



SERVOTOUGH Laser SP (Model 2930)

Operator Manual

(For Windows Software v. 6.1)

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SERVOMEX.COM

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1. INTRODUCTION

1.1 Safety Information

Read this manual and ensure that you fully understand its content before you attempt to install, use or maintain the Laser monitor. Important safety information is highlighted in this manual as WARNINGS and CAUTIONs, which are used as follows:

	<p style="text-align: center;">WARNING</p> <p>Warnings highlight specific hazards which, if not taken into account, may result in personal injury or death.</p>
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<p style="text-align: center;">CAUTION</p> <p>Cautions highlight hazards which, if not taken into account, can result in damage to the Laser monitor or to other equipment or property.</p>
--

This manual also incorporates “be aware of” information, which is used as follows:

- ☞ This highlights information which it is useful for you to be aware of (for example, specific operating conditions, and so on).

1.2 General

This manual contains information of installation, operation and maintenance of the SERVOTOUGH Laser Monitor. A description of the SERVOTOUGH Laser Monitor and its basic features is also included.

For instructions specific to hazardous area installations please refer to section 3.

European and International Approvals: (EX1 and EX2)


ATEX and IECEx Approved for Gas and Dust. Outside and Process Atmosphere. See Appendix 3 for further information.

Note that the EX1 and EX2 versions can also be used where flammable samples are to be monitored in otherwise safe areas.

North American Approvals (CS2):

CSA Approved for Gas and Dust. Outside Atmosphere only. See Appendix 3 for further details.

Please read entire manual carefully before using the SERVOTOUGH Laser Monitor. It is a sophisticated instrument utilising state-of-the-art electronic and laser technology. Installation and maintenance of the instrument require care and preparation and should only be attempted by competent personnel. Failure to do so may damage the instrument and void the warranty.

 There are no user serviceable parts in the SERVOTOUGH Laser.



WARNING

The Laser monitor must not be used as personal protective equipment.



WARNING

The Safe area monitor is only suitable for use in unclassified areas.



WARNING

The EX2 and CS2 Hazardous Area variants cannot be used for oxygen enriched samples, that is gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

The EX2 Variants are not suitable for use with a process atmosphere that requires EPL Ga. (eg: Zone 0) If used within this process atmosphere, the hazardous area certification may be invalidated.



WARNING

The EX1 and EX2 Variants are certified for use with a flammable process atmosphere at a pressure of 0.8 to 1.1 bar absolute. If used with a flammable process atmosphere beyond these limits, the hazardous area certification is invalidated.



WARNING

The EX1 Variants are intended for use with a suitably certified Purge Control System (PCS). Do not install an EX1 variant in a hazardous area without a purge controller.

1.3 Measuring principle

The SERVOTOUGH Laser Monitor is an optical instrument designed for continuous in-situ gas monitoring in stack, pipes, process chambers and similar applications and is based on tunable diode laser absorption spectroscopy (TDLAS). The SERVOTOUGH Laser Monitor utilises a transmitter/receiver configuration (mounted diametrically opposite each other) to measure the average gas concentration along the line-of-sight path.

- ☞ SERVOTOUGH Laser Monitor is suitable for use in industrial environments or environments where it may be connected to a mains electrical network supplying domestic premises.

The measuring principle used is infrared single-line absorption spectroscopy, which is based on the fact that each gas has distinct absorption lines at specific wavelengths. The measuring principle is illustrated in Figure 1-1. The laser wavelength is scanned across a chosen absorption line of the gas to be measured. The absorption line is carefully selected to avoid cross interference from other (background) gases. The detected light intensity varies as a function of the laser wavelength due to absorption of the targeted gas molecules in the optical path between transmitter and receiver. In order to increase sensitivity the wavelength modulation technique is employed: the laser wavelength is slightly modulated while scanning the absorption line. The detector signal is spectrally decomposed into frequency components at harmonics of the laser modulation frequency. The second harmonic of the signal is used to measure the concentration of the absorbing gas. The line amplitude and line width are both extracted from the second harmonic line shape, which makes the measured concentration insensitive to line shape variations (line broadening effect) caused by background gases.

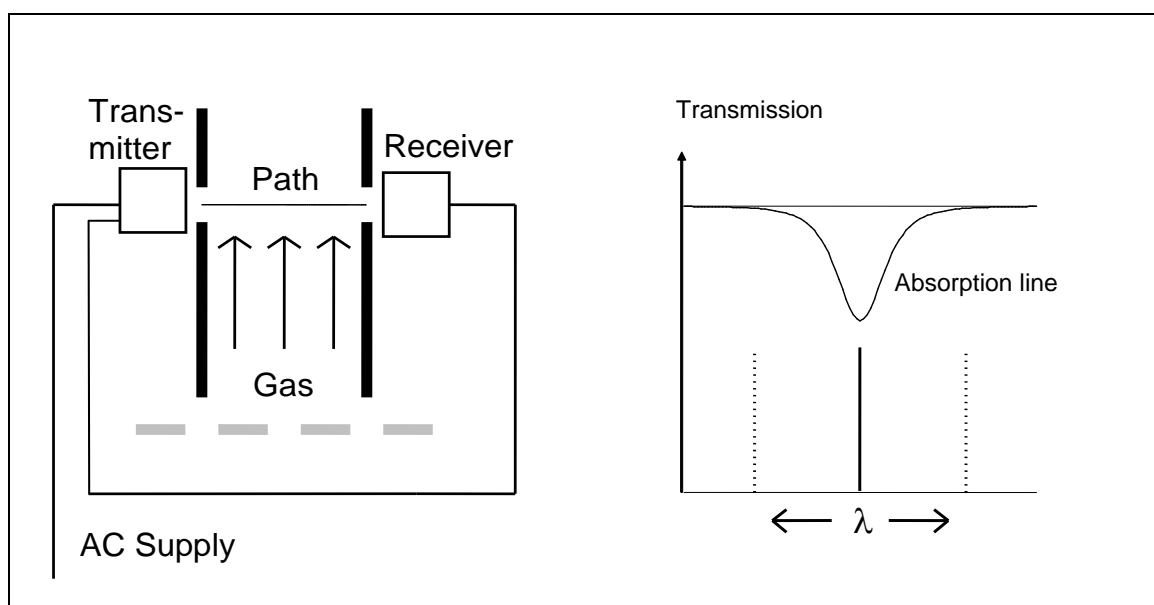


Figure 1-1: Measuring Principle SERVOTOUGH Laser Monitor

NOTE: The SERVOTOUGH Laser Monitor measures the concentration of only the **FREE** molecules of the specific gas, thus not being sensitive to the molecules bound with some other molecules into complexes and to the molecules attached to or dissolved in particles and droplets. Care should be taken when comparing the measurements with the results from other measurement techniques.

1.4 Instrument description

The SERVOTOUGH Laser Monitor consists of 2 separate units:

- Transmitter unit with power supply and purging
- Receiver unit with purging

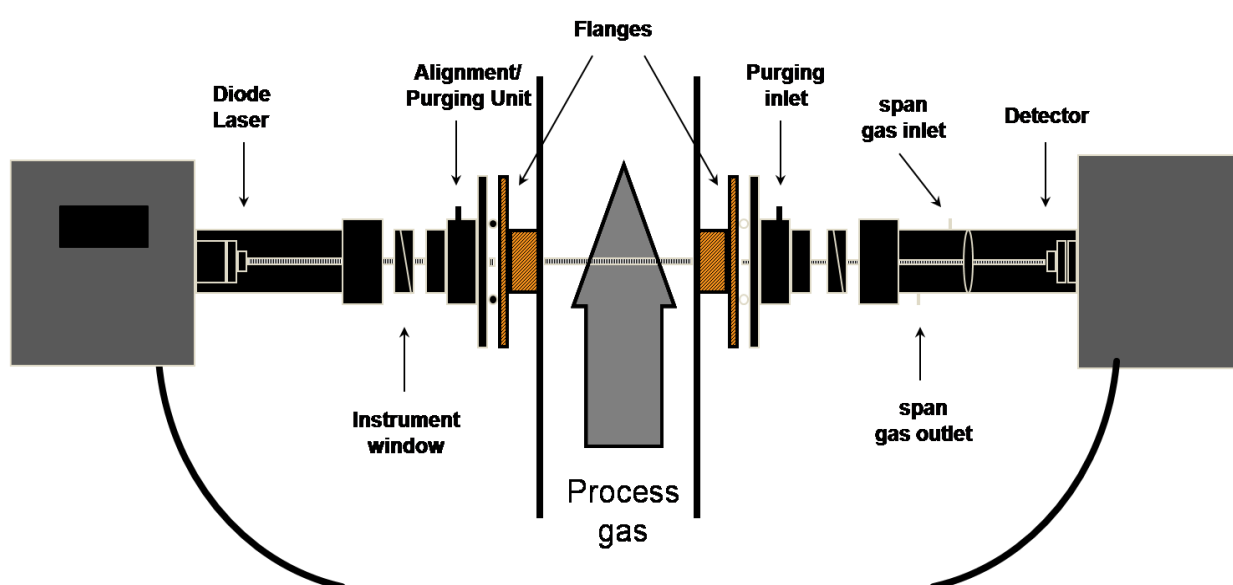


Figure 1-2: General view of SERVOTOUGH Laser Monitor

The transmitter unit contains the laser module with a temperature stabilised diode laser, collimating optics, and the main electronics in a coated aluminium box. The receiver unit contains a focusing lens, the photo detector and the receiver electronics in a coated aluminium box.

Both transmitter and receiver units have environmental protection to IP66. The monitor is installed by assembling the transmitter and receiver units with the supplied purging and alignment units, which in turn are mounted onto the DN50 process flanges (see Figure 3-1). The optical alignment is robust and reliable, and the purging prevents dust and other contamination from settling on the optical windows.

A block diagram of SERVOTOUGH Laser Monitor is shown in Figure 1-3.

The receiver electronics are connected with the transmitter electronics with a multi-core cable. The detected absorption signal from the photo-detector is amplified and transferred to the transmitter unit through this cable. The same cable transfers the required power from the transmitter unit to the receiver unit.

The transmitter enclosure contains the main CPU board, power supply, Aux pcb, optional Ethernet card and provides all customer connection terminals. The CPU board performs all instrument control and calculation of the gas concentration. The main board incorporates all electronics required for instrument operation such as diode laser current and temperature control and analogue-to-digital signal conversion. A display (LCD) continuously displays the gas concentration, laser beam transmission and instrument status. The RS-232 port can be used for direct serial communication with a PC. The optional Ethernet board provides TCP/IP communication via LAN (local area network), which can be used instead of serial communication. The auxiliary board provides output options such as 4-20 mA current outputs for gas concentration and laser beam transmission (the latter optional), relays for control of the instrument status (warning / error) as well as a gas-alarm relay.

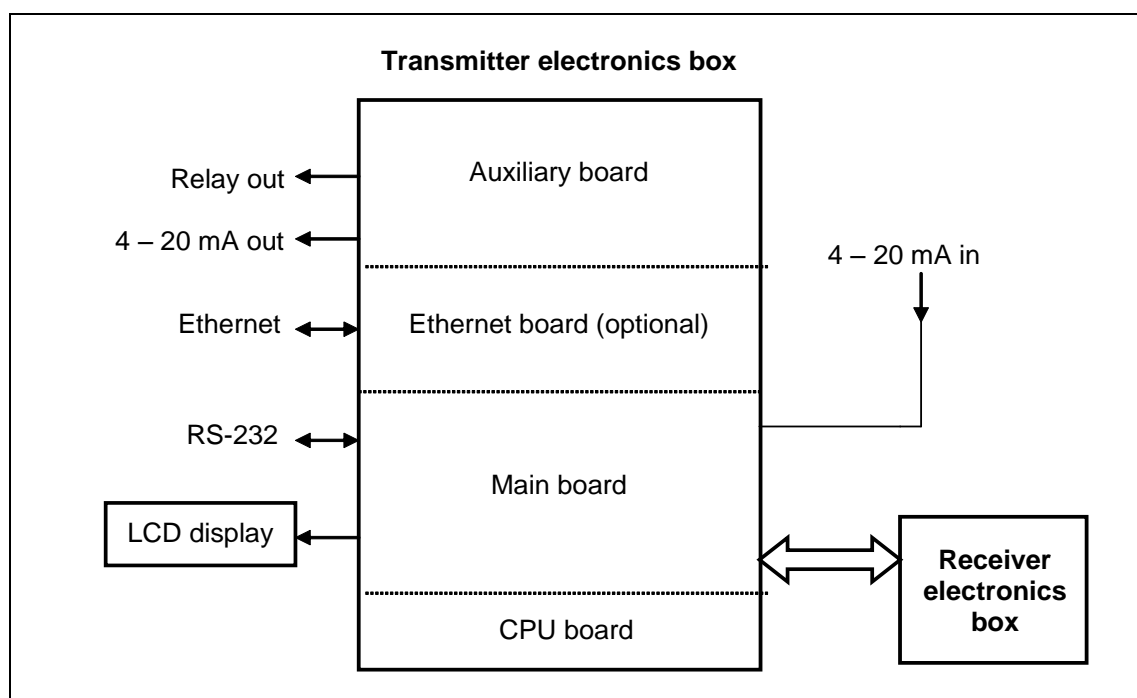


Figure 1-3: Block diagram of instrument electronics

1.5 Software

Software for the SERVOTOUGH Laser Monitor consists of 2 programs:


1. A program hidden to the user and integrated in the CPU electronics, running the micro controller on the CPU card. The program performs all necessary calculations and self-monitoring tasks.
2. A Windows based program running on a standard PC connected through the RS-232 connection. The program enables communication with the instrument during installation, service and calibration.

The operator will need to use the PC based program only during installation and calibration and not during normal operation of the instrument. See Chapter 4 for more details.


1.6 Laser classification


The diode lasers used in the SERVOTOUGH Laser Monitor operate in the near infrared (NIR) range between 700 and 2400 nm depending on the gas to be measured. The lasers have an output power, which according to IEC 60825-1 latest edition classifies the SERVOTOUGH Laser Monitor as a **Laser Class 1M product**.

NOTE: The lasers emit invisible light!

	<p>WARNING</p> <p>CLASS 1M LASER PRODUCT</p> <p>LASER RADIATION - DO NOT VIEW DIRECTLY WITH OPTICAL INSTRUMENTS</p>
---	---

The optional alignment jig uses a laser classified to **Laser Class 3R**. The alignment jig has not been assessed for use in hazardous area, and can therefore only be used when no explosive atmosphere is present.

	<p>WARNING</p> <p>CLASS 3R LASER PRODUCT</p> <p>LASER RADIATION – AVIOD DIRECT EYE EXPOSURE</p>
---	---

	<p>WARNING</p> <p>The laser alignment jig must not be used when an explosive atmosphere may be present in the 'Outside atmosphere' or the 'Process atmosphere'</p>
---	---

1.7 Product data

Model:	SERVOTOUGH LaserSP
Dimensions (L x H x W):	Transmitter: 600 x 285 x 200 mm Receiver: 415 x 220 x 125 mm
Mass:	Transmitter: 12 kg Receiver: 5 kg

Environmental conditions:

Operating temperature -20°C to +55°C (-4°F to +131°F)

Note: +65°C operation possible for selected applications. (Contact Servomex for availability)

Storage temperature -20°C to +55°C (-4°F to +131°F)

Apparatus is suitable for outdoor use

Operating ambient pressure range: 101.3 kPa, -20%, +10%
(1.013 bar -20%, +10%)

Maximum operating altitude: 2000 m

Protection classification IP66

Maximum process pressures:

Safe area version: 150 kPa absolute (1.5 bar absolute)

Hazardous Area version: 110 kPa absolute (1.1 bar absolute)

Note: For use with greater process pressures please contact Servomex.

Electrical Data:

Input power supply unit (mains): 100 – 240 VAC, 50/60 Hz, 50 VA Max.

Input power supply (24V dc): 20 – 30 VDC, 25 W Max.

4 - 20 mA output: 500 Ohm Max. isolated

Relay output: 1 A at 30 V DC/AC

Laser Class: Class 1M according to IEC 60825-1:2007

Laser power: Max 30mW at 700 to 2300nm

2. PREPARATIONS

2.1 Tools and other equipment

The following equipment is necessary to install and calibrate the equipment:

- 2 pcs open-end spanners for M16 bolts
- 1 pcs Allen key 5 mm for the locking screws on flanges and Tx lid screws
- 1 pcs Allen key 3 mm for the RS232 cover screws
- 1 pcs PC (386 or higher). Used during installation and calibration
- 1 pcs flat screwdriver 2.5 mm for electrical connections
- 1 pcs flat (6 mm) or cross head (No 2) screwdriver for Rx lid screws
- 1 pcs 9/16" or 15mm spanner for 1/4" purge caps
- 1 pcs 33mm spanner for Receiver cable gland fitting
- 1 pcs Allen key 10mm for removing Receiver blanking plug

2.2 Flow conditions at measuring point

When deciding the placement of the SERVOTOUGH Laser Monitor in the process, we recommend a minimum of 5 stack diameters of straight duct before and 2 stack diameters of straight duct after the point of measure.

2.3 Monitor placement

Both the transmitter and receiver units should be easily accessible. A person should be able to stand in front of either the transmitter unit or the receiver unit and adjust the M16 fixing bolts using two standard spanners. For each unit there should be at least 1 m free space measured from the flange fixed to the stack and outwards as shown in Figure 2-1.

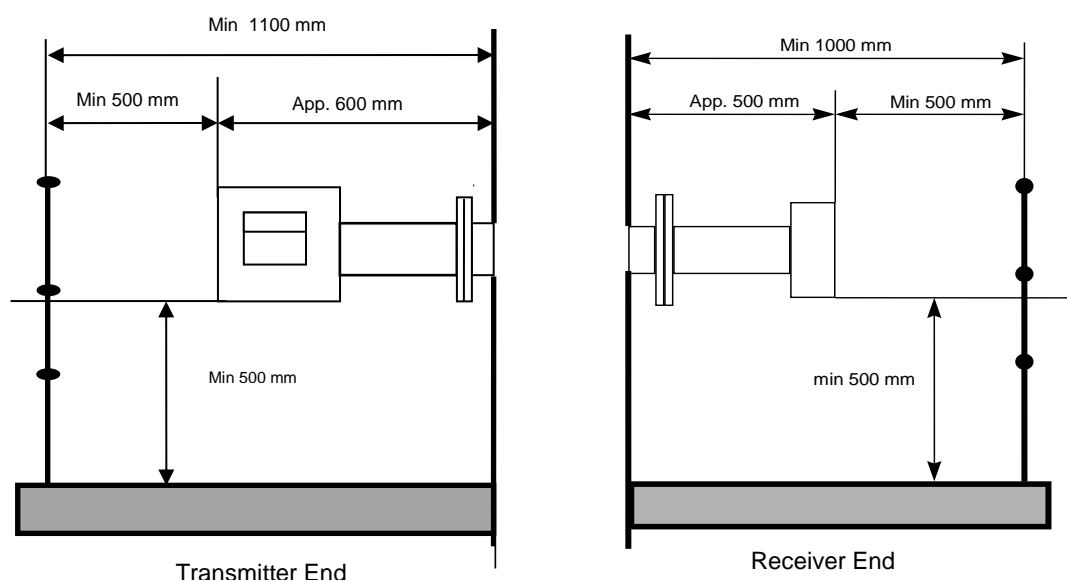



Figure 2-1: Transmitter and receiver installation tolerances

2.4 Flanges and stack hole requirements

The monitor requires two holes diametrically opposite to each other, at least 50 mm in diameter. Standard flanges used for connection are DN50/PN10 with an inner diameter of 50 mm and an outer diameter of 165 mm. The flanges can either be welded directly to the process, or optionally be part of a valve connected to the process for safety purposes. The two alternatives are illustrated in Figure 2-2.



WARNING
You must mount the Laser monitor on a structure which is capable of supporting the mass of the Laser monitor (refer to PRODUCT DATA).

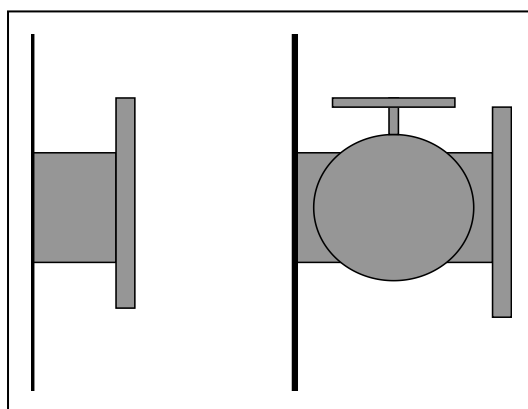


Figure 2-2: Flanges with and without valve

The SERVOTOUGH Laser Monitor is designed with an adjustment mechanism that can tilt the flanges. The flanges welded to the stack should, however, initially fulfil the specifications given in Figure 2-3 and Figure 2-4.

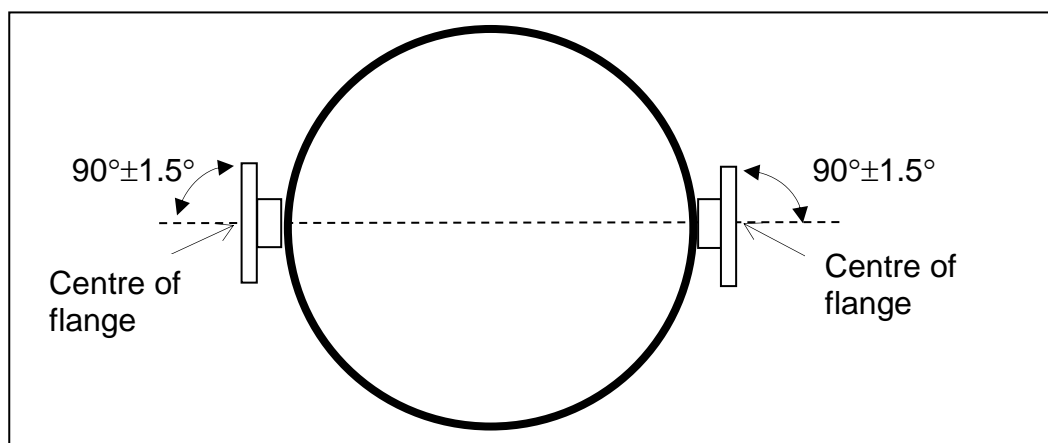


Figure 2-3: Flange angle alignment tolerances

The flange line-up should initially be better than 1.5° as specified in Figure 2-3.

The distance between the imaginary parallel lines AB and CD (Figure 2-4) should fulfil the specifications in the table to ensure that the tubes do not shield the laser beam.

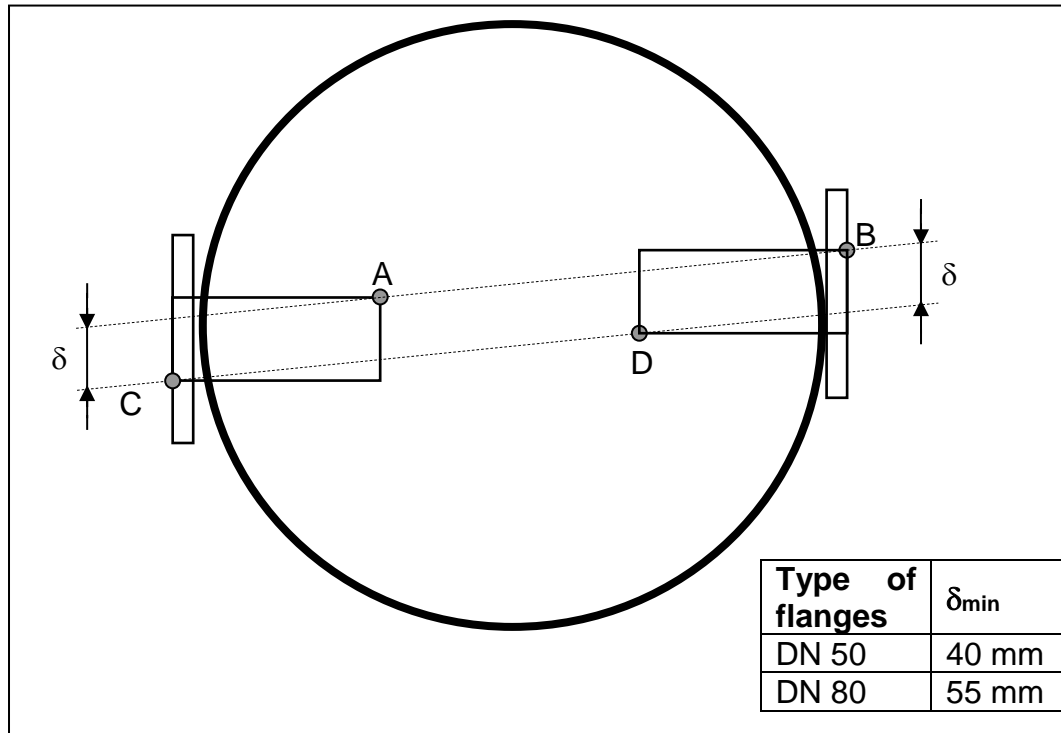


Figure 2-4: Flange line-up tolerances (when using optional insertion tubes)

After correct adjustment and line-up of the instrument, the maximum allowed drift in angle between laser beam and receiver unit centre axis due to temperature effects or vibration, is $\pm 0.3^\circ$ without having effect on the measurements.

2.5 Cables and electrical connections

The transmitter and receiver units are connected with a cable (receiver cable). This cable should not be exchanged without SERVOMEX's permission nor should the cable length be modified by more than 20 m as this may influence calibration or the instrument's accuracy.

The user should verify that the cable length for the 4-20 mA analogue current output from the transmitter unit does not influence the measurements (due to inductance etc.). The Service PC cable is 3 m long, but can be extended to app. 10 m.

The max. length of the power cable (power supply to transmitter unit) is 100 m.

The max. length of the loop cable (transmitter to receiver unit) is 150 m.

The max. length of the (optional) Ethernet cable is 100 m or more (depending on configuration of local network).

If electrical connections have to be made at installation, refer to Chapter 6.



WARNING

Ensure that the electrical installation of the Laser monitor conforms to all applicable local and national electrical safety requirements.



WARNING

Wiring to or from this device, which enters or leaves the system enclosure, must utilize wiring methods suitable for Class 1, Division 2 and/or Zone 2 Hazardous Locations, as appropriate for the installation.

3. INSTALLATION



WARNING

You must install and use the Laser monitor in accordance with the requirements of this section and subsequent sections of the manual. If you do not, people may be injured, the protection facilities incorporated into the design of the Laser monitor may not operate as intended, measurements may not be accurate, or the Laser monitor may be damaged.



WARNING

The Laser monitors are not suitable for use in hazardous areas unless the correct certification labels have been affixed by Servomex and a suitable purge control system is installed (EX1 versions).

Instructions Specific to Hazardous Area Installations



WARNING

For Hazardous area installations:

- The operating environment is within the limits specified in “Product Data”
- The process flange to which the product is attached is limited to a maximum surface temperature of 135°C.
- To avoid propagating brush discharges, the unit is not to be installed in a high velocity dust-laden atmosphere.
- In addition, the equipment shall only be cleaned with a damp cloth.



WARNING

The EX2 and CS2 Hazardous area variant cannot be used for oxygen enriched samples, that is gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

The EX2 Variants are not suitable for use with a process atmosphere that requires EPL Ga. (eg: Zone 0) If used within this process atmosphere, the hazardous area certification may be invalidated.



WARNING

The EX1 and EX2 Variants are certified for use with a flammable process atmosphere at a pressure of 0.8 to 1.1 bar absolute. If used with a flammable process atmosphere beyond these limits, the hazardous area certification is invalidated.






(Reference European ATEX Directive 94/9/EC, Annex II, 1.0.6.)

European and International Approvals (EX1 and EX2)

The following instructions apply to equipment covered by certificate numbers:
Baseefa 10ATEX0100X






The following instructions also apply to equipment covered by certificate number
IECEX BAS 10.0038X

Mains Power details:

PART OF Baseefa 10ATEX0100X AND IECEX BAS 10.0038X	
SERVOTOUGH Laser 2900 Analyser Series <small>SERVOMEX GROUP Ltd, Crowborough, East Sussex, United Kingdom</small>	
WARNING! DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE MAY BE PRESENT. DO NOT OPEN WHEN ENERGISED.	
Baseefa 10ATEX0100X  II 3(2)G Ex nA nC op is IIC T4 Gc  II 3G(1D) Ex nA nC op is IIC T4 Gc  II 2D(2G) Ex tb IIIB T1 35°C IP66 Db  II 2(1)D Ex tb IIIB T1 35°C IP66 Db (-20°C ≤ Ta ≤ +60°C)	IECEX BAS 10.0038X [Ex op is IIC T4 Gb] [IIIB T1 35°C Da] [Ex op is IIC T4 Gb] [IIIB T1 35°C Da]
02930/254/1	

Process Flange Temperature	T Class	Dust Surface Temperature	Process Dust Temperature	Ambient Temperature Range
≤65°C	T4	T75°C	T70°C	-20°C ≤ Ta ≤ +60°C
≤100°C	T4	T100°C	T100°C	
≤135°C	T4	T135°C	T135°C	

24V Supply details:

PART OF Baseefa 10ATEX0100X AND IECEX BAS 10.0038X	
SERVOTOUGH Laser 2900 Analyser Series <small>SERVOMEX GROUP Ltd, Crowborough, East Sussex, United Kingdom</small>	
WARNING! DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE MAY BE PRESENT. DO NOT OPEN WHEN ENERGISED.	
Baseefa 10ATEX0100X  II 3(2)G Ex nA nC op is IIC T4 Gc  II 3G(1D) Ex nA nC op is IIC T4 Gc  II 2D(2G) Ex tb IIIB T1 35°C IP66 Db  II 2(1)D Ex tb IIIB T1 35°C IP66 Db (-20°C ≤ Ta ≤ +65°C)	IECEX BAS 10.0038X [Ex op is IIC T4 Gb] [IIIB T1 35°C Da] [Ex op is IIC T4 Gb] [IIIB T1 35°C Da]
02930/264/1	

Process Flange Temperature	T Class	Dust Surface Temperature	Process Dust Temperature	Ambient Temperature Range
≤65°C	T5	T75°C	T70°C	-20°C ≤ Ta ≤ +65°C
≤100°C	T5	T100°C	T100°C	
≤135°C	T4	T135°C	T135°C	

Note: For an explanation of the coding refer to Appendix 6

- The equipment may be located where flammable gases and vapours of groups IIA, IIB or IIC or combustible dusts of groups IIIA or IIIB may be present. The equipment is only certified for use in ambient temperatures in the range -20°C to +65°C.
- The equipment has not been assessed as a safety-related device (as referred to by Directive 94/9/EC, Annex II, Clause 1.5).
- Installation of this equipment shall be carried out by suitably trained personnel in accordance with the applicable code of practice (EN/IEC 60079-14).
- Repair of this equipment shall be carried out by the manufacturer or in accordance with the applicable code of practice (EN/IEC 60079-19).
- If the equipment is likely to come into contact with aggressive substances, then it is the responsibility of the user to take suitable precautions that prevent it from being adversely affected, thus ensuring that the type of protection is not compromised.


Aggressive substances e.g. acid liquids or gases that may attack metals or solvents that may affect polymeric materials.

Suitable Precautions e.g. regular checks as part of the routine inspections or establishing from the material's data sheet that it is resistant to specific chemicals.

North American Approvals – CS2


The following instructions apply to equipment covered by certificate numbers: CSA 11.2393527X

Mains Power details:

PART OF CSA 11.2393527X	
WARNING: EXPLOSION HAZARD–Substitution of components may impair suitability for CL I, Div 2. Do not open when energized. Do not open when an explosive atmosphere may be present. Ne pas ouvrir sous tension. Ne pas ouvrir en atmosphère explosive.	
CL I, Div 2 Gr ABCD; CL II, Div 1 & 2, Gr FG; CL III; T4 Ex nA nC op is IIC T4 Gc CL I, Zone 2, AEx nA nC op is IIC T4 Gc DIP A21 T135°C Zone 21, AEx tD T135°C Db (–20°C ≤ Ta ≤ +60°C)	 CSA 11.2393527X 02930/265/0

Process Flange Temperature	T Class	Dust Surface Temperature	Ambient Temperature Range
≤65°C	T4	T75°C	–20°C ≤ Ta ≤ +60°C
≤100°C	T4	T100°C	
≤135°C	T4	T135°C	

24V Supply details:

PART OF CSA 11.2393527X	
WARNING: EXPLOSION HAZARD–Substitution of components may impair suitability for CL I, Div 2. Do not open when energized. Do not open when an explosive atmosphere may be present. Ne pas ouvrir sous tension. Ne pas ouvrir en atmosphère explosive.	
CL I, Div 2 Gr ABCD; CL II, Div 1 & 2, Gr FG; CL III; T4 Ex nA nC op is IIC T4 Gc CL I, Zone 2, AEx nA nC op is IIC T4 Gc DIP A21 T135°C Zone 21, AEx tD T135°C Db (–20°C ≤ Ta ≤ +65°C)	 CSA 11.2393527X 02930/268/0

Process Flange Temperature	T Class	Dust Surface Temperature	Ambient Temperature Range
≤65°C	T5	T75°C	–20°C ≤ Ta ≤ +65°C
≤100°C	T5	T100°C	
≤135°C	T4	T135°C	

3.1 Installation and adjustments

The installation procedure described in this section refers to Figure 3-1.

CAUTION

Please note only trained persons should install SERVOTOUGH LaserSP monitors. Training must include practical actions of aligning receiver and transmitter units on mounting flanges using an alignment tool.

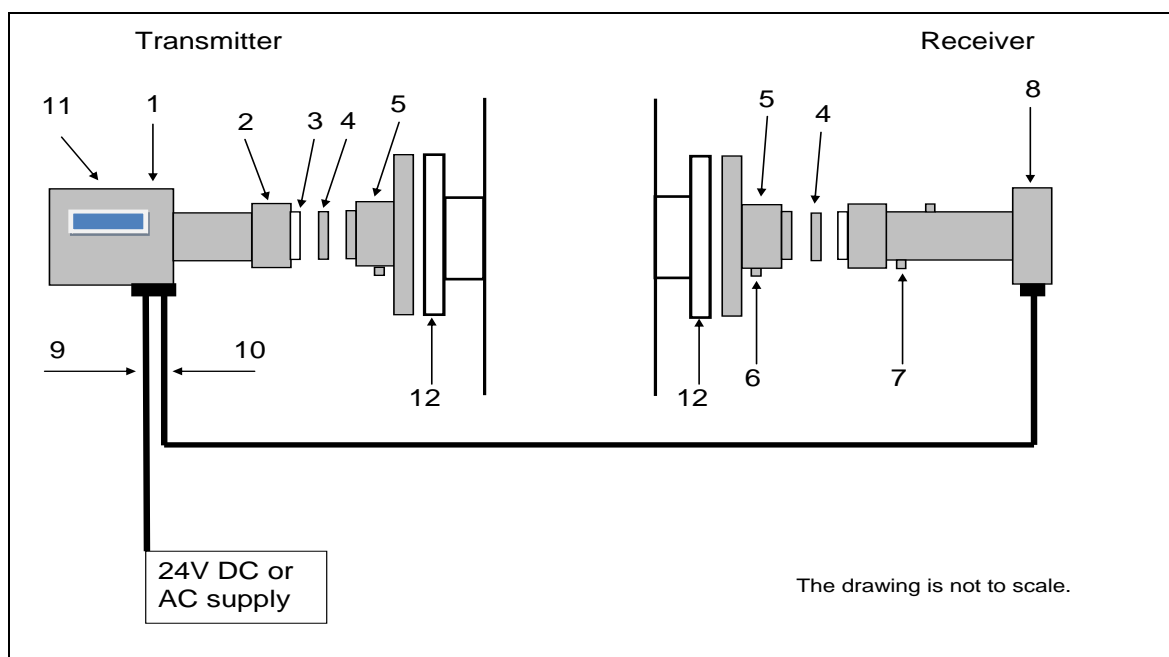


Figure 3-1: SERVOTOUGH Laser Monitor units and their main components

1. Transmitter electronics and housing
2. Mounting nut
3. Optical window
4. Adapter ring
5. Alignment and purging unit (DN50 flange)
6. Purging gas inlet
7. Span cell inlet (non-corrosive gases, see also section 7)
8. Receiver electronics and housing
9. Power cable
10. Receiver cable
11. LCD display
12. Process Flange

3.1.1 SERVOTOUGH Laser installation

**WARNING**

You must not modify the Laser Monitor in any way (either mechanically or electrically). If you do, the certification of the monitor will be invalidated, and it may not operate safely.

**WARNING**

The Laser Monitor must be installed by a suitably skilled and competent technician or engineer in accordance with this manual and to the special conditions of installation contained within the Certification Supplement Manual, Part Number: 02930008A.

**WARNING**

Make sure that power is disconnected or switched off before connecting any cable.

**WARNING**

Obey the safety instructions given below when you install the Laser Monitor; if you do not, the monitor certification may be invalidated, the monitor may not operate correctly, or it may be damaged.

**WARNING**

You must mount the Laser Monitor on a structure which is capable of supporting the mass of the Laser monitor (refer to product data).

**WARNING**

Sample and calibration gases may be toxic, asphyxiant or flammable. Ensure that the external connections are leak free at full operating pressure before use of sample or calibration gases and that they vent to avoid exposure to personnel.



WARNING

If using toxic, asphyxiant or flammable sample or calibration gases, always purge the enclosures with non-hazardous gas during operation to reduce the risk of hazardous concentrations accumulating within the monitor. Purge the enclosures for a suitable time before opening to ensure any concentrations are reduced to safe levels. Open transmitter or receiver enclosures in a force ventilated open area, or in another appropriate environment in which any hazardous gases are directed away from the user.



WARNING

The EX2 and CS2 Hazardous area variant cannot be used for oxygen enriched samples, that is gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

You must ensure that, when the Laser Monitor is in its installation location:

- The operating environment is within the limits specified in "Product Data"
- The process flange to which the product is attached is limited to a maximum surface temperature of 135°C.
- To avoid propagating brush discharges, the unit is not to be installed in a high velocity dust-laden atmosphere.
- In addition, the equipment shall only be cleaned with a damp cloth.

CAUTION

Do not install the Laser Monitor on a surface which is subject to high levels of vibration or sudden jolts. If you do, sample measurements may not be accurate, or the monitor may be damaged.

The environmental conditions for the SERVOTOUGH Laser Monitor are listed in the Product data section 1.7 of this manual.

EX1 versions must be used with a suitable Purge Control Unit that is certified to EN/IEC 60079-2:2007, which must meet the necessary pressurisation requirements, and is supplied with the necessary pressurisation and control components.

Connect up any safety purge system required for safe operation in a hazardous area.

**WARNING**

EX1 where appropriate, the user must refer to the detailed instructions provided in the manual supplied with the purge control unit.

**WARNING**

The installation of the Laser Monitor in a hazardous area must comply with any 'Special Conditions for Safe Use' and/or 'Schedules of Limitations' as specified in the safety certification. See Certification Supplement Manual Part Number: 02930008A

Read thoroughly all instructions prior to installation.

All external parts are made of stainless steel or aluminium.

The Receiver unit is shipped with a small bag of silica gel inside the enclosure unit. Ensure that this bag of gel is removed before operating the instrument. If the bag has ruptured during transit, ensure that any particles of silica gel are removed from the instrument before operation.

**WARNING**

Remove Silica Gel sachet before attempting to operate the instrument

The cable gland entry on the bottom of the receiver unit is shipped sealed with a stopping plug. Remember to replace this plug with the cable gland supplied in the loose items kit. Additionally, all purge ports are sealed with blanking nuts.

Ensure that any plugs, nuts and washers that are removed during the course of wiring and plumbing the instrument are retained in the event that the instrument needs to be transported to another location.

**WARNING**

Ensure that any parts which are removed for the purposes of installation are retained. They must be refitted in the event the instrument is transported to another location

A pack of PBC (PolyButylCuprysil) grease is included in the loose items kit supplied with your instrument. This grease must only be used on flange fasteners, it must not be used on any other threaded parts of the instrument or on any O-ring seals. Where other threaded mating parts/O-ring seals require lubrication, use a suitable non-outgassing/inert grease such as Halocarbon grease or Barrierta fluid (not supplied).

Both receiver and transmitter units have optical windows installed by the factory. **They should not be taken off and their angular positions should not be changed.** This is important for successful alignment. Please note that there is no separate mains switch on instrument.

Inspect, test and replace seals regularly to ensure that external connections are leak free at full operating pressure at all times.


WARNING

The transmitter unit contains a small battery. Do not open when an explosive atmosphere may be present.

To install the instrument on the process follow the steps below. Please ensure that the flanges on the process walls are mounted as detailed in Section 2 and their alignment was confirmed.

1. Install transmitter alignment/purging flange (5) onto the process flange (12) with the large O-ring and 4 pcs. M16 x 60 bolts (ref. Figure 3-3). Grease threads of M16 bolts with included PBC grease and fasten using nuts and washers supplied. All 4 bolts must be tightened firmly to compress the large O-ring. Use the gap gauge (were available) to set the initial gap to 6mm all around the flange. This assures a uniform and minimum satisfactory compression of the O-ring.
2. Install pressurised instrument window purging as described in Section 3.1.2.
3. Put the window adapter ring (4) on the alignment unit. Make sure that the O-ring on the alignment unit is tight and greased (note, do **not** use the included PBC grease).
4. Begin purging of the instrument windows. Refer to Section 3.1.2 for details.
5. Affix an O-ring (not greased) to the adapter ring and connect the transmitter unit to the alignment unit. The guiding pin on the adapter ring must fit the hole in the transmitter window. Tighten the transmitter-mounting nut (2), whilst supporting the transmitter unit. Please note after fully tightening the transmitter-mounting nut, do not turn the transmitter unit anticlockwise, as such action can break the thread locking of the TU mechanical parts. If it is necessary to rotate the transmitter unit, first loosen the transmitter mounting nut, then rotate the transmitter unit. Re-tighten the nut again whilst supporting the TU. Please note it is recommended that two people install the TU, one to support the TU whilst the other tightens the mounting nut.
6. Repeat steps 1-5 for the receiver unit.
7. If not pre-connected from factory, connect both cables in the transmitter unit (the main power and receiver cables, Figure 6-1). Refer to Table 6-1 and Table 6-3.
8. If not pre-connected from factory, connect the receiver cable in the receiver unit (ref. Table 6-2).

9. Connect optional output signals (4-20mA, warning relays, etc.) to the “Auxiliary” terminals in the transmitter unit (use an auxiliary cable entry, Figure 6-1). Refer to Section 6.7.
10. Input signals such as external temperature and pressure probes are connected to the assigned terminals in the transmitter unit. Refer to Section 6.6.
11. Connect the transmitter and power supply with the corresponding cable.

3.1.2 Purging of flanges

The instrument windows are kept clean by setting up a positive flow of air through the flanges and into the stack. This purging will prevent particles from settling on the optical windows and contaminating them. The purge gas must be dried and cleaned. Instrument air or other non-hazardous gas shall be used for purging. If instrument air is not available a separate blower is needed. A purge flow of approximately 20–50 l/min (process dependent) is sufficient for most installations. Alternatively, the initial velocity of the purge flow in the flanges is set to 1/10 of the gas velocity in the duct. After completion of the installation the purge flow is optimised as described in Section 5.3.

The air quality should conform to standard set by ISO 8573.1, Class 2- 3. This means particles down to 1 micron should be removed, including coalesced liquid water and oil, and a maximum allowed remaining oil aerosol content of 0.5 mg/m³ at 21°C. (Instrument air)

Note that some instruments require nitrogen purging, e.g. O₂ instruments for high temperature or pressure applications, some H₂O instruments etc.

3.1.3 Purging of transmitter and receiver for measurement purpose

For applications where purging (for measurement or cooling) of transmitter and receiver units is required the direction of flow is illustrated in Figure 3-2. Since there are optical surfaces inside these units, the cleanness of the gas should be ensured and additional filtering may be necessary. Note that so called “instrument air” may contain some oil and water. If receiver and transmitter are purged with such air they can be permanently damaged after a short time. Nitrogen or other non-hazardous gas shall be used as a purge gas. A purge flow of less than 0.5 l/min will ensure pressure does not build-up inside the units.

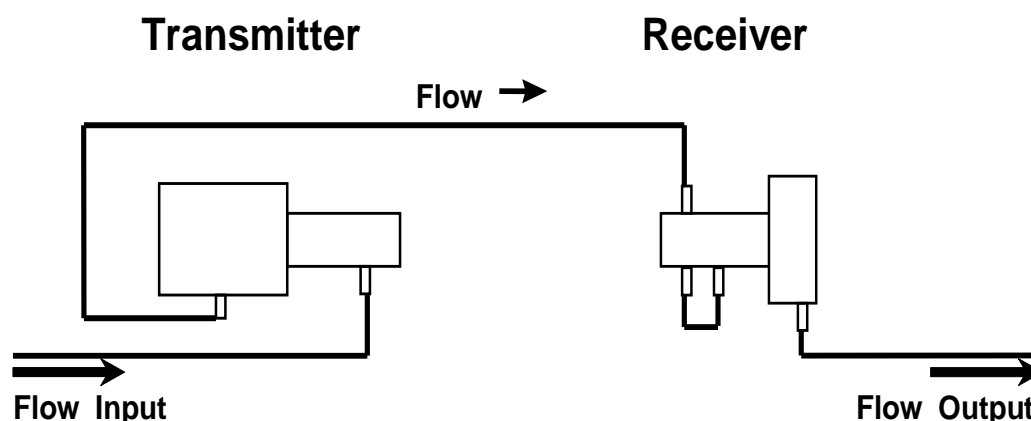


Figure 3-2: Purging of the transmitter and receiver units.

Please note this is application dependant. For long distances between the TU and RU, it may be more convenient to have two separate lines for cooling/purging the RU and TU.

3.2 Start-up

Having completed the installation of the transmitter and receiver according to the previous sections the SERVOTOUGH Laser Monitor is ready for start-up. The start-up of the system consists of 3 main activities:

- Start-up of electronics
- Alignment of transmitter
- Alignment of receiver

3.2.1 Start-up of electronics

Switch on the electronics. The LCD in the transmitter unit will enter start-up mode showing:

STL MONITOR 6.1a1		
- power -		
Self-test		OK
Start-up		0.998

The start-up sequence will make sure the laser is tuned to the correct temperature before it is switched on, and the instrument performs a self-test on all systems. Allow about 5 minutes for the instrument to start the laser.

The LCD will probably show «Laser line-up error» and «Low transmission» when the laser has started up. This is normal and indicates misalignment of the receiver

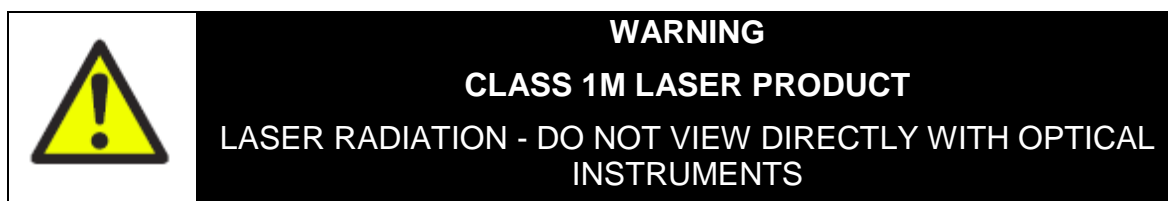
and transmitter units, i.e. the laser beam does not hit the detector inside the receiver unit.

If you use an IR card for alignment of the transmitter/receiver refer to Section 3.3.

If you use a red laser alignment jig for alignment of the transmitter/receiver refer to Section 3.4.

3.3 Alignment of transmitter/receiver using IR card

3.3.1 Alignment of Transmitter unit



Necessary tools and other equipment for the adjustment procedure:

- 1 pcs IR-card (this produces visible image of laser beam spot)
 - 2 pcs spanners to adjust the flange bolts (M16)
 - 1 pcs 5mm Allen key for the locking screws
 - 6mm gap gauge or other suitable measuring tool
1. Leave the instrument switched ON, and disconnect the **receiver** from the alignment unit by loosening the mounting nut (the window adapter ring will be left on the purging unit). The laser beam from the transmitter is not visible. **Avoid looking directly into the transmitter!**
 2. Use an IR-card to locate the laser beam on the receiver side. The spot image is hard to detect in daylight - using a black plastic bag for cover will help. If the laser beam cannot be detected, loosen the adjustment screws shown in Figure 3-3 on the transmitter unit and move it carefully from side to side and up and down to locate the laser beam using the IR card. (You will need two people!)

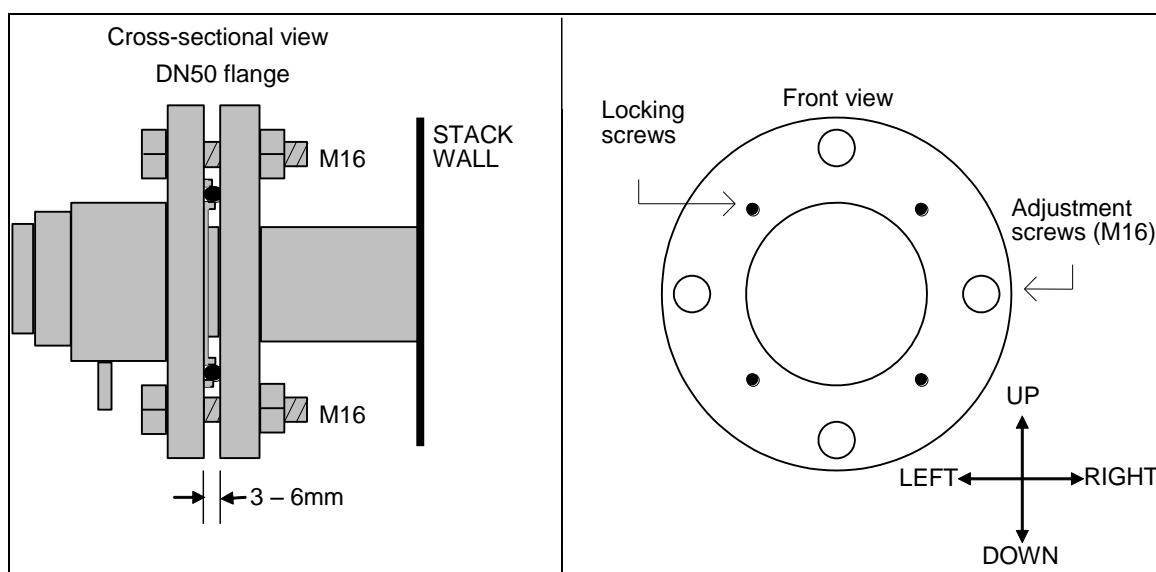


Figure 3-3: Alignment mechanism details

3. Having found the laser beam, adjust the beam to the centre of the hole by carefully adjusting the adjustment screws on the transmitter side. Lock the alignment by tightening the locking screws on the transmitter side and check that the alignment has not changed.

CAUTION

You must ensure that after alignment, the maximum gap between the process flange and the alignment flange is no more than 6mm, otherwise the main O-ring may not be compressed (see Figure 3 3).

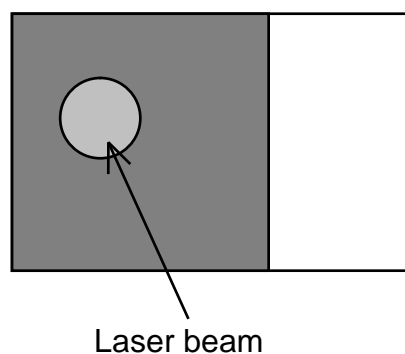


Figure 3-4: IR-card for centring of laser beam

4. The laser beam is now centred, but not necessarily parallel with the optical axis of the receiver unit. The following section describes the procedure for aligning the receiver unit to maximise the signal of the SERVOTOUGH Laser Monitor.

3.3.2 Alignment of receiver unit


Mount the receiver unit to the alignment unit on the receiver side. Check the transmission reading on the transmitter unit LCD. It is recommended that two people with a radio link perform this operation with one working on the RU and the other on the TU. Proceed to Section 3.5, where tuning for maximum transmission using a voltmeter connected to the plug J14 on the RU side is described.

Please note that in order to move the RU field view axis to left direction (see Figure 3.3) one should use the following procedure.

Firstly, loosen the adjustment screw on left side of the flange (e.g. one $\frac{1}{4}$ turn anticlockwise) then loosen two right locking screws and tighten right adjustment screw. If more movement in the left direction is necessary, then repeat the same procedure. When the required alignment is achieved, tighten the locking screws.

After adjustment check the maximum gap between the process flange and the alignment flange is no more than 6 mm. For movement of the RU field of view axis to the right, the opposite procedure should be followed. Always hold and support the receiver unit when tightening the locking screws and the adjustment screw on the receiver unit.

3.4 Alignment of transmitter/receiver using red laser alignment jig




WARNING

LASER ALIGNMENT JIG – CLASS 3R LASER PRODUCT

LASER RADIATION – AVOID DIRECT EYE CONTACT

Note that the red laser alignment jig (including laser pen) is not Ex certified.

This alignment jig cannot be use where there is a flammable atmosphere present in the ‘Outside atmosphere’ and the ‘Process atmosphere’.



WARNING

The laser alignment jig must not be used when an explosive atmosphere may be present in the ‘Outside atmosphere’ or the ‘Process atmosphere’

3.4.1 Alignment of transmitter unit

Necessary tools and other equipment for the adjustment procedure:

- 1 pcs red laser alignment jig
- 2 pcs spanners to adjust the flange bolts (M16)
- 1 pcs 5mm Allen key for the locking screws
- 6mm gap gauge or other suitable measuring tool

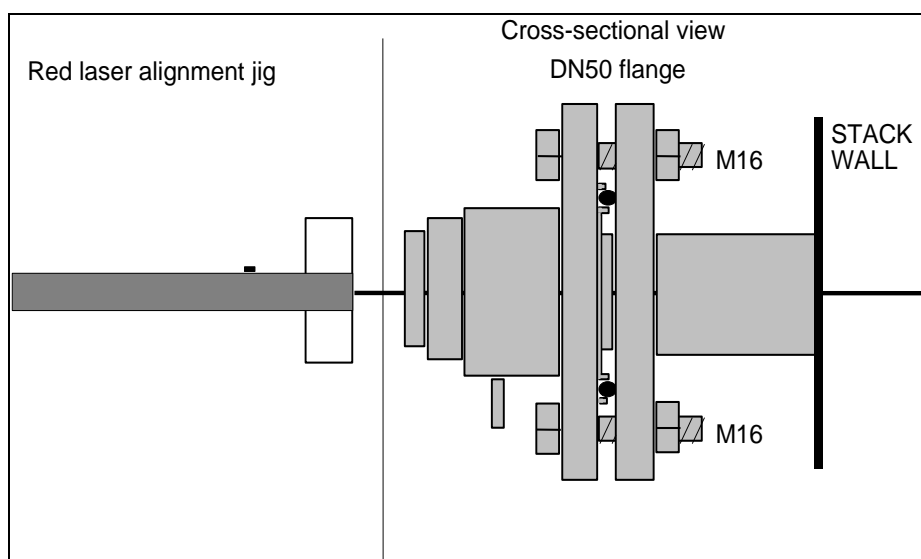


Figure 3-5: Red laser alignment jig

1. Switch off the unit, and disconnect both the transmitter and receiver units from their alignment flanges by loosening the corresponding mounting nuts.
2. Remove the adapter ring (no.4 in Figure 3-1) from both the transmitter and receiver alignment unit.
3. Fit the 'target window' which is included in the red laser alignment jig kit to the receiver alignment unit.
4. Mount the red laser alignment jig on the transmitter side using the supplied mounting nut and locate the laser beam on the receiver side. In order to eliminate deviation of the red beam from the axis between the centres of the RU and TU, one should rotate the body of the alignment base and observe that the red laser beam is at the same point within 360° rotation. If not, the red laser beam circle should be centred on the RU axis.
5. For initial adjustment, loosen the adjustment screws shown in Figure 3-3 on the transmitter unit purging flange and move it carefully from side to side and up and down to locate the laser beam in the receiver hole/target window (you may need two people). Always hold and support the transmitter unit when tightening the locking screws and the adjustment screw on the transmitter unit side.
6. Having found the laser beam, move the beam to the centre of the target window by carefully adjusting the adjustment screws on the transmitter side (following the procedure described above). Lock the alignment by tightening the locking screws on the transmitter side and check that the alignment has not changed.
7. After adjustment, check the maximum gap between the process flange and the alignment flange is no more than 6 mm.
8. The laser beam is now centred, but not necessarily parallel with the optical axis of the receiver unit. The following section describes the procedure for aligning the receiver unit to maximise the signal of the SERVOTOUGH Laser Monitor.

3.4.2 Alignment of receiver unit

1. Disconnect the red laser alignment jig from the transmitter alignment unit and remove the target window from the receiver alignment unit.
2. Remount the target window on the transmitter alignment unit and connect the red laser alignment jig onto the receiver alignment unit.
3. Locate the laser beam on the transmitter side target window. Loosen the adjustment screws shown in Figure 3-3 on the receiver unit purging flange and move it carefully (following the procedure described above) from side to side and up and down to locate the laser beam in the transmitter target (you may need two people).
4. Having found the laser beam, move the beam to the centre of the target by carefully adjusting the adjustment screws on the receiver side. Lock the alignment by tightening the locking screws on the receiver side and check that the alignment has not changed.
5. After adjustment, check the maximum gap between the process flange and the alignment flange is no more than 6 mm.

Having completed the previously described operations successfully, the transmitter and receiver should be re-mounted and switched on. Check the transmission reading on the transmitter unit LCD. Proceed to Section 3.5, where tuning for maximum transmission using a voltmeter is described.

3.5 Tuning for maximum signal

The alignment voltage varies from 0V at 0% transmission to -3V (typically, for some applications with large distance between the RU and TU >4 m, the voltage can be -1.0V and -1.5 V) at 100% transmission. Fine alignment of the transmitter and receiver unit to ensure maximum transmission can be aided by measuring the alignment voltage with a voltmeter. The fine-tuning procedure is as follows:

1. Connect a voltmeter with floating inputs (battery powered) to one of the following measurement points:
 - a) Open the transmitter electronics box, and connect the voltmeter to the positive and negative terminals of “direct signal”, or
 - b) Connect the voltmeter to the plug J14 “line-up voltage”, or
 - c) Open the receiver electronics box. Connect voltmeter (+) to the cable connection No.14 and the voltmeter (-) to the connection No.13 in the receiver unit.
2. Reduce the voltmeter reading towards -3V (alternatively maximise transmission reading on LCD) by using the transmitter adjustment screws.
3. Reduce the voltmeter reading towards -3V (alternatively maximise transmission reading on LCD) by using the receiver adjustment screws.
4. Repeat step 2 and 3 until no further improvements in voltmeter (transmission) readings.
5. Tighten the locking screws and check that the alignment has not changed.
6. Disconnect the voltmeter and close the unit.

3.6 Connecting a PC

Please note that the PC should be placed in a non-hazardous (safe) area. For long distance communication we recommend use of the optional Ethernet connection. The software for service communication with the SERVOTOUGH Laser Monitor is supplied with the instrument and will run under Windows98/2000/XP/VISTA and Windows 7. The service program runs as a self-contained .exe file, requiring no installation.

1. Copy the software supplied with floppy disk or CD onto the hard disk into a specified directory, which may be called for example "SERVOTOUGH Laser".
2. Connect a PC serial port to the RS-232 connection (beneath cover on side of transmitter unit) using a serial cable. The service program uses the serial port configured as 9600 baud, no parity, 8 bits and 1 stop bit. If network communication is used, connect the network cable to the Base-T connection inside the transmitter unit (see Table 6-7). Note that in this case the serial cable must be disconnected from the instrument.
3. Thoroughly check the following parameters against the installation details and set them using the software (see Chapter 4 for detailed description):
 - Process gas pressure and temperature (Chapter 4.3.5)
 - Instrument gas alarm level (Chapter 4.3.6)
 - Gas concentration corresponding to 4 and 20mA (Chapter 4.3.6)
 - Concentration averaging (Chapter 4.3.5)
 - Instrument time (Chapter 4.3.5)
 - Gas concentration unit (Chapter 4.3.6)
 - Optical path parameters (Chapter 4.3.5)

Having completed the setting of all necessary parameters, the instrument is in normal operation mode and should indicate this by updating the gas concentration on the LCD periodically. Operation, maintenance and calibration of the instrument are further explained in Chapter 5.

3.7 Connecting a modem

Please note that any modem should be placed in a non-hazardous (safe) area. A standard 56k analogue modem is connected to the instrument. Use a null modem cable or the RS-232 cable with an adapter between modem and instrument. NB: A gender changer may be required. In addition to the modem connected to the instrument, a standard 56k analogue modem capable of 9600 baud has to be connected to one of the PC's serial ports. At start-up of the instrument the modem is initialised, and at start-up of the service program the PC-modem is initialised. No additional configuration of the modems is necessary. Reset the instrument by cycling the power.

4. THE SERVICE PROGRAM

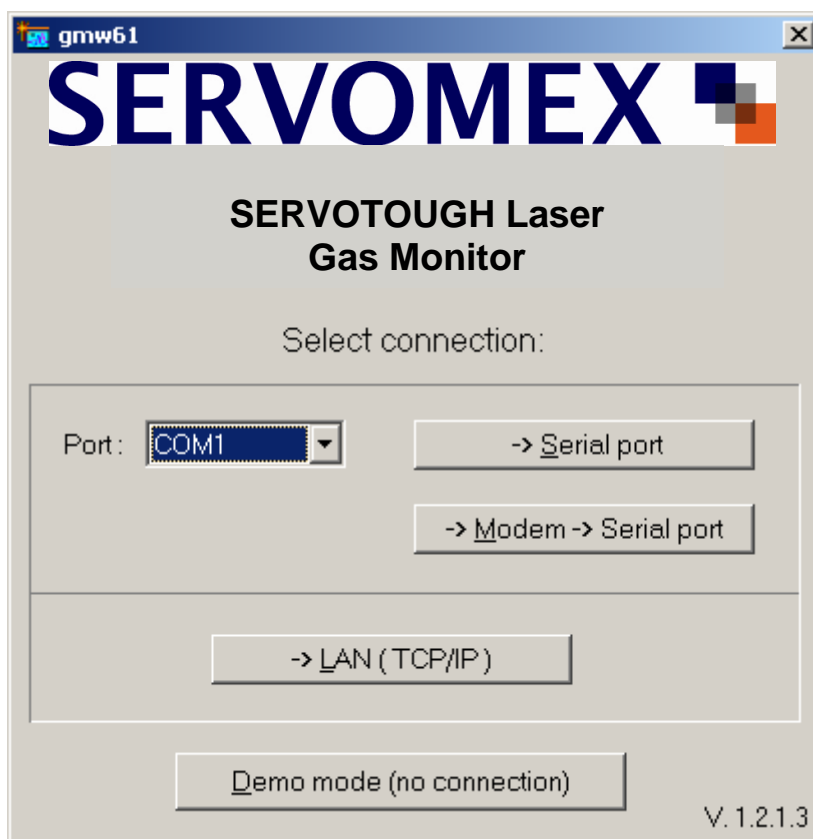
The instrument calculates the gas concentration from the measured signal, which depends on several process parameters. The instrument must therefore be configured for the specific installation. With the service program the user communicates with the instrument and changes installation or process relevant settings. With a PC connected to the instrument via a standard serial communication port or the optional Ethernet connection the operator can perform the following major tasks:

1. Monitor the measured concentration and the laser beam transmission;
2. Plot the measured concentration as a function of time;
3. Log the concentration and other control parameters to a file;
4. Display the measured signal;
5. Save the measured signal and other control parameters to a file;
6. Observe and erase the instrument error logging;
7. Configure the 4-20 mA process temperature and pressure inputs;
8. Configure the 4-20 mA measurement output;
9. Change the measurement averaging time;
10. Set the gas alarm level;
11. Set the optical path parameters;
12. Change the concentration units;
13. Change the format of the displayed concentration;
14. Change the instrument clock time;
15. Calibrate the instrument;
16. Save all instrument parameters to a file;
17. Restore the instrument parameters from a file;
18. Configure the (optional) Ethernet connection.

Through different menus the necessary installation parameters may be set. After setting the necessary parameters the PC is no longer needed. The SERVOTOUGH Laser Monitor has all the parameters stored in the internal memory. The PC can therefore be disconnected and the SERVOTOUGH Laser Monitor can be turned off and on without resetting the parameters.

4.1 Software start-up

After starting the program a welcome screen will display a selection of instrument to PC connections:



The version of the service program is printed in the right bottom corner (in the example above V1.2.1.3).

For direct serial or modem connection, select the PC serial port from the dropdown list of available ports and press the corresponding button. When using a modem, you will be asked for a telephone number to dial. If the first digit in this phone number is zero, the software will pause after dialling the zero before dialling the rest of the digits. If additional pausing is needed, apply "," between the digits.

If communication via LAN is used, you will be asked for IP address and port number: The IP address and port number are typically set to default values 192.168.1.237 and 5001, respectively. If the IP address and port number need to be changed, run the program with direct serial connection and configure TCP/IP parameters as described in Section 0.

After the connection with the instrument has been established you are prompted to start the program in User or Advanced mode.

Press <User mode> to start the program. This program mode provides a simplified interface with limited access to the instrument setting parameters and should be used during installation and normal operation of the instrument. A password is only

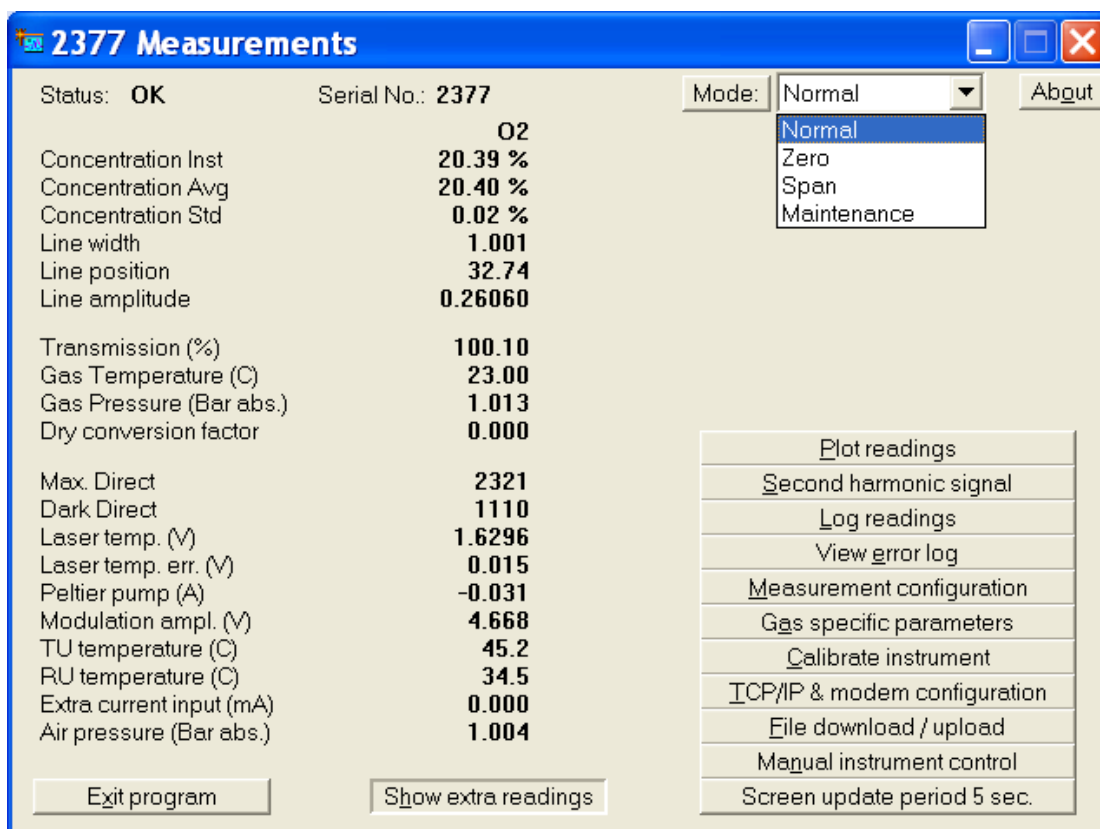
required for Advanced mode that enables full access to all the instrument setting parameters. This program mode should be used during service adjustment of the instrument. Your local distributor or SERVOMEX can provide the password on request.

Note that if the connection is moved to another instrument the program must be shut down and run again. It is possible to run several program windows simultaneously to communicate with different instruments using one PC.

The service program can also be started without a connection to an instrument by pressing <Demo mode>. This is for demonstration purposes of the service program. Two extra files are needed for this mode to work: *.dmp or *.rea and *.set or *.stt. These files can be created using the service program when a PC is connected to an instrument. The files are created by downloading the instrument readings to *.rea and settings to *.set (ref. Section 4.3.9). Alternatively, one can use the files supplied with the service program on the floppy disk or CD. These files were downloaded from the instrument at the factory prior to shipment.

4.2 The measurement menu

After pressing the <User mode> button the program opens the **Measurements** menu. The example below is for an instrument measuring oxygen.



The serial number of the instrument is shown in the title line of the menu. The bottom right of the screen shows different menus which can be accessed either by pressing the buttons or by pressing the underlined shortcut letters (e.g. <S> for Second

harmonic signal). By pressing <Exit menu> one can always go back to the previous menu. The description of each menu will follow.

The rest of the screen is used to display different readings/parameters. By default only the main readings/parameters are displayed. By pressing <Show extra readings> all readings/parameters are displayed. (NB: <Show extra readings> is activated in the example above).

The instrument readings update period is set by pressing <Screen update period>, which is 5 seconds by default. This time should not be shorter than the time required to calculate the concentration (the update time of the LCD).

The readings/parameters are explained in detail below:

Status: The instrument status which may be SLEEPMODE / STARTUP / OK / WARNING / ERROR. See Section 5.

Serial no.: Serial number of the SERVOTOUGH Laser Monitor.

Mode: The measuring mode of the instrument. By clicking on the mode button 4 different measuring modes may be selected. See Section 5.1 for details.

Concentration instant: Displays the last value calculated by the SERVOTOUGH Laser Monitor with no averaging. This is referred to as a primary measurement.

Concentration average: Displays the running average calculated by the SERVOTOUGH Laser Monitor (not by the service program) from the last N values, where N is the averaging count specified in menu <Measurement configuration>. A description of the averaging method will be given in that subsection.

Concentration standard: Gives an estimate of the running standard deviation also calculated by the SERVOTOUGH Laser Monitor. This number indicates how much the calculated gas concentration fluctuates from its average value. If the gas concentration is truly constant it will provide a measure of the instrument precision.

Line width: Relative measure of the width of the absorption line. In combination with the line amplitude it determines the integrated absorption, which in turn is used to calculate the gas concentration. The reference line width parameter is equal to 1.000 at $T = 23^{\circ}\text{C}$ and $P = 1.013 \text{ bar}$ (1 atm.) and when the gas composition is equal to those used when calibrating the instrument. The line width increases with gas pressure and decreases with gas temperature. It also depends on the gas composition, for example water vapour broadens the absorption lines significantly.

Line position: The position of the line peak (maximum absorption) in samples of the AD converter [0..63]. The value should be close to the reference line position, which is given in the menu <Gas specific parameters> for the corresponding line. The instrument automatically tracks the line, i.e. if it deviates more from the reference position than a given value, the instrument adjusts the laser temperature and thereby the wavelength.

Line amplitude: Relative measure of the peak of the absorption line of the second harmonic signal. If this value approaches 0.5-1.0 the absorption is strong and saturation of the AD converter may be very close (actual saturation initiates the ERROR). In the region 0.01-0.1 the signal is good. Below 0.01 the signal is approaching the low level below which line width cannot be measured and line tracking is off.

Transmission (%): Indicates how much light the receiver detects in % of the maximum value. If the optical windows are covered with dust and the transmission drops below a pre-set level, a warning will appear on the display of the SERVOTOUGH Laser transmitter unit. The optical windows of the instrument should then be cleaned. The warning will also appear for improper alignment of the transmitter and receiver.

Gas temperature (C): The temperature in degrees Celsius currently used to calculate the gas concentration. It may be a fixed value set by the user, the value measured by a 4-20 mA current T-probe or the value measured by the instrument itself optically or electrically. Optically measured temperature is called Spectral temperature. Electrically measured temperature is the temperature measured by the embedded temperature sensors (only used when the gas temperature is equal to ambient temperature) offset-corrected to be equal the ambient air temperature. In the example above the gas temperature is set equal to the Spectral temperature. These settings can be configured in the <Measurement configuration> menu.

Gas pressure (Bar abs.): The pressure in Bar absolute currently used to calculate the gas concentration. It may be a fixed value set by the user, the value measured by a 4-20 mA current P-probe or the value measured by the instrument itself using the embedded pressure sensor (mainly for O₂ instruments and only used when the gas pressure is equal to the ambient air pressure). This is configured in the <Measurement configuration> menu.

Dry conversion factor: Factor currently used to multiply the gas concentration if dry basis conversion is selected (see Section 4.3.5). The initial (wet) concentration reading may be converted to dry reading if the H₂O concentration is known. If dry basis conversion is not activated the factor is always 1.0.

Max. direct: Maximum value of the direct signal in the levels of AD converter [0 - 4096]. This value together with *Dark direct* determines the value of the light transmission.

Dark direct: Optical zero of the direct signal measured when the laser is switched off for a short period. The unit is the same as for *Max. direct*.

Laser temp. (V): The voltage across the thermistor located in the vicinity of the diode laser. Higher voltages indicate lower laser temperature. Changing laser temperature changes the laser wavelength.

Laser temp. error: The amplified difference in Volts between the measured *Laser temp* and the reference value. Should be around 0.000. It indicates the quality of the laser temperature regulation and thus the quality of the wavelength stabilization.

Peltier pump (A): The current drawn by the Peltier element.

Modulation ampl. (V): Amplitude of the high frequency modulation voltage to the laser.

TU/RU temp.: The temperatures measured by the embedded thermistors located inside the transmitter and receiver unit.

Extra current input (mA): Current measured on extra current input (Flow 4-20 mA input).

Air pressure (Bar): The ambient pressure measured by the embedded pressure sensor located inside the transmitter unit.

4.3 The program menus

4.3.1 Plot readings

Plot readings plots the measured average and instant concentration of gases, transmission and spectral temperature (if measured). Two different plots can be shown simultaneously. Clicking on the axis labels modifies the scale of the plot.

4.3.2 Second harmonic signal

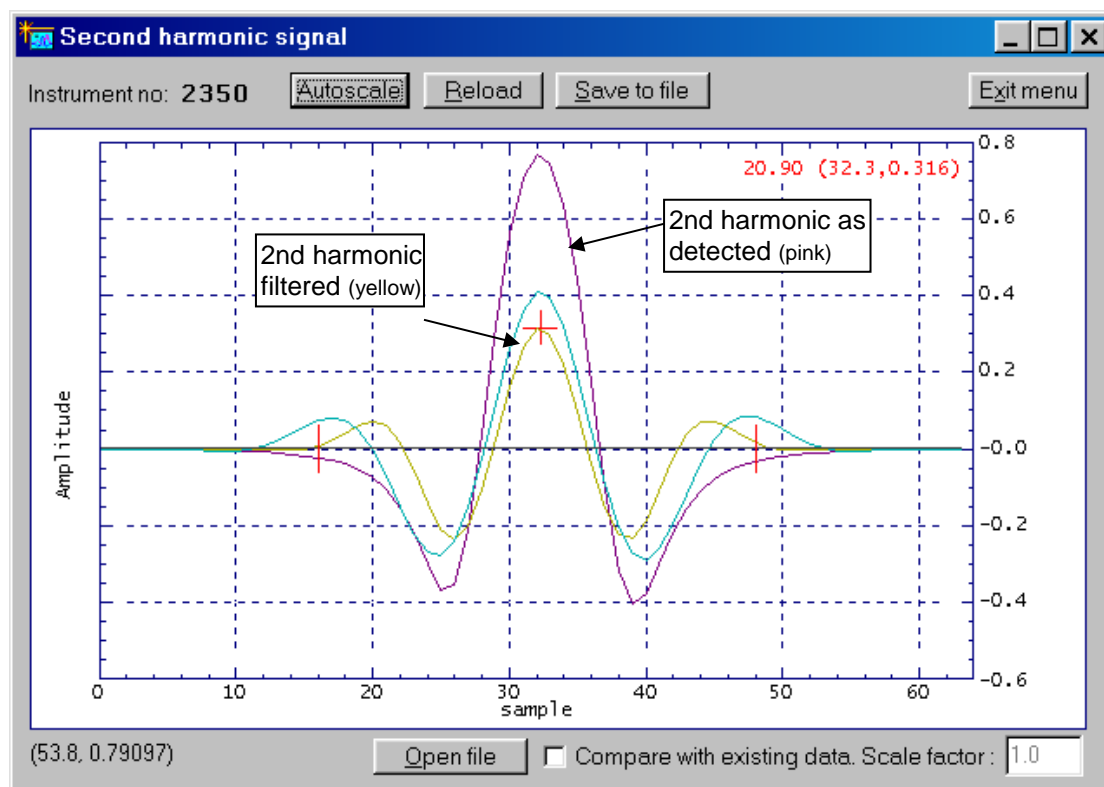
Second harmonic signal displays signals recorded by the instrument for calculation of the gas concentration. This signal is also useful for inspection and analysis of the absorption spectra, verification of proper laser function, and fault diagnostics. In total three curves are displayed: the normalised second harmonic signal as detected (pink curve) and the same signal after filtering with two different filters (yellow and blue curves). For some instruments only one filter is applied to the signal.

The example given below displays the signal from an oxygen absorption line. The peak of the yellow curve is marked with a red cross. The instantaneous gas concentration as measured from this line; the sample number and position of the peak are printed in the upper right corner in parenthesis. The latter are referred to as *Line position* and *Line amplitude* described in previous Section 4.2. The line position must be within the acceptance window marked by the two vertical red lines. For some instruments such as dual gas instruments more than one absorption line is plotted.

With the <Reload> button the second harmonics signal is updated. The data can be saved to file (<Save to file>) for later analysis. This is equivalent to <Download

readings> in the **File download/upload** menu (Section 4.3.9). The scale of each axis is modified by clicking on the axis label.

It is possible to open a previously saved signal and scale it to compare with existing signal.

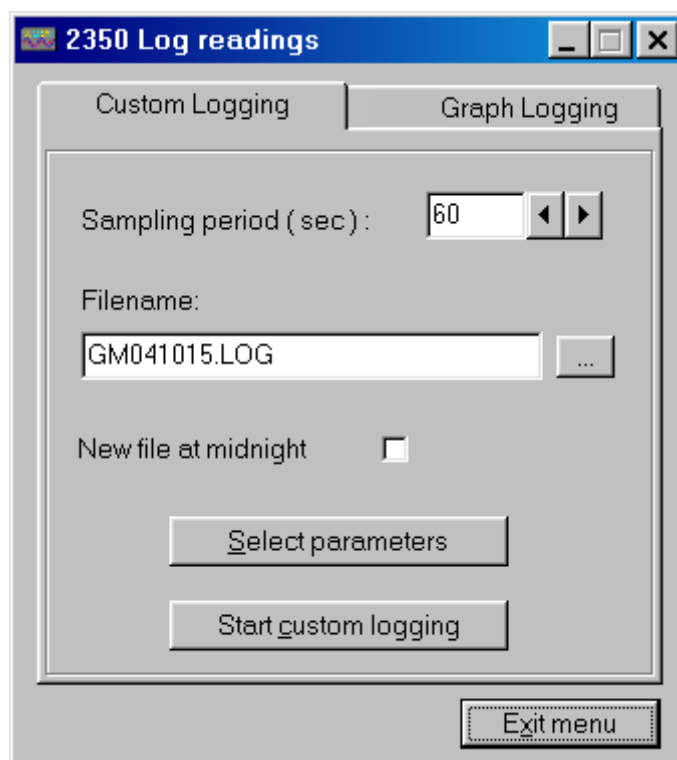


4.3.3 Log readings

With <Custom Logging> all data displayed in the **Measurements** menu can be logged to an ASCII file at specified regular intervals. The sampling period (logging interval), file directory, and the filename are user defined (default filename is "gmYYMMDD.log"). If <New file at midnight> is selected the program will create a new logging file at every midnight with the default filename reflecting the new date.

Before logging <Select parameters> should be pressed and the parameters of interest should be marked. The selected parameters are automatically arranged in columns in the logging file. The first column is always seconds after the last midnight (PC time) and the last two columns are always the instrument status (-4 (sleepmode)/ -1 (startup)/ 0 (ok)/ 1 (warning)/ 2 (error)) and the measurement mode (0 (ok)/ 1 (zero)/ 2 (span)). Parameters can be added to or deleted from the logging file without interrupting the logging process. The configuration of the logging file may be modified (e.g. specify text qualifier, data separator, add comment on top etc.).

The second possibility to log data is *Graph logging*. *This is not currently supported*. The output format cannot be selected, the filename cannot be changed and <New file at midnight> is always selected.



4.3.4 View error log

After pressing <View error log> the program downloads the log of the instrument's errors and warnings (see Section 5.5 for description of the errors) including the date and time of their last activation and deactivation. The currently active errors and warnings are marked with a cross (x), while the inactive errors are marked with a dash (-). <Save error log> saves the current list of errors to a text file. <Clear error log> clears all the errors and warnings from the instrument's internal memory.

The instrument also stores the log (System log) of internal status and self-test information. This information is useful for advanced diagnostics and faultfinding and downloaded to a text file by pressing <Save system log>. Older system information may be downloaded by pressing <Rewind system log 100 lines> and subsequently <Save system log>.

In case of instrument failure it is always useful to download the error log and the system log and send both files to SERVOMEX for diagnostics.

4.3.5 Measurement configuration

In this menu the most important parameters can be set:

Gas pressure	(page 1)
Gas temperature	(page 1)
Pressure / temperature input method	(page 1)
Pressure / temperature PLC input range	(page 1)
Concentration averaging	(page 2)
Optical path variables	(page 2)
Instrument time	(page 2)

Note that the parameters are modified in the program but the instrument is not updated with the new values until the button <Update instrument> is pressed.

The screenshot shows a software window titled "2350 Config" with three tabs: "Page 1", "Page 2", and "Page 3". The "Page 1" tab is active. It contains two sections of settings. The first section is for pressure, with a dropdown menu set to "Fixed". Below it are input fields for "Current pressure" (1.013), "Fixed gas pressure (Bar abs.)" (1.013), "PLC 4 mA gas pressure" (1.013), and "PLC 20 mA gas pressure" (1.013). The second section is for temperature, with a dropdown menu set to "Fixed". Below it are input fields for "Current temperature" (23.0), "Fixed gas temperature (C)" (23.0), "PLC 4 mA gas temperature" (23.0), and "PLC 20 mA gas temperature" (23.0). At the bottom of the window are four buttons: "Reload readings (P, T, date)", "Reload variables", "Update instrument", and "Exit menu".

Gas pressure and temperature

The strength of the absorption line and line width are pressure and temperature dependent. This is compensated for by calculating a correction factor based on deviation of pressure and temperature from the standard atmosphere ($P=1.013$ bar, $T=23$ C). For relative concentration units (ppm, %, mg/Nm^3 , g/Nm^3) the gas pressure and temperature are in addition directly involved in calculation of the concentration through the ideal gas law. Therefore, correct setting of gas pressure and temperature is important for the accuracy of the measurement. *Current pressure* and *Current temperature* are the values used for calculation at present. These

values are only downloaded from the instrument after an update of parameters or explicitly after pressing <Reload readings (P, T, date)>.

Note that the gas pressure is always specified in bar **absolute**. To convert pressure from bar gauge to bar absolute use the following relation:

$$P(\text{bara}) = 1.013 + P(\text{barg})$$

To convert pressure from Psig to bar absolute use the following relation:

$$P(\text{bara}) = 1.013 + P(\text{psig})/14.5$$

Note that the gas temperature is always specified in Celsius. To convert temperature from Fahrenheit to Celsius the following relation can be used:

$$T(\text{C}) = (T(\text{F}) - 32)/1.8$$

To convert temperature from Kelvin to Celsius the following relation can be used:

$$T(\text{C}) = T(\text{K}) - 273$$

Pressure and temperature input method

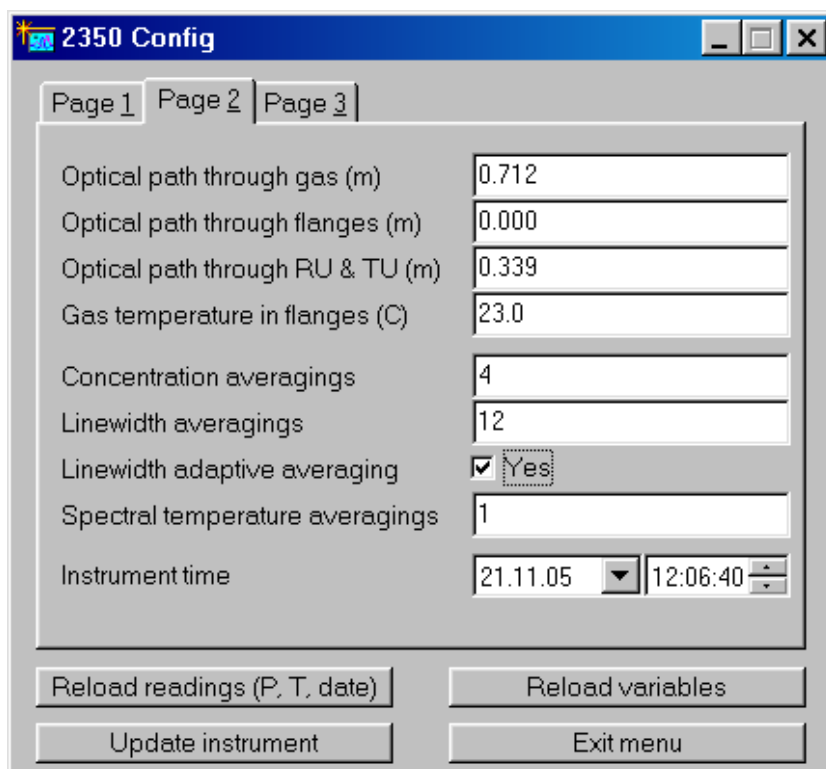
<Pressure/Temperature input method> defines if the values are fixed or read with one of the following methods: Current loop, Internal, Spectral, and Serial.

If method "Current loop" is activated the values are input from the corresponding 4-20 mA current input. In this case the PLC 4 mA and PLC 20 mA values must be specified.

Method "Internal" sets the gas pressure equal to the ambient pressure measured by the internal pressure sensor (*Air pressure* in **Measurements** menu). The gas temperature is set equal to the average of the measured temperatures inside the RU and TU (*TU* and *RU Temp* in **Measurements** menu), which are offset corrected to be approximately equal to the ambient temperature.

Method "Spectral" (only for temperature) sets the gas temperature equal to the temperature measured spectroscopically. This method is only applicable for instruments measuring gas temperature like the O₂ + Temperature monitor.

Method "Serial": Pressure and temperature input through RS-232 or Ethernet connector (requires special data packet, contact SERVOMEX for details).



Parameter	Value
Optical path through gas (m)	0.712
Optical path through flanges (m)	0.000
Optical path through RU & TU (m)	0.339
Gas temperature in flanges (C)	23.0
Concentration averagings	4
Linewidth averagings	12
Linewidth adaptive averaging	<input checked="" type="checkbox"/> Yes
Spectral temperature averagings	1
Instrument time	21.11.05 12:06:40

Optical path through gas (m)

The length (in meters) of the optical path through the gas to be measured (L_g in Figure 4-1). It is normally equal to the stack diameter or the free space between insertion tubes. In case of installations with a measurement cell it is equal to the length of the cell.

Optical path through flanges (m)

The combined length of the flanges ($L_{f1} + L_{f2}$ in). This parameter is important only if the measured gas is present in the flange region and the instrument must compensate for this extra gas absorption. This is usually the case for O_2 , H_2O , CO_2 , CH_4 monitors, i.e. monitors measuring atmospheric gases. Note that for this compensation to work, the gas concentration in the flanges must be specified in **Gas specific parameters** menu (Section 4.3.6).

Optical path through RU & TU (m)

The optical path through the transmitter and receiver units (TU & RU). This is the internal optical path of the instrument. The value is set by the factory. If this parameter is changed, the original value should be noted down in order to be able to restore the original setting when required. This parameter is only important if the measured gas is present in the internal instrument volume so that the additional gas absorption must be compensated for (see above). Note that for this compensation to work, the gas concentration in RU & TU must be specified in **Gas specific parameters** menu (Section 4.3.6).

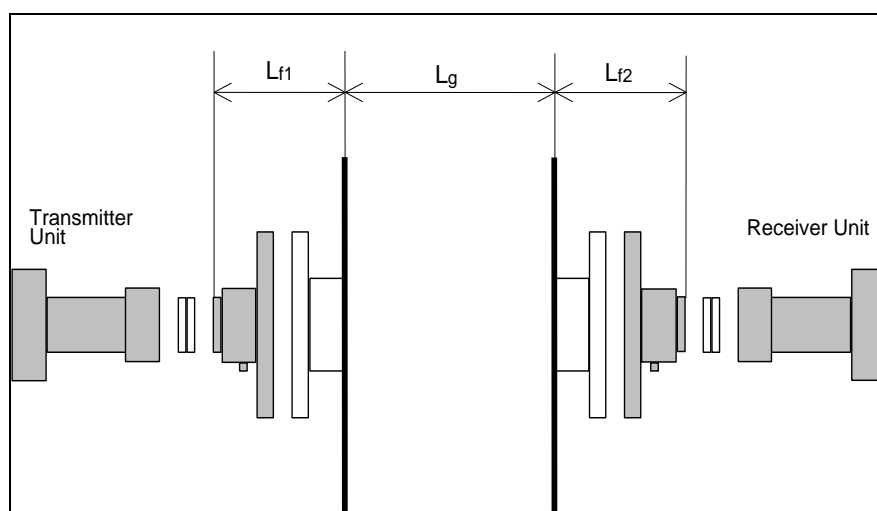


Figure 4-1: Optical lengths needed for setting initial parameters.

Gas temperature in flanges (C)

The average temperature of the gas in the flanges in degrees Celsius. If the measured gas is not present in the flanges, the flange temperature is irrelevant.

Note: Proper setting of the optical path parameters is important for correct measurements.

Concentration averagings

The amount of primary measurements used to calculate the averaged concentration (*Concentration Avg* in **Measurements** menu). The instrument measures and calculates the gas concentration at regular intervals. A primary measurement (*Concentration Instant* in **Measurements** menu) takes approximately 1-4 seconds depending on the gas type. The instrument calculates a “running” average of the primary measurements, which is then output in the following three ways: 1) printed on the display in the electronics unit, 2) driven through the 4-20 mA analogue output, and 3) transmitted as a digital signal in the optical fibre output (optional). All these output channels use the averaged gas concentration. The display and the current loop are updated after every primary measurement, while new data is transmitted through the fibre optic output after the defined averaging time. The amount of averaging is specified by the averaging count ($T_{av} = N \times T_{prim}$).

Line width averagings

Specifies the number of values used for line width averaging.

Line width adaptive averaging

Switched OFF = the rolling average (as for concentration) applies.

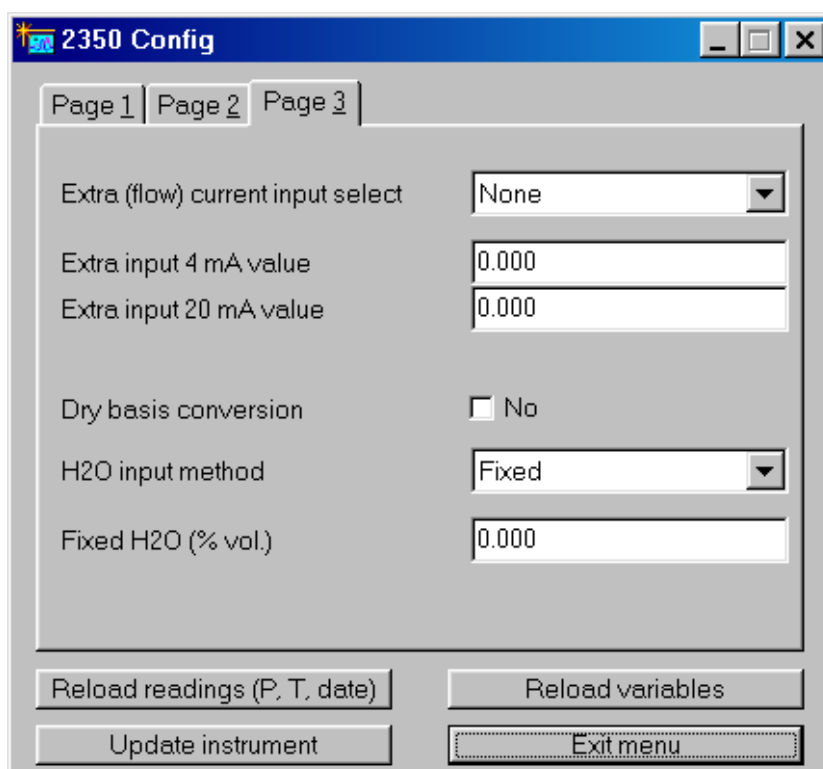
Switched ON = the number of averaging depends on the signal strength i.e. weak signals are averaged longer. NB: This will only be effective if line width averaging is specified > 10.

Spectral temperature averagings

Specifies the number of values used for spectral temperature averaging.

Instrument time

The instrument has a built-in clock, which also runs when power is off. Using this menu the instrument time should be set equal to the local time. The current instrument time is only downloaded from the instrument after an update of parameters or explicitly after pressing <Reload readings (P, T, date)>.



Extra (flow) current input select

Configures the extra (denoted as “Flow”) current input to the instrument. It can be set to “None”, “Gas - % vol”, “Gas - g/Nm³”, “Gas – g/m³”, and “Flow”. Input “None” simply deactivates the extra current input. For all other inputs the 4 mA and 20 mA values must be specified. The current input can be used to connect an external gas sensor (typically an H₂O sensor for dry basis conversion) to the instrument. In this case “Gas” input with the corresponding concentration unit should be selected. The measured input current can be monitored in the **Measurements** menu. Input “Flow” is currently not implemented.

Dry basis conversion

The primary measurements of the gas concentration are always on wet basis. The instrument can also present the results on dry basis if the H₂O concentration is known. If <Dry basis conversion> is selected the instrument converts the measured concentrations according to the following simple equation:

$$N(\text{dry}) = N \cdot 100 / (100 - \text{H}_2\text{O}(\%))$$

where N is the originally measured gas concentration on wet basis and H₂O(%) is the input H₂O concentration in % vol. The factor that multiplies N is *Dry conversion factor* which can be monitored in the **Measurements menu**.

H₂O input method

The following input methods for the H₂O concentration can be selected: Fixed, Current loop, Measured, Calculated.

Method “Fixed” sets the H₂O concentration equal to the manually specified value. With method “Current loop” the H₂O concentration is input from an external H₂O sensor via the Extra (flow) current input. In this case Extra (flow) current input select must be set to “Gas-unit”, where “unit” corresponds to the output concentration unit of the external H₂O sensor. The 4 and 20 mA values must be specified. Method “Measured” can be used when the SERVOTOUGH Laser Monitor is configured to measure several gases and one of them is H₂O. The maximum H₂O concentration used for dry basis conversion with this method is limited to 50% vol. If the measured concentration exceeds this value the value used for dry basis conversion will still be 50% vol. When method “Calculated” is selected, the instrument calculates saturated water vapour concentration based on the gas temperature and pressure input values. The calculated H₂O concentration is then used for dry basis conversion. The maximum gas temperature for this method is about 90 deg. C and the maximum calculated H₂O concentration is limited to 70% vol. The same H₂O limit is used also for “Fixed” and “Current loop” methods.

4.3.6 Gas specific parameters

If the instrument monitors more than one absorption line a selection menu with the relevant gases appears first.

Upon selection of one gas the following menu is displayed (see next page):

Measured gas

Displays the gas type. Cannot be modified if the program runs in User mode.

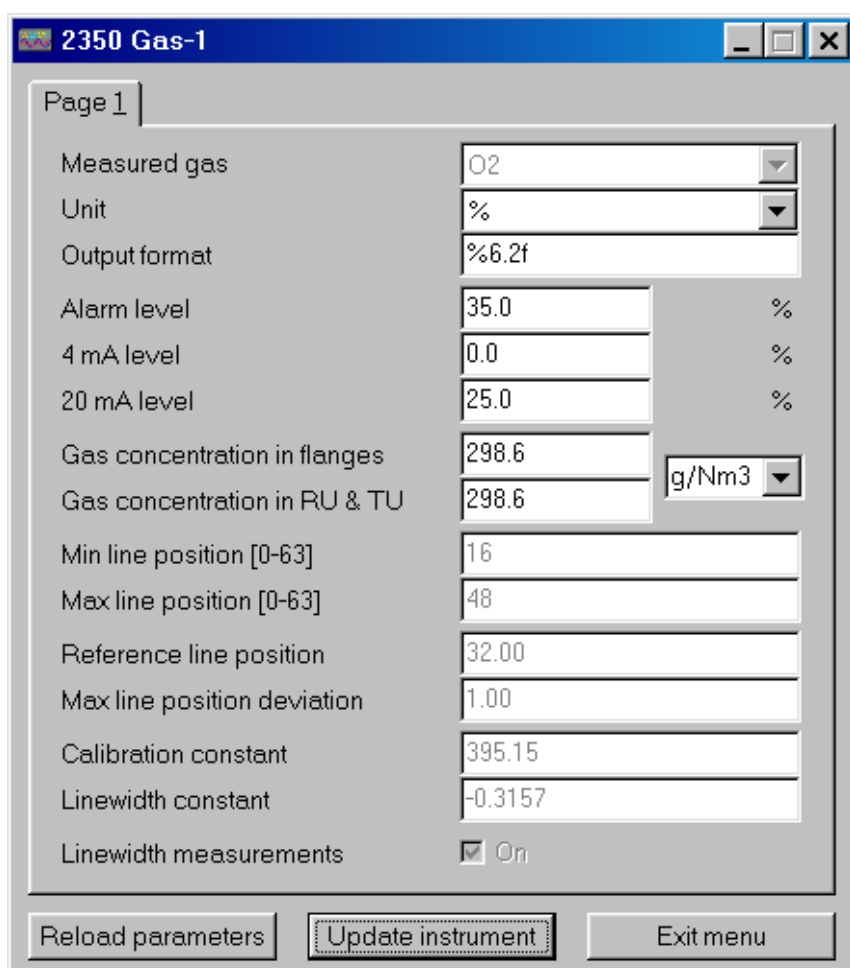
Unit

Select the appropriate unit for output of the gas concentration from the dropdown list.

The units may be grouped in two different categories, the absolute units: *g/m³*, *mg/m³* and *µg/m³* (*µg* refers to micrograms) and the relative units: %, *ppm*, *ppb*, *g/Nm³*, *mg/Nm³* and *µg/Nm³*.

Some more specific units are also available such as *%*m*, *ppm*m* and *ppb*m*. These units are often used for open path SERVOTOUGH Laser Monitors and represent the concentration recalculated to 1 meter optical path length. Note that the actual path length in **Measurement configuration** menu should nevertheless be set to the correct value.

The primary unit used by the instrument to calculate the gas concentration from the absorption line is the absolute unit *g/m³*. All other units are calculated from this primary unit assuming the ideal gas law is applicable.



The screenshot shows a software window titled "2350 Gas-1" with a "Page 1" tab. It contains a list of configuration parameters for gas measurement, each with a text input field and a unit dropdown menu. The parameters and their current values are:

Parameter	Value	Unit
Measured gas	O2	%
Unit	%	%
Output format	%6.2f	
Alarm level	35.0	%
4 mA level	0.0	%
20 mA level	25.0	%
Gas concentration in flanges	298.6	g/Nm3
Gas concentration in RU & TU	298.6	g/Nm3
Min line position [0-63]	16	
Max line position [0-63]	48	
Reference line position	32.00	
Max line position deviation	1.00	
Calibration constant	395.15	
Linewidth constant	-0.3157	
Linewidth measurements	<input checked="" type="checkbox"/> On	

At the bottom of the window are three buttons: "Reload parameters", "Update instrument", and "Exit menu".

The relative units g/Nm^3 , mg/Nm^3 and $\mu g/Nm^3$ are the values obtained from the conversion of the absolute units (g/m^3 , mg/m^3 and $\mu g/m^3$) to 'normal' pressure and temperature assuming the ideal gas law. According to the European standard which applies for the SERVOTOUGH Laser Monitor these values are $P = 1.013$ Bar and $T = 273.1$ K. Please note that the US standard for the relative units g/Nm^3 and mg/Nm^3 deviates with regard to standard temperature and refers to 298 K. Note that the gas concentration is always measured on "wet basis", i.e. no correction is done for water vapour present in the process gas.

Output format

The numerical format of the gas concentration on the LCD display and in most parts of the service program.

The format is presented according to the programming language C (%6.2f means that the floating number will be presented with 2 decimals and 6 digits including the decimal point, e.g. 123.45).

Gas conc. alarm level

The gas concentration level for which the alarm relay is activated. The gas alarm level is specified in the currently active unit for gas concentration. If a different unit is later selected, the gas alarm level will not automatically be converted to the new unit but must be set manually. The alarm level is selected individually for different

gases, although the alarm relay is common. Thus, if the concentration of any of the measured gas is above its alarm level, the alarm relay is activated. To exclude one or several gases from activating the alarm the corresponding alarm levels are set to deliberately unreachable values. See also Section 6.11 for different configurations of the gas alarm relay.

4 mA & 20 mA level

These set the 4-20 mA range in gas concentration units.

Gas concentration in flanges, RU and TU

The gas concentrations in the flanges and in the RU & TU. The units can be chosen between g/Nm^3 , % or *ppm* from the dropdown list. If the measured gas is not present inside RU and TU and/or in the flanges the corresponding gas concentration must be set to zero.

Note that the corresponding optical path lengths are specified in the **Measurement configuration** menu.

Min/Max line position [0-63]

These values define the acceptance window (in samples) for the line position in the second harmonic signal (see Section 4.3.2). The values cannot be modified if the program runs in User mode.

Reference line position

Specifies the position of the absorption line (in samples) in the second harmonic signal. The value cannot be modified if the program runs in User mode.

Max line position deviation

Specifies the maximum deviation of the line position (in samples) from the reference line position. If the deviation is larger than the specified value the instrument will adjust the laser temperature to bring the line back to the reference position. The value cannot be modified if the program runs in User mode.

Calibration constant

The constant used in calculation of the gas concentration. The calibration constant is modified after calibration (see Section 4.3.7). The value cannot be modified manually in this menu if the program runs in User mode.

Line width constant

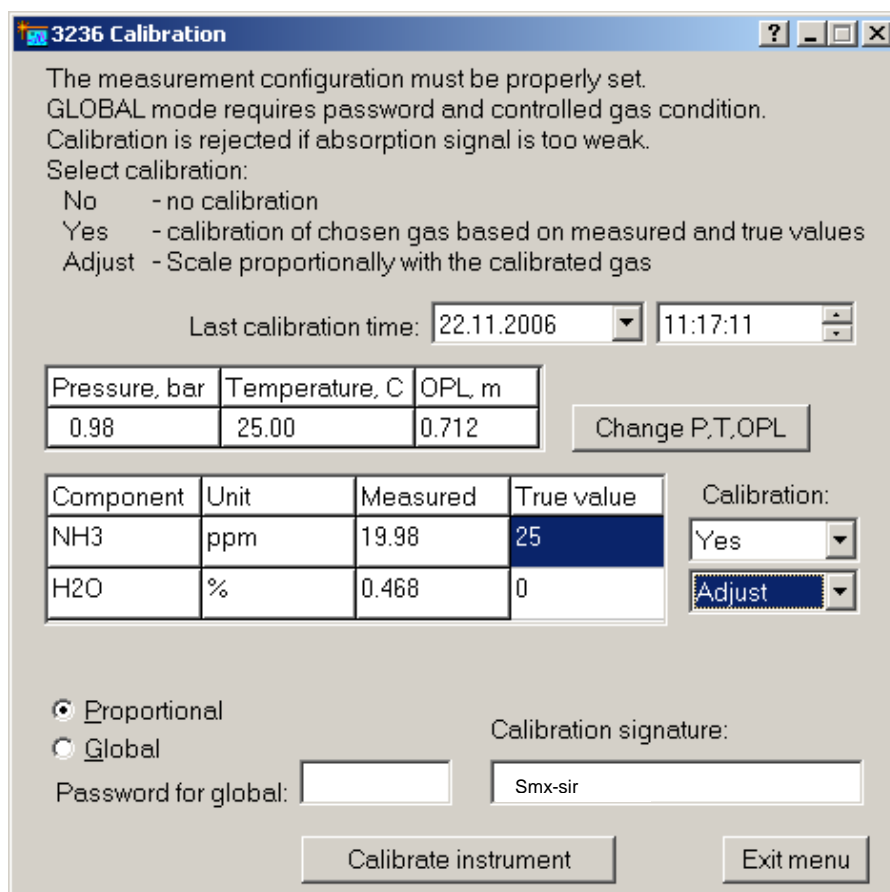
The constant used to calculate the line width, which in turn is used to calculate the gas concentration. The line width constant can be modified together with the calibration constant after calibration (see Section 4.3.7). The value cannot be modified manually in this menu if the program runs in User mode.

Line width measurement

This parameter switches the line width measurement function ON and OFF. If switched OFF the theoretical line width for the given gas pressure and temperature is used. If switched ON the line width is measured from the shape of the second harmonic absorption line. The value cannot be modified manually in this menu if the program runs in User mode.

4.3.7 Calibrate instrument

Calibration of all gases and the spectral temperature (if applicable) is carried out in this menu. The example below is for an instrument measuring two gases.



3236 Calibration

The measurement configuration must be properly set.
GLOBAL mode requires password and controlled gas condition.
Calibration is rejected if absorption signal is too weak.
Select calibration:
No - no calibration
Yes - calibration of chosen gas based on measured and true values
Adjust - Scale proportionally with the calibrated gas

Last calibration time: 22.11.2006 11:17:11

Pressure, bar	Temperature, C	OPL, m
0.98	25.00	0.712

Change P,T,OPL

Component	Unit	Measured	True value
NH3	ppm	19.98	25
H2O	%	0.468	0

Calibration: Yes Adjust

☒ Proportional
☐ Global

Password for global: Smx-sir

Calibration signature:

Calibrate instrument Exit menu

There are two available calibration modes: "PROPORTIONAL" and "GLOBAL", which can be toggled. The default calibration mode is **PROPORTIONAL**. In this mode the instrument performs proportional adjustment of the calibration constant based on the measured and supplied concentrations. There are no special requirements to the gas parameters and signal quality. The PROPORTIONAL calibration may be done whenever it appears necessary to the user that the instrument measurements should be adjusted, for example during measurement of process gas. Please note the following:

- All gases can be calibrated individually. The true gas value is specified and "Calibration" is set to "Yes" from the corresponding dropdown list.
- For gases that are not to be calibrated, "Calibration" is set to "No" from the corresponding dropdown list.

It is also possible to auto-calibrate gases. Gas A is calibrated by filling in the true value and selecting "Yes". Gas B is auto-calibrated by setting the true value to zero and select "Adjust". In this case the calibration constants for line amplitude and line width for gas B are adjusted according to the calibration of gas A. This is useful if

only one calibration gas is available or if the relative ratio of the measured concentrations after the calibration is to be preserved.

In the example above, NH_3 gas is calibrated to 25 ppm. The calibration constants for H_2O will be adjusted accordingly.

Enter your initials for identification of calibration.

Press <Calibrate instrument> to update the instrument with a new calibration. The instrument will use the currently measured average concentration to perform all necessary calculations. The new calibration will be stored permanently. The calibration time will be updated automatically.

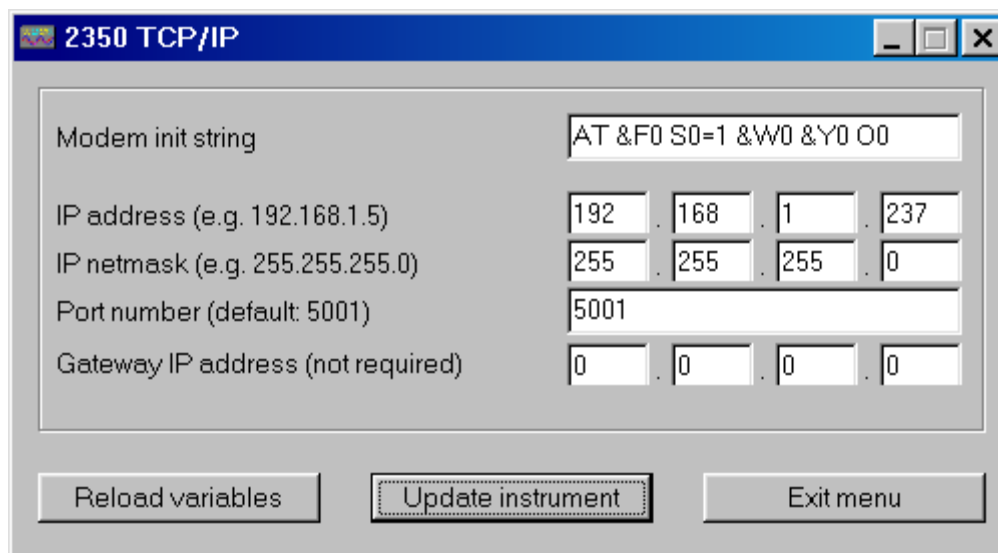
SERVOMEX calibrates all instruments under controlled conditions using certified gas. This calibration is then verified for the specified range of temperature and pressure. There is no need to calibrate the instrument upon reception. However, if the measured concentration does not match an expected value or wet chemical control measurement, the user may wish to recalibrate the instrument directly on the process. **Please note that after such a calibration the factory is relieved of responsibility for correct instrument calibration in the specified range of gas temperature and pressure.** An O_2 SERVOTOUGH Laser Monitor can measure incorrect zero level after such a calibration. This can happen if the new calibration constant does not correspond to the background oxygen absorption in the receiver and transmitter units and/or in the flanges.

In the **GLOBAL** calibration mode the instrument performs reference measurements of the absorption line width in addition to the line amplitude. The calibration constant and reference line width are then adjusted based on these measurements. This calibration procedure requires stable and controlled conditions of the reference gas. It should be performed using a test cell and a certified mixture of measured gas with nitrogen and only if it was verified that the current calibration is not valid. The procedure requires technical skills and some experience in handling gas mixtures. As a rule only qualified personnel should perform GLOBAL calibration after major services. General recommendations concerning this calibration option are given in Section 5.4. To calibrate the instrument proceed in the same way as described above for PROPORTIONAL calibration mode. The only difference is that the program will ask for a password, which is available from the local distributor or the factory. The GLOBAL calibration, if performed correctly (ref. Section 5.4), guarantees the validity of the calibration parameters in the specified pressure and temperature range.

Calibration mode PROPORTIONAL/GLOBAL is common for all gases. Nevertheless, it is possible to calibrate one gas in global mode and another in proportional mode. In this case the mode is set to GLOBAL and the line width measurements for the gas, which should be calibrated proportionally, must be switched OFF in **Gas specific parameters** menu (only for the program running in Advanced mode). It can be switched back ON after the calibration. Calibration mode is not applicable to the spectral temperature.

4.3.8 TCP/IP and modem configuration

TCP/IP parameters of the embedded Ethernet board (optional) and the initialising string of a modem can be configured using this menu.



Modem init string

This string is used to initialise the modem connected to the transmitter unit via a null modem cable (see Section 3.7). The string is sent to the modem during start-up of the instrument. If the string has been modified, the instrument should be restarted in order to re-initialise the connected modem. Normally the string should be the same as in the example above: "AT &F0 S0=1 &W0 &Y0 O0". If it is not, modify it and update the instrument.

IP address

The address assigned to the Ethernet board of the instrument. Default IP address is typically set to 192.168.1.237 for LAN communication. The user can assign any free local IP address or a valid global IP address for direct internet connection.

IP netmask

Defines the subnet mask for LAN connection. Default netmask is 255.255.255.0.

Port number

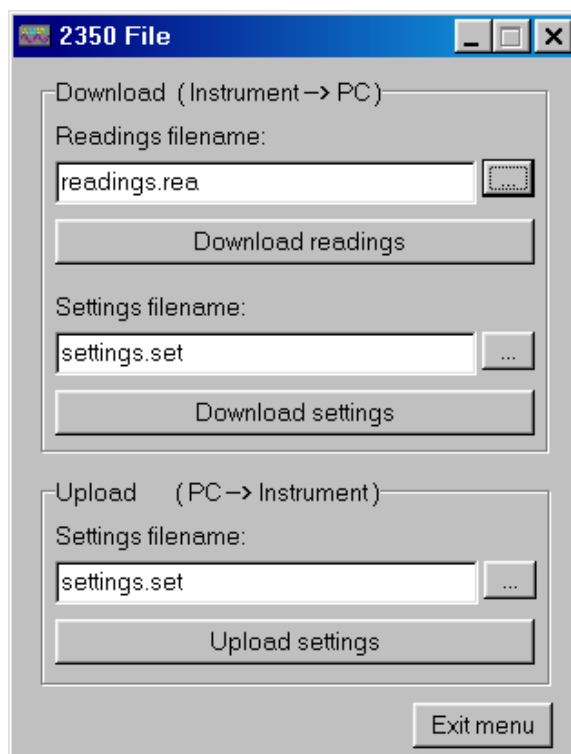
Specifies the port number for TCP/IP communication. Default port number is 5001, but the user can assign any free port number.

Gateway IP address

The address of a server used to route TCP/IP traffic to/from the Ethernet board to another network. This is normally not needed for local communication, but may be needed when the Ethernet board is setup for internet connection.

4.3.9 File download/upload

This menu allows the user to save/restore instrument data to/from file.



Two different types of data can be downloaded from the instrument to a PC and saved into ASCII text files: the instrument readings and the instrument settings. The readings file contains the measured data shown in the **Measurements** menu. The settings file contains all static parameters of the instrument including those in the different menus described above.

The filenames can be edited. We recommend using the file extension *.rea* or *.dmp* for the instrument readings and the extension *.set* or *.stt* for the instrument settings. If an existing file name is chosen the new data is appended to this file.

After pressing <Download readings> the readings data is downloaded and written to a file with the specified name. The data can be viewed and analysed. Alternatively, the instrument readings can be downloaded from the **Second harmonic signal** menu.

After pressing <Download settings> the instrument setting parameters are downloaded and written to a file with the specified name. The setting file is useful as backup of the instrument settings. It is advisable to save instrument settings before modifying the instrument parameters, and before and after each calibration.

It is possible to upload instrument settings from a PC, thus updating the instrument with new settings or restoring a previously saved instrument configuration. It is important to ensure that the settings file is correct and actually belongs to this SERVOTOUGH Laser Monitor. The settings file can be edited with any text editor. Parameters that are not to be uploaded can be removed from the file.

Note that updating the instrument with wrong settings such as laser current and laser temperature may damage the laser.

4.3.10 Manual instrument control

Enter sleepmode

The instrument will be forced into sleepmode.

Reset microcontroller

Microcontroller is reset.

Collect AD statistics

For service purpose only.

Current loops and digital i/o

This menu is for testing the relays and 4-20 mA inputs or outputs mainly during installation of the Laser monitor. Note that the instrument will be set into sleep mode for these tests.

Save system log

See section 4.3.4

Rewind system log 100 lines

See section 4.3.4.

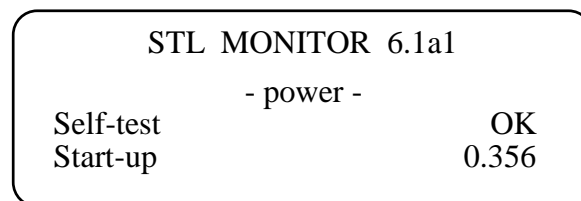
5. OPERATION, MAINTENANCE AND CALIBRATION

5.1 Operating modes

After having set all necessary instrument parameters as described in chapter 4, the instrument is ready for operation. During continuous operation, the SERVOTOUGH Laser Monitor may be in any of these three modes:

1. Start-up mode
2. Measuring mode (or Normal mode)
3. Fault mode (or Error mode/Sleep mode)

1. Start-up mode: After turning on the power the instrument runs through initialising, self-test and start-up before starting measurements. This is indicated by appropriate texts in the instrument display (LCD). The instrument stays in start-up mode until the laser temperature stabilises within acceptable limits. The LCD typically shows the following:



In the upper right corner of the LCD the software version used by the instrument is printed. In this case the version is 6.1a1.

The next row shows the cause for the instrument being in start-up mode. Normally it will show *-power-* indicating that the power has recently has been switched on. In case of a restart due to unexpected software or hardware conditions the word *-watchdog-* would be printed instead.

If the self-test has passed successfully, a number appears in the lower right corner of the LCD. This number decreases as the laser temperature stabilises. When the number is below 0.3, the instrument slowly powers up the laser. The start-up mode normally lasts less than 3 minutes.

2. While the operating mode is «measuring», the instrument can be in 4 measuring modes:

- a) «Normal»: Normal measurement.
- b) «Zero»: Measurement of zero point.
- c) «Span»: Measurement of span (with span cell).
- d) «Maintenance»: Measurements as normal but with relay 3 indicating maintenance (if configured for maintenance, see Section 6.11).

The measuring mode is defined by input through two channels, either

- through digital communication (e.g. with service program see Section 4.2).
- or electrical signals through the AUX connector (see Section 6.7.1 and Table 6-5).

If measuring mode is «Normal», both channels can initiate another measuring mode, but this locks the input channel. While in «Zero», «Span», or «Maintenance» mode, the same channel must be used to set the measuring mode back to «Normal», while the other channel is ignored.

a) In normal mode the measured gas concentration is periodically 1) printed on the LCD, and 2) output to the 4-20 mA current loop (PLC) (optional). Measurements can also be polled through serial cable (RS-232) with the service program, or through an Ethernet cable (optional). The measured gas concentration is updated every 1-5 seconds depending on factory settings which are optimised for the application. If the instrument can measure two gases the LCD might look as follows:

Tr	100 %	STL	6.1a1
CO	21.32 %		
CO2	32.64 %		

The LCD shows the measured average gas concentration(s) in the chosen unit and the laser beam transmission, which indicates how much light hits the detector relative to the maximum value (calibrated by the factory).

In case of a warning, the instrument continues to measure the gas concentration as usual while displaying the message in the bottom line. In case of an error, the LCD shows <Instr. ERROR> instead of the concentration, and displays the message in the bottom line. If the optional auxiliary board is installed a warning causes the WARNING relay to deactivate (i.e. open), but it does not affect the PLC output. An error condition causes both the WARNING and ERROR relays to deactivate, and the PLC output is optionally set to 2 mA (ref. Section 6.10). An explanation of LCD messages is given in Section 5.5.

b) and c)

Zero and span check functionality are optional features of the Laser monitor. Please refer to Section 7 for a more detailed description of these options.

d) In maintenance mode the instrument will continue to measure as normal but relay 3 will indicate a maintenance situation (assuming that relay 3 is configured for maintenance, see Sections 6.10 and 6.11 for details). This mode is mainly required for emission monitoring applications regulated by authorities.

3. **Fault mode** is entered when the instrument has detected a severe failure (e.g. overheating), which might permanently damage the instrument. In this case the instrument stops measuring the gas concentration and most instrument functions are turned off. The WARNING and ERROR relays are deactivated (opened), the GAS ALARM relay is activated and the PLC output is optionally set to 2 mA (ref. Section 6.10). This operating mode is indicated on the LCD with `<Instrument Off>`, no gas concentration is displayed, and the bottom line of the display indicates the nature of the fault (see Section 5.5). The instrument automatically attempts a restart after one hour.

5.2 Maintenance

The SERVOTOUGH Laser Monitor is designed to reduce maintenance to a minimum. Experience has shown that maintenance interval of more than 3 months is acceptable for most applications. The maintenance operations described in this section will secure a continuous and safe operation of the monitor.

5.2.1 Routine maintenance

SERVOMEX gas monitors have no moving parts and require no consumables. For best performance, however, we recommend to routinely carry out the following steps:

- Check optical transmission regularly (daily). This can be done automatically by use of instrument output (if ordered) or WARNING relay or similar.
- Clean windows and adjust alignment when necessary (see below).
- For applications where the concentration of measured gas is normally zero (“zero” gas application): Check instrument response by applying some gas at least once every 3 months. Apply sufficiently high gas concentrations to obtain a strong instrument response for at least 10 minutes (at least 70 minutes after power on). No warnings or errors should be displayed during the test. For certain instruments this procedure is not necessary as the laser is tracking on another absorption line than the “zero gas” line (e.g. H₂O line for an HF instrument). Contact SERVOMEX if you are in doubt about your instrument.
- Check calibration every 3 - 12 months (depending on the required accuracy). Recalibrate if necessary. (See below).
- At each calibration check, save instrument settings and measurement data recorded with some gas (“setting-files” and “dump-files”). This is for tracking purposes in case of future service issues.

5.2.2 Cleaning of optical windows

Dust or other contamination on the optical windows will reduce the signal level. The instrument is designed to allow a considerable reduction of the signal level (down to 10-30%) without influencing the quality of the measurements. However, if the signal level drops below the level of reliable measurements, the LCD shows «Low transmission», and the windows should then be cleaned. To reduce accumulation of dust on the optical windows, each instrument is normally equipped with a purging unit. A check of the optical windows should also be done in connection with purging failures.

The optical windows can be cleaned with non-hazardous, nonabrasive detergents or solvents. If there are cracks or damage the window should be replaced. Since the windows are wedged, the orientation of the new window must be the same in order to preserve the system alignment.

5.2.3 Alignment of the instrument

The alignment of the receiver and transmitter units may change due to outer strains. The signal level can, therefore, decrease with time. The LCD will show «Laser line-up error» alternating with «Low transmission». To realign the transmitter and receiver follow the installation procedure explained in Sections 3.3 to 3.5.

5.3 Optimising the flange purge flow

It is difficult to advise in general terms how much purge gas to use for given applications, because this will depend on the gas velocity in the duct, the length and diameter of flanges etc. As a rule of thumb one can start with a velocity of the purge flow in the flanges equal to 1/10 of the gas velocity in the duct.

If the gas concentration to be measured is fairly constant (and non-zero) over a few minutes one can try one of the following procedures to measure the required purge flow:

Alternative 1:

1. Connect the service PC and start <Custom logging> with *Concentration Instant* selected and 2 seconds sampling period (ref. Section 4.3.3). Alternatively, you can write down the instant concentration manually while watching **Measurements** menu.
2. Quickly turn off the purge flow for 30-60 seconds and then back on. The flanges will be filled with duct gas a few seconds after the purge gas is turned off.
3. Repeat step (2) a few times to be sure to have good reproducibility of the change in the measured gas concentration, as opposed to true fluctuations in the process.
4. From the data in the log file calculate the ratio of measured gas concentration without and with flange purge air. Compare this with the ratio of the length RU-to-TU-window to the length flange-tip-to-flange-tip. From this one can estimate the "fill-fraction" of purge air in the flanges. If the ratios are equal the flanges are

completely filled with purge air. If the gas-ratio is less than the length-ratio the flanges are only partly filled with purge air.

5. Adjust the amount of purge gas and repeat the test until the flanges are filled with purge air.

Alternative 2:

1. Set the measurement length (Optical path through gas, ref. Section 4.3.5) of the instrument equal to the distance from the RU window to TU window.
2. Turn off the purge flow for sufficiently long to fill the flanges with gas, and measure the concentration.
3. Reset the measurement length equal to the distance from flange tip to flange tip.
4. Increase the purge flow until it measures the same as in step 2.

If the windows have become dirty during the tests, remember to clean them. If the required amount of purge gas is difficult to obtain, alternatively Optical path through gas can be adjusted according to the test results.

5.4 Calibration of the instrument

The SERVOTOUGH Laser Monitor is factory calibrated using certified gas mixture and a calibration certificate is supplied together with the instrument. There is therefore no need for the user to calibrate the instrument upon delivery.

After some period of operation the instrument parameters may change due to ageing of the diode laser. In this case a new calibration might be necessary. We recommend verifying calibration of the instrument once a year using a certified test gas and the supplied gas cell. The certified test gas must be a mixture of **nitrogen** with the measured gas. O₂ SERVOTOUGH Laser Monitors can be tested and calibrated using dry air. Percent level H₂O SERVOTOUGH Laser Monitors are normally calibrated using calibration gas generators (e.g. type HovaCAL) to generate defined moisture concentrations. For alternative methods please contact SERVOMEX or your local distributor.

Since the calibration of the instrument affects all subsequent measurements, the user should verify the need for a new calibration. We do not recommend performing a calibration if the instrument readings deviate less than 2 – 3 % from the nominal value within the recommended concentration levels indicated below. This is the typical absolute accuracy for calibration gas mixtures. One should also account for the precision of the SERVOTOUGH Laser Monitors, which is about 1% of the measured value. (So for O₂ SERVOTOUGH Laser Monitors measuring air, the deviation should not exceed about 0.2 % O₂ when the values for the cell pressure and temperature are correctly set in the instrument).

The second harmonic technique used in the SERVOTOUGH Laser Monitors is intrinsically a baseline-free technique. Therefore, a calibration of the zero level is never done. If one attempts to calibrate the zero level, the service program will display an error message. The monitor can only be calibrated if it detects an absorption signal

amplitude above a predefined level. This level is factory set and is typically 20 times the detection limit for an optical path length of 1 m.

To obtain the optimal signal-to-noise ratio when using our calibration cell (accessory available from SERVOMEX), the gas concentrations of Table 5-1 should be used for our standard monitors (contact your local distributor for non standard monitors). Note that the optical path-length for the standard SP monitor is 0.712 m when mounted onto the calibration cell. Please note that HF is calibrated with a special 0.1 – 0.15m Teflon cell with sapphire windows. This cell can be supplied by Servomex.

If only a gas mixture with higher gas concentration is available, dilute the gas mixture with nitrogen using a calibrated gas mixing system to the specified values below. Significantly lower concentrations should not be used because the measurements might be influenced by noise as well as by adsorption and de-sorption processes in the cell and the tubes.

Measured gas	Recommended concentration range
HF	50 – 500 ppm (Teflon cell)
HCl	15 – 200 ppm
NH ₃	30 – 400 ppm
H ₂ O (low conc.), HCN, CH ₄	50 – 500 ppm
H ₂ S	300 – 2000 ppm
CO, CO ₂	0.5 – 5 % vol.
CO, CO ₂ (low conc.)	50 – 500 ppm
NO	500 – 5000 ppm

Table 5-1: Recommended gas concentrations for calibration

Follow the steps described below to perform verification and calibration.

1. Let the instrument operate for at least 1 hour before performing the verification and/or calibration.
2. Connect the transmitter and receiver units to the test cell as shown in Figure 5-1. Run the service program (ref. Chapter 4.1 for start-up).
3. Make sure the optical path length parameters are properly set, as described in Section 4.3.5. The flange length or concentration should be set to zero. Check that the manually set temperature and pressure are correct, or that the PLC inputs for the gas temperature and pressure are correct.
4. Introduce the calibration gas into the cell. Wait until the system reaches stable levels.
5. Check if the reading is in agreement with the concentration of the certified gas. If required, perform calibration (PROPORTIONAL or GLOBAL) as described in Section 4.3.7.
6. Save the instrument settings to a file as described in Section 4.3.9.
7. Re-set the optical path parameters, pressure and temperature back to the installation values (ref. Section 4.3.5).

8. The instrument can now be mounted back in its measuring position.

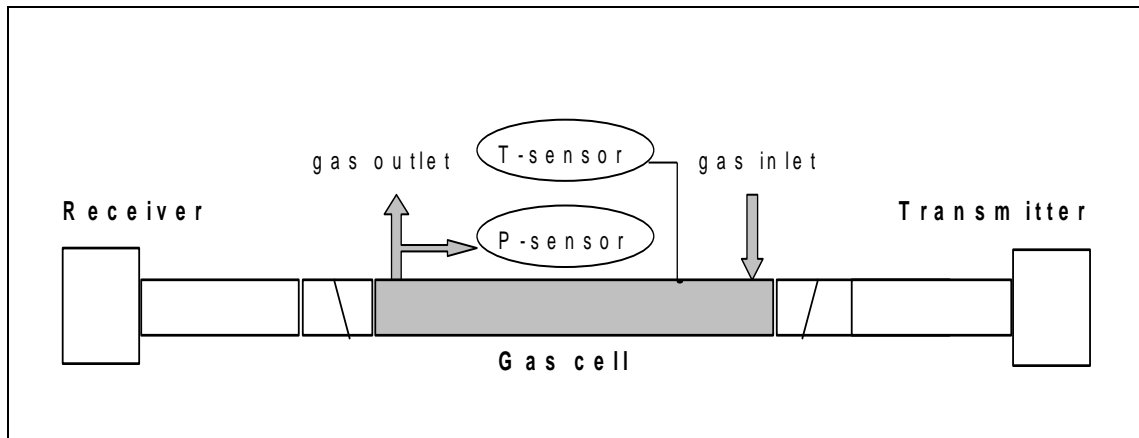


Figure 5-1: Calibration cell with monitor connected

Note that when gas is flushed through the cell, the cell pressure is higher than the ambient pressure. The pressure difference depends on the flow rate and the diameter and length of the outlet tubes. It is therefore highly recommended to measure the gas pressure close to the cell, using an absolute pressure sensor in order to provide the instrument with correct gas pressure during the verification and calibration procedure. If only the ambient pressure is known or the pressure sensor is located far away from the cell, one can switch off the gas flow before calibration, wait 1 minute for the readings to stabilise and subsequently perform calibration. In this case the gas pressure is equal to the ambient pressure.

Special care should be taken for reactive and “sticky” gases such as HF, NH₃, H₂O, HCl and H₂S. Because of the nature of these gases, it is difficult to obtain the required concentration in the calibration cell due to adsorption and de-sorption in the connection tubes and within the cell itself. The following recommendations should then be followed:

- Use stainless steel cells (Teflon for HF!)
- Use Teflon connection tubes.
- Use the shortest possible length of the tubes.
- When flushing calibration gas through the cell, use large flow rates such as 5-7 l/min.
- Wait until the concentration in the cell has stabilised.
- Switch off the flow and observe how fast the concentration degrades. If it degrades rapidly, the cell needs to be passivated.
- Check that the measured concentration remains the same with an increasing flow. If it does, the concentration in the cell most likely has reached the expected value.

5.4.1 PROPORTIONAL versus GLOBAL calibration

Line broadening compensation requires a large number of parameters to be measured. These parameters are critical for accuracy, but only when line broadening compensation is used. Most of the parameters seldom or never need to be adjusted.

PROPORTIONAL calibration:

This calibrates the span of the gas concentration by adjusting the proportionality between the peak amplitude of the absorption line and the gas concentration. Only the *proportional calibration constant* is affected by PROPORTIONAL calibration.

GLOBAL calibration:

Calibrates both the gas concentration span and line width parameters. It is important to follow the calibration procedure carefully and specify to the instrument the exact pressure and temperature of the calibration cell. The P, and T values can be set fixed with the service program, or use 4-20 mA inputs if such probes are connected to the calibration cell. One can also use the internal sensors if these are close to the values for the calibration cell. It is also important to use dry gas mixed with nitrogen. For O₂, dry air can be used.

USE GLOBAL calibration:

- If spectral properties of laser are believed to have drifted. This can be evaluated by qualified service personnel from dump-files recorded with the instrument when it is measuring on a calibration gas.
- After major instrument services such as replacement of laser module, main board or receiver board. (Qualified service personnel only!)
- After adjustment of laser parameters (modulation amplitude or phase, or other laser currents). (Qualified service personnel only!)

DO NOT use GLOBAL calibration when:

- The instrument is measuring on the process (with process gas).
- The concentration of the calibration is low or the path length of calibration cell is short such that the signal-to-noise ratio is not good.
- The conditions for GLOBAL calibration described above are not satisfied. If recalibration is required in such cases, use PROPORTIONAL calibration instead.

5.5 Troubleshooting the instrument

During operation essential status information about the instrument is displayed on the LCD mounted in the transmitter/main unit. The instrument messages and their possible explanations and actions to be taken are given in the table below. If there is no output to the display, please refer section 6.9.

Fault message	Explanations and actions
« Low transmission »	WARNING The optical transmission has dropped below the limit for reliable measurements. This might indicate misalignment of the optical units or contamination of the optical windows. Clean windows and check alignment.
« Laser line-up error »	ERROR The laser beam does not reach the detector. Clean the optical windows, check the optical path for obstructions, and check the alignment.
« PLC T-read error »	ERROR Failure reading temperature through 4-20 mA PLC input. Input current from temperature sensor is either above 23.7 mA or below 0.3 mA. Check connections to temperature sensor or use fixed temperature setting in the SERVOTOUGH Laser Monitor.
« PLC P-read error »	ERROR Failure reading pressure through 4-20 mA PLC input. Input current from pressure sensor is either above 23.7 mA or below 0.3 mA. Check connections to pressure sensor or use fixed pressure setting in the SERVOTOUGH Laser Monitor.
« T-read out of range »	WARNING Input current from temperature sensor is either above 22 mA or below 3.2 mA. The measured gas temperature may be wrong. Check temperature sensor or use fixed temperature setting in the SERVOTOUGH Laser Monitor.
« P-read out of range »	WARNING Input current from pressure sensor is either above 22 mA or below 3.2 mA. The measured gas pressure may be wrong. Check pressure sensor or use fixed pressure setting in the SERVOTOUGH Laser Monitor.
« P/T out of range »	WARNING Pressure and temperature compensation or dry value conversion (if applicable) is outside acceptable range. The accuracy of the measured gas concentration may be reduced. If supplied values are correct, the instrument is operating outside specifications.

Fault message	Explanations and actions
« Ex-read out of range »	WARNING Input current from external gas sensor is either above 22 mA or below 3.2 mA. Check Extra (Flow) current input.
« Voltage supply fail »	The power supply voltage input to the instrument (transmitter unit) is exceeding acceptable range (for standard instrument; 20-30V). Check and correct voltage. If the error remains, contact service personnel.
« Low laser temp. » « High laser temp. »	ERROR The laser temperature regulation has failed and the laser is too cold/warm. The instrument has entered FAULT mode and attempts automatic restart after one hour. If the transmitter unit is overheated, cool it down by thermal shielding and/or improved ventilation. If transmitter is not overheated, the error might indicate a bad electrical contact or other hardware failure. Contact service personnel if repeated.
« Low box temp. » « High box temp. »	ERROR Internal temperature of transmitter or receiver is exceeding the operating limit. The instrument has entered FAULT mode and attempts automatic restart after one hour. Check ambient temperature for receiver and transmitter, and correct by thermal shielding and/or ventilation if temperature is exceeding instrument specifications. Otherwise contact service personnel.
« EEPROM error »	ERROR Failure of the internal memory of the instrument. Upload a backup settings file (with the original settings) to the instrument. Contact service personnel if repeated.
« Self-test fail »	ERROR The instrument has detected a self-test error during start-up. Try to restart the instrument. If the failure remains, write down all messages as they appear on the LCD, download Error log and System log, and contact service personnel.

Fault message	Explanations and actions
« Low line position » « High line position » « No absorption line »	ERROR The instrument has detected a spectroscopic fault. This can have several causes: 1) Unknown interference gas in process. 2) Incorrect laser temperature (wavelength). 3) Transmitter unit is operating outside acceptable temperature range, or 4) Laser malfunction. Check the instrument on calibration cell with a gas concentration suitable for calibration, and allow it to run continuously for > 70 minutes. If error does not disappear or calibration is significantly wrong contact service personnel.
« Saturation of direct »	ERROR The photo-detector is saturating or transmission is > 130%. If the error remains when the receiver window is obscured, this is an electronic fault. Otherwise the error may occur after replacement of laser module or receiver electronics. Reduce receiver amplification (contact service personnel for details) or transmission. If the problem cannot be solved contact service personnel.
« Saturation of harm. »	ERROR A second harmonic signal is saturating. This may be for one of the following reasons: 1) The gas concentration is too high or the length of the optical path for measurement is too long. Reduce the amplification for the second harmonic signal in the receiver (contact service personnel for details), or use a shorter measurement length for high gas concentrations. 2) If the error remains when the receiver window is obscured, this is an electronic fault. Contact service personnel.
All other error messages	Write down all the LCD messages and contact service personnel.

Table 5-2: Instrument LCD error messages

6. ELECTRICAL CONNECTIONS

Note that in the table columns labelled “DESCRIPTION”, the indicated polarities of the items are for naming only and do not necessarily reflect the polarity of real voltages. All potentials are floating and none of them should be grounded to box. This applies to all connection tables.



WARNING

Ensure that the electrical installation of the Laser monitor conforms to all applicable local and national electrical safety requirements.



WARNING

Wiring to or from this device, which enters or leaves the system enclosure, must utilize wiring methods suitable for Class 1, Division 2 and/or Zone 2 Hazardous Locations, as appropriate for the installation.



WARNING

Obey the safety instructions given below when you install the Laser monitor; if you do not, the Laser monitor certification may be invalidated, the Laser monitor may not operate correctly, or it may be damaged.



WARNING

Isolate mains power before commencing installation.



WARNING

Make sure that power is disconnected or switched off before connecting any cable.

6.1 Transmitter unit interface

The electronic interface for the transmitter unit is depicted in Figure 6-1. Receiver and main power cable entries are recommended by the factory. Any of the three cable entries (top of view) can be used as auxiliary, service, or network/comms.

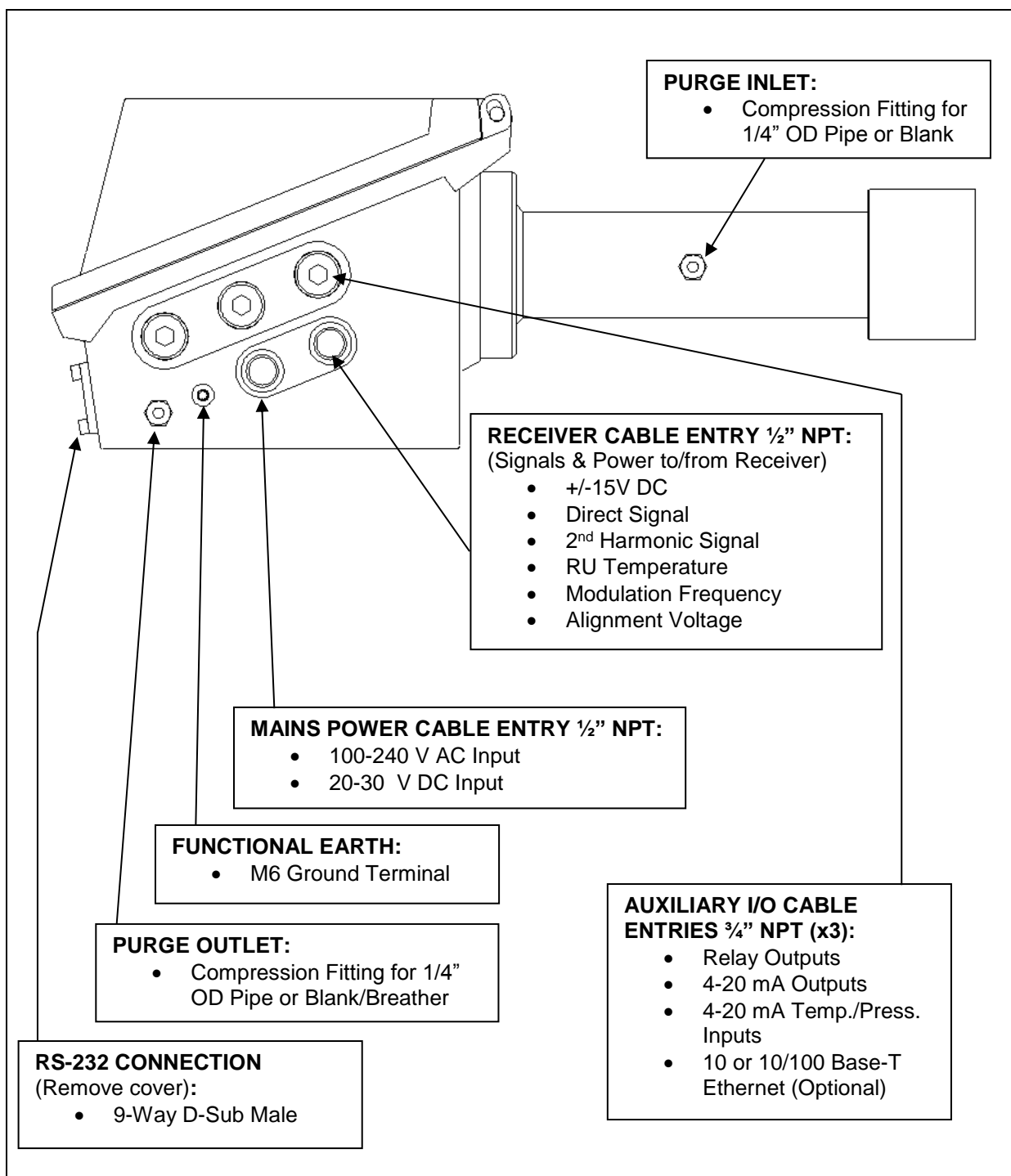


Figure 6-1: Transmitter unit electronic interface



☞ Cable entries shown in Figure 6-1 have the "Caution - refer to manual" symbol nearby.

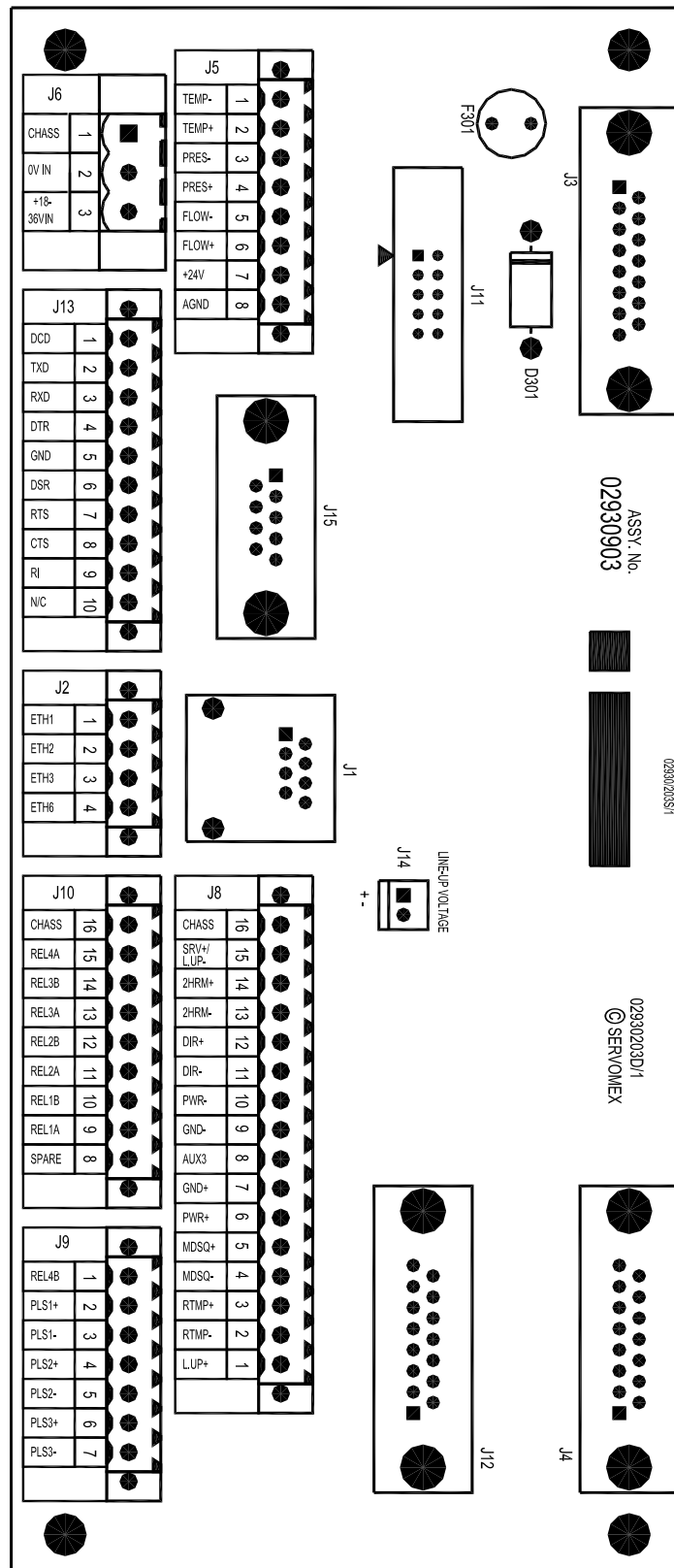


Figure 6-2: Internal input and output connectors

The receiver cable connects the transmitter and receiver unit. The power cable connects power to the transmitter unit. Custom auxiliary cables (e.g. 4–20 mA output) can be connected through the auxiliary cable entries. The receiver and main power cable entries are $\frac{1}{2}$ " NPT threads and the auxiliary *cable entries are $\frac{3}{4}$ " NPT threads*.

6.2 Electrical Safety

The Laser monitor does not incorporate an integral on/off switch. You must provide a means of externally isolating the electrical supply from the Laser monitor: use a suitable switch or circuit breaker located close to the Laser monitor, clearly marked as the disconnecting device for the Laser monitor.

- The electrical supply circuit must incorporate a suitable fuse or over-current protection device, set to or rated at no more than 10 A.
- The Laser monitor must be connected to an external protective earthing system, using the Protective Earth terminal (see Section 6-3).
- Ensure that your electrical supply can provide the necessary maximum power consumption: refer to PRODUCT DATA.
- Equipment connected to the mA input, mA output, RS232, Ethernet and relay terminals must be separated from mains voltages by at least reinforced insulation.
- Ensure that the cables that you connect to the Laser monitor are routed so that they do not present a trip hazard.
- All signal and electrical supply cables must be rated for temperatures of 70°C or higher.
- When you carry out insulation testing, disconnect all cables from the Laser monitor.

6.3 Power cable connections

6.3.1 Mains Power Connection



WARNING

AC Power for EX1 versions may only be connected via a suitably certified Purge Control Unit.

The power cable shall be a three core cable with Line/Live (L), Neutral (N), Earth/Ground (E) conductors.

The power cable connection terminals are suitable for solid or stranded conductors 0.5 to 2.5 mm² (AWG 24 to 12).

When you make your mains electrical supply cable, ensure that the earth (ground) conductor is longer than the live and neutral conductors. This will ensure that if the cable is accidentally dragged and the strain relief on the cable-gland fails, the earth (ground) conductor will be the last conductor to be pulled from the Laser monitor.

Connect your mains electrical supply cable to the Laser monitor as follows:


1. Pass your mains electrical supply cable through a suitable cable-gland fitted to the base of the power/interface compartment.
2. Connect the protective earth to the terminal shown in Figure 6-3(a) using the arrangement shown in Figure 6-3(b).
3. Connect the wires in the supply cable to the appropriate electrical supply terminals on the power supply, as follows and shown in Figure 6-4:

Signal	Terminal on mains power supply
Live	L
Neutral	N

4. Carry out a continuity test to confirm that the Laser monitor is connected to protective earth by the mains cable.



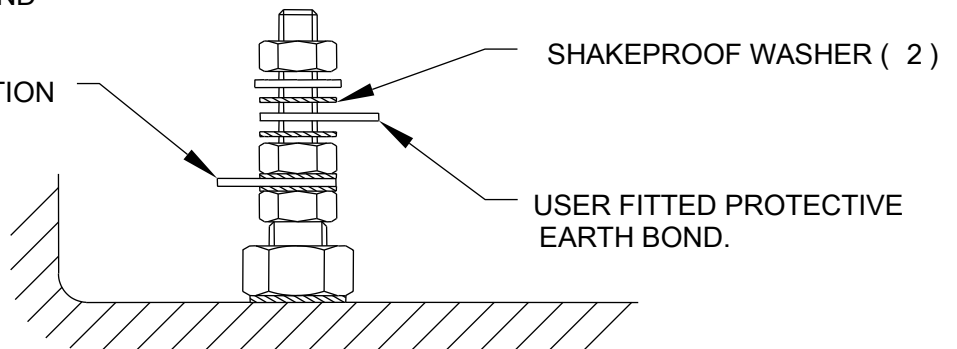
WARNING

Do not disconnect the protective earth wire, from the mains power supply terminal marked 



a) Protective earth terminal

PROTECTIVE EARTH BOND
TO POWER SUPPLY.
WARNING! DO NOT
REMOVE THIS CONNECTION



b) Method of fixing protective earth connection

Figure 6-3: Protective earth connection



Figure 6-4: Mains power connections

6.3.2 DC Power Connection

A direct connection can be made to a 24V DC connection (20-30V DC) available on site.

CAUTION

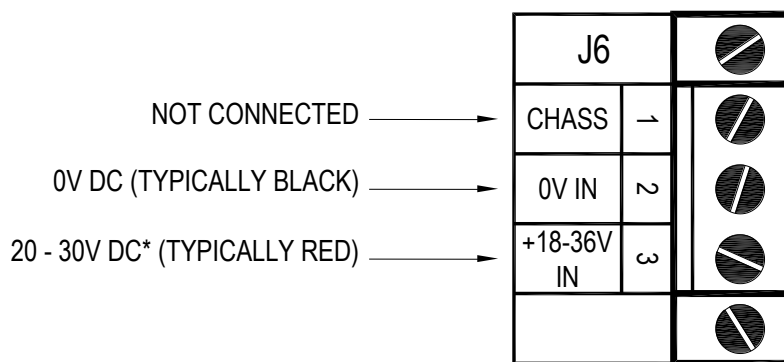
To comply with EMC requirements, you must use screened cables. It is recommended that the screens are terminated at the cable glands or local earth studs.

Connect your DC electrical supply cable to the Laser monitor as follows:

1. Pass your DC electrical supply cable through a suitable cable-gland fitted to the base of the power/interface compartment.
2. Connect the DC supply directly to terminal J6 on the connection PCB (Figure 6-2 and Figure 6-5) as follows:

Signal	Terminal J6
0V	PIN 2
20-30V	PIN 3

The connection terminals are suitable for solid, stranded and wire ferrule conductors 0.5 to 2.5mm² (AWG 24 to 12).



* REQUIREMENT FOR HAZARDOUS AREAS

Figure 6-5: DC power connections

6.4 Functional earth (ground) connection

CAUTION

To comply with the EMC emissions and susceptibility standards, the functional earth (ground) terminal on the base of the Laser monitor must always be connected to a local EMC earth (ground). The conductor that you use must not exceed 2 metres in length.

Use a suitable conductor to connect the Laser monitor external earth (ground) terminal (Figure 6-1) to a local EMC earth (ground) point: see the caution above. You can use flexible or solid conductors, up to 10 mm².

6.5 Receiver cable connections

CAUTION

To comply with EMC requirements, you must use a screened cable. It is recommended that the screen is terminated at the cable glands or local earth studs.

CAUTION

You must use the cable provided by Servomex to connect the receiver to the transmitter.

Table 6-1 and Table 6-2 show wiring of the receiver cable on the transmitter side and the receiver side, respectively.

<i>Junction list</i>	<i>Terminal:</i>	<i>Pair no:</i>	<i>Color code:</i>	<i>Description:</i>
J8	1		NC	
J8	2	3	Pink	RU Temp-
J8	3	3	Grey	RU Temp+
J8	4	4	Red	MODSQ-
J8	5	4	Blue	MODSQ+
J8	6	5	Black	RU PWR +
J8	7	5	Violet	RU GND +
J8	8	7	Green/White (*)	Servo Sig (*)
J8	9	6	Grey/Pink	RU GND -
J8	10	6	Blue/Red	RU PWR -
J8	11	1	Brown	Direct -
J8	12	1	White	Direct+
J8	13	2	Yellow	2. Harmonic -
J8	14	2	Green	2. Harmonic +
J8	15	7	Green/Brown (*)	Servo +5V (*)
J8	16		NC	Chassis

Table 6-1: Transmitter unit - receiver cable connections

() Only connected for instruments equipped with the “Span check with internal sealed cell” option.*

RU Temp – signal from embedded Receiver temperature sensor.

MODSQ – modulation signal from Transmitter to Receiver (used for detection of second harmonic).

RU PWR – power supply to Receiver unit.

Direct – direct laser transmission signal from Receiver detector, signal may be used for alignment purposes (see Sections 3.3 – 3.5).

2. *Harmonic* – detected second harmonic signal from Receiver detector.

Servo – control of servomotor moving sealed cell.

Note that the voltage for alignment purposes (see Sections 3.3 – 3.5) is also available at plug J14.

<i>Terminal:</i>	<i>Pair no:</i>	<i>Color code:</i>	<i>Description:</i>
1	7	Green/White (*)	Servo Sig (*)
2		NC	
3		NC	
4	7	Green/Brown (*)	Servo +5V (*)
5	3	Grey	RU Temp+
6	3	Pink	RU Temp-
7	4	Blue	MODSQ+
8	4	Red	MODSQ-
9	5	Black	RU PWR +
10	5	Violet	RU GND +
11	6	Grey/Pink	RU GND -
12	6	Blue/Red	RU PWR -
13	1	White	Direct +
14	1	Brown	Direct -
15	2	Green	2. Harmonic +
16	2	Yellow	2. Harmonic -

Table 6-2: Receiver unit – receiver cable connections

(*) Only connected for instruments equipped with the “Span check with internal sealed cell” option.

6.6 Current loop (4-20 mA) input connections (PLC)

CAUTION

To comply with EMC requirements, you must use screened cables. It is recommended that the screens are terminated at the cable glands or local earth studs.

External pressure and temperature probes to the instrument are wired inside the transmitter unit. The probe outputs are connected to the screw terminals according to Table 6-3 i.e. the probe outputs are connected to the screw terminals marked with Probe+ and Probe- (or +24V for passive probe). Probe is referred to either Temperature, Pressure or Extra (Flow). Note that conductors with area 0.14-0.5 mm² (AWG 26-20) must be used (SERVOMEX recommends 0.25mm²).

<i>Junction list</i>	<i>Terminal:</i>	<i>Pair no:</i>	<i>Color code:</i>	<i>Description:</i>
J5	1			Temperature Probe -
J5	2			Temperature Probe +
J5	3			Pressure Probe -
J5	4			Pressure Probe +
J5	5			Flow Probe -
J5	6			Flow Probe +
J5	7			Probes +24V
J5	8			Probes AGND

Table 6-3: Transmitter unit – current loop (4-20mA) input connections

Figure 6-6 and Figure 6-7 show how active and passive 4-20 mA current loop input probes (referred to as PLC) are connected to the instrument. The *Probe+* and *Probe-* constitute a differential input which is tolerant to common mode voltages up to $\pm 200V$. *Probe+* and *Probe-* are connected internally in the instrument by a 100 Ω resistor, which gives a voltage drop of 2 V at 20 mA. Several instruments can therefore be chain connected to the same probe by connecting *Probe-* of the first instrument to *Probe+* of the next instrument, etc.

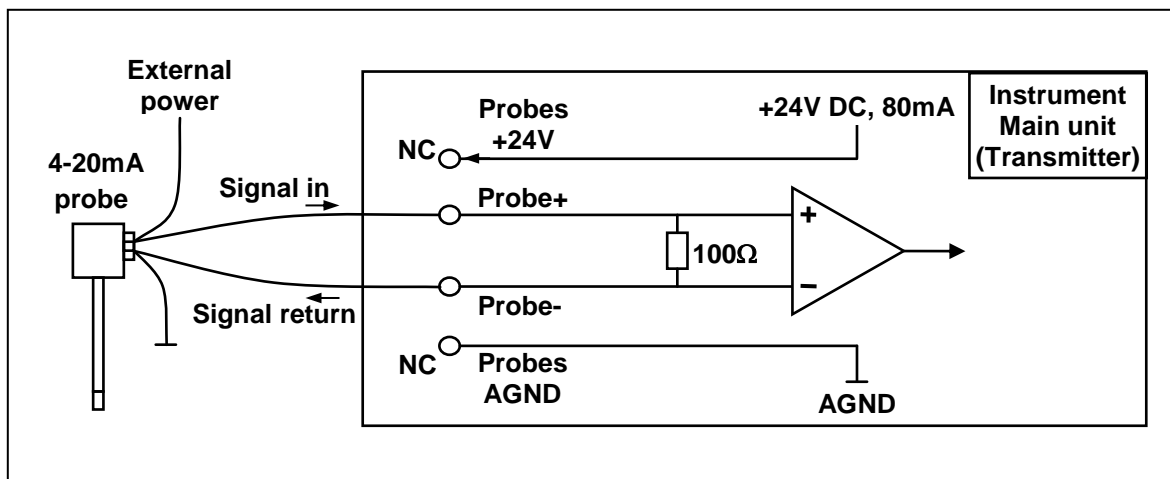


Figure 6-6: Current loop input, active probe

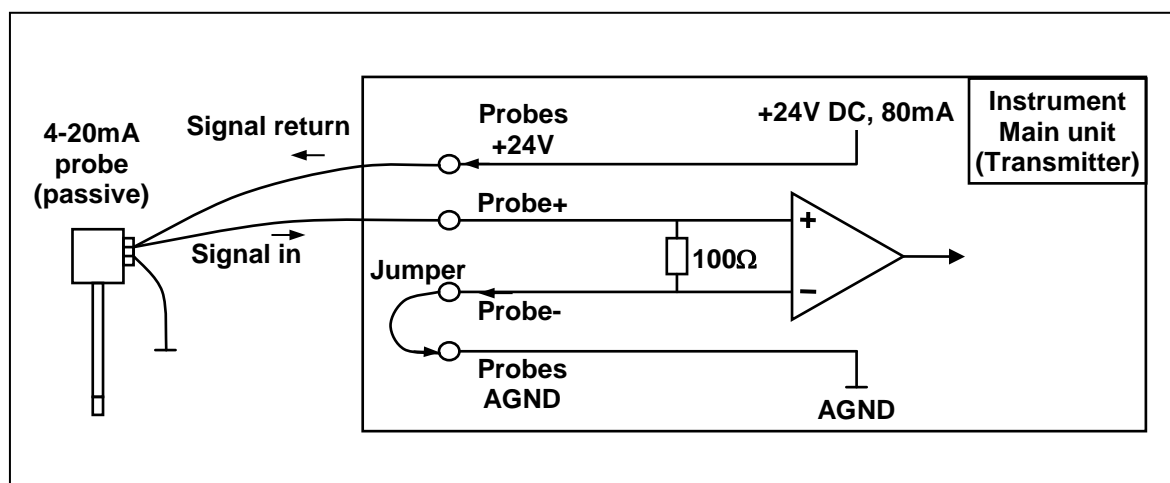


Figure 6-7: Current loop input, passive probe

6.7 Auxiliary board connections

CAUTION

To comply with EMC requirements, you must use screened cables. It is recommended that the screens are terminated at the cable glands or local earth studs.

Connect 4-20 mA outputs and relays contacts according to Table 6-4.
Note that conductors with area 0.14-0.5 mm² (AWG 26-20) must be used (SERVOMEX recommends 0.25 mm²). The cable outer diameter must be 7–12 mm.

<i>Junction list</i>	<i>Terminal:</i>	<i>Pair no:</i>	<i>Color code:</i>	<i>Description:</i>
J9	1			Span
J9	2			4 - 20 mA PLS1 Output
J9	3			4 - 20 mA PLS1 GND
J9	4			4 - 20 mA PLS2 Output
J9	5			4 - 20 mA PLS2 GND
J9	6			4 - 20 mA PLS3 Output
J9	7			4 - 20 mA PLS3 GND
J10	8			Span/Zero Com.
J10	9			Relay 1 - A (Error)
J10	10			Relay 1 - B
J10	11			Relay 2 - A (Warning)
J10	12			Relay 2 - B
J10	13			Relay 3 - A (High Gas)
J10	14			Relay 3 - B
J10	15			Zero
J10	16			Chassis

Table 6-4: Transmitter unit – Auxiliary connections

Relay x – A & B in Table 6-4 refers to the 2 connections on Relay x.

The instrument relays (Error, Warning and Gas Alarm) can be integrated to external circuits (ref. Section 6.10 for relay combinations). They may be connected to 30 V DC/AC and can withstand currents up to 1.0 A. By default the relays are set “NC”, normally closed. This may be changed to “NO”, normally open with dip switches marked “Rel x NC/NO” on the AUX board.

Note that external relays connected to the instrument may induce currents or voltages that exceed the above ratings. If in doubt external protection diodes must be implemented to protect the internal instrument relays.

The PLC (Programmable Logic Controller) 4-20 mA outputs are of ACTIVE type and isolated electrically from the electronics unit's electronics. Maximum load is 500Ω. There are up to 3 different 4-20 mA outputs available. By default only the outputs for gas concentration are implemented.

For single gas instruments the outputs are configured as follows:

PLC1 – output for gas concentration,

PLC2 – optional output for transmission (4 mA=0%, 20 mA=100% transmission),

PLC3 – not used.

For dual gas instruments the outputs are configured as follows:

PLC1 – output for gas-1 concentration,

PLC2 – output for gas-2 concentration,

PLC3 – optional output for transmission (4 mA=0%, 20 mA=100% transmission).

For instruments measuring gas and temperature the outputs are configured as follows:

PLC1 – output for gas concentration,

PLC2 – output for spectral temperature,

PLC3 – optional output for transmission (4 mA=0%, 20 mA=100% transmission).

6.7.1 Selection of zero, span and maintenance mode

The electrical input signals for «Zero», «Span», and «Maintenance» are by potential free switches/relays through AUX-board terminal 1 to terminal 8 (GND) and terminal 15 to terminal 8 (GND). The combinations are shown in Table 6-6. The switch voltage/current = 5 V/10 mA. Mode is controlled through junction list 9 and 10 screw terminals 1 and/or 15 connected to 8 (GND). HZ=terminal unconnected (high impedance), 0V=terminal connected to AUX board ground (screw terminal J9-8).

Mode	Electrical inputs - AUX board terminals	
	J9-1	J10-15
Normal	HZ	HZ
Zero	HZ	0V
Span	0V	HZ
Maintenance	0V	0V

Table 6-5: Selection of zero, span and maintenance mode

6.8 RS-232 and Ethernet connections

CAUTION

To comply with EMC requirements, you must use screened cables. It is recommended that the screen for the Ethernet connection is terminated at the cable glands or local earth studs.

<i>Junction list</i>	<i>Terminal:</i>	<i>Color code:</i>	<i>Description:</i>	<i>Comments:</i>
J13	1		Data Carrier Detect	Connected to 4
J13	2		Transmitt Data	Used by ext. conn
J13	3		Receive Data	Used by ext. conn
J13	4		Data Terminal Ready	
J13	5		Ground	Used by ext. conn
J13	6		Data Set Ready	Connected to 4
J13	7		Request To Send	Connected with 8
J13	8		Clear To send	Connected with 7
J13	9		Ring Indicator	Not Connected

Table 6-6: Transmitter unit – RS 232 connection

Alternatively connector J15 or external connector (see figure 6-1) may be used (gender changer may be required).

<i>Junction list</i>	<i>Terminal:</i>	<i>Color code:</i>	<i>Description:</i>	<i>Comments:</i>
J2	1	White/Orange	TX+	for straight-
J2	2	Orange	TX-	through con-
J2	3	White/Green	RX+	nection (hub)
J2	4	Green	RX-	

<i>Junction list</i>	<i>Terminal:</i>	<i>Color code:</i>	<i>Description:</i>	<i>Comments:</i>
J2	1	White/Green	TX+	for cross over
J2	2	Green	TX-	connection
J2	3	White/Orange	RX+	(direct to PC)
J2	4	Orange	RX-	

Table 6-7: Transmitter unit – Ethernet RJ-45 connection

6.9 Transmitter board - fuses and LED's

The transmitter board has one main fuse and some LED's to indicate status of different supply voltages. Figure 6-8 shows the main/transmitter board layout.

If the LED close to the main fuse ("20-30 V Input OK") is lit but the other LED's are not, check the main fuse. If all LED's are dark, check the 24 V supply to the instrument. If some LED's are lit and others are not, please note which are lit and which are not lit, and contact Servomex as the board might have to be serviced.

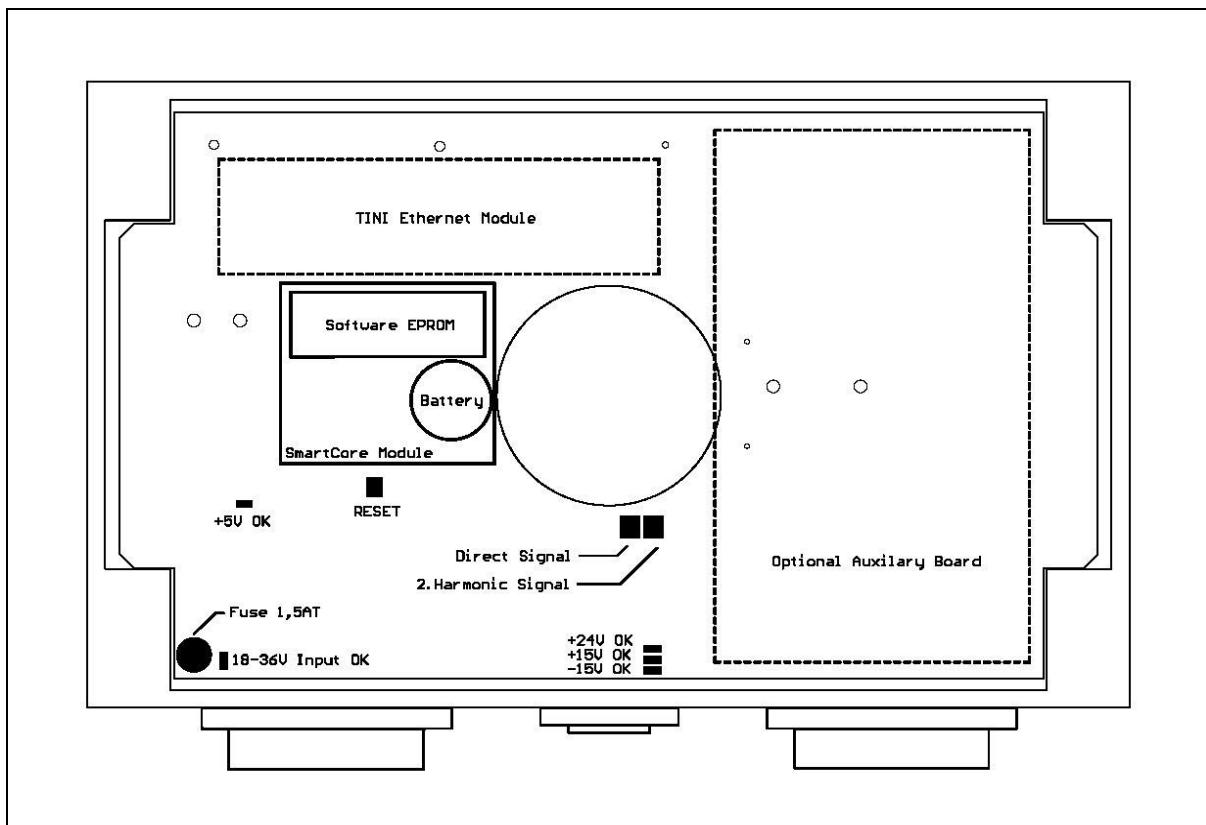


Figure 6-8: *Power electronics card fuses and LED's layout*

6.10 Relay indications

The following table shows the different relay indications:

	Operating mode	Status and measuring mode	Relay 1 Error	Relay 2 Warn.	Relay 3 Gas alarm (Standard) (Note 1)	Relay 3 Maintenance	Output 4-20 mA	Output Digital
1	Power Off		O	O	O	O	0 mA	N.A.
2	Start up		O	X	X	O	0 mA	0
3	Measuring, Normal	OK	X	X	X	O	Gas conc.	Gas conc.
4		Warning	X	O	X	O	Gas conc.	Gas conc.
5		Error	O	O	X	O	2 mA / Last (2)	Last (2)
6		Gas Alarm	X	X/O	O	O	Gas conc.	Gas conc.
7	Measuring, Maintenance	Zero	X/O (3)	X/O (3)	X (4)	X	Zero conc.	Zero conc.
8		Span	X/O (3)	X/O (3)	X (4)	X	Span conc.	Span conc.
9		Maintenance	X/O (3)	X/O (3)	X/O (4)	X	Gas conc.	Gas conc.
10	Sleep (Fault)	Normal	O	O	X	O (5)	2 mA	Last (2)
11		Zero	O	O	X	X (5)	2 mA	Last (2)
12		Span	O	O	X	X (5)	2 mA	Last (2)
13		Maintenance	O	O	X	X (5)	2 mA	Last (2)

Table 6-8: Relay indications and outputs

Relay indications:

X = Activated (conducting)

O = Deactivated (not conducting)

Notes:

- 1 «Relay 3: Gas alarm» is the only function of relay 3 in all software versions prior to 6.1c1 (check with your distributor or SERVOMEX if in doubt about the SW version of your instrument)
- 2 «Last» means the last valid measurement concentration before an error occurred.
- 3 Relays 1 (Error), 2 (Warning) are set as for rows 3-6 independent of the input switch of Normal/Maintenance/Zero/Span.
- 4 If relay 3 is configured for «Gas Alarm» this relay is set as for rows 3-6 independent of the input switch of Normal/Maintenance/Zero/Span, otherwise maintenance mode is indicated.
- 5 When entering sleep (fault) mode, relay 3 is set according to measuring mode immediately before. The state of relay 3 does not change even if attempting to change measuring mode while in sleep mode.

The WARNING relay deactivates when the SERVOTOUGH Laser Monitor detects a possible problem in the measurements, and the instrument measurements may not be correct or accuracy of the measurements reduced. Examples of such cases are low laser beam transmission due to dust on the optical windows, misalignment

or incorrect values of the 4-20 mA PLC inputs for pressure and temperature. A corresponding warning message will be displayed on the bottom line of the LCD.

The ERROR relay deactivates immediately after the instrument has detected a failure. Deactivation of the ERROR relay tells that the instrument is not able to measure the gas concentration. The error message will be displayed on the LCD.

There are two options for the behaviour of the 4-20 mA PLC output in case of deactivating of the ERROR relay (contact your local distributor if you want to change this option)

Option 1:

Immediately after the ERROR relay has been deactivated the PLC holds the last measured value for a time interval that is proportional to the instrument averaging time. In the current software version the time interval is $\tau = 3 \cdot T$. After that the PLC sets the output to 2 mA as an error notification in addition to the ERROR relay.

Option 2:

The 4-20 mA PLC holds the last measured value for the gas concentration until the ERROR relay is activated again. The PLC output is, thus, independent of the errors, and the only error notification is the ERROR relay.

6.11 Configuring relay 3 output

Relay-3 can be configured in three ways by software as

- 1) Normal gas alarm
- 2) Inverted gas alarm
- 3) Maintenance

These three configurations are mutually exclusive. In addition the relay-3 function can be inverted by hardware.

The different functions of relay-3 are selected by setting the parameter “Gas conc alarm level” (see Section 4.3.6).

6.11.1 Normal configuration of relay-3, «Gas alarm»

Alarm is signified when the measured gas concentration $>$ abs(Gas conc alarm level) for one or more of the measured gases. Normal configuration:

Alarm OFF = Relay-3 conducting (X)

Alarm ON = Relay-3 isolating (O).

6.11.2 Inverted configuration of relay-3, «Gas alarm»

This is defined by setting the parameter “Gas conc alarm level” < 0 (negative value) for gas-1. Inverted relay-3 function then also applies to gas-2 and gas-3 alarm levels (if applicable) irrespective of their sign. Alarm is signified when the measured gas concentration > abs(Gas conc alarm level) for one or more of the measured gases. Inverted configuration:

Alarm ON = Relay-3 conducting (X)

Alarm OFF = Relay-3 isolating (O).

6.11.3 Maintenance configuration of relay-3

Maintenance indication is done by relay no. 3 by setting the parameter “Gas conc alarm level” = -10^{20} (= -1E20) *for all gaslines, N*, of the instrument (see Section 4.3.6). This ensures that «Gas Alarm» is disabled for all realistic gas concentrations and does not interfere with the maintenance function.

“Normal” measuring mode: Relay-3 isolating (O)

“Zero”, “Span”, or “Maintenance” mode: Relay-3 conducting (X).

6.11.4 Inverting relay-3 output by hardware switch

The AUX-board switch SW1-3/C is by default set to position 3 (REL3_NC). This gives the relay outputs as described in the sections above. When the AUX-board switch SW1-3/C is set to position C (REL3_NO), the relay function is interchanged. This also applies to operating mode “Power off” (see also Section 6.7).

7. SPAN AND ZERO CHECK OPTIONS

The SERVOTOUGH Laser Monitor may be fitted with different options to carry out span and zero checks for validation on the process. The following are available:

- a. Span check for non-corrosive gases (e.g. O₂, NO, CO, CO₂) with internal flow through cell inside receiver unit
- b. Span and zero check with internal sealed span cell

Contact your local distributor for more information about these options.

7.1 Span check with flow through cell

Span checks to validate Laser monitor performance may be carried out with the instrument installed on the process. For non-corrosive gases the internal 100 mm volume between receiver window and receiver lens is used to this end. For corrosive gases a dedicated span cell (accessory available from SERVOMEX) mounted between receiver unit and process applies. The span gas is measured in parallel with the process gas; therefore it is important that during normal operation this internal or span cell is empty for span gas.

The span mode is initiated by input through two channels, either;

- through digital communication (with the service program see Section 4.2),
- or electrical signals through the AUX connections (see Section 6.7.1 and Table 6-5).

Note that the same channel must be used to set the measuring mode back to «Normal», while the other channel is ignored.

The instrument calculates and stores the absorption signal for the gas concentration measured in normal mode just before the span check. This absorption signal is continuously subtracted from the measured signal during span check operation. The resulting signal, therefore, corresponds to the signal from the internal cell (or span cell) providing that the signal from the process remains stable. Ambient temperature and pressure recorded with the internal temperature and pressure sensors located inside the receiver unit is used to calculate the concentration of the span gas. By default the concentration is referred to 1-meter path length. This means that, if the span gas concentration is for example 1% vol., the measured span will be 0.1% vol. (The span can be scaled to another path length. Contact Servomex for details.)

The span check procedure:

1. Initiate span check through one of the channels described above. The instrument is forced to span check operation. After a few seconds the message, "SPAN" appears on the transmitter LCD. The measured concentration should come to zero, which indicates that the process absorption signal is properly subtracted.
2. Start flushing the internal cell with the span gas. Use moderate flow rates (approximately 1 – 2 l/min) to avoid pressure build-up in the cell.
3. Measure span concentration.
4. Remove any residual span gas from the flow through span cell by flushing it with Nitrogen or air.
5. Set the instrument back to normal operation (remember to use the same channel as used for initiating span mode).

7.2 Span and zero check with internal sealed cell

Note that this option also includes zero check functionality.

Span and zero checks may be carried out with the instrument installed on the process. The receiver unit includes a small sealed gas cell containing the gas to be measured. This cell is moved into the laser beam path by a compact servomotor.

The span and zero mode is initiated by input through two channels, either

- through digital communication (with the service program see Section 4.2),
- or electrical signals through the AUX connections (see Section 6.7.1 and Table 6-5).

Note that the same channel must be used to set the measuring mode back to «Normal», while the other channel is ignored.

The instrument calculates and stores the absorption signal for the gas concentration measured in normal mode just before the span check. This absorption signal is continuously subtracted from the measured signal during span check operation. The resulting signal, therefore, corresponds to the signal from the internal cell providing that the signal from the process remains stable during span procedure (typically 15 seconds). Ambient temperature and pressure recorded with the internal (integrated inside the receiver unit) temperature and pressure sensors are used to calculate the concentration of the span gas. By default the internal span cell is calibrated to give a 75 – 80% of full-scale reading. (alternative calibration is possible, contact SERVOMEX or you local distributor).

APPENDIX 1 COMPLIANCE AND STANDARDS INFORMATION

- The SERVOTOUGH Laser monitor complies with the European Community "Electromagnetic Compatibility Directive" and "Low Voltage Directive".
- The Laser monitor is rated in accordance to Overvoltage Category II, Pollution Degree 2.
- The Laser monitor complies with the Class B digital apparatus requirements of ICES-003 of Canada through the application of EN 55011:2007.
- L'analyseur est conforme aux Conditions B numériques d'appareillage de classe de NMB-003 du Canada par l'application du EN 55011:2007.
- This Laser monitor complies with Part 15 of the US FCC Rules for Class B equipment. It is suitable for operation when connected to a public utility power supply that also supplies residential environments.
- The Laser monitor has been assessed to IEC 61010-1:2001 +Corr 1: 2002 + Corr 2:2003 for electrical safety including any additional requirements for US and Canadian national differences.
- Servomex Group Ltd is a BS EN ISO 9001 and BS EN ISO 14001 certified organisation.

**APPENDIX 2 DISPOSAL IN ACCORDANCE WITH THE WASTE
ELECTRICAL AND ELECTRONIC EQUIPMENT (WEEE)
DIRECTIVE**

The SERVOTOUGH Laser monitor is not considered to be within the scope of the Waste Electrical and Electronic Equipment (WEEE) Directive.

The Laser monitor is not intended for disposal in a municipal waste stream but shall be submitted for material recovery and recycling in accordance with any appropriate local regulations.

For additional information and advice on the disposal of the Laser monitor, contact Servomex:

Servomex Group Limited,
Jarvis Brook,
Crowborough,
East Sussex,
TN6 3FB,
England
Tel: (44) 1892 652181
Fax: (44) 1892 662253
Global email: info@servomex.com

If you send the Laser monitor to Servomex or your local Servomex agent for disposal, it must be accompanied by a correctly completed decontamination certificate.

APPENDIX 3 ATEX DIRECTIVE AND OTHER NON-EUROPEAN HAZARDOUS AREA APPROVALS

ATEX Directive 94/9/EC

IECEX

CSA

NOTE

Depending on the variant ordered an additional Safety Certificate Manual may be supplied. This contains all the relevant safety certificates and declarations for the EX1, EX2 and CS2 variants.



WARNING

The EX2 variants are not suitable for use with a continuously flammable process atmosphere. If used with a continuous flammable process atmosphere, the hazardous area certification is invalidated.



WARNING

The EX1 and EX2 variants are certified for use with a flammable process atmosphere at a pressure of 0.8 to 1.1 bar absolute. If used with a flammable process atmosphere beyond these limits, the hazardous area certification is invalidated.



WARNING

The EX2 and CS2 Hazardous area variant cannot be used for oxygen enriched samples, that is gases over 21% O₂. If used with gases containing over 21% O₂ the hazardous area certification is invalidated.



WARNING

The installer and/or the user of the Laser monitor must be satisfied that the installation complies with any "Special Conditions for Safe Use" or "Schedules of Limitations" contained in the certificates included in the separate certification manual.

02930 Safety Approvals	
Variant	Certification
Safe Area	Only suitable for installation in a non-hazardous area.
EX1	The 02930 Series EX1 version is ATEX and IECEx certified to Type 'p' standard EN/IEC 60079-2 and the Optical Radiation Standard EN/IEC 60079-28 and is suitable for use in areas that require EPL Gb. The Laser monitor is marked Ex px IIC T5 Gb . The 02930 Series EX1 version is also ATEX and IECEx certified to the Optical Radiation Standard EN/IEC 60079-28 for a flammable process gas that requires EPL Ga. The Laser monitor is marked [Ex op is IIC T6 Ga] . (See Note 1)
EX2	<p>The 02930 Series EX2 version is ATEX and IECEx certified to Type 'n' standard EN/IEC 60079-15 and the Optical Radiation Standard EN/IEC 60079-28, and is suitable for use in areas that require EPL Gc. The Laser monitor is marked Ex nA nC op is IIC T4 Gc for flange temperatures up to 135°C.</p> <p>The 02930 Series EX2 version is also ATEX and IECEx certified to the Optical Radiation Standard EN/IEC 60079-28 for a flammable process gas that requires EPL Gb. The Laser monitor is marked [Ex op is IIC T4 Gb]. (See Note 1)</p> <p>The 02930 Series EX2 version is also ATEX and IECEx certified to Dust standard EN/IEC 60079-31, and is suitable for use in areas that require EPL Db. The Laser monitor is marked Ex tb IIIB T135°C IP66 Db for flange temperatures up to 135°C.</p> <p>The 02930 Series EX2 version is also ATEX and IECEx certified for a flammable process dust that requires EPL Da. The Laser monitor is marked [IIIB T70°C Da]. (See Note 1)</p>
CS2	The 02930 Series CS2 version is CSA certified for use in either Divisions or Zones, gas or dust classified locations in both USA and Canada.

Note 1: Where the process gas or dust is non-flammable, these markings can be ignored and any associated conditions do not apply.

Note 2: A flammable process gas is limited to normal atmospheric pressure (0.8 to 1.1 bar) and less than 21% oxygen content.

Note 3: If the pressure of the process gas is greater than 1.5 bar, the Pressure Equipment Directive (PED) applies.

Note 4: Currently the CS2 certification does not address Flammable process conditions.

APPENDIX 4 - EQUIPMENT PROTECTION LEVELS – ATEX/IECEX**4.1 Traditional Relationship of Equipment Protection Levels (EPLs) to Zones:**

Equipment Protection Level (EPL)	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22

When these are used in the installation, no further risk assessment is required. Where a risk assessment has been used, this relationship can be broken so as to use a higher or lower level of protection. For more information on Equipment Protection Levels (EPLs) refer to Annex D of IEC 60079-0:2007 or EN 60079-0:2009

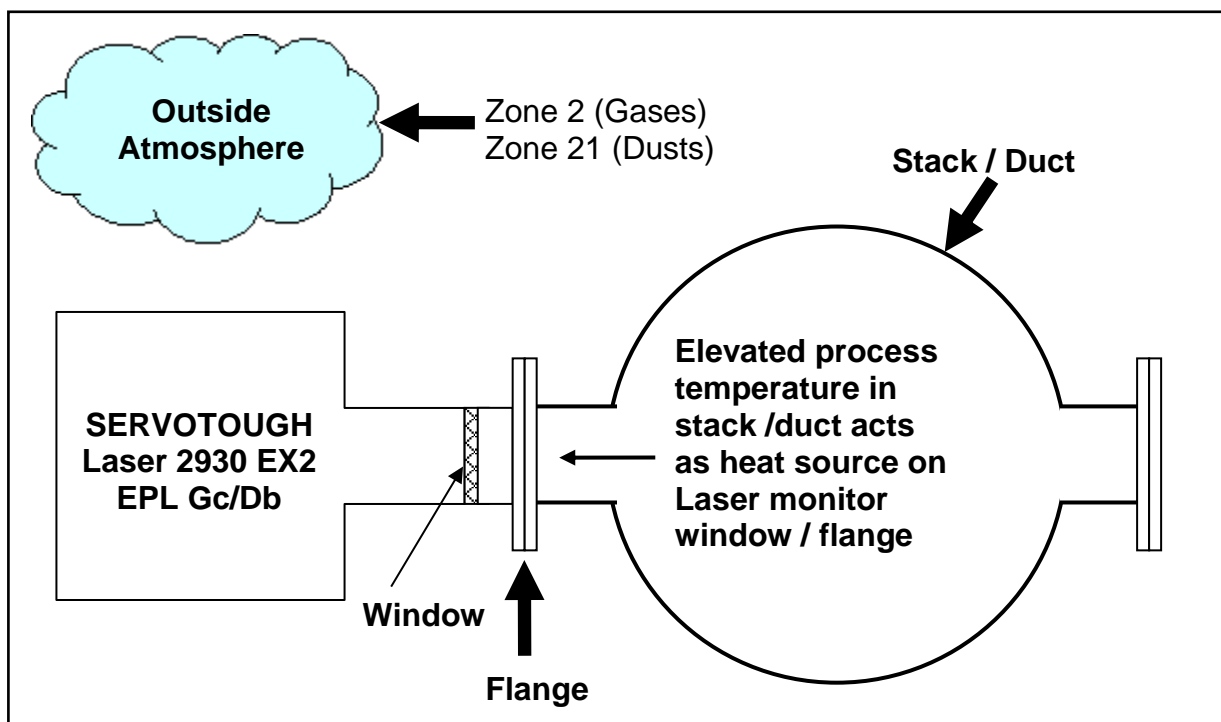
4.2 Relationship of Equipment Protection Levels to ATEX Categories:

Equipment Protection Level (EPL)	ATEX Category
Ga	1G
Gb	2G
Gc	3G
Da	1D
Db	2D
Dc	3D

APPENDIX 5 – PROCESS CONSIDERATIONS – ATEX/IECEx ONLY

5.1 Effect of Process Temperature on Laser Monitor

The ATEX Directive and IECEx standards require that all heat sources be considered. If the process is running at an elevated temperature then the Laser monitor will receive a thermal gain through the flange. This has been allowed for in the certification.



For situations where there is heat gain from the process, the following table may be used to determine the maximum operating ambient temperature and maximum surface temperature for dust of the equipment:

Mains Powered Units

Process Flange Temperature	T Class	Dust Surface Temperature	Process Dust Temperature	Ambient Temperature Range
≤65°C	T4	T75°C	T70°C	-20°C ≤ Ta ≤ +60°C
≤100°C	T4	T100°C	T100°C	
≤135°C	T4	T135°C	T135°C	

24V Powered Units

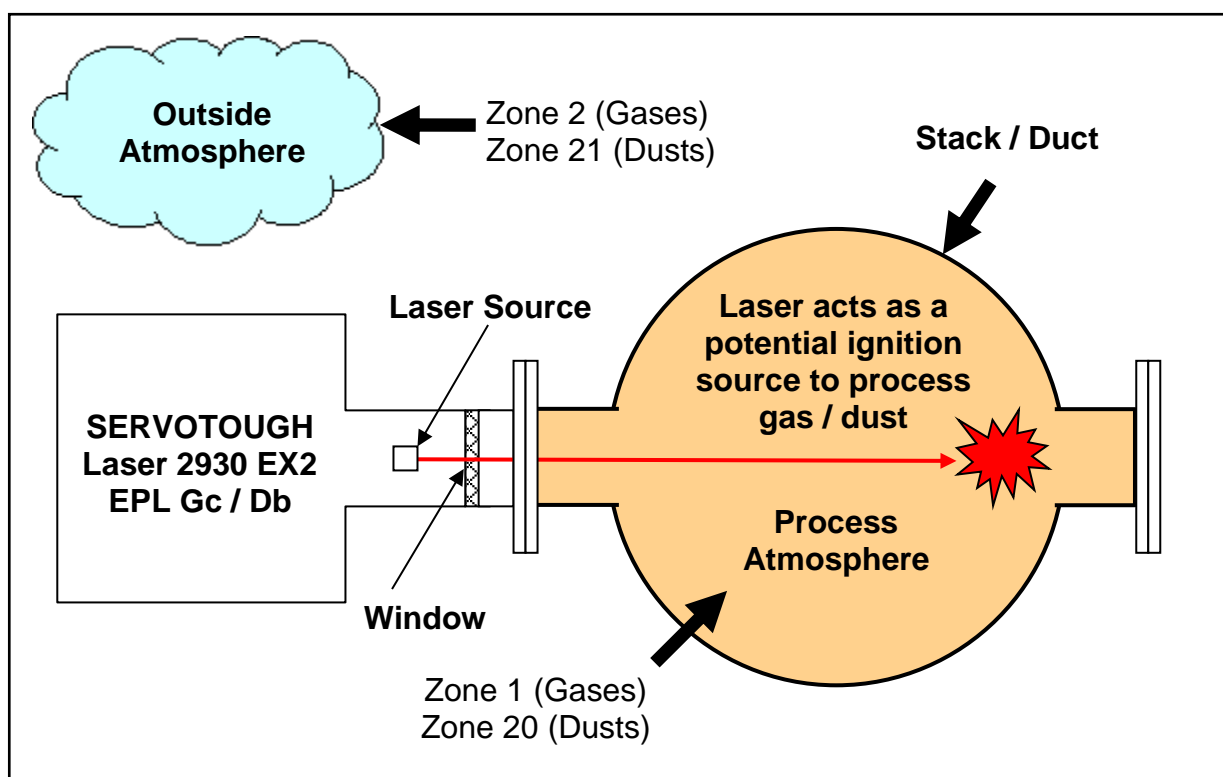
Process Flange Temperature	T Class	Dust Surface Temperature	Process Dust Temperature	Ambient Temperature Range
≤65°C	T5	T75°C	T70°C	-20°C ≤ Ta ≤ +65°C
≤100°C	T5	T100°C	T100°C	
≤135°C	T4	T135°C	T135°C	

5.2 Flammable Process Atmosphere (Gas or Dust)

Although the Laser Monitor is located in the outside atmosphere, it transmits laser energy into the process atmosphere where it becomes a potential source of ignition. It is possible to ignite a flammable gas or combustible dust using a laser.

The ATEX Directive and the IECEx standards requires that all ignition sources be considered.

The SERVOTOUGH Laser monitor has been certified to the Optical Radiation Standard EN/IEC 60079-28 for both the outside atmosphere (apparatus) and the process atmosphere (associated apparatus) as inherently safe, “Ex op is” and “[Ex op is]”.

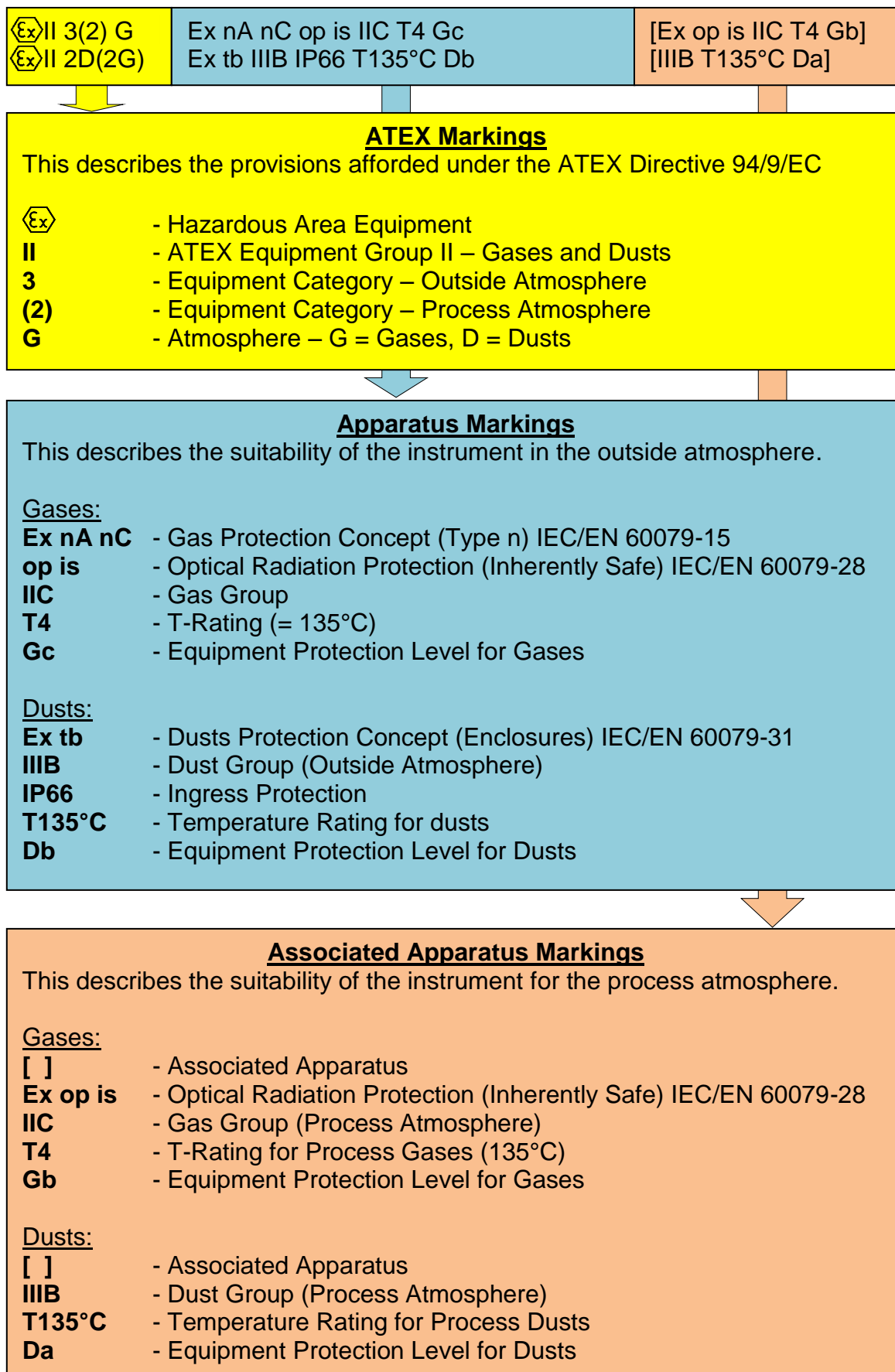


Note 1: This is only relevant where the atmosphere inside the stack / duct has been zoned in accordance with EN/IEC 60079-10.

The EX2 variant is certified as EPL Gc/Db for use in Zone 2 (gases) or Zone 21 (dusts) and may be connected to a Zone 1 (gases) or Zone 20 (dusts) process atmosphere. The possible combinations are summarised in the table.

Outside Atmosphere		Process Atmosphere	
Zone	EPL	Zone	EPL
2	Gc	1	Gb
2	Gc	20	Da
21	Db	1	Gb
21	Db	20	Da

APPENDIX 6 – EXPLANATION OF CODING – ATEX/IECEX



APPENDIX 7 – EXPLANATION OF CODING – CSA

