** strings do not have a date and time field. The time in the **$GFDTA** string is taken from the **GasFinderFC** internal clock.

4-20mA Option

Note that the 4-20mA output is taken from the pins in the DB15 output connector. The 4-20mA output is configured using the **GasFinderFC** keypad. Details are given on page 4.6.

Data Transmission

The data cable carries the RS232 signal from the **GasFinderFC** to the computer which stores and displays the data. The cable length should not exceed 30m. If a longer distance is required, other options are available:

1. RS232: This is the standard configuration output and allows a twisted pair of wires to carry the data up to 30m. The output is powered through the RS232 port.

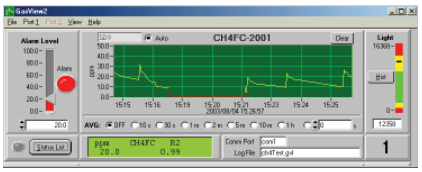
2. RS485: These are two small units, one at the **GasFinderFC** and the other at the computer. They boost the signal and allow a twisted pair of wires to carry the data 200 to 300m. They both require a small amount of power to operate.

3. Fibre-optic modems: These are two small units, one connected to the **GasFinderFC** and the other to the computer with a short data cable. They are both linked together with a multi-mode fibre optic cable and powered through the RS232 ports. Distances covered can be many kilometres.

4. Wireless modems: These are two small units about 0.5kg each and each connected, one to the **GasFinderFC** and the other to the computer with a short data cable. They are usually spread-spectrum type and can transmit data over distances determined by the power output or the antenna. They can work in, or surrounded by, buildings and their range is from 50 to 500m. The transmitter is 100mW. They both require a small amount of power to operate.

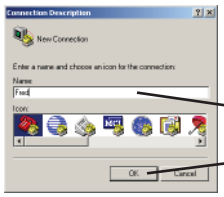
5. 4–20mA loop: The DB15 connector on the rear panel of the **GasFinderFC** has output pins that will give a current output for transmission to a compatible input system.

Downloading Data


GasViewOP

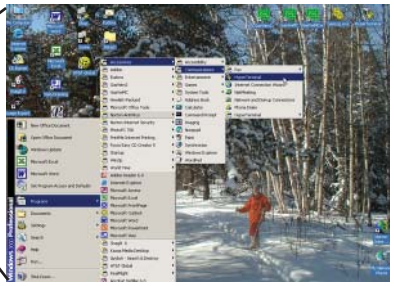
The serial data from the **GasFinderFC** can be viewed using a computer that has a serial port. Boreal Laser Inc. has developed the **GasViewOP** program to view and log the data. This program is described fully in the **GasViewOP** manual. Alternatively, any computer with a Hyperterminal program can be used to download the data. HyperTerminal is a standard accessory in Windows 9X and Windows NT & XP. Windows 7 requires a Hyperterminal emulator program to be downloaded.

HyperTerminal

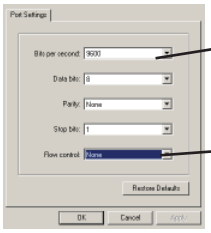


Choose **Program Files**, **Accessories**, **Communications, HyperTerminal.**

Choose a **name** and an **icon**, and click **OK**.

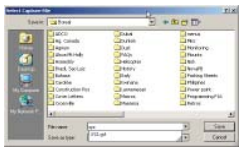


In the **Connect to** display, bypass the phone connections and under **Connect Using**, scroll down to the correct port (i.e. go directly to **COM1** or **COM2**). Click **OK**.

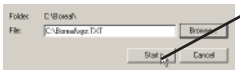


In the **Port Settings** window, change the **bits per second** (baud rate) to the correct value, typically **9600.** Also select **8** data bits, **no** parity, and **1** stop bit.
Flow control should be set to **none**. Click **OK.**
If the computer is correctly connected to the **GasFinderFC**, the data should now be appearing on the screen.

To save the data to a file, on the Upper Toolbar click on **Transfer** and **Capture Text**.



Designate a file in the **Capture Text** window, or use the **Browse** option to choose one, and the data can be recorded to a file in a specific location.



Clicking **Start** will activate the recording procedure and on the lower toolbar the word **Capture** will be highlighted.

To stop recording the data, in the upper Tool Bar click on **Transfer**, **Capture Text,** and **Stop**.

Note: Some versions of Windows may have a different path for accessing HyperTerminal. The data can be loaded into Excel, but each line will be separated by a space. The extra spaces can be removed within Excel using a Data Sort routine or a Macro.
The file is in Unix format and has a L/F and C/R end of line character string, not C/R and L/F.
.

4-20mA details

Note that in a dual gas system, Gas B does not have a 4-20mA output.

- 4 mA is equivalent to the lowest value of gas programmed, usually 0 ppmm.
- > 4mA and < 20mA varies proportionately to the gas concentration.
- 20mA is equivalent to the maximum ppmm or greater.

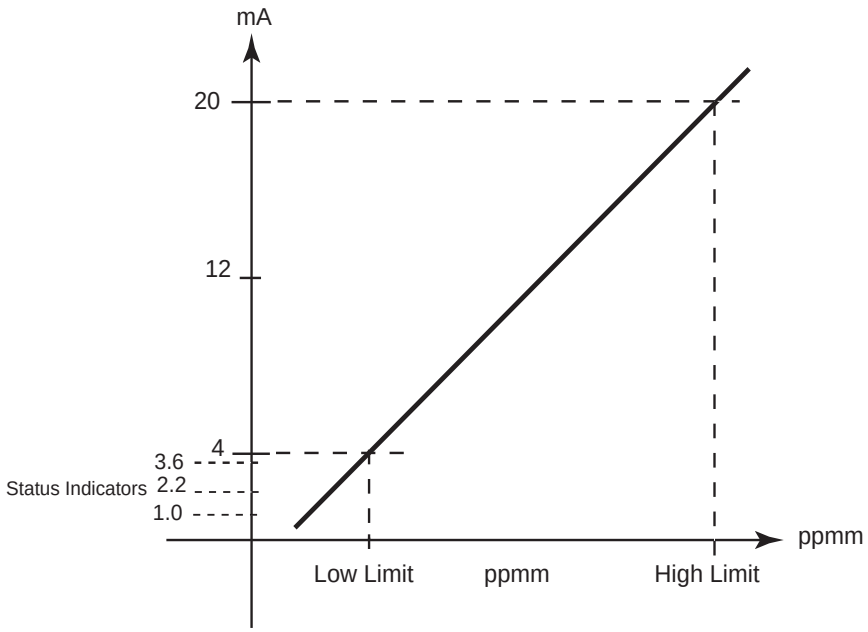
If the **D**istributed **C**ontrol **S**ystem(DCS) is capable of a full 0 - 20mA resolution, the following values are configured:

- 3.6mA indicates a system fault
- 1.0mA indicates a Low Light condition*.

These values can be changed at the factory to suit particular needs.

*Note that where loop isolators are used the Low Light condition will be 2.2mA as the isolators require 2.2mA to operate.

This relationship is illustrated by the following diagram.



Graph showing the relationship between ppmm and the 4-20mA output.

Section 5. Operating Instructions

Start Up

1. These start up instructions assume that the **GasFinderFC** has been set up in accordance with the procedures specified in Section 3, and the unit is connected to a power supply and the remote heads pointing at a retroreflector.

When first switched on, the display for a hydrogen fluoride system will read:

This warm-up cycle lasts two (2) minutes. A count-down timer in the lower right of the display will indicate the time remaining.
Units configured for other gases may show different warm-up times.

2. After the warm-up cycle, if the system is receiving enough returning light, the display will read:

This indicates that the **GasFinderFC** is checking the internal reference cell and performing calibration diagnostics.
If the system is not receiving sufficient light it will not calibrate.

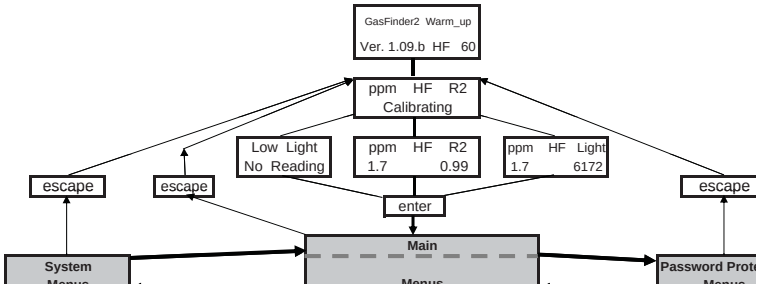
3. If the remote head or probe has not been aligned with the retroreflector, the display will read:

Refer to Section 3 for alignment details.

If the operator presses and holds the **ENT** key any time the instrument is in the normal operating mode, the system will enter the parameter display/adjustment menus. The arrow keys can be used to move between the various menu items. When the operator is in the menu system, pressing the **ENT** key will enter the adjustment mode of the displayed menu item. A blinking "***Adj***." will be visible in the bottom-left corner of the display, and the value of the parameter displayed can be raised or lowered using the arrows. Pressing the **ESC** key always jumps back to the previous level; that is, if the user is in the adjust mode, pressing **ESC** once will move back to the display mode of that item, and pressing **ESC** again will return the user to the main display menu.

The menus are divided into three separate sections:

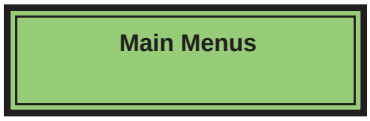
Main Menus - Used for the normal operation of the **GasFinderFC**.
System Menus - Used for initial set up and various checks.
Password Protected Menus - This can only be accessed by qualified personnel and is used to change calibration parameters.



See Appendix A for the complete menu diagram.

4. In order to display the correct value for ppm the distance between the remote head or probe and the retro must be set correctly in the **GasfinderFC**.

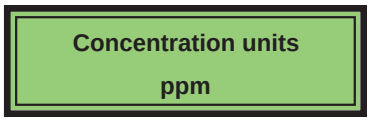
a) Hold down the **Ent** key until the display changes to:
Main menus



b) Press the **Ent** key.

c) The display should now read: **Serial** number
Software version

d) Press the down ↓ arrow and the display will show:
Concentration units



e) Press the down ↓ arrow again and the display will show:
Light Value Dist

f) Adjust the distance to the retroreflector by pressing the **ENT** key again. A flashing "Adj." will be visible in the lower left corner of the display. Pressing ↑ or ↓ keys increase or decrease the distance. Once the appropriate distance has been entered, press the **ESC** key. The display will now show the entered distance.

Note that the **GasFinderFC** does not measure the distance to the retroreflector. The distance, in metres, must be entered manually. It is measured from the window of the remote head or probe to the retroreflector.

g) Press **Esc** until the instrument enters a self calibration mode. This may take between one and three minutes depending on temperature and the type of gas being measured.

After the computer checks the calibration, the display will read:

This example indicates a path-averaged hydrogen fluoride concentration of **1.3ppm** with an R2 of **0.99** (99%). Of course, this display will depend upon the type of gas and the actual concentration. Note that to get the correct value for **ppm**, the path length (distance to the reflector) has to be set correctly — see item (f).

Use the X–Y mount adjusting screws on the remote head to locate the retroreflector in the cross hairs of the scope. Fine-tune the adjustment so that the displayed light value is at a maximum. If the light value is above 16,000 the receiver electronics may saturate and erratic readings may be displayed, e.g. unrealistically high concentration values and low confidence factors. An attenuator on the fibreoptic cable should be used lower the light value. The optimal range is between 4000 – 8000 but the system can operate well with a light value between 2,000 and 12,000.

If the light value is below 1,000, the system is in a minimal light situation and may fail to make a correct measurement. When the light value drops below a factory set value, usually 1000, the system will give a status message in the display indicating “low light - no reading”. To increase the light value, re-align the instrument, adjust the attenuator or increase the number of retros.

Caution: Do not look at the reflector through the scope over short distances when the red laser is operating.

Menu Details

Note: The **ESC** key returns to the *previous* menu section. If the user becomes “lost” within the menu system, press the **ESC** key until the system returns to the normal operation mode.

Main Menus

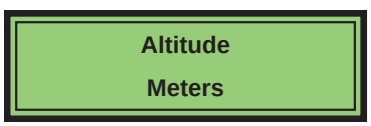
1. **Serial ## Version #.##.#:** This is the first menu item accessed when the **ENT** key is pressed in the Main Menus. This item provides a convenient way of checking the serial number of the instrument and the software version currently installed. This is not an adjustable item.

2. **Concentration Units:** This item displays the units chosen to display the concentration in the main display.
The units can be adjusted to display:
ppmm (parts per million metre): the total amount of gas along the path.
ppm (parts per million): average concentration along the path.
mg/Nm^3 (milligrams per normalised cubic meter): See Appendix E for details.
ppmm / m = **ppm**. See Appendix C for a more detailed explanation.

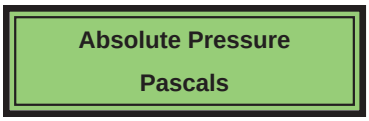
3. **Light Value Dist:** Pressing the down ↓ key will display Light Value and Distance. This also displays the entered distance to the retroreflector. The distance can be adjusted to correspond to the actual distance. This item is explained in detail on page 5.2(f) in this manual.

4. **Path Temperature**: Set this value to the average temperature of the path between the remote head and the retro.

5. **Altitude**: Set this value to the Altitude of the path above sea level. If the correct Absolute Pressure is known and entered, the nominal altitude is automatically calculated and displayed. Entering the correct Absolute Pressure is the prefered method.



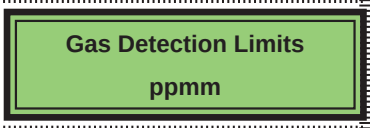
6. **Absolute Pressure**: Set this number to the Absolute atmospheric pressure of the path. If the altitude is entered the nominal pressure is automatically calculated and displayed.



7. **Light Menus**: This contains the 'Minimum Acceptable Light' value which is set at the factory. The value is usually 1000.

8. **Gas Light/R2:** Pressing the down key will show the display as Gas Concentration and a choice of Light Value or R2.

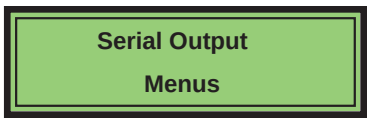
9. **Gas Detection Limits:** this item shows the limit for the gas concentration. This item is only displayed when the **GasFinderFC** is a dual gas system.



10. **Min. acceptable R2:** This item allows the user to specify the value of the confidence factor below which the concentration is deemed to be insignificant. Operators can adjust this value to reduce the occurrence of "noisy" readings in the presence of factors such as steam, traffic or thermal scintillation. *Consult with Boreal Laser Inc. before changing this value from the factory default value*.

10b. **Min acceptable R2:** This item is the same as item 6 but is for **Gas B**.

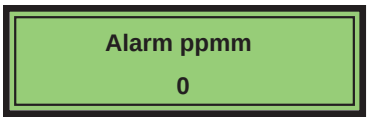
11. **Serial Output Menus**: This contains a submenu with two items.



a). The output can be set to 1). Real Time
2). Run Average
3). Block Average

b). The number of readings to compile the average for 2) and 3) above can be adjusted.

12. **Alarm ppmm:** When fitted, this item allows the user to select the set-point at which the optional audible alarm will sound. For more information on the audible alarm option, contact Boreal Laser Inc. Note: The units for the alarm are always in ppmm.



13. **4-20mA Current Loop Settings**: This submenu allows the user to configure the 4-20mA current loop option.

a). **4mA ppmm Set Point**: Sets the value in ppmm which corresponds to a loop current of 4mA.

b). **20mA ppmm Set Point**: Sets the value in ppmm which corresponds to a loop current of 20mA.

c). **4-20mA enable**: Enables or disables the 4-20m current loop output.

14. **Log to Memory Menus:** This submenu enables the **GasFinderFC** to be used as a data logger. The storage capacity is 131,072 samples. Recording a data point every second will give over 36 hours of recording. If the average is set to one minute using the **Average Window** set to 58, then the recording time is nearly 3 months.

Wrap

The data can be stored in the buffer in a **wrap**-around mode where data overwrites the initial records when the memory is full. Thus only the latest data is recorded.

Fill

Alternatively, if the **fill** mode is used, the data will fill the buffer and once full no new data will be captured.

Downloading

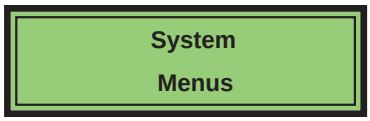
The buffer can be downloaded to a computer using **GasViewOP** or a terminal program such as Hyperterminal. For a large download the baud rate on both the **GasFinderFC** and the computer should be set to a high value in order to keep the memory download time to a reasonable level.

Powering Off

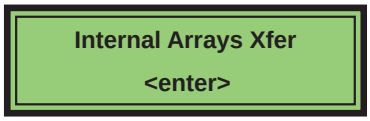
Powering off the **GasFinderFC** off does not erase the data. The data log is only cleared using **Clear Log** in the **Log Menus** option. For more detailed instructions on using the **Log Menus** options, see Appendix F.

System Menus

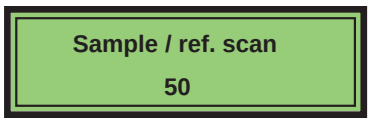
When the **Main Menus** is showing in the window, pressing the down arrow will display the **System Menus**. This block contains items which do not need to be regularly accessed. With **System Menus** showing in the display press the **Ent** key.



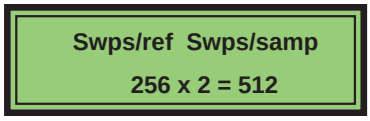
15. **Internal Arrays Xfer:** If there is a need to check the system, the **Internal Arrays Xfer** allows the instrument's internal array configuration and various other parameters to be downloaded to a file. The operator can transmit this file to Boreal Laser Inc. for analysis.



16. **Sample / ref. scan:** This item selects the number of times the sample path is measured before the reference cell is checked.
It should not be necessary to change this value from the factory default setting.



17. **Swps/ref Swps/samp:** The laser drive electronics are designed to vary the emission wavelength of the laser from just below to just above the selected wavelength. This varying laser wavelength effectively 'sweeps' across the selected line, and the resulting readings are called '**sweeps**'. A series of '**sweeps**' are averaged to form a '**scan**'. When the data for the 'sample scan', 'reference cell scan', and 'associated readings' are incorporated into the calculations of gas concentration by the onboard computer, the resulting value is called a '**sample**'. One '**sample**' typically takes just over 1 second.



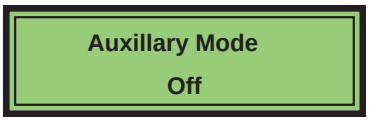
18. **Sweeps / Reference:** this item selects the number of times the reference cell is measured**.**
It should not be necessary to change this value from the factory default setting.

19. **Serial Checksum:** To ensure the integrity of the data when it is sent to a data logger or the **GasViewOP** program, a checksum string is added to the serial data. This option should be enabled in order to achieve compatability with all versions of **GasViewOP.**

20. **Serial Baud Rate:** This item allows the user to select the baud rate at which data are transmitted from the **GasFinderFC** instrument. Available options are: 300,1200, 2400, 4800, 9600, 19200, 38400, 57600,115200 and 230400 baud (9,600 is the usual setting). The serial data parameters are detailed in Section 4 of this manual.

21. **Serial Commands:** this item enables the **GasFinderFC** to receive commands from a computer running the **GasViewOP** program or any terminal program. These commands are described in Appendix F and the user manual for the **GasViewOP**.

22. **Auxiliary Mode:** This mode is for factory use only.

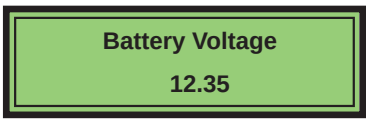


23. **Real Time Clock:** This submenu allows the user to set the Real Time Clock (RTC). Press the **ENT** key to cycle through the date and time entries. The up and down keys will change the item, and pressing **ESC** will back out of the submenu.

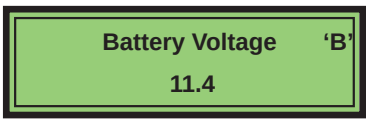
The values will automatically be saved on exit.

24. **Ref. Cell Check:** this item automatically displays the quality as a percentage of the original value and also the integrity of the internal reference cell. **(Quality & R2)**
This is not an adjustable item.

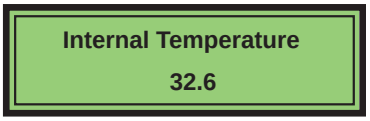
25. **Battery Voltage:** This provides a convenient way of checking the voltage of the 12V power supply.



If the voltage falls below 11.5V, a flashing 'B' will appear in the top right corner of the display.
If the voltage falls below 11.0V the **GasFinderFC** will shut down to protect the electronics. The data will be stored and can be retrieved when power is restored.
This is not an adjustable item.



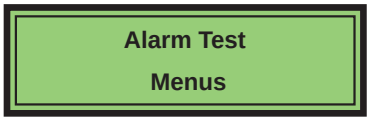
26. **Internal Temperature:** This displays the internal temperature of the **GasFinderFC**. It is usually 10^0C above ambient.
This is not an adjustable item.



27. **Enhanced Analysis:** Used for factory debugging.

28 **System Diagnostics:** Used for factory debugging.

29. **Alarm Test Menus:** This submenu is only applied when a 4-20mA option is being used. It allows the operator to simulate various alarm conditions in order to test the control systems.



30. **Service Menus:** This Submenu is only available to qualified personnel and requires a password to enter.

31. **Password Protected Menus**: These menus are accessible only for Boreal Laser personnel and their representatives.

Section 6. Maintenance

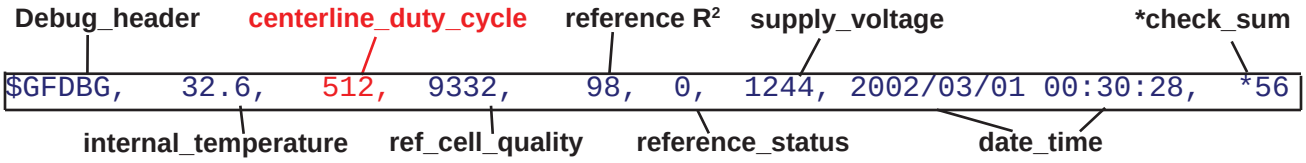
GasFinderFC

Note. If the GasFinderFC is working well it is best to leave it alone while keeping a check on the parameters mentioned below.

The **GasFinderFC** requires little maintenance and **there are no user-serviceable parts.** Calibration is done automatically at periodic intervals with an on board reference cell. Unless damage has been incurred through an accident, maintenance is limited to cleaning the window of the remote heads and probes and the windows of the retro enclosure. Over time(years) the Centreline Duty Cycle may require adjusting and Boreal Laser will instruct on this procedure.

Diagnostic Data:
Periodically, strings containing diagnostic data **($GFDBG)** are sent from the **GasFinderFC**. These can be seen in the ViewData window of the **GasViewOP** program. If the centreline duty cycle is below 300 or above 800 it would be advisable to contact Boreal laser Inc. for further instructions.

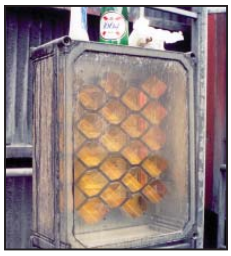
Example of a Debug string:



Remote Heads and Duct Probes
The Remote Heads and Duct Probes rely on a clear optical path to obtain accurate readings of gas concentration. Dust settling on the windows must be cleaned off whenever it degrades the instrument's performance. The average value for the light level should be kept between the recommended values set at the time of installation. Regularly inspect the equipment and remove all obstructions such as bird nests, cobwebs, etc. Only if necessary clean the windows. The time between cleaning can only be determined from experience.
See cleaning procedure on the next page.
If movement of the X-Y mounts has occurred, re-alignment may be necessary. In areas with a lot of dust and/or humidity, some lubrication of the X-Y mount may be required. If the remote head is consistently moving out of alignment, the structural stability of the mount supports should be reassessed.
Duct probes are usually operating in more severe conditions than heads and will require more frequent servicing. Purge air is usually required to minimise dirt build-up on windows.

Cables
Both coaxial and fibreoptic cables are best left alone if the equipment is operating well.

Retroreflectors



There are no moving parts and the only maintenance required is to clean the windows. The windows are usually Lexan which is a soft plastic and great care must be used when cleaning to avoid scratches.
The need for cleaning will be indicated by a consistent loss of light, which may result in poor gas-concentration readings. Difficulty in obtaining an adequate light level may indicate that the head or probe has moved out of alignment and should be checked first.

> **Note:** The instrument relies on a clear optical path to obtain readings of gas concentration. Dust settling on the window of the retroreflector enclosure must be cleaned off whenever it degrades the instrument's performance. The average value for the light level should be kept at the recommended values as determined at the initial installation. It is difficult to clean the windows without scratching them and should only be done it adequate light levels can not be obtained by re-alignment.

Many dusts, especially aluminium oxide, are very abrasive, and care must be taken not to scratch the windows when cleaning them. The recommended procedure for cleaning is as follows:

- Blow off any dust using canned compressed air[A]. Note that compressed "shop" air may contain oil from the compressor, and should not be used without a filter or oil trap.
- If the window is streaked with rain-deposited particles, wash the window with copious amounts of water, using a spray bottle, (laboratory or other type) and clean fingers.
- Gently wipe with a soft tissue.
- Spray a small quantity of anti-static[B] solution on the window.
- Gently wipe clean with a dry, soft tissue.

[A] These cans are available from camera shops and electronic stores or directly from Boreal Laser Inc.

[B] A suitable anti-static solution is "Novus™ No.1", used by plastic fabricators and it can be obtained directly from Boreal Laser Inc.

Light Level History is a good indicator of the condition of the equipment and forecasting a time for cleaning. Cleaning intervals may vary from once per week to once per year depending on environmental conditions.

The history can determine whether the light loss is gradual or intermittent.

- A gradual decrease may indicate that dirt is building up on the windows.
- A sudden drop may indicate a local fog, obstruction of the path, a break in a cable or a misalignment problem.
- A diurnal variation will indicate movement of the remote head mounting structure due to solar heating. See Section 7.7.

Section 7. Troubleshooting

Symptom: ***System not operating, display not illuminated.***

Solution: → Check the power supply.
- is the equipment plugged and the supply socket live?
- is the power cable intact? (See Appendix G)

Symptom: ***"Low Light - No Reading".***

Solution: → Check that the optical path is clear.
- Vehicle/personnel obstruction? – move!
- Heavy fog? – wait.
- Heavy rain? – wait.
- Cobwebs/birds? – Clean and prevent a recurrence.
- Window dirty? – Clean (see page 6.2).

→ Verify optical alignment (see page 3.6).

Note: If the system enters the "Low Light - No Reading" status condition due to a temporary path obstruction, normal operation will automatically resume once the obstruction has been removed (e.g. fog lifts, rain stops or vehicle/equipment is moved).

Symptom: ***No data transmission from GasFinderFC to the computer.***

Solution: → Check that the correct **baud rate** is selected (usually 9600).
- Enter **System Menus**, and scroll to the **Serial Baud Rate** window.

Verify that the data cable is connected and the cable is OK (see page 3.10)

Note: It is possible with a digital voltmeter to see a very short signal pulse between pins 2 and 5 on the DB9 connector.

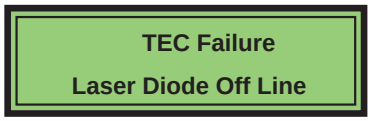
Symptom: ***The light is always at the maximum of 16368.***

Solution: → To lower the light, use a fibreoptic attenuator. If an attenuator is not available, remove or cover some of the retroreflectors or position the reflective tape at an angle to the beam. →

Note: If there is too much light returning to the photo diode, it is possible to damage the optical components. See Section 3.

Symptom: ***The display always shows "TEC Failure Laser Diode Off Line".***

If a problem develops with the **I**nternal **T**hermoelectric **C**ooler (TEC) or the associated electronics, the system will protect the laser diode by shutting the laser off and the display will read:



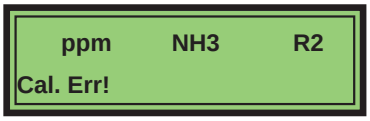
Solution: → In this situation, the operator should contact Boreal Laser Inc. for further information on resolving the problem.

Symptom: ***Display shows "Cal. Err!".***

If the system has difficulty verifying the internal calibration, the "**Cal. Err!**" display will flash. In this situation, the concentration reading from the instrument may not be valid. The display will

read something like:

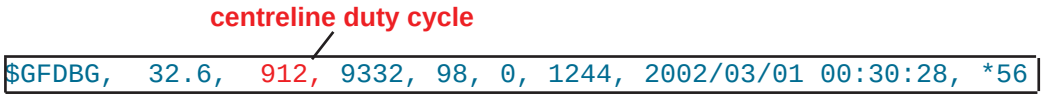
followed by:



Solution: → In some cases, especially if the system has been subjected to large variations in temperature, the problem can be resolved by switching the unit off, waiting a minute, and switching the unit back on.

→ If the display still shows Cal. Err!, collect an Arrays Transfer File (page 7.4) and send it to Boreal Laser together with 30min of data from the .gvl text file. This will allow Boreal Laser to diagnose the problem.

→ Periodically, strings containing diagnostic data ($GFDBG) are sent from the **GasFinderFC**. These can be seen in the ViewData window of **GasViewOP**. If the centreline duty cycle is below 300 or above 800 it would be advisable to contact Boreal laser for further instructions.



Symptom: ***Display reads "Unlocked No reading".***

If the signal being analysed by the onboard electronics falls below a certain set value, and the returning light level is within the acceptable bounds, problems may exist with the internal receiver electronics.

In this case, the system will display:

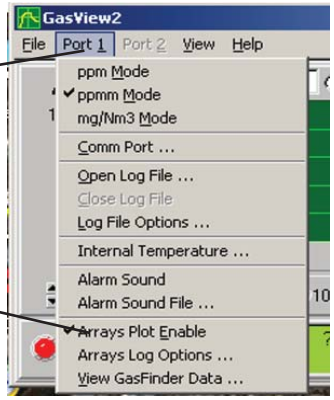
Solution: → If this situation persists, collect an Arrays Transfer File and send it to Boreal Laser together with 30min of data from the .gvl text file.
This will allow Boreal to diagnose the problem.

Array Transfers

The internal arrays and the various parameters stored internally in the **GasFinderFC** are a very important diagnostic tool. In cases of suspected problems with the equipment, if data from an Arrays Transfer together with 30min of .gvl data are sent (emailed) to Boreal Laser Inc., a diagnosis and solution can often be made without the necessity of returning the system to the factory, and with minimum delay.
These internal arrays can be accessed by downloading an array transfer file to an external computer. The **GasViewOP** software can be used to record the file.

To download the arrays:

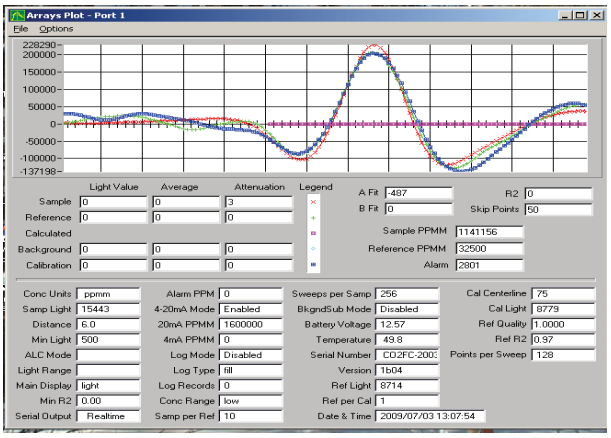
- Connect the **GasFinderFC** to a computer and run **GasViewOP**
- Click on Port and then Arrays Plot Enable.



- At the **GasFinderFC** enter the menu and in the System Menus the first item is 'Internal Arrays Transfer'.
- Press Enter.
  The display will read - Acquiring, Transferring.

The computer screen will show a series of curves.

- The file containing the data can be saved by clicking on File in the top left of the tool bar and saving it to a specific location. It can then be sent to Boreal Laser for diagnosis.



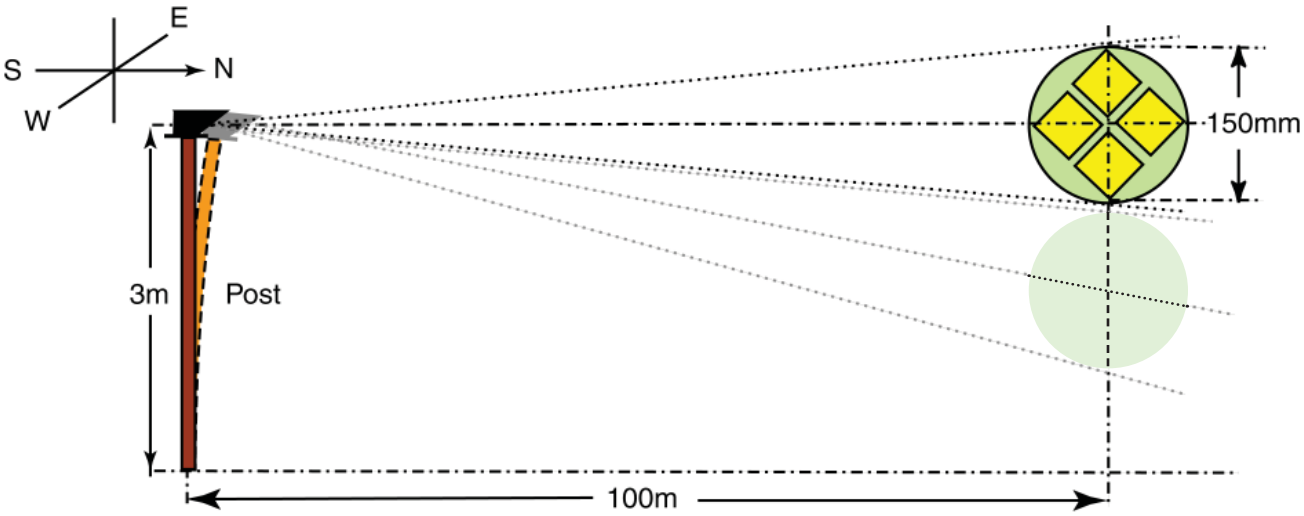
If the user does not have **GasViewOP**, the Arrays Transfer and Data files can be viewed and downloaded using Hyperterminal (page 4.5).

Stability of Support Structures

The diameter of the laser beam when it exits the remote head is about 1.5mm and the divergence is approximately 1.5mrad (milliradians). This means that at a distance of 100m the beam diameter is 1.5 x 100 = 150mm (6”). Similarly, at a distance of 1,000m, the beam diameter would be 1,500mm (59”). The beam intensity falls off towards the edge.
The remote head can be mounted on a tripod, post, or platform, and directs the laser beam to a reflector, which can be from a few metres to several hundred metres distant. This article deals with the stability requirements for the mounting structure.

Calculating the Effects of Movement

Consider the example of a 150mm-diameter retroreflector array located 100m due north of the remote head.



The post, and therefore the remote head, can move vertically or horizontally 150mm (6”) either side of the centreline before the beam will move completely off the retro array. This movement is referred to as ***translational***. In practice, significant translational movement is unlikely to occur, as the post is usually fastened to a solid base. However, because it is fixed at the bottom, ***torsional*** or bending movement is much more likely, due to wind loading or thermal distortion. Any East - West bending (i.e. perpendicular to the centreline) is manifested as a lateral motion and will have a minimal effect. Conversely, any North - South bending will have a serious negative effect: the top of a 3m (~10’) tall post can only move 4.5mm (0.177”) before the beam will have moved 150mm all the way off the retro. For a 500m path length, with the retroreflector array doubled in diameter to 300mm (12”), the top of the 3m post can only move 1.8mm (0.071”) before the beam will completely miss the retroreflector. A 10m post can move 6mm (0.236”) and cause the same result.

Note: Movement of the retroreflectors has little effect compared to movement of the remote head. The retro support does not require the same structural stability as that required by the remote head support.

Types of Supports

All posts require a solid concrete base. In areas where freeze/thaw conditions occur, the base of the concrete needs to be well below the frost level and an air space left between the base and the surrounding earth down to the frost level. Above ground, the post can be concrete (preferred) or metal. A 100mm x 100mm (4”x 4”) metal post can be used for heights up to 2m; above 3m, torsion limits the path length to 100m.

Solid metal support

Longer distances or higher supports require a wider base. This can be obtained by using self-supporting lattice towers or a number of posts joined at the top and well braced.

Lattice tower
Photo by M. Ball

Provided it is in the correct location, a building can often provide a very stable support for a remote head. However it should be noted that the metal roof structures of long buildings oriented east-west are very susceptible to diurnal movement caused by solar heating.

Scaffold support

Scaffolds can be used for temporary mounting structures but they must be ‘CupLock’, ‘Z-Lock’ or other rigidly braced types. The clip-together types are not stable enough. To comply with safety regulations, the height of a scaffold cannot exceed three times the width of the narrowest base dimension. This gives a very stable platform however the alignment will often move slightly when the operator descends. The scaffold can also be placed on adjustable legs to accommodate different ground elevations.

Thermal Effects

Differential heating of support legs can cause diurnal variations in alignment. This is very common on long paths (over 100m) and can be minimized by shading, insulating the legs, or using non-metallic materials such as concrete, wood, or fibreglass. The effect can be seen by looking at the **light level history** over a number of sunny days. A sinusoidal variation is an indication of solar heating. In severe circumstances a dispersed retro array may be the only solution.

Wind Effects

On outside paths these effects can be minimised by using open-member supports. Note that guy wires can sometimes oscillate and cause movement.

GasFinder mounted separately from the work platform

Platform Separation

Note: It is critical that the platform for the remote head is not connected to the same platform that the operator stands on for installation or maintenance work. This may preclude the use of scaffolds for long paths.

Alignment Procedures for a Moving Building

All buildings move. Some move more than others depending on the external and internal forces. In most cases, this movement goes unnoticed until cracks form in concrete or a small piece of plaster flakes off. Movement can occur over years as the building foundations settle, or over seconds as wind forces or cranes move the structure. Settlement over a long time is too slow to cause an alignment problem, because any movement is incrementally small, and can be compensated for with periodic adjustments. When the movement is caused by wind, the structure returns to its previous position once the wind has passed. In the same way, the shaking motion produced by the movement of overhead cranes is not usually a problem as the structure quickly returns to its original position when the crane has stopped.
Movement caused by thermal expansion due to solar heating is different. Metal structures are particularly susceptible to deflection when the solar heating produces large differential forces, which result in a twisting or warping motion of the structure. This is seen, especially on sunny days, as a diurnal variation in the **GasFinderFC** light level. This variation is caused by the expansion and contraction of the metal structure carrying the laser mount, which twists with respect to the longitudinal axis of the original laser path. This causes the laser beam to move away from the reflectors and results in a drop in the returning light level. The amount of movement will vary considerably with the orientation of the building and the attachment of the mount within the building and the length of the path.

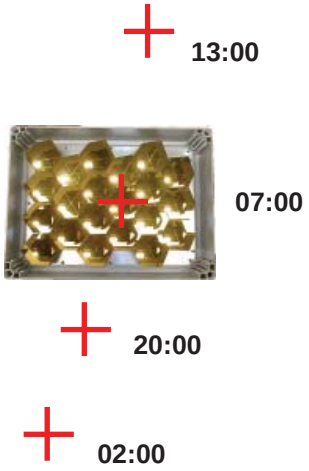


Figure 1

If movement is suspected, it can be verified and measured as follows:

Arrange to have access to the mount where the remote head and telescope are located, and plan to make observations through the telescope at least four times throughout the day. Movement is usually at a maximum on bright, sunny days. At each observation, note the time and the position of the cross hairs in the telescope with respect to a part on the reflector. Shining a flashlight beam on the reflector will make it easy to see at long distances. Do not adjust any alignment screws. At the end of the day, you should have a number of points showing the different positions of the cross hairs. This difference will indicate the amount and direction of movement of the laser beam. See figure1.

The observations can be made over a shorter time period, but the results may not give an accurate picture of the movement. A plot of the positions over time will yield a graph similar to figure 2. This graph can be used to estimate the maximum movement of the beam.

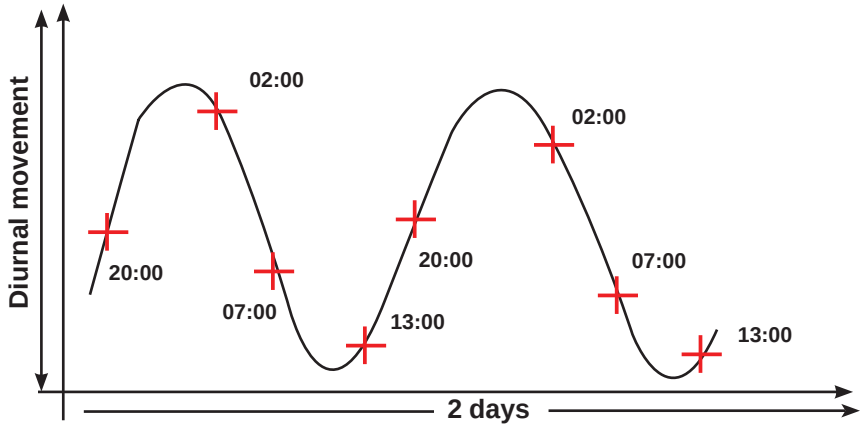


Figure 2

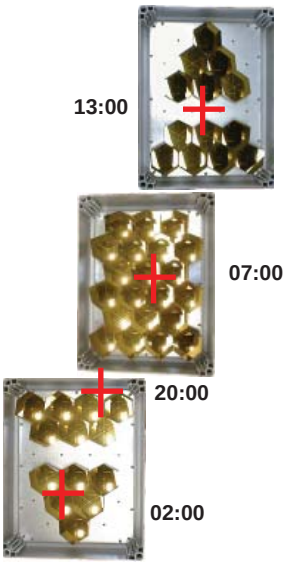


Figure 3

Rather than use a motorised mount to adjust the alignment of the remote head, the preferred to solution is to use a dispersed array of retro reflectors.

In the preceding example, the final retro array will be similar to the shape shown in figure 3.

The number of reflectors may have to be increased from the number used in the single enclosure, and their spacing will also have to be changed. Contact Boreal Laser for more specific details.

Centering the Cross Hairs with the Centre of the Laser Beam

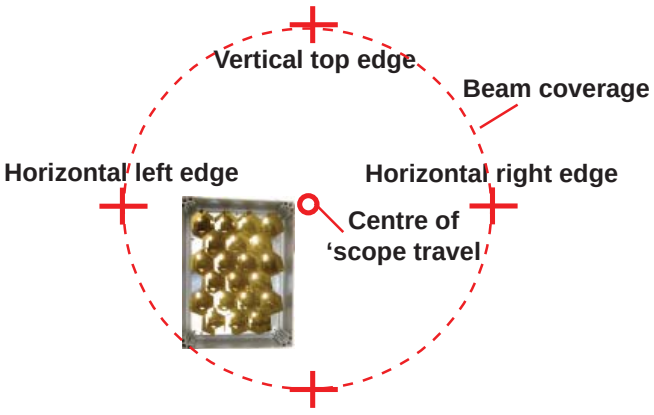
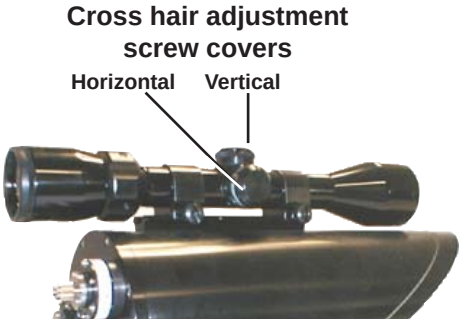


Figure 4

At 400m, the diameter of the beam is about 600mm, so the area of the beam may be larger than the enclosure. To find the edges of the beam, the remote head has to be traversed horizontally and vertically until the light level drops. Note where the cross hairs are in the scope relative to the reflector at these positions, (see figure 4) and position the head, so that the cross hairs are in the centre of the travel. In the example shown, the cross hairs would be at the top right corner of the reflector when the beam is centred on the retro.

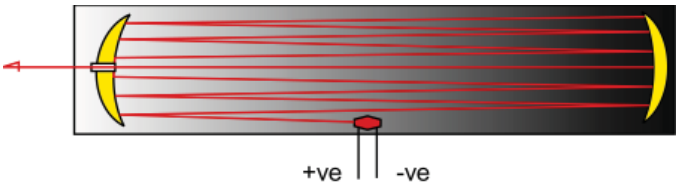


Looking through the telescope, and without adjusting the alignment of the remote head, adjust the crosshairs to the centre of the reflector.
This is done by removing the two cover caps in the centre of the scope body and turning the screws underneath so that the cross hairs are centred on the middle of the reflector. The vertical cross hair is adjusted by the screw on the top, and the horizontal cross hair is adjusted by the screw on right.

Section 8. The Basics of Laser Gas Detection

Tuneable Diode Laser

Laser is an acronym for: **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation



In principle, the laser is a tube with a mirror at each end. In the tube is a crystal or gas mixture which is induced to emit radiation by stimulating it with electricity. The radiation in the tube bounces between the two mirrors and starts a chain reaction. The chain reaction, or *light amplification*, would cause the device to burn up if continued indefinitely. For this reason, a small amount of the reflective coating on one mirror is removed or a small hole placed in it. This causes a small stream of identical photons to be released through the hole. The emitted stream of photons is identical in both time and space. This is the 'coherent' radiation characteristic of a laser. A crystal or gas is selected which will emit radiation at a specific wavelength. A ruby crystal emits a visible red beam with a wavelength of 6500 angstroms or 650 nanometers.

Gas Laser

Diode Laser

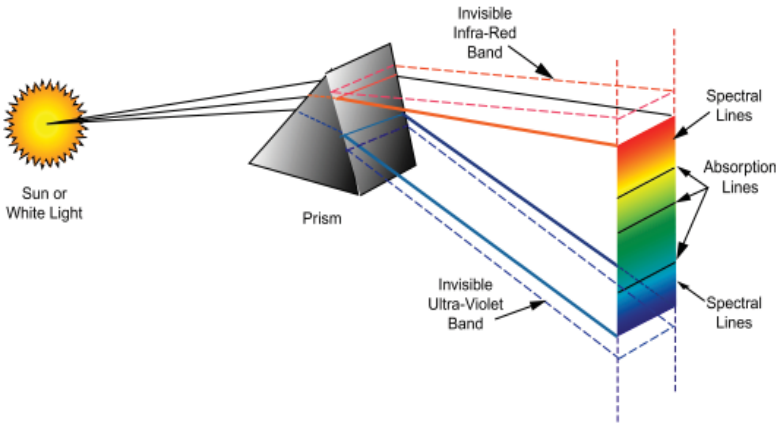
Pencil

A **Diode Laser** works on the same principle except that the tube, mirrors, and crystal are all combined in a small package using semiconductor technology. The diode laser is composed of a pn junction, as in the light emitting diode (LED), and specially cleaved mirror facets that form the optical cavity. The output wavelength is fixed. The size of the laser and focusing optics is similar to the size of the eraser on the end of a pencil.

A **Tuneable Diode Laser (TDL)** can have its wavelength altered very slightly while it is operating. This can be done by changing the operating temperature or the drive current.

Absorption Lines

If a beam of sunlight is sent through a glass prism, a spectrum of colours can be seen leaving the prism, which can be projected onto a screen. Blue, which has a shorter wavelength, is bent more than the red. The visible spectrum is only a small part of the emissions. Extending beyond the blue is the ultra-violet and beyond the red is the infra-red.



If the projected spectrum is sharp and defined, a number of black lines may be seen at various locations. These lines are absences of light where atoms and molecules of gas in the sun or the light beam path have absorbed the light at a particular wavelength. This results in a black line on the display. These lines are called **absorption lines**.

Gas Detection with a Laser

Every gas is composed of atoms or molecules. If the target gas is hydrogen fluoride, then one atom of hydrogen would have combined with one atom of fluoride to give one molecule of hydrogen fluoride. These molecules have various frequencies or wavelengths at which they resonate or vibrate. See figure 1. These are known as the absorption wavelengths, because when the molecules absorb a portion of the light energy, they vibrate at these wavelengths. Because molecules of other gases have different atomic weights, these gases absorb light at different wavelengths from the target gas. Wavelengths for laser gas detection are chosen in regions where the absorption of the target gas is not interfered with by the absorption wavelength of any other gases that may be present.

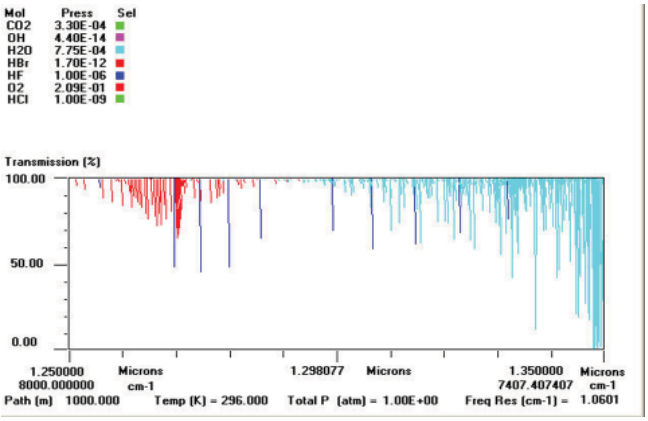


Fig. 1

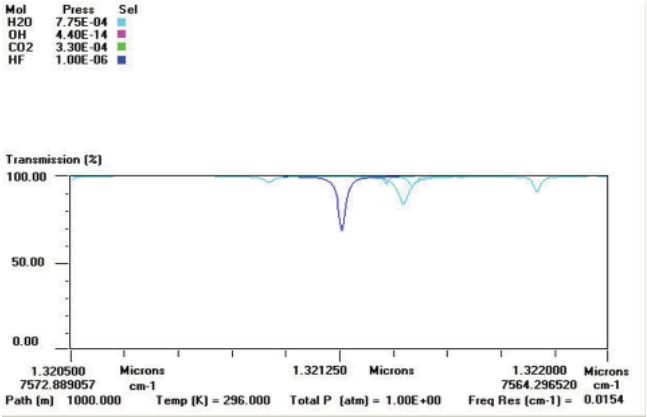


Fig. 2

A laser beam can be chosen which operates at a specific absorption wavelength for this target gas. See figure 2. The laser operating wavelength is kept stable by housing it in a temperature-controlled box. A fluctuating (saw-tooth) current is used to drive the laser, and this causes the wavelength to change slightly so that the laser scans across the absorption wavelength.

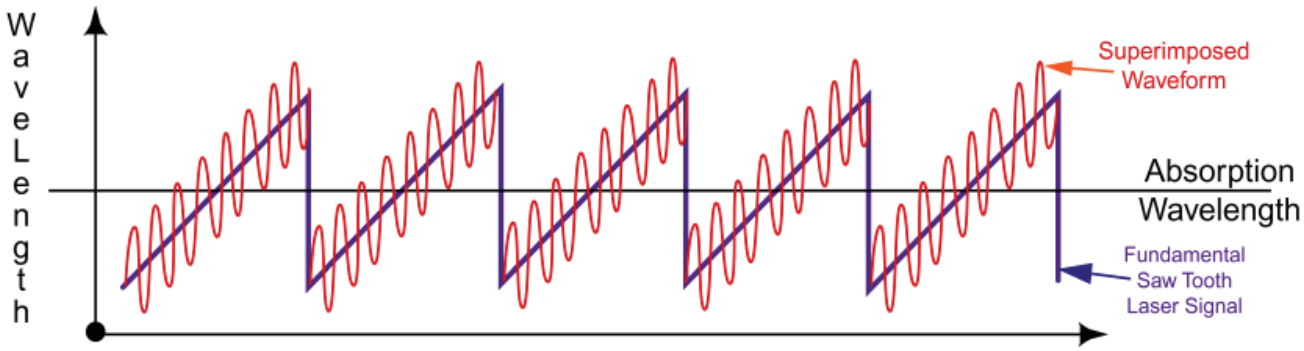


Fig. 3

The laser beam has a signal superimposed on it at a different frequency. See figure 3. When the gas molecule is struck by the laser beam, the molecule is induced to vibrate. These vibrations affect the laser beam by changing this superimposed frequency. This difference is detected by a receiver in the instrument, when the laser beam is reflected back.

The difference in the superimposed signal, together with the intensity of the returning beam, is used by a computer to obtain a measurement of the target gas concentration. The laser operates in the near infra- red spectrum (1300 to 1700 nanometers) and cannot be seen with the eye. It has a line width of about 0.3nm and is concentrated and very intense. For the same power output, it is able to penetrate dust and steam better than a visible laser.

Retroreflectors(Retros)

The laser beam is transmitted to a retroreflector made with a special type of corner cube arrangement. This causes the signal to be reflected directly back to the detector in the transmitter enclosure. With the appropriate number of reflectors, path lengths up to 1 km can be traversed.

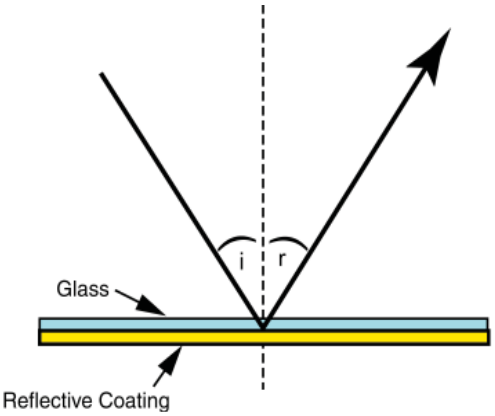


Fig. 4 Flat Mirror

Most mirrors reflect light the same way as a flat, glass bathroom mirror, where the angle of incidence(i) = the angle of reflection(r). A bathroom mirror has the reflective coating on the rear, behind the glass. See figure 4.

A retroreflector is different in that the reflected light returns in the same direction as the incident light. The beam is reflected 180 degrees. A retroreflector is like a section through a corner and has three faces that form the inside corner of a cube. Some highway reflectors are everyday examples. See figure 5. Because retroreflectors used for laser gas detection have the reflective surface on the front, the base material can be glass or metal. The surface coating is usually a very thin layer of gold or sometimes silver. This means that cleaning the fragile coating is very difficult and is done with an air brush to avoid touching the surface.

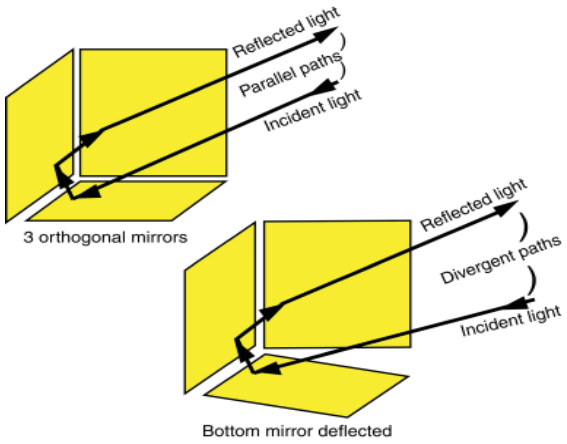


Fig. 5 Retroreflector

OP3 Remote Head

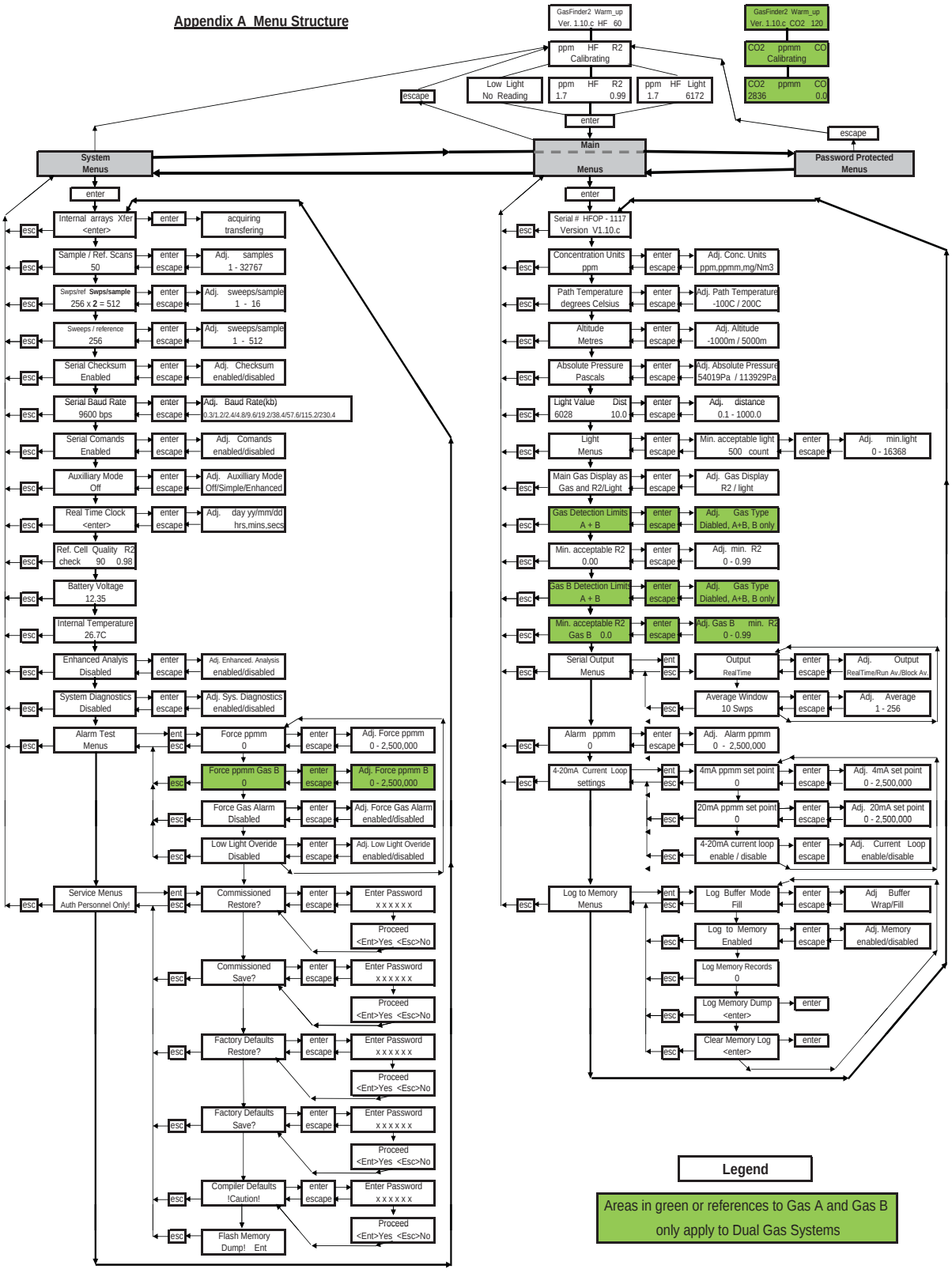
6 Retros

75 Element retro

Glossary of Common Terms and Abbreviations.

absorption lines	Dark lines in the spectrum due to absorption of the light.
absorption wavelength	The wavelength at which a gas absorbs light.
angle of incidence(i)	The angle to the perpendicular that a beam makes.
angle of reflection(r)	The angle to the perpendicular that a reflected beam makes.
angstrom	Measurement of wavelength 0.000 000 000 1 part of a meter.
arrays	A group of graphs or curves.
corner cube	Special type of reflector surface (see retroreflector).
coherent	Having the same frequency and phase.
digitised	Represented by numbers.
facets	Sides or faces.
frequency	Number of repeated oscillations a wave makes in a set time.
inert	Not reactive.
infra- red	Long wavelength electromagnetic radiation.
laser	**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.
microcontroller	A small device using a microcomputer.
microcomputer	A small computer the size of a postage stamp.
micron	0.000 001 part of a meter.
modulated	Like a wave.
molecule	A collection of atoms bonded together.
multimode	A light beam containing many different frequencies.
nanometer	0.000 000 001 part of a meter.
NIST	**N**ational **I**nstitute of **S**tandards and **T**echnology.
OTDR	**O**ptical **T**ime **D**omain **R**eflectometer.
orders of magnitude	Multiples of ten.
permeation tube	A device to generate a gas at a known and controlled rate.
photo-diode	An electronic device used to detect light.
ppm	parts per million.
ppmm	parts per miliion metre.
ppb	parts per billion.
retroreflector	A device to reflect a beam back to where it came from.
retro arrays	A group of retro reflectors.
saw-tooth	Serrated, or shaped like the teeth on a saw.
singlemode	A light beam containing only one frequency.
spectroscopy	Measurement of different radiation spectra.
TDLS	**T**uneable **D**iode **L**aser **S**pectroscopy.
tuneable diode	A diode (emitter) that can have its wavelength altered.
wavelength	Distance between the same points in two consecutive waves.

Appendix A — Menu Structure



Appendix B — Status Codes

When the **GasFinderFC** is used in conjunction with 'Hyperterminal' or Boreal Laser's '**GasViewOP**' data-logging program, the data stream which is sent to the file is as follows:

```
$GFDTA,  122.8, 99, 235.5, 8835, 2002/03/06 10:21:25, HF-1015,2800 *  2F
```

$GFDTA	122.8	99	235.5	8835	2002/02/06	10:21:25	HF-1015	2800	*	2F
Header	ppmm	R^2	Distance (meters)	Light level	Date	Time	Serial number	Status code	End of string	Check sum

Status Code **2 8 0 0**

Hex	n_{15}	n_{14}	n_{13}	n_{12}
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

Hex	n_{11}	n_{10}	n_9	n_8
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

Hex	n_7	n_6	n_5	n_4
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

Hex	n_3	n_2	n_1	n_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
A	1	0	1	0
B	1	0	1	1
C	1	1	0	0
D	1	1	0	1
E	1	1	1	0
F	1	1	1	1

n_{15}	n_{14}	n_{13}	n_{12}	n_{11}	n_{10}	n_9	n_8	n_7	n_6	n_5	n_4	n_3	n_2	n_1	n_0

n_{15} - CAL_ERR: calibration line centre error
n_{14} - WAVG_ENAB: averaging enabled
n_{13} - NOT_CALIB: calibration not verified
n_{12} - LOW_BAT: low battery indication
n_{11} - MENU_MODE: unit is currently in menu mode
n_{10} - CALIB_ERR: reference cell out of factory calibration
n_9 - OVERFLOW: gas concentration >8 digits
n_8 - OVERRANGE: receiver signal beyond gain switch control

n_7 - LD_COLD: TE Failure, laser diode off line
n_6 - Lt_Lv_ERR: turbulence, timed out
n_5 - NOLOCKDET: receiver unlocked, low signal
n_4 - LOW_LIGHT: laser path blocked, low light
n_3 - R2_LOW: R^2 lower than set minimum value
n_2 - NOT_CTRD: laser not centred on gas wavelength
n_1 - GAS_HIGH: concentration higher than set maximum
n_0 - NO_ERROR: normal operation, no errors

Examples:

(a). The above sample status code of "2800" corresponds to "0010_1000_0000_0000".
This indicates an instrument status of: **n_{13} - NOT_CALIB, n_{11} - MENU_MODE**

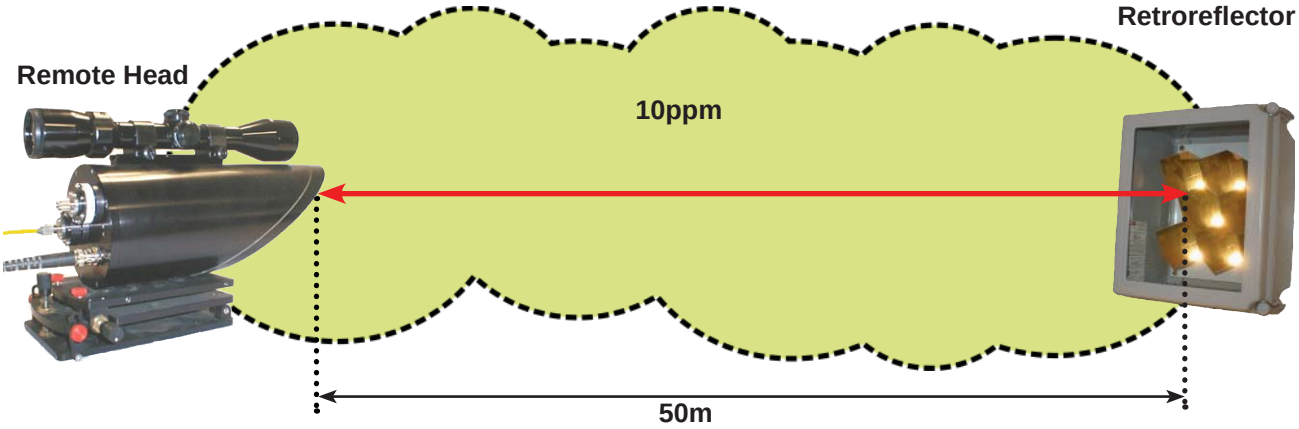
(b). Code "A42E" would correspond to "1010_0100_0010_1110" and indicate an instrument status of:
n_{15}-CAL_ERR,n_{13} -NOT_CALIB,n_{10}-CALIB_ERR,n_5-NOLOCKDET,n_3-R2_LOW,n_2-NOT_CTRD,n_1-GAS_HIGH

Under normall operating conditions, the most common status code is "1". This is actually 0001, but the software ignores the leading zeros and indicates a status code of "1". This corresponds to "0000_0000_0000_0001", and indicates an instrument status of: **n_0 - NO_ERROR.**

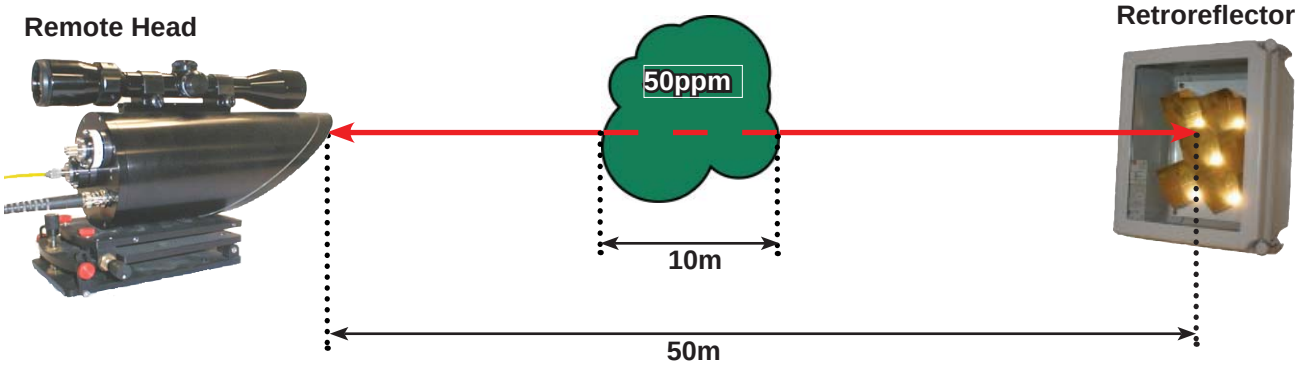
Appendix C — Explanation of ppmm

Gas concentration is measured in ppm, 'parts per million' by volume. If a room measuring 100m x 100m x 100m (1 million cubic metres) has 10 cubic metres of air replaced by a pure gas, then the gas concentration is expressed as 10 ppm. Open path monitors, like the **GasFinderMC-1**, measure the total amount of a specific gas such as HF in the path of the laser beam between the transmitter unit and a reflector. This is a 'total path' measurement. The units are 'parts per million metres', or 'ppmm'.

A uniform background concentration of 10 ppm over 50 m gives a reading of 500ppmm.
10ppm x 50m = 500ppmm



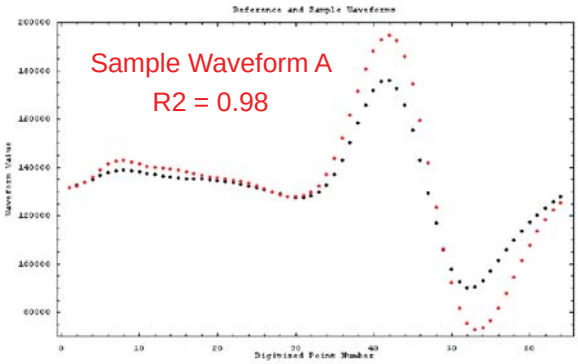
A concentrated cloud of 50 ppm, 10 m in diameter, in a background of 0 ppm also gives a reading of 500 ppmm. 50ppm x 10m = 500ppmm

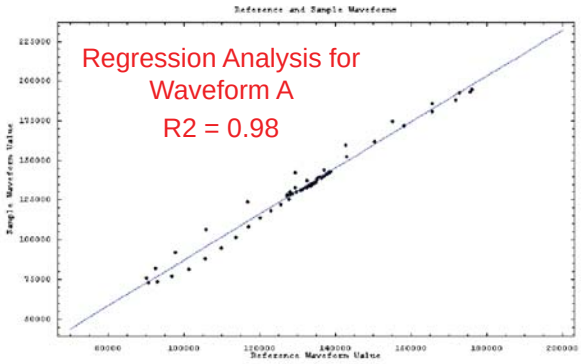


When the 500 ppmm is divided by 50 m the result is a value of 10 ppm, which is the 'path averaged' concentration.

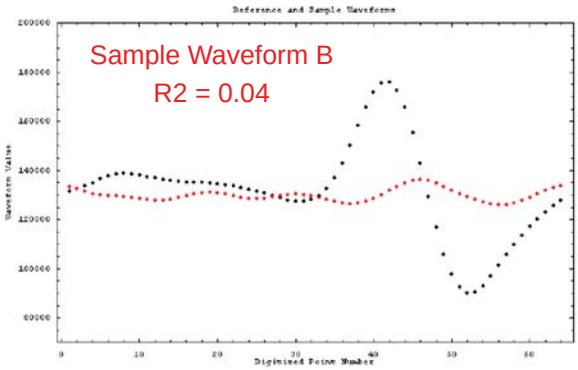
Appendix D — Explanation of R^2

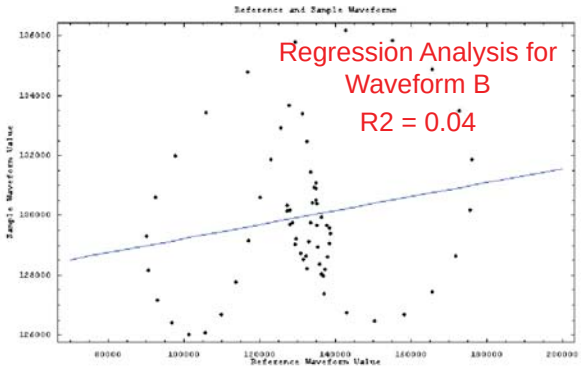
When the **GasFinderFC** receives the returning laser signal after it has passed through the sample gas, the receiver converts it to the shape of a specific waveform or curve. This is the sample waveform. The **GasFinderFC** also receives a similar signal after the laser beam has passed through the internal reference cell. These curves are then digitised and compared as two numeric arrays.





An accepted mathematical procedure to compare curves or numeric arrays is the **Linear Least Squares Regression** analysis. This analysis results in a measure of the similarity (**R^2**), between the waveform of the **sample** gas and that of the **reference** cell gas. A perfect similarity would give a value for **R^2** of 1.0, and a total mismatch would be 0.0.

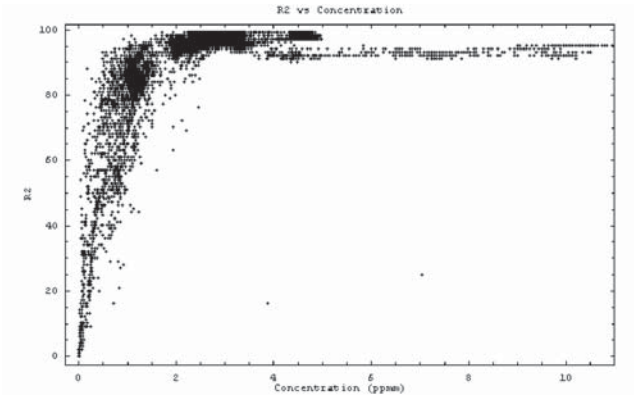




The dark line represents the **Linear Least Squares** fit of the data and is the best fit of a straight line between the reference (X) and sample (Y) data points. The slope is a component in the ratio-metric calculation of gas concentration.

Explanation of R^2 (continued)

A typical plot of **concentration** versus **R^2** will give the following graph:



R2

ppmm

With lower levels of sample gas, the **R^2**s decrease, and equal zero when there is no gas present. As the signal from the gas becomes stronger, the effect of noise, both electronic and optical, is reduced and the **R^2**s will increase (i.e., the signal to noise ratio will increase). The general shape of the plot is the same for all gases; however, the x-axis values will depend on the sensitivity of the instrument to the gas species being observed.

Use of R^2

The point at which the bend or 'knee' of the curve occurs in the plot of R^2 / ppmm can be used to determine the sensitivity of the instrument to the gas concentration measurement. This varies with the instrument and the type of gas but an R^2 of 0.85 is generally agreed to be the point at which the readings can be considered valid. Below this the readings should be treated with suspicion.

Appendix E — Conversion from ppm to mg/nm³

(Parts per million to milligrams per cubic metre)

To convert from ppm to mg/m³ the following equation is used and follows the EPA Air Emissions Monitoring Guidance Note #2 (AG1):

$$\text{Concentration (mg/m}^3\text{)} = \text{Concentration (ppm)} \times \frac{\text{molecular weight (g)}}{\text{molar volume (l)}}$$

In the following example Hydrogen Fluoride (HF) is used to illustrate the conversion:

HF reading from **GasFinder**	=	1ppm at STP*
Molecular weight of HF	=	20.006 g/mole
At STP the molar volume of an ideal gas	=	22.41 litres
Therefore the concentration	=	$1 \times \frac{20.006}{22.41}$
1ppm HF	**=**	**0.8927 mg/m³ at STP**

*STP refers to:

Standard Atmospheric Pressure (P)	=	101.325kPa
Standard temperature (K)	=	273.15K

If the measurement is not taken at STP then an aditional correction is required to adjust to STP:

$$\text{Concentration (mg/m}^3\text{ at STP)} = \text{Concentration (mg/m}^3\text{)} \times \frac{T}{273.15} \times \frac{101.325}{P}$$

where T is the path temperature (Kelvin)
P is the absolute path pressure (kilopascals)

eg. With a reading of 11 ppm, a path temperature of 30°C and path pressure of 94.34 kPa:

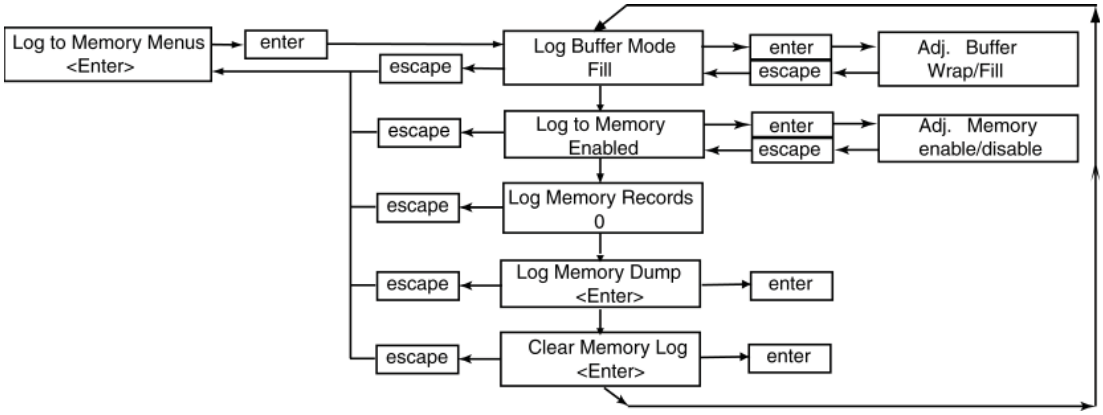
$$\text{Actual Concentration} = 11 \times 0.8927 \times \frac{303.15}{273.15} \times \frac{101.325}{94.34} \text{ mg/m}^3$$

$$= 9.8197 \times 1.11 \times 1.074 \text{ mg/m}^3$$

11ppm of HF = 11.71 mg/m³.

Note: If the measured ppm values have already been corrected for pressure and/or temperature using either the onboard compensation or the supplied compensation curves, then in the above equation use T = 293.15K and/or P = 101.325kPa; not the sample measurement conditions.

Appendix F — Log to Memory



Log to Memory Menus: To use this option, enter the **Menu** by pressing **Ent** on the keypad. The display will read **Concentration Units**. Press the up arrow five times and the **Log to Memory Menus** will be displayed.
Press **Ent** and
Log Buffer Mode will be displayed.

Buffer Mode: Pressing **Ent** again will enable the user to choose between **fill** and **wrap** mode. The data can be stored in the memory in a **wrap** - around mode where, when the memory is full, data overwrites the initial records. Thus only the last readings(131,072) are retained. Alternatively, if the **fill** mode is used, once 131,072 readings have filled the memory, all future data are discarded. Pressing **ESC** will return to **Log Buffer Mode**, and then pressing the down arrow will lead to the next item.

Log to Memory: When this is **Enabled**, the internal logging option is activated.

Log Memory Records: This item lists the number of records currently in the memory. The storage capacity is 131,072 lines. Recording a data point every sample will give over 36 hours of recording. If the average is set to one minute using the **Average Window** set to 55 seconds(see example 2 on the following page), then the recording time is nearly 3 months.

Log Memory Dump: Pressing **Ent** will download the stored data to a computer terminal through the serial data port. The data can be captured using **GasViewOP** or **Hyperterminal**. See the description of **HyperTerminal** on page 4.5.
Downloading the data will not erase the data in the internal memory. It can be downloaded as many times as required, provided it has not been cleared.

Clear Memory Log: Pressing **Ent** will erase all data stored in the memory. Switching the **GasFinderFC** off does not erase the data. Data can only be erased using **Clear Memory Log**.

To return to the normal operating mode, press **ESC** twice.

Example 1:

If data are to be recorded every sample, '**Log to Memory'** should be **Enabled**, set the **'Serial Dump per Sample Sweep'** to **'Serial Dump per Sample Sweep'**, and set the '**Average Window'** to **1**.

Example 2:
To record data with a one-minute average, '**Log to Memory'** should be **Enabled**, set the '**Average Window'** to about **55**, and set the '**Serial Dump per Sample Sweep**' to '**Serial Dump per Average Window'**. In this configuration, the recording time is nearly 3 months.
To calculate the correct figure for the sample:

- Check the date/time entry in the ViewData window of **GasviewOP**. Note the time taken for 50 samples to occur, say 55 seconds. This means that the time for one sample is 1.1 second(33/30). 50 samples will usually ensure that one reference cell check is included in the calculation.
- The time for a one minute average will be 55 seconds(60/1.1).

> **Note:** To ensure that the logging proceeds correctly, three menu items should be checked: **'Log to Memory'** (should be enabled), **'Serial Dump per Sample/ Average Sweep'** (set to Average) and '**Average Window' (**should be calculated and entered).

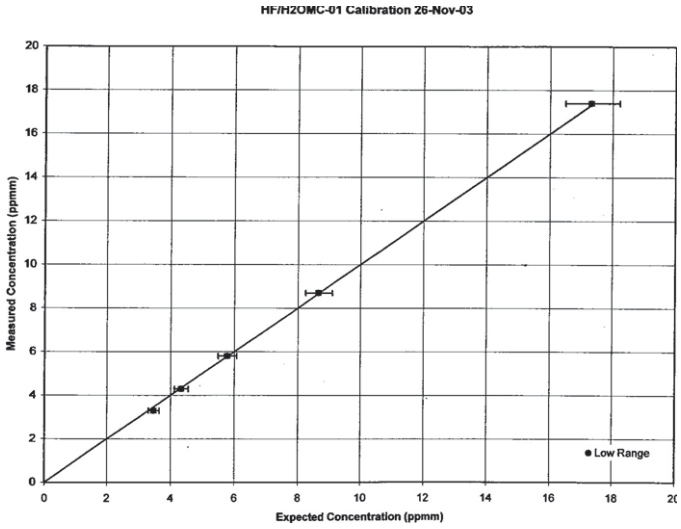
When the **GasFinderFC** is in **Menu Mode**, the data output is set automatically to once per sample. This can appear confusing if the **Average Interval** is set to a value other than one. However, when the **Menu Mode** is exited, data will be stored at the selected rate.

Care should be taken if the **GasViewOP** program is used at the same time as the **Log to Memory** is enabled in an averaging mode. Due to possible re-averaging by the **GasViewOP** program, false values may be generated.

Appendix G — Calibration

The **GasFinderFC** is shipped already calibrated and does not require any calibration in the field.

The calibration of the **GasFinderFC** is done by passing a known concentration of gas through a test cell, which is placed in the path of the laser beam. Gases which are very reactive or unstable, such as ammonia and hydrogen fluoride, are generated at the time of use with a permeation tube. The tube is placed in a temperature-controlled chamber and emits the calibration gas at a known rate. A measured flow of inert dilution gas creates a concentration of gas which is traceable to NIST standards. The calibration data are stored in the instrument's software as a standard reference waveform.



During operation, the **GasFinderFC's** internal reference cell is compared with this stored waveform at frequent intervals. Any significant deviation generates a status code to alert the user to a potential calibration problem. The **GasFinderFC** software can be used to check the reference cell, as well as to download sample, reference, and calibration waveforms (System Menus/Internal Arrays Transfer) to verify that the system is functioning correctly. If **GasViewOP** is being used, these waveforms can be displayed on the computer (Port1/Arrays Plot Enable and press the 'Arrays Transfer' in the **GasFinderFC** menu).

A technical note detailing the calibration procedure and quality assurance is available from Boreal Laser Inc.

Appendix H — Pre-Ship Settings

Pre-Ship Checkout Sheet for GasFinder 2.0 Aug 2012

Checked by	Date	Serial #	Software version
			Coldfire v1.10.c

Main Menu	Setting
Concentration Units ppm/ppmm/mg/Nm3	
Light Value / Distance 0.1 - 1000 m	
Path Temperature C	
Altitude m	
Absolute Pressure Pa	
Light: Minimum Acceptable Light 0 - 16368	
Main Gas Display as Gas and R2/Light	
Min. Acceptable R2 0 - 0.99	
Serial Output: Output RealTime/RunAv/BlockAv	
Serial Output: Average Window 1-256	
Alarm ppmm 0 - 65535	
4-20 ma Menu: 4ma ppmm set point 0 - 65535	
4-20 ma Menu: 20ma ppmm set point 0 - 65535	
4-20 ma Menu: 4-20ma current loop enabled/disabled	
Log to mem.: Log Buffer Mode wrap / fill	
Log to mem.: Log to Memory enabled/disabled	

System Menu	
Samples per ref Scan 1 - 32767	
Swps/Ref x Swps/Smpl 1 - 16	
Sweeps/Reference	
Data Check Sum enabled/disabled	
Serial Baud Rate 1200/2400/9600/19200/57600bps	
Serial Commands enabled/disabled	
Auxillary Mode Off/Simple/Enhanced	
Reference cell quality / R2	
Enhanced Analysis enabled/disabled	
Sys. Diagnostics enabled/disabled	

Password Protected menu	Setting
Ref. Cell ppmm	
Ref Light 0 - 16368	
Ref.swps/calibr.chk 0 - 65535	
Calibr Centreline / Light Value	
Reference cell quality / R2	
Cal as Reference DIS/ENA	
Skip points/swp at start 0 - 126	
Points per sweep 0 - 128	
Gas Shift Menu: Gas Shift Enable	
Gas Shift Menu: Gas Shift	
Centre Line Menu: End Point centre	
Centre Line Menu: Skip Pts centre	
Centre Line Menu: Target scan Peak at	
Modulation Index	
output lin menu: Output Linearization Enable/Disable	
output lin menu: Number Points	
Light Comp: Light Compensation Enable/Disable	
Light Comp: Number Points	
Periodic Array Xfer Enable/Disable	
Min Attn Index:	
Attn: Attn[1]/[2]/[3]/[4]	

Notes

Serial communication check
4-20 mA output
RTC Set
Scope & Visible Laser Align @100m
CL Duty
m0=

Signed By:

Appendix I — Accessories

GasFinderFC
Range Finder binocular
GasFinderFC Manual
Calibration Documentation

Software
GasViewOP Software (version #)
GasViewOP Manual

Cabinets
As required

Remote Heads
OP1 Open Path Transceiver Head
OP3 Open Path Transceiver Head
Duct Transceiver
Windows available in Lexan, Borosilicate, Saphire and Glass

Mount
Small Boreal X-Y Mount
Large Boreal X-Y Mounta

Stainless Steel Enclosure
Enclosure for OP3 Remote Head

Cables
Data Cable
Data Cable (DB15M-DB9F)
Data Cable (DB15M-DB9F with 4-20mA pair)

Fibreoptic Cable
Preterminated with FCAPC connectors
Multi-core
Armoured fibre

Coaxial Cable
Belden 9880
Armoured coaxial
Connectors ‘N’ type

Retroreflectors
Retro Tape Roll, Red/White
Retro Tape Sheet, Grey
1½” Opticon Retros
2” IMOS Retros
2½” Opticon Retros

Retro Enclosures
Various sizes available in FRP or stainless steel
Windows available in Lexan, Borosilicate and glass

Retroreflector Accessories
Retro Enclosure Heater, High Voltage
Retro Enclosure Heater, Low Voltage

Appendix J — Cable Compensation

The returning signal from the remote head or duct probe is carried by an Ethernet coaxial cable. Long cable runs attenuate the signal by different amounts depending on the length of the cable. The value of the compensation is specific to each channel and is entered at the time of commissioning by using the appropriate section in the Menu.

Cable Distance m	Cable Compensation
50	1.04
100	1.09
150	1.14
200	1.19
250	1.24
300	1.29
350	1.35
400	1.41
450	1.47
500	1.53
550	1.60
600	1.67
650	1.74
700	1.81
750	1.89
800	1.98
850	2.06
900	2.15
950	2.25
1000	2.34

Appendix K — 2-Way Serial Communication

All **GasFinderFC** gasfinders with software version 1.09b(July 2012) or later have the ability to be controled remotely with commands passed through the data cable. This cable requires three conductors and is marked with a yellow band. The remote control enables the user to alter various parameters without entering the menu in the **GasFinderFC** with the ensuing time delay while the system recalibrates.
If the user is operating with **GasViewOP**, the commands are done automatically, otherwise a terminal program such as Hyperterminal is required.

All commands adhere to the following format: gf[<cc>][<n>][? | = [<m>]]

- lowercase “gf” preceeds all commands.
- <cc> is a 2 character command acronym.
- <n> is a single digit channel number.
- Parameter access commands are followed by ? or = for get and set respectively.
- ‘set’ commands take a parameter <m>.
- There are no white space characters to keep the interface lean.
- All commands are terminated by carriage return (Enter).
- Commands are responded to using the **GasFinderFC** checksummed output line convention “$GF{CER | COK[,<n>]}*XX” where “XX” is the hexadecimal checksum, ie “$GFCER*55” for an unrecognized, malformed or out of range command.

Command	Response	Description
gf	$GFCOK*46	Check for command interface
gfal?	$GFCOK,{0 | 1}*XX	Aiming laser status, ‘0’ for off and ‘1’ for on
gfal={0|1}	$GFCOK*46	Aiming laser control, ‘0’ for off and ‘1’ for on
gfam?	$GFCOK,<d>*XX	Get altitude in metres
gfam=<d>	$GFCOK*46	Set altitude in metres
gflc	$GFCOK*46	Internal log clear
gfld	$GFCOK*46	Internal log dump
gflg?	$GFCOK,{0 | 1}*XX	Is logging enabled
gflg={0|1}	$GFCOK*46	Internal logging off ‘0’ or on ‘1’
gflr	$GFCOK,<n>*XX	Internal log query number of records in memory <n>
gfpa?	$GFCOK,<p>*XX	Get pressure in Pascals
gfpa=<p>	$GFCOK*46	Set pressure in Pascals
gfpl	$GFCOK,<d>*XX	Path length query, <d> is path length in decimetres
gfpl=<d>	$GFCOK*XX	Set path length to <d> in decimetres
gftc?	$GFCOK,<c>*XX	Get path temperature in degrees Celsius
gftc=<c>	$GFCOK*46	Set path temperature in degrees Celsius
gfxd	$GFCOK*46	Arrays dump
gfvn	$GFCOK*46	Firmware version query

Section 10. Drawings

1. GasFinderFC Dimensions – GF-D-3D-0002-A
2. OP1 Head Overall Dimensions – BOR 02110-J
3. OP3 Remote Head Dimensions – JB 0930 RH-B
4. V1 Duct Probe General – DP-D-V1-001
5. V1 Duct Probe Dimensions – DP-D-V1-002
6. V1 Duct Probe Installation – DP-D-V1-003
7. OP3 SS Enclosure Dimensions – BOR 02910
8. OP3 SS Tilting Joint Dimensions – BOR 02915

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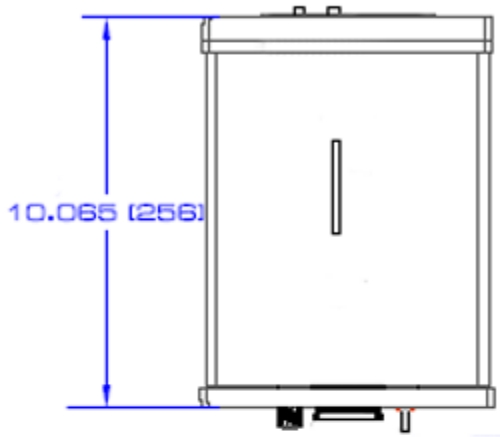
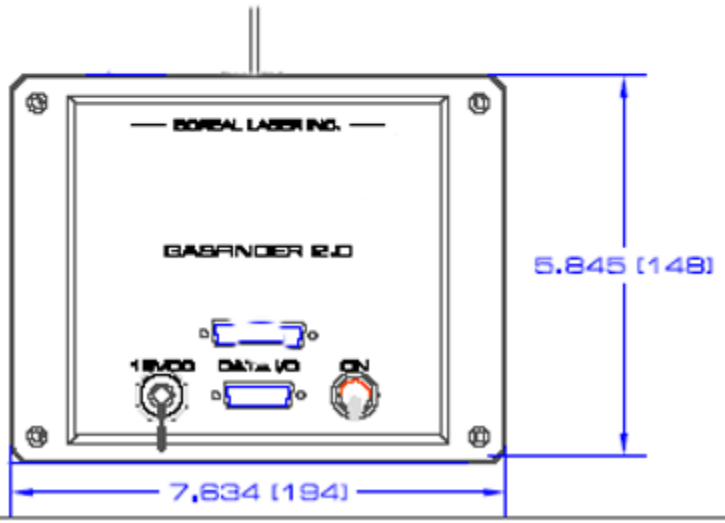
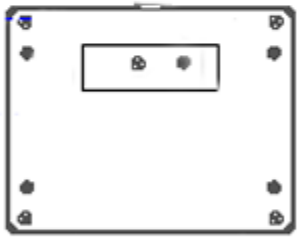
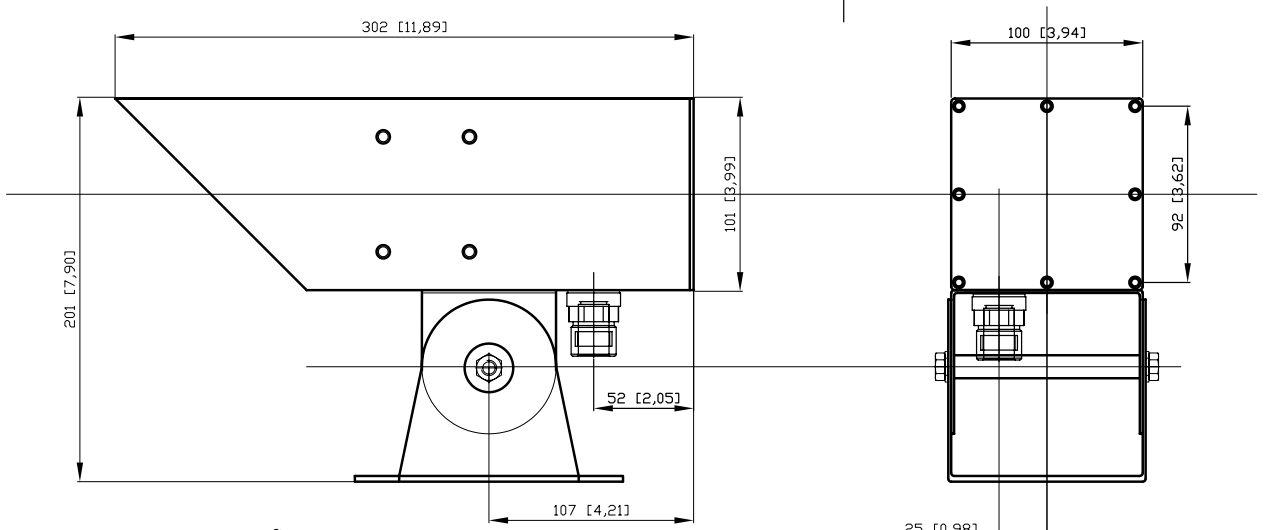


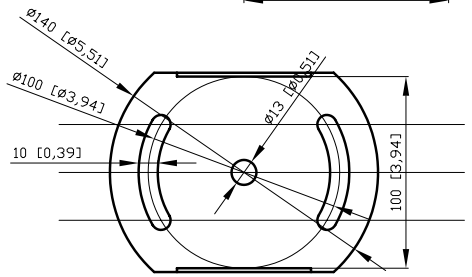




	BOREAL LASER INC. GASFINDER 2.0 DIM 3D MODEL			
Dim: Inches [mm]	SIZE	FSCM NO.	DWG NO. GF-D-3D-0002-A	REV
	SCALE	12/5/2006	SHEET	

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED





BOREAL LASER INC.

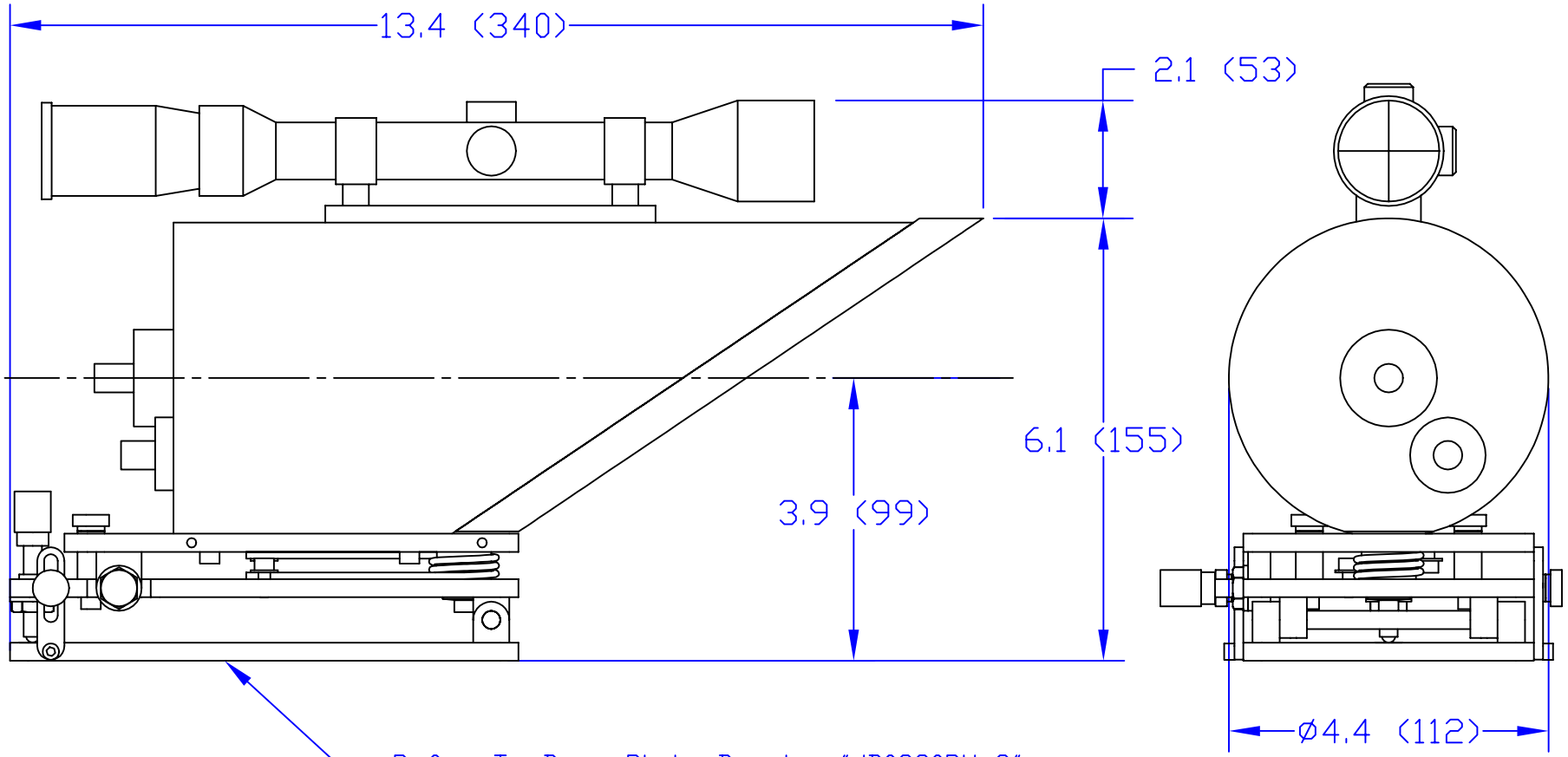
OP1 Head Overall Dimensions

Dim: mm [inches]

SIZE	FSCM NO.	DWG NO.	REV
B		BOR02110-J	A

SCALE		SHEET
NTS		1 of 1

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



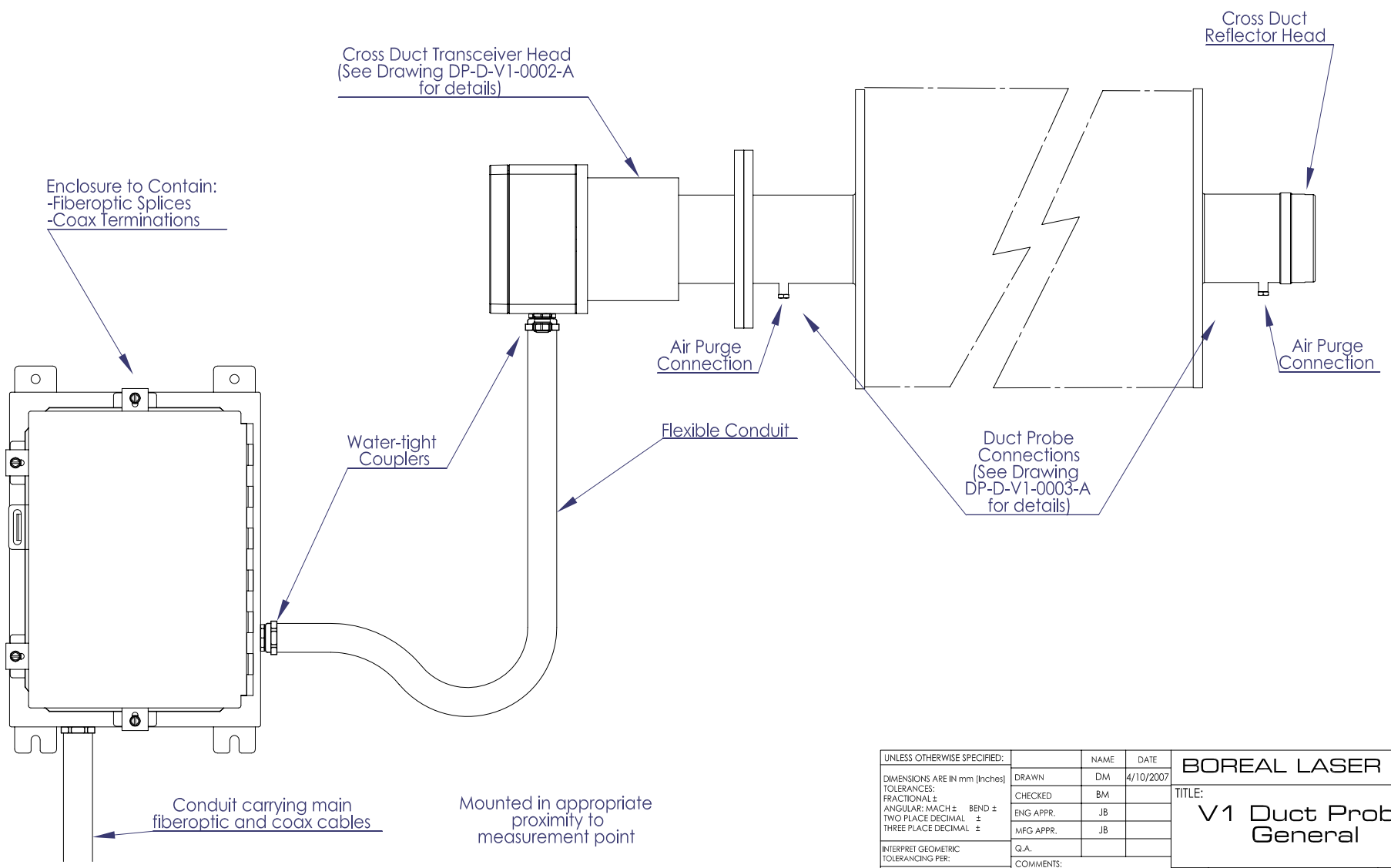
Dim: inches (mm)

BOREAL LASER INC.
Remote Head Dimensions

Shell Caroline Central Compressor Two Staging
Service Contract No. 03234-00-CS-001

SIZE	FSCM NO.	DWG NO.	REV
A		JB0930RH-B	

SCALE	NTS		SHEET	1 of 1



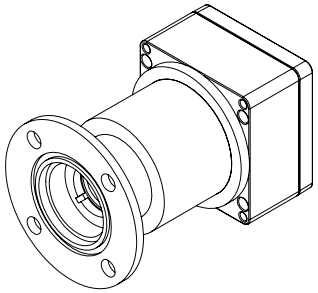
UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN mm [Inches]	DRAWN	DM	4/10/2007
TOLERANCES:	CHECKED	BM	
FRACTIONAL ±	ENG APPR.	JB	
ANGULAR: MACH ± BEND ±	MFG APPR.	JB	
TWO PLACE DECIMAL ±	Q.A.		
THREE PLACE DECIMAL ±	COMMENTS:		
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL 6061 Al Plate - 3.18 [1/8] thick			
FINISH Yellow Anodizing			

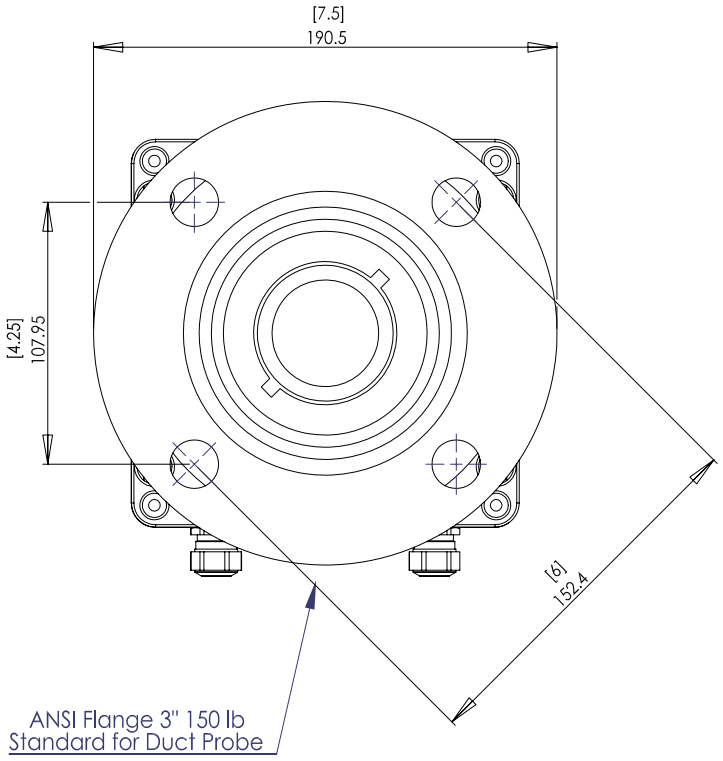
BOREAL LASER INC

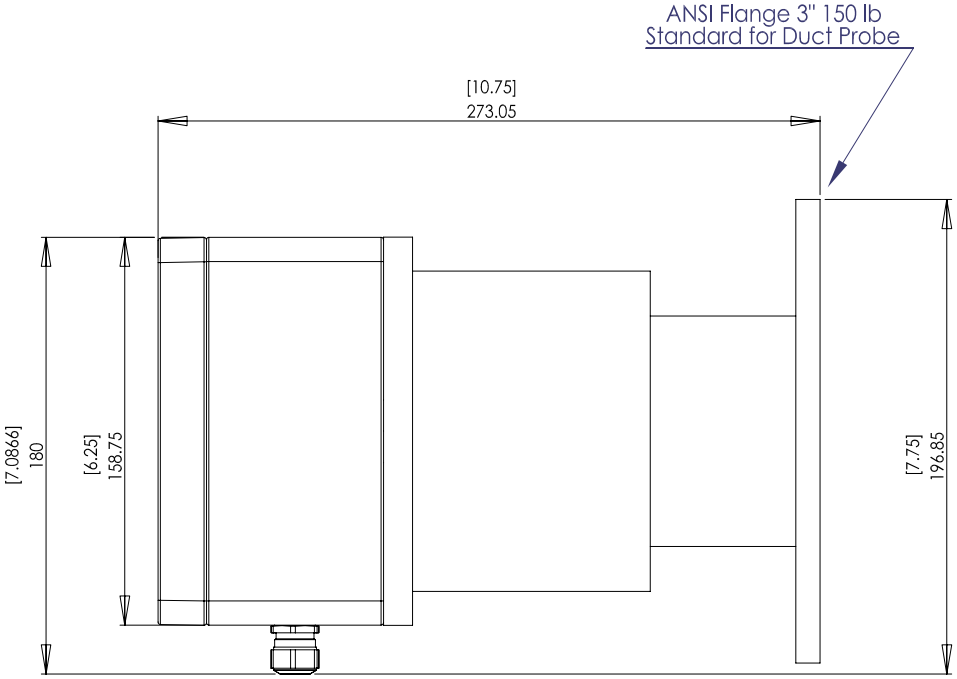
TITLE: V1 Duct Probe-General

SIZE	DWG. NO.	REV
B	DP-D-V1-0001	A

SHEET 1 OF 3







UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN mm [Inches]	DRAWN	DM	4/10/2007
TOLERANCES:	CHECKED	BM	
FRACTIONAL ±	ENG APPR.	JB	
ANGULAR: MACH ± BEND ±	MFG APPR.	JB	
TWO PLACE DECIMAL ±	Q.A.		
THREE PLACE DECIMAL ±	COMMENTS:		
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL			
FINISH			

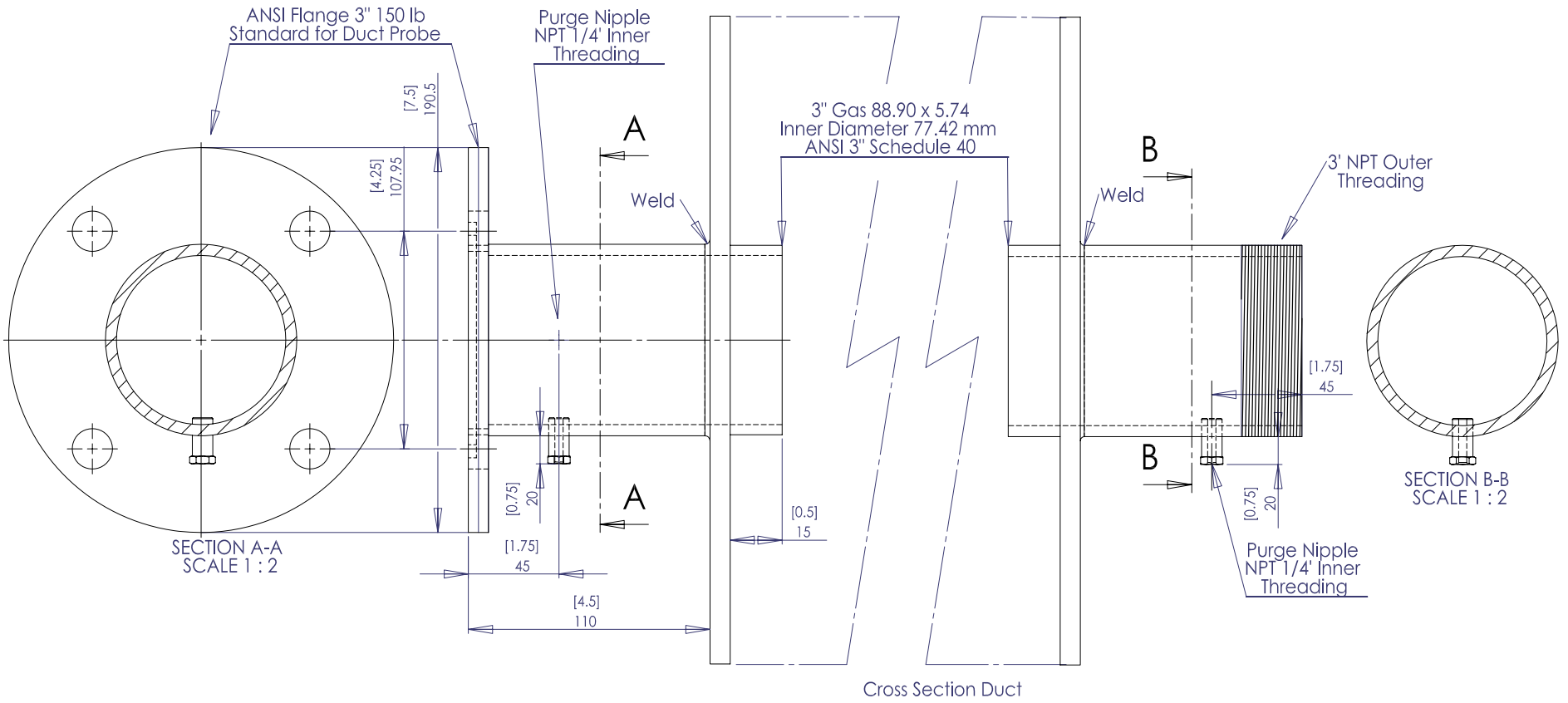
BOREAL LASER INC

TITLE:

V1 Duct Probe-Dimensions

SIZE	DWG. NO.	REV
B	DP-D-V1-0002	A

SHEET 2 OF 3



REMARKS:

To align both stubs a 2.5" pipe has to be put through both stubs during welding.

UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN mm [Inches]	DRAWN	DM	4/10/2007
TOLERANCES:	CHECKED	BM	
FRACTIONAL ±	ENG APPR.	JB	
ANGULAR: MACH ± BEND ±	MFG APPR.	JB	
TWO PLACE DECIMAL ±	Q.A.		
THREE PLACE DECIMAL ±	COMMENTS:		
INTERPRET GEOMETRIC TOLERANCING PER:			
MATERIAL			
FINISH			

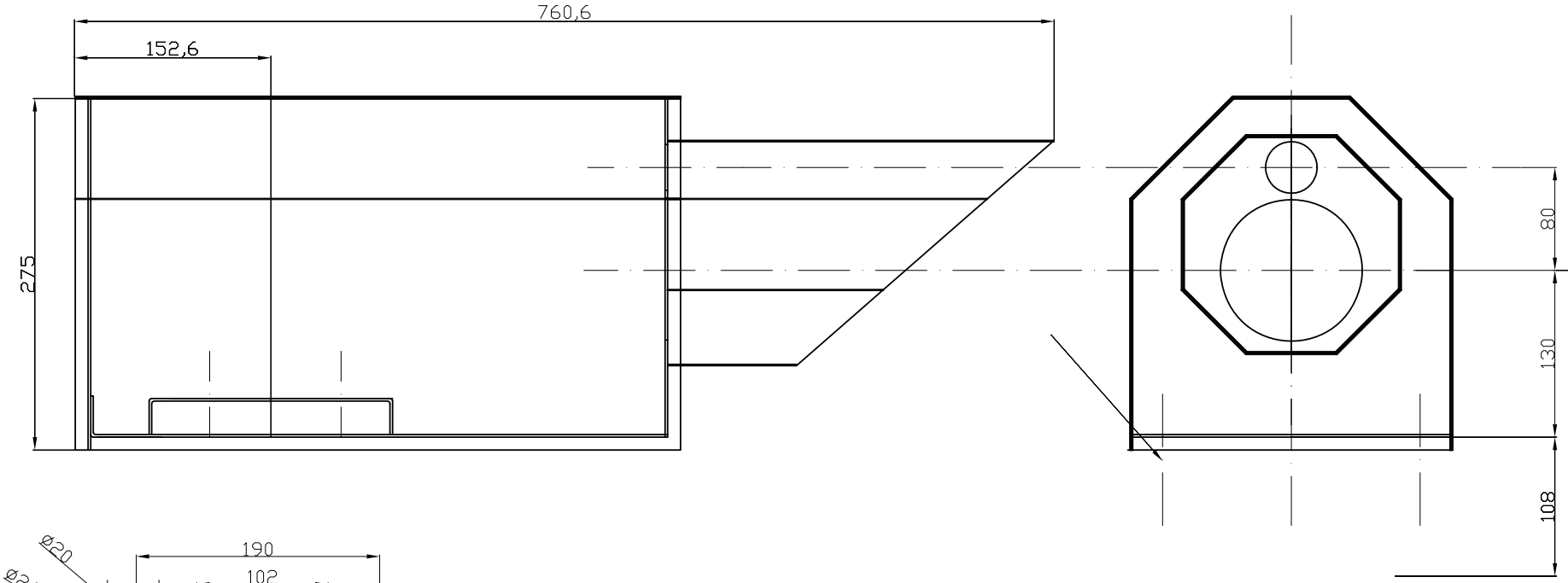
BOREAL LASER INC

TITLE: V1 Duct Probe-Connections

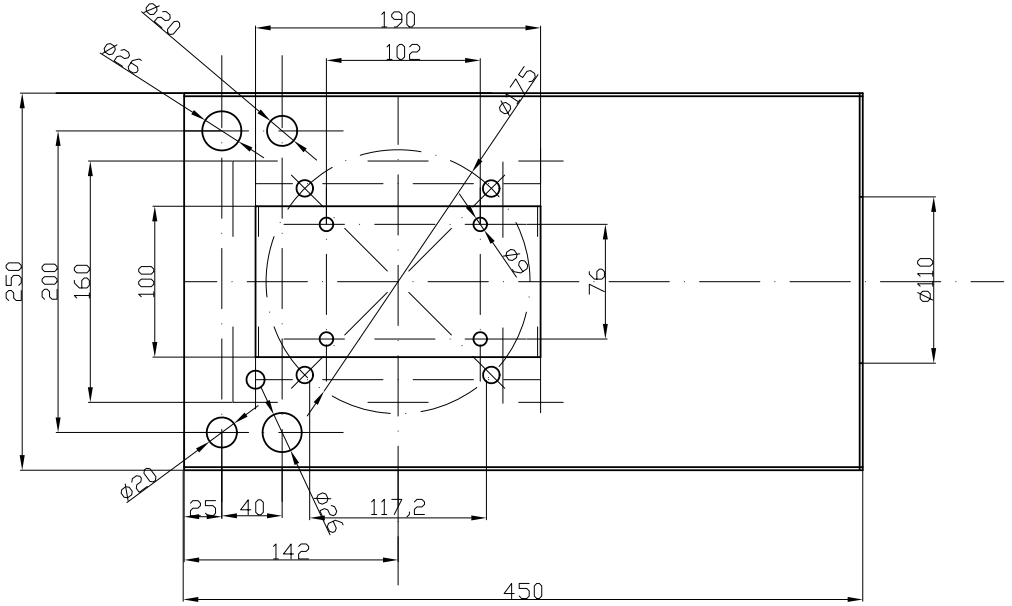
SIZE	DWG. NO.	REV
B	DP-D-V1-0003	A

SHEET 3 OF 3

RevNo	Revision note	Date	Signature	Checked
1	Changed shape assembly	13-3-05	MS	



Front View

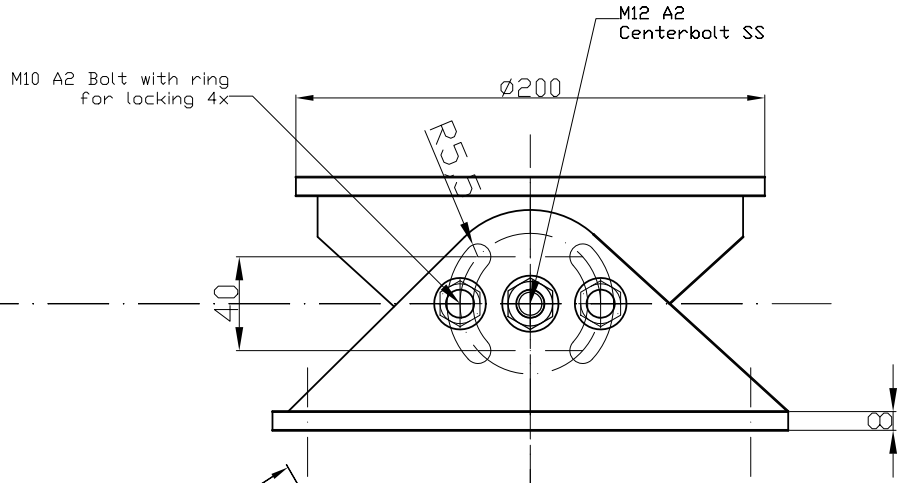


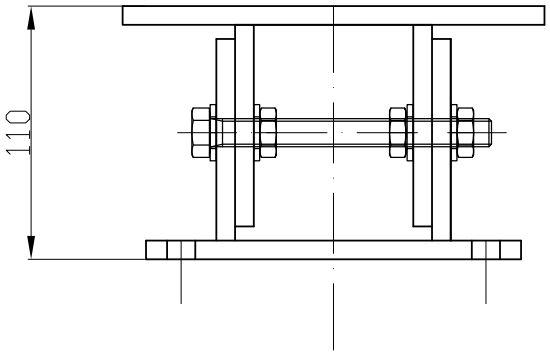
Remarks:

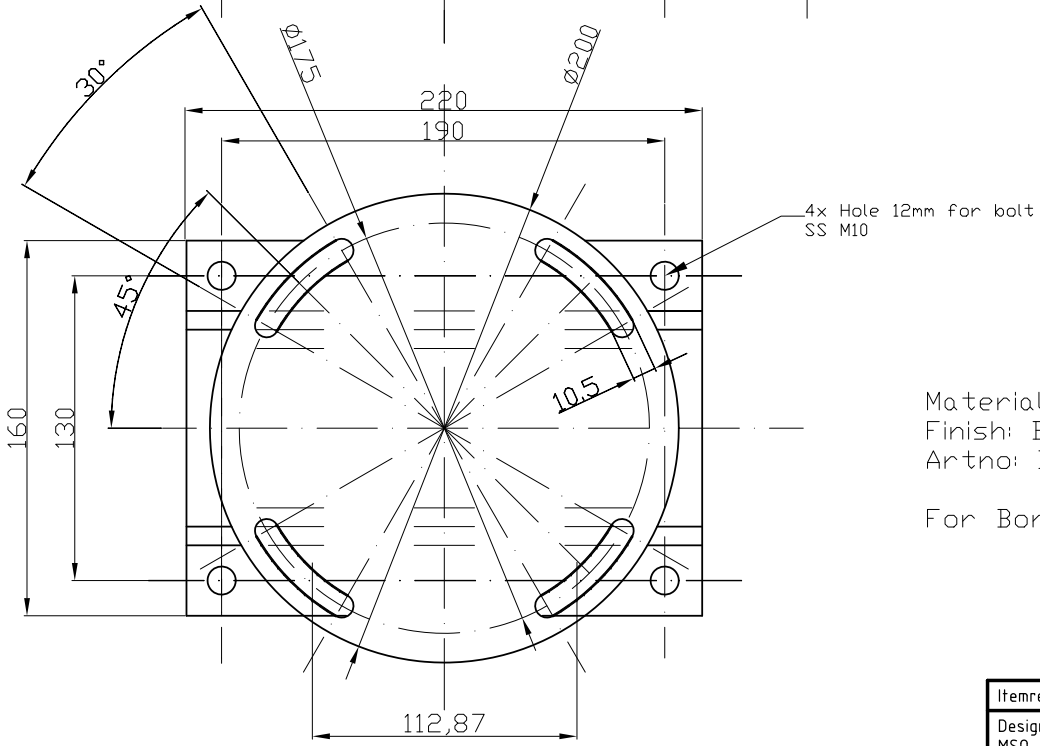
Construction must be free of vibration and no radial or axial movement is allowed! Be aware of elongation due to temperature and the consequenses regarding to misalignment!

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by mso		Checked by mso	Approved by - date mso - 14/04/2005	File name BOR0210	Date 14/04/2005	Scale 1:2.5
Sosef Engineering BV		Transmitter Housing SS				
		BOR0210			Edition 0	Sheet 1/1

RevNo	Revision note	Date	Signature	Checked







Material: Stainless steel type 304L T=8mm
Finish: Blasted with glass pearls
Artno: BOR02915

For Boreal Transmitter Assembly

Itemref	Quantity	Title/Name, designation, material, dimension etc			Article No./Reference	
Designed by MSO		Checked by MSO	Approved by - date MSO - 03/04/06	File name BOR02915	Date 03/04/2006	Scale 1:2
Boreal Laser BV				Tilting Joint TR		
				BOR02915	Edition 0	Sheet 1/1