TENSOR

User Manual

I 22200

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This manual is the original documentation for the FT-IR spectrometers TENSOR 27 and TENSOR 37.

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SAFETY

1

GENERAL INFORMATION

Read the following safety instructions carefully before putting the spectrometer into operation. Keep this manual in a suitable place for future reference.

Always observe the instructions described in this manual to ensure user safety and to avoid property damage. Improper use or failure to follow these safety instructions can result in serious injuries and/or property damage. Any non-observance of the precautions will infringe the intended use (i.e. performing spectroscopic measurements) of the spectrometer. In this case, Bruker Optik GmbH will not assume any liability.

It is the operator’s duty to plan and implement all necessary safety measures and to supervise their observance. Moreover, the operator must ensure that the spectrometer is in proper functioning condition. A safe and faultless operation can only be guaranteed if the spectrometer is transported, stored, installed, operated and maintained properly according to the procedures described in this manual.

Never remove or deactivate any supporting safety systems during spectrometer operation. Ensure that objects and/or material not required for the measurement are out of the spectrometer operating area.

The spectrometer complies with the IEC/EN 61010-1 safety regulations.

Protective Earthing

To avoid personal injuries and/or property damage caused by electrical power, the spectrometer is equipped with a safety plug. Connect this plug only to a socket outlet with earthing contact. Make sure that the socket complies with IEC (International Electrotechnical Commission).

Qualified Personnel

Initial installation and all maintenance and repair works not described in this manual should only be performed by Bruker service personnel. Only authorized operating personnel that have been briefed about the spectrometer operation and all relevant safety aspects should operate and maintain (i.e. only maintenance works that are described in this manual) the spectrometer.

All repairs, adjustments and alignments on any spectrometer component must be performed in accordance with the safety regulations and standards applied in the country in which the instrument is installed.

Correct Usage

The spectrometer and its components should only be used according to the instructions described in the manual or advised by a Bruker engineer. In case of accessories or components made by other manufacturers and used in connection with the spectrometer, Bruker does not assume any liability for safe operation and proper functioning.

WARNING LABELS

When operating the spectrometer you have to observe a number of safety instructions which are highlighted by various warning labels. This section describes the warning labels and explains their meaning. All warning labels on the spectrometer must always be kept legible. Immediately replace a worn or damaged label.

The following warning labels indicate different dangerous situations which may be caused by improper use of the spectrometer.

Caution - General Hazard

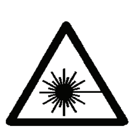
This warning symbol indicates general hazard. Observe the safety instructions and follow the precautions described to avoid personal injury and/or property damage.

Caution - Electrical Shock

This warning symbol indicates electrical hazard. The symbol is located near live parts or on enclosures behind which are live parts that represent an accidental contact hazard. Never touch these parts. Before removing the corresponding compartment covers and beginning any maintenance or repair work, first turn off the main power switch and unplug the main power cable. Ensure that all live parts do not come into contact with a conductive substance or liquid. Non-observance of these safety instructions can cause severe personal injury and/or property damage.

Caution - Hot Surface

This warning symbol indicates components and surfaces which can become very hot during spectrometer operation. Do not touch these components and surfaces. Risk of skin burn! Be careful when operating near hot components and/or surfaces.



Caution - Laser Radiation

This warning symbol indicates the existence of laser radiation. Never look directly into the laser beam or use any kind of optical instruments to do so. Otherwise permanent eye damage can be the result.

Caution - Frostbite

This warning symbol indicates cryogenic materials (e.g. liquid nitrogen) required to operate the spectrometer (e.g. cooling detector). Skin contact with these liquids or cooled components causes severe frostbite. Always handle the liquids with utmost care. Observe the safety instructions for handling of cryogenic liquids.

Caution - Harmful Material

This warning symbol indicates the existence of harmful or irritant material (e.g. the window material BaF_2). Observe the safety instructions on the packaging, and the safety data sheets attached. Non-observance may cause personal injury.

Caution - Toxic Material

This warning symbol indicates the existence of toxic material (e.g. the window material KRS-5). Observe the safety instructions on the packaging, and the safety data sheets attached. Non-observance may cause severe personal injury or even death.

Besides the dangers described above, there can also be hazardous situations caused by the sample material. Depending on the type of hazardous substances you work with, you have to observe specific substance-relevant safety instructions. Put on the corresponding warning label on the appropriate spectrometer position. The label must be legible and permanently discernible. The following list contains some examples of hazardous substances:

Caution - Infectious Material

This warning symbol indicates the possible presence of bio-hazardous and infectious material. When working with this kind of material always, observe the prevailing laboratory safety regulations and take all necessary precautions and disinfection measures (e.g. wearing protective clothing, masks, gloves etc.). Failure to do so may cause severe personal injury or even death. (For information on how to use, dilute and efficiently apply disinfectants, refer to the *Laboratory Biosafety Manual: 1993* by WHO - World Health Organization.)

Caution - Radioactive Material

This warning symbol indicates the possible presence of radioactivity. When working with radioactive material, always observe the safety regulations and take all necessary protective measures (e.g. wearing protective clothing, masks gloves etc.). Failure to do so may cause severe personal injury or even death.

Caution - Corrosive Substance

This warning symbol indicates the possible presence of corrosive substances. When working with corrosive substances, always observe the laboratory safety regulations and take protective measures (e.g. wearing protective masks and gloves). Failure to do so may cause severe personal injury or even death.

Waste Disposal

Dispose all waste produced (chemicals, infectious and radioactively contaminated substances etc.) according to the prevailing laboratory regulations. Detergents and cleaning agents must be disposed according to the local waste regulations.

SAFETY NOTES

The following chapters describe all relevant safety aspects of the spectrometer operation. Depending on the degree of hazard the safety instructions are classified as follows:

Danger indicates that death, severe personal injury or substantial property damage WILL result if proper precautions are not taken.

Warning indicates that death, severe personal injury or substantial property damage CAN result if proper precautions are not taken.

Caution indicates that minor personal injury or property damage CAN result if proper precautions are not taken.

Note draws your attention to particularly important information on the product, e.g. product operation or to a special part of the manual.

The safety instructions Danger, Warning and Caution stand out by the corresponding warning labels.

GENERAL

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GENERAL TENSOR FEATURES

TENSOR is an advanced flexible benchtop FT-IR spectrometer suitable for routine applications as well as for demanding laboratory analysis. **TENSOR 27** - the basic spectrometer configuration - is designed for measurements mainly in the mid-infrared region, whereas **TENSOR 37** - the advanced spectrometer configuration - allows also measurements in the near-infrared region by substituting the MIR components (source, detector, beamsplitter and sample compartment windows) for the corresponding NIR components. These optical spectrometer components can be replaced by the operator.

The TENSOR spectrometer is mainly operated by using a data system (PC workstation, notebook etc.). Setting the measurement parameters, starting the spectroscopic measurement as well as validating the spectrometer are done by means of the spectroscopy software OPUS. In addition, the Ethernet interface at the spectrometer rear side provides the possibility to operate the spectrometer also via your intranet or the internet.

The sample compartment (in case of TENSOR 27) or the sample compartment and the optical bench (in case of TENSOR 37) are purgeable. Purging the spectrometer with dry air or nitrogen gas reduces the content of unwanted atmospheric interferents (e.g. water vapor and carbon dioxide) inside the spectrometer significantly. Residual absorption by these atmospheric gases can lead to a significant high noise level and may mask in the spectrum weak spectral features of the sample. Purging is the most common method of reducing these effects of atmospheric contaminants.

The sample compartment is equipped with the QuickLock mechanism that allows for an exact and reproducible positioning and locking of various measurement accessories (provided the accessory is equipped with a QuickLock baseplate). The QuickLock mechanism enables a solid lock even for heavy and bulky accessories.

The TENSOR spectrometer is equipped with a number of features such as AAR (Automatic Accessory Recognition) ACR (Automatic Component Recognition) and Performance Guard that facilitate performing spectroscopic measurements and ensure reliable measurement results. The function AAR recognizes automatically the accessory installed in the sample compartment, performs several predefined tests and loads automatically the corresponding experiment file including the pre-defined measurement parameters. ACR recognizes automatically the currently installed optical components like source, detector and beamsplitter. These components are electronically coded so that the spectrometer firmware is able to recognize them. This information is passed on to the application software OPUS. The purpose of ACR is to enable the user to select the correct optic parameters in OPUS. In addition, the spectrometer components are monitored permanently to ensure that they operate within the specification range. This feature is called PerformanceGuard. Its purpose is to facilitate fault diagnostics.

The TENSOR spectrometer and the spectroscopy software OPUS are designed for validating the spectrometer to ensure that the spectrometer operates within the specifications and delivers reliable measurement results. For this purpose, the spectrometer is equipped with a computer-controlled internal validation unit (IVU) as a standard feature. The IVU is a wheel equipped with different filters. Depending on which test protocol (OQ[1] or PQ[2]) is running, the corresponding filter is moved automatically in the beam path. Validation intervals and test protocols (OQ and PQ) are defined by the user using OVP[3] (OPUS Validation Program). For detailed information about OVP and spectrometer validation, refer to the OPUS Reference Manual.

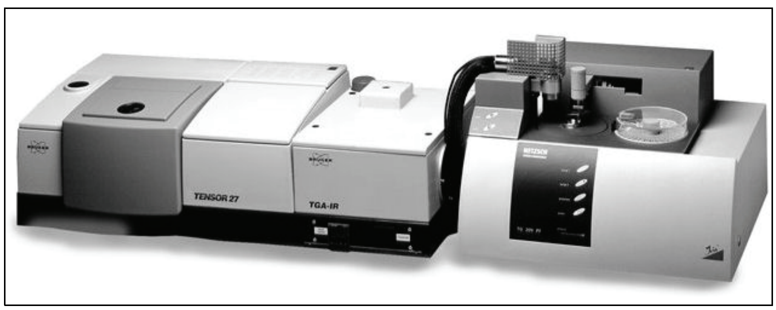
The IR beam outlet port at right spectrometer side allows the connection of an accessory. Depending on the individual application demands, a multitude of optional accessories is available, for example:

- IR microscope (e.g. HYPERION)
- HTS-XT module (High Throughput Screening Extension)
- coupling of TGA[4] instruments
- external sample compartment
- accessory PMA50 (Polarization Modulation Accessory) for applications in the field of VCD[5] and PM-IRRAS[6]

1. OQ - Operational Qualification
2. PQ - Performance Qualification
3. OVP - OPUS Validation Program
4. TGA - Thermogravimetric Analysis
5. VCD - Vibrational Circular Dichroism
6. PM-IRRAS - Polarization Modulation Infrared Reflection Absorption Spectroscopy

TENSOR coupled to a HTS-XT module

TENSOR coupled to a TGA-IR module plus a thermo balance by Netzsch



TENSOR coupled to a FT-IR microscope HYPERION

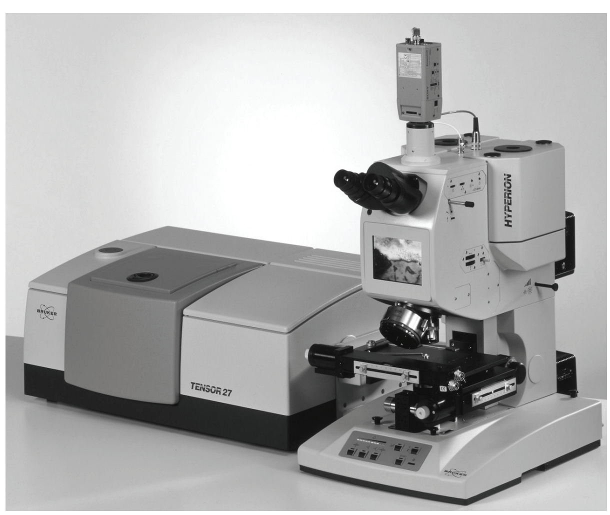


Figure 1: Examples possible instrumental setups

The optional multiplexer box with four switchable beam outlet ports allows for connecting simultaneously external accessories like IR microscope, TGA coupling etc. to the TENSOR spectrometer.

DIFFERENCES BETWEEN TENSOR 27 AND TENSOR 37

TENSOR 27 and **TENSOR 37** differ from each other with regard to:

Feature	**TENSOR 27**	**TENSOR 37**
Source	MIR	MIR and NIR **Note:** An additional source holder inside the spectrometer is intended for the storage of the source not in use.
Beamsplitter	1x beamsplitter (The beamsplitter is factory-integrated in the interferometer block, i.e. substituting the beamsplitter is **not** possible.) **Note:** The actual beamsplitter material depends on your TENSOR 27 variant. See section *TENSOR 27 Variants* below in this chapter.	**Standard:** KBr beamsplitter **Option:** several MIR and NIR beamsplitters (See chapter *Overview*, section *Beamsplitter*.) Substituting the beamsplitter is possible. **Note:** There is also a beamsplitter storage box with humidity indicator and desiccant cartridge. See E and F in fig. 16.
Detector	**Standard:** DLaTGS detector **Option:** several MIR detectors (See chapter *Overview*, section *Detector*.)	**Standard:** DLaTGS detector **Option:** several MIR and NIR detectors (See chapter *Overview*, section *Detector*.)
Sample compartment windows	1x sample compartment window (separating the sample compartment from the interferometer compartment, see fig. 18) **Note:** The actual window material depends on your TENSOR 27 variant. See section *TENSOR 27 Variants* below in this chapter.	**Standard:** 2x KBr windows (separating the sample compartment from the interferometer compartment and the detector compartment, see fig. 18) **Options:** Various window materials are available. (See chapter *Maintenance and Repair*, section *Replacing a damaged Sample Compartment Window*.)
Laser class	1	2
Purgeable spectrometer compartment	sample compartment	sample compartment and optical bench
Desiccant cartridge	1x desiccant cartridge (in interferometer compartment)	3x desiccant cartridges (1x cartridge in the interferometer compartment, 1x cartridge in the detector compartment and 1x cartridge in the beamsplitter storage box)
Spectral range extension	The user can not extend the spectral range.	The user can extend the spectral range by substituting the optical components (source, beamsplitter, sample compartment windows and detector).

TENSOR 27 VARIANTS

The following variants of the **TENSOR 27** spectrometer are available:

Standard variant of TENSOR 27

Spectral range	Source	Beamsplitter	Window material	Detector
7,500 - 370cm^{-1}	MIR (globar)	KBr (standard)	KBr	DLaTGS[a]

a. DLaTGS detector - deuterated L-alanine doped triglycene sulphate detector

Optional variants of TENSOR 27

Spectral range	Source	Beamsplitter	Window material	Detector
10,000 - 400cm^{-1}	MIR (globar)	KBr (broad band)	KBr	DLaTGS
5,000 - 210cm^{-1}	MIR (globar)	CsI	CsI	DLaTGS
6,000 - 500cm^{-1} (high humidity variant)[a]	MIR (globar)	ZnSe	ZnSe	DLaTGS

a. This variant is recommend for the spectrometer usage in a humid environment.

The above listed TENSOR 27 variants are available only ex-factory!

INSTALLATION

3

GENERAL INFORMATION

Unpacking and initial installation of the TENSOR spectrometer is done by Bruker service engineers. The operating company has to provide an installation site that meets the site requirements described in this chapter. (See also the technical documentation *Installation Requirements for TENSOR 27/37* provided by Bruker Optik prior to the spectrometer delivery.)

This chapter contains a list of the standard as well as the optional spectrometer components and describes the procedures for connecting the spectrometer to the power supply and to a PC as well as installing the purge gas connection. For information about how to install the computer, refer to the computer manual.

DELIVERY SCOPE

TENSOR allows upgrading the measurement system with optional components and/or accessories. Depending on the spectrometer configuration you have ordered, your delivery scope may not include all optional components listed below.

Standard Components

The basic configuration includes the following items:

- Spectrometer TENSOR 27 or TENSOR 37
- PC compatible data system (If desired, the PC can also be provided by the customer.)
- External power supply unit with low-voltage cable, power cord with country-specific power plug
- Data cable (CAT5, crossover cable for 10/100Base-T Ethernet standard)
- Tools and spare parts kit (hex keys and screwdrivers of different sizes, flange tool, 2x o-rings for sample compartment, desiccant
- OPUS software for spectrometer control, data acquisition, manipulation and evaluation

Optional Components

The delivery scope can also include the following optional items:

- optional spectrometer components (e.g. optional beamsplitter, detectors)
- optional accessories
- optional OPUS software packages (e.g. QUANT)

Inspecting the Packaging

After having received the spectrometer, inspect the packaging for damages. If there are any signs of damage, contact your local shipping representative before opening the shipping box.

Warning: Do not put a spectrometer into operation that shows signs of damage. Failure to do so may result in severe personal injuries and/or property damage.

Transportation

Due to its substantial weight (ca. 37kg), the TENSOR spectrometer has to be carried by at least two persons. Alternatively, you can also use a fork lifter. When transporting the spectrometer, use the original packaging to avoid damages.

SITE REQUIREMENTS

Space Requirements

The approximate spectrometer dimensions are 67cm (w) x 44cm (d) x 28cm (h) (26“ x 18“ x 11“). (For exact spectrometer dimensions refer to appendix D.) At the rear side, the spectrometer requires a clearance of at least 25cm (10“). The spectrometer should be placed on a stable and horizontal base which is able to bear the weight of the spectrometer (approx. 37kg) and its possible accessories.

When preparing the installation location for the spectrometer, take into consideration that the main power supply connection is easily accessible at any time. The mains power supply can be interrupted, for example, either by pulling the mains plug of the power cord or by pulling the power cord from the external power supply unit.

Environmental Requirements

Ideally, the spectrometer should not be installed near vibration sources (e.g. ventilation hoods, air conditioners, motors, elevator etc.) or in rooms with intense floor vibration.

To ensure optimum spectrometer performance and long-term reliability the following environmental conditions are essential:

Temperature range: 18 - 35 °C (64 - 95 °F)

Humidity (non-condensing): ≤ 80% (relative humidity)

Temperature variations (during measurement): max. ± 1°C

Temperature variations can impair the results of long-term measurements. Therefore, the temperature variations should be less than 1°C an hour and not more than 2°C per day for this type of measurements.

Power Supply

The spectrometer is designed for the connection to a circuit which is either double or reinforced isolated from the primary supply circuits (SELV - safety extra low voltage). The spectrometer power supply is realized by the supplied external power supply unit[1]. The external power supply unit has a wide input range which means that it is able to adapt itself to the most common public supply mains.

Input range: 100 - 240 V AC, 2.5V, 50 - 60 Hz

Output: 24 V DC, 4.75 A, max. 90 W

To provide for good data quality and a long spectrometer service life, ensure that the following site requirements are met:

- Do not install the spectrometer near sources of potential inductive electrical interference (e.g. pumps, switching motors, microwave ovens etc.), sources of high energy pulses, and sources that might cause magnetic or radio frequency interference.
- Do not place devices such as large electric motors, heaters, welding equipment, radio transmitting equipment, units emitting pulsed NMRs, or high powered lasers in close vicinity to the spectrometer. These devices can interfere with the spectrometer and cause spectrometer malfunction. Ensure that these types of devices are not connected to the same electrical circuit as the spectrometer.
- If there are any problems concerning main power supply (e.g. brownouts, power surges, frequent thunderstorms), we recommend using an UPS unit to ensure an uninterruptible power supply and consequently an operation without interruptions.

1. The external power supply unit is certified by UL and TÜV. An approved power supply is required.

CONNECTING TENSOR TO POWER SUPPLY

Connection Procedure

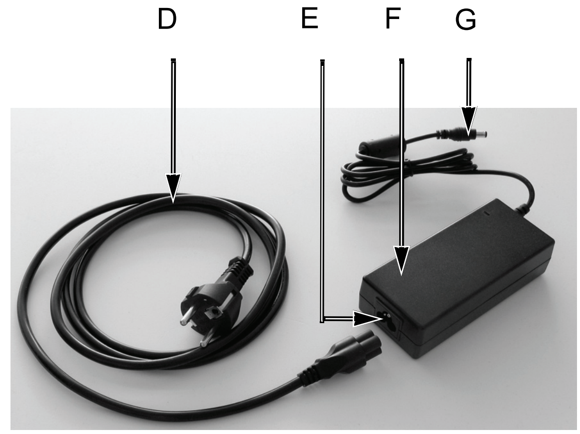
1. First make sure that the spectrometer is switched off. Check the setting of the on/off switch (B in fig. 2).
2. Connect the low-voltage cable (G in fig. 2) to the low-voltage socket (C in fig. 2) at the spectrometer rear side.
3. Connect the power cord (D in fig. 2) to the C5 connector of the external power supply unit (E in fig. 2).
4. Connect the power plug of the power cord to the mains socket outlet.

Warning: Connect the power plug of the power cord only to a socket outlet with earthing contact. Otherwise, there is the risk of personal injury and spectrometer damage!

To ensure a safe external power supply unit operation, observe the following safety instructions:

- **Operate the external power supply unit only in a dry environment.**
- **Make sure that the external power supply unit is not exposed to direct sunlight. Avoid temperatures above +50 °C. Provide for sufficient air circulation.**
- **Position the external power supply unit in such a way that it does not present a trip hazard.**
- **Do not put heavy objects on the external power supply unit.**
- **Do not place the external power supply unit on a hot surface.**
- **If the external power supply unit is damaged disconnect it instantly from the supply circuit. Never put a damaged external power supply unit into operation! Only authorized technicians are allowed to repair the external power supply unit!**

Figure 2: a) Spectrometer Rear Side Connections for Power Supply and PC



b) External power supply unit

Fig. 2	Component
A	Ethernet port (for connecting the data cable)
B	On/off switch (for switching the spectrometer on or off)
C	Low-voltage socket (male connector for connecting the low-voltage cable)
D	Power cord
E	C5 connector (for connecting the power cord to the external power supply unit)
F	External power supply unit
G	Low-voltage cable

CONNECTING TENSOR TO A PC

General Information

Basically, the following connection variants are possible:

- Connecting the spectrometer directly to a stand-alone PC (It is the standard variant.) See fig. 4.
- Connecting both the spectrometer and PC to a network. See fig. 5.
- Connecting the spectrometer to a network computer. See fig. 6.

Depending on the connection variants, two different data cable types are required:

Data cable type	For realizing the following connection variant	Included in the delivery scope
Crossover cable	• Stand-alone operation, i.e. spectrometer is connected to a stand-alone PC. See fig. 4. • Spectrometer is connected to a network computer. See fig 6.	Yes (1 item)
Straight through cable	• Spectrometer and PC are connected to a network. See fig. 5. • Spectrometer is connected to a network computer. See fig 6.	No **Note**: A straight data cable, category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T is required. **Note**: The data cable length should not exceed 100m (without repeater).

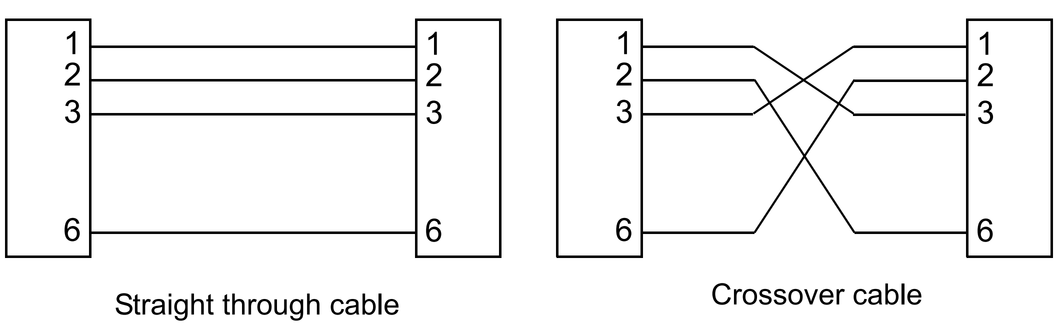


Figure 3: Schematic presentation of the different data cable types

Possible Connection Variants

Variant A (Standard): Connecting the Spectrometer to a stand-alone PC

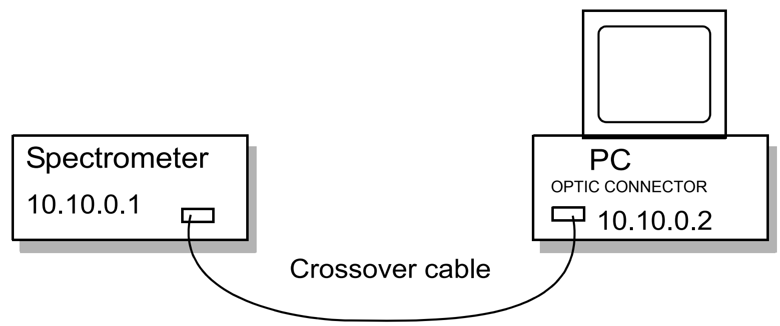


Figure 4: Stand-alone operation

The implementation of this connection variant involves the following steps:

1. Connect the supplied crossover data cable to the Ethernet port at the spectrometer rear side (A in fig. 2) and to the OPTIC CONNECTOR (fig. 4) at the PC rear side.

Note: **Only in case you have NOT purchased the computer at Bruker, you have to assign the IP address 10.10.0.2 to the computer to which you want to connect the spectrometer.**

2. Check the data transfer connection (See the corresponding section below in this chapter.)

Advantages:

- Full bandwidth available for data transfer between the spectrometer and PC.
- No access conflicts with other PCs that try to access the spectrometer as well.
- No problems caused by varying data transfer rates.

Disadvantages:

- No remote access to the spectrometer from other PCs on which OPUS is installed.
- PC has no access to the network resources.
- A local printer needs to be connected to the stand-alone PC to print out the measurement results.

Variant B: Connecting both Spectrometer and PC to a Network

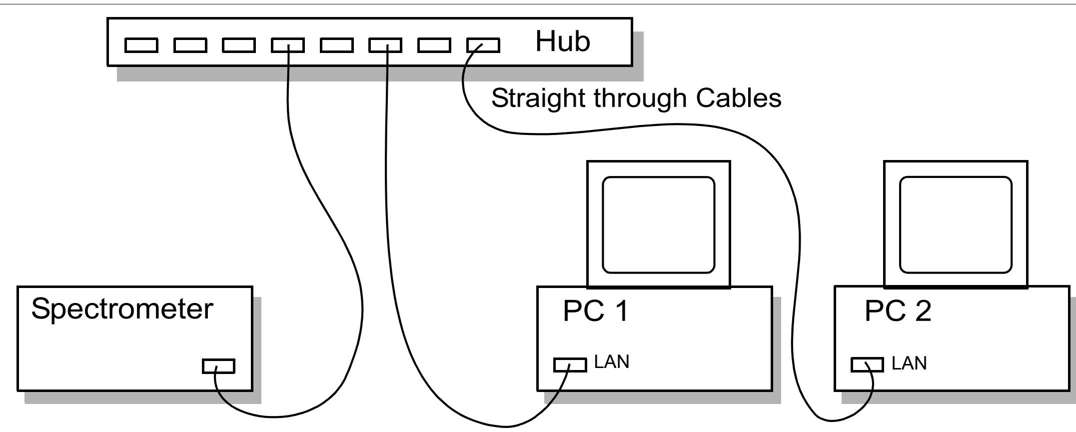


Figure 5: Direct Integration of the Spectrometer into a 10/100Base-T Ethernet Network

The implementation of this connection variant involves the following steps:

1. Procure straight through cables category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T. (Note: The number of data cables depends on the number of PCs you intended to connect to the network.)
2. **Spectrometer:** Connect one straight through data cable to the Ethernet port at the spectrometer rear side (A in fig. 2) and to the network hub.
3. **PC:** Connect the other straight through data cable to the LAN connector (fig. 5) at the PC rear side and to the network hub.
4. Assign an IP address to the spectrometer. (See the corresponding section below in this chapter.) This IP address needs to be defined by your network administrator.
5. Assign an IP address to the PC (LAN network interface card). This IP address needs to be defined by your network administrator.
6. Check the data transfer connection (See the corresponding section below in this chapter.)

Advantages:

- Remote access to the spectrometer via the internet or the intranet is possible.
- The PC can access to all network resources.

Disadvantages:

- Data cables are required which are not included in the delivery scope.
- Only a fraction of the bandwidth is available for the data transfer between PC and spectrometer. Due to data transfer delays, the measurement time may increase.
- Access conflicts caused by other PCs that try to access the spectrometer as well.

Variant C: Connecting the Spectrometer to a Network PC

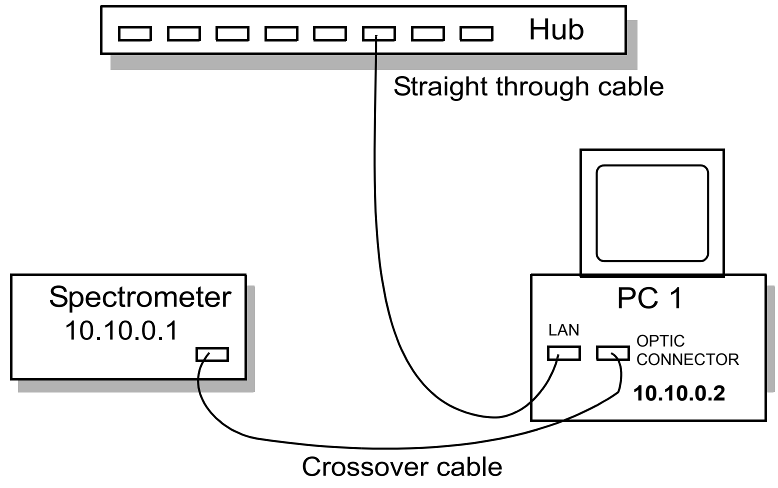


Figure 6: Integration of the Spectrometer into a 10/100Base-T Ethernet Network via a PC

The implementation of this connection variant involves the following steps:

1. Procure a straight through cable category 5, with RJ45 plugs for the Ethernet standard 10/100Base-T.
2. **Spectrometer:** Connect the supplied crossover data cable to the Ethernet port at the spectrometer rear side (A in fig. 2) and to the OPTIC CONNECTOR (fig. 6) at the PC rear side.
3. **PC:** Connect the straight through cable to the LAN connector (fig. 6) at the PC rear side and to a network hub.
4. Assign an IP address to the PC (LAN network interface card). This IP address needs to be defined by your network administrator.

Note: **Only in case you have NOT purchased the PC at Bruker, you have to assign the IP address 10.10.0.2 to the network interface card of the computer to which you want to connect the spectrometer.**

5. Check the data transfer connection (See below in this chapter.)

Advantages:

- Full bandwidth is available for the data transfer between the spectrometer and PC.
- Remote access to the spectrometer via internet or intranet is possible.
- The PC has access to all network resources.
- Different data transfer rates for the data exchange between the spectrometer (10/100Base-T) and the network (no restriction) are possible.

Disadvantages:

- A straight through cable is required which is not included in the delivery scope.
- A decrease in computing speed, due to the integration of the PC in a network, may affect time-critical measurements.

Network Addresses

Depending on the connection variant, different network addresses for spectrometer and PC are required:

Network Addresses in case of Connection Variant A (factory-configured variant):

Spectrometer:	IP address	10.10.0.1
	Subnet Mask	255.255.255.0
	Gateway	0.0.0.0 (no entry in case of Windows 2000 or XP)
PC:	IP address	10.10.0.2
	Subnet Mask	255.255.255.252
	Gateway	0.0.0.0 (no entry in case of Windows 2000 or XP)

The spectrometer and the PC delivered by Bruker are factory-configured for the stand-alone operation, i.e. all network addresses for a stand-alone operation are already assigned. Only in case you did **not** obtain the PC from Bruker you have to assign the above network addresses to the PC.

Network Addresses in case of Connection Variant B:

For this connection variant, both the spectrometer and the PC must have a unique IP address. These addresses depend on your intranet and have to be defined by your network administrator. To ensure that the spectrometer can be accessed via internet also a gateway address has to be assigned. The gateway links your intranet domain to other domains (e.g. domains being part of the internet). Otherwise, set the gateway address to 0.0.0.0. In case of the operating system Windows 2000 or XP do not specify a Gateway. **A wrong IP address can cause problems with other devices connected to the network!**

Network Addresses in case of Connection Variant C:

The implementation of this connection variant requires three network address sets: the first set is for the spectrometer, the second set is for the NIC[1] OPTIC CONNECTOR (communication between spectrometer and PC) and the third set is for NIC LAN (communication between PC and network). Note: Spectrometer and NIC OPTIC CONNECTOR are already factory-configured, provided you have obtained the PC from Bruker:

Spectrometer:	IP address	10.10.0.1
	Subnet Mask	255.255.255.0
	Gateway	0.0.0.0 (no entry in case of Windows 2000 or XP)

Network interface card to which the spectrometer is connected:

IP address	10.10.0.2
Subnet Mask	255.255.255.252
Gateway	0.0.0.0 (no entry in case of Windows 2000 or XP)

Network interface card to which the network hub is connected:

IP address	defined by your network administrator
Subnet Mask	defined by your network administrator
Gateway	defined by your network administrator

1. NIC - Network Interface Card (They are at the PC rear side.)

Assigning Network Address to the Spectrometer

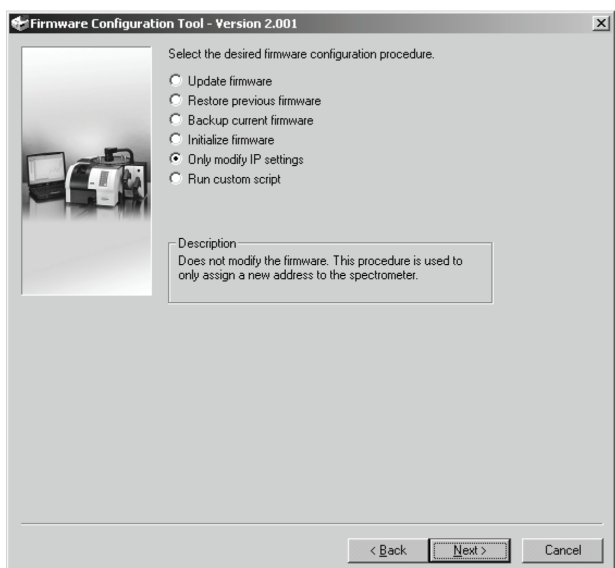
General Information

The spectrometer is delivered with the factory-assigned standard IP address 10.10.0.1, i.e. in case of connection variant A and C you need not assign network addresses to the spectrometer.

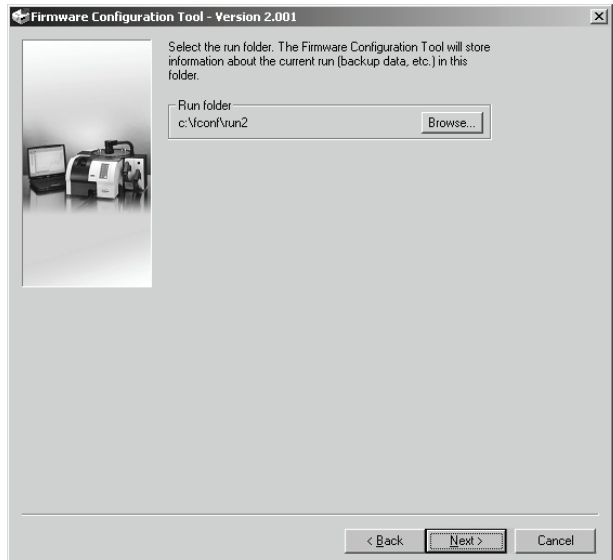
Only in case of connection variant B (i.e. connecting the spectrometer directly to a network, see fig. 5), different spectrometer network addresses are required. They need to be defined by your network administrator and assigned to the spectrometer using the FCONF program (Firmware Configuration). This program is part of the OPUS software.

IP Address Assignment Procedure

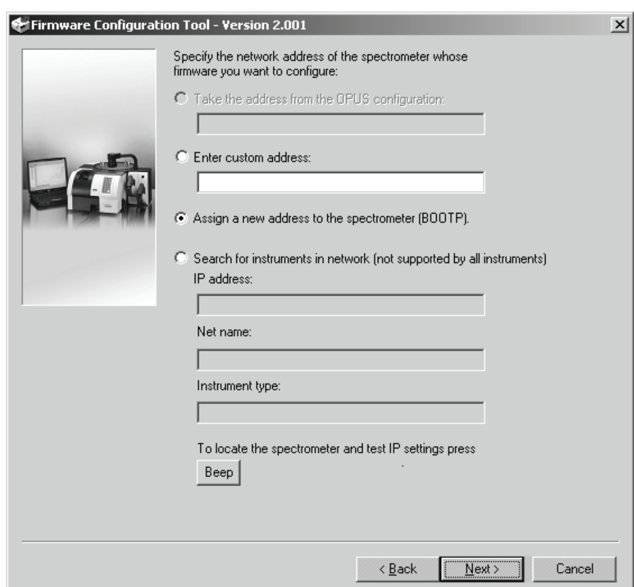
- Start the FCONF program. (You will find it in the OPUS directory or directly on the OPUS CD.)



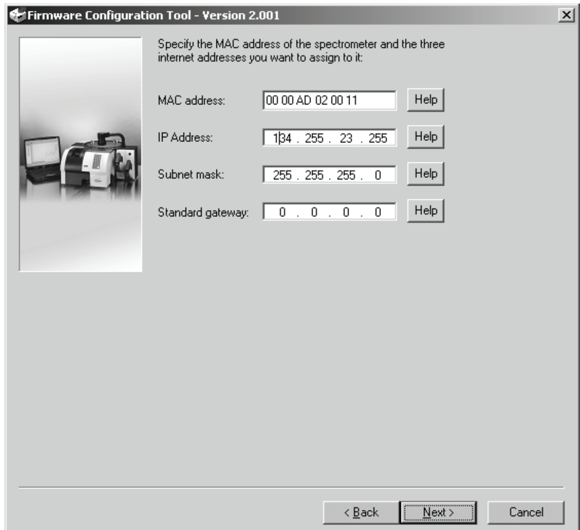
- Select the option *Modify IP settings* and click on the *Next* button.

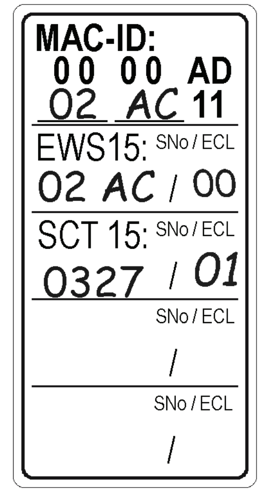


- Accept the settings by clicking on the *Next* button.



- Activate the radio button *Assign a new address to the spectrometer* and click on the *Next* button.
- The following dialog window opens:

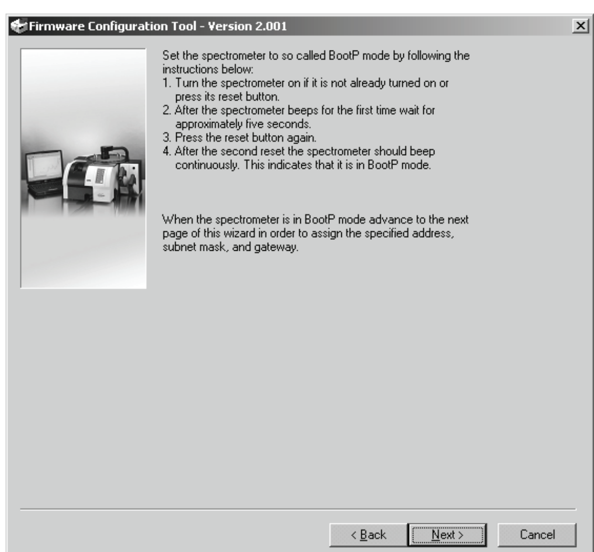




- Enter the MAC address[1], the new IP address, the subnet mask and the gateway address. After having entered all addresses, click on the *Next* button.

You will find the spectrometer MAC address on the label at the spectrometer rear side. (See the above figure. In this example, the MAC address is 00 00 AD 02 AC 11.) The network addresses (IP address, subnet mask and gateway) need to be defined by your network administrator. See section *Network Addresses* above in this chapter.

- Now you are asked to set the spectrometer into BootP-mode. Follow the instructions on the screen.



Note: The reset button (I in fig. 68) is on the spectrometer rear side.

1. MAC address (Media Access Control) It is the address of the network adapter (network interface card) that is integrated in a device. This address allows an unique identification of a device connected to a network.

- When the spectrometer is in BootP mode, click on the *Next* button to start the procedure. Otherwise, the BootP-mode will be canceled automatically after 2 minutes.
- The assigning process starts immediately and may take several minutes.
- After a successful completion, a message appears and the spectrometer reboots automatically.
- Now the spectrometer starts up with the newly assigned IP setting and can be accessed by the computer.

PC Network Addresses

By default, the PC supplied by Bruker is equipped with two network interface cards labelled OPTIC CONNECTOR and LAN. The network interface card OPTIC CONNECTOR is factory-assigned to the IP address 10.10.0.2, i.e. the PC is factory-configured for the spectrometer stand-alone operation. (See fig. 4, connection variant A.)

In case of connection variant B (fig.5) and variant C (fig. 6), your network administrator needs to define the network addresses for the PC. These addresses need to be assigned to the network interface card LAN of the PC.

In case you have not obtained the PC from Bruker, you have to assign the correct network addresses to the network interface card(s) of the PC to which you connect the spectrometer. Note: The network address for the PC depend on the your connection variant. See to section *Network Addresses* above in this chapter. In case of connection variant C (fig. 6), make sure that the PC is equipped with two network interface cards.

Checking the Communication between TENSOR and PC

After having implemented all cable connections and, if required, assigned the network addresses to the spectrometer and the PC, it is recommended to check the communication between the spectrometer and the PC. Proceed as follows:

1. Switch on the spectrometer. (See chapter *Operation*, section *Switching TENSOR on or off*.)
2. Wait until PC and spectrometer have started up.

Note: The operational availability of the spectrometer is indicated by a green STATUS indicator (fig. 10), i.e. after the spectrometer initialization is completed, this indicator turns from red to green.

3. Start the your Internet browser.
4. Check whether the Internet browser is **not** in offline mode.

Note: In case of the Microsoft Internet Explorer, the offline mode is indicated by a tick in front of *Offline Mode* in the *File* menu of the browser.

5 Ensure that the Internet browser does **not** use a proxy server, or at least not for addresses of direct access in the 10.10.x.x.-range.

Note: In case of the Microsoft Internet Explorer, you can check this by selecting the *Internet Options* function in the *Extra* browser menu. Click on the *Connections* tab. Then, click in the *LAN-Settings* group field on the *Settings* button.

6 Enter the spectrometer IP address in the browser entry field (See fig. 7.) and press the enter key.

7 In case of a successful communication between spectrometer and PC, the Internet Explorer now displays the home page of your spectrometer firmware.

Entering the spectrometer IP address
Note: The actual spectrometer IP address depends on your connection variant.

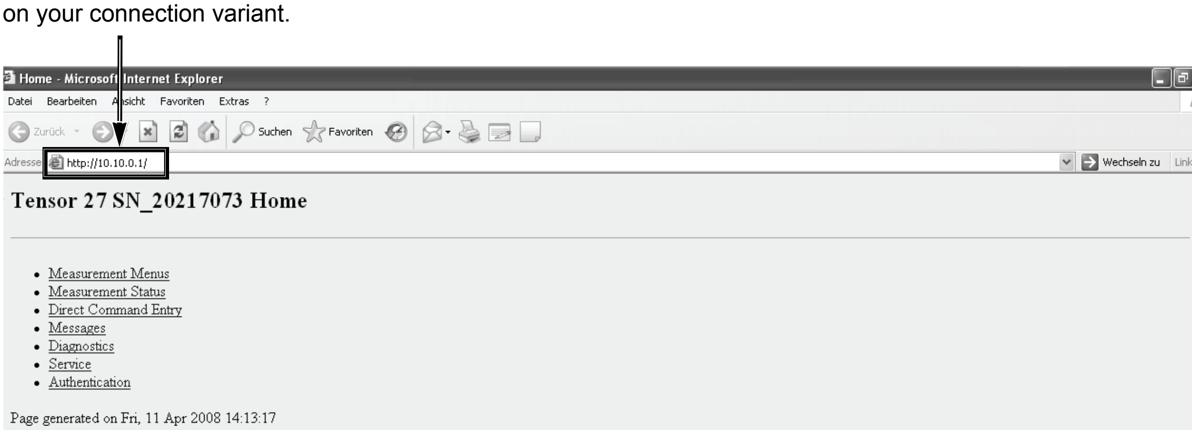


Figure 7: Microsoft Internet Explorer displaying the Homepage of the connected TENSOR

If the communication fails the Internet browser shows a blank page. In this case, check the spectrometer IP address for correct spelling. If this action does not solve the problem, refer to chapter *Troubleshooting,* section *Problem - Possible Cause - Solution*, subsection *No communication between spectrometer and computer*.

CONNECTING TENSOR TO THE PURGE GAS SUPPLY LINE

General Information

In case of TENSOR 27, only the sample compartment can be purged, whereas in case of TENSOR 37, both the sample compartment and the optical bench (i.e. interferometer and the detector compartment) can be purged. Consequently; TENSOR 27 has only one purge gas inlet and TENSOR 37 two purge gas inlets. The purge gas inlets are at the spectrometer rear side.

Note: In case of TENSOR 27, purging the detector and interferometer compartment is an optional feature. This feature is available only ex factory.

By default, the required connecting hoses (PVC, outer diameter: 6mm) are not included in the spectrometer delivery scope. Only in case of the purge options S139/B or S316/7, the required connecting hoses (including air flow regulator) are included in the delivery scope.

For detailed information about the required purge gas supply conditions refer to the chapter *Operation*, section *Purging the Spectrometer*.

Procedure

TENSOR 27

A stiff hose (PVC hose) with an outer diameter of 6mm is required.

- Remove the plug from the purge gas inlet (for the sample compartment) by pressing the lock ring inwards and pulling the plug out. (See fig. 8.)
- Insert the one end of the hose into the purge gas inlet at the spectrometer rear side and connect the other end of the hose to your purge gas supply line.

TENSOR 37

In case of TENSOR 37, there are two variants for connecting the purge gas hose depending on whether you want to purge either only the sample compartment or both the sample compartment plus the optical bench (interferometer compartment and detector compartment). For the first variant, see the procedure described above for TENSOR 27.

For the latter variant, a T-shape connection hose (PVC, outer diameter: 6mm) with two hose ends leading to the spectrometer is required. The installation procedure is described below.

- Remove the plugs from the purge gas inlets (for the sample compartment and for the interferometer and detector compartment) by pressing the lock ring inwards and pulling the plug out. (See fig. 8.)
- Connect the main end of the hose to your purge gas supply line. Insert one of the other two hose ends into the purge gas inlet for the sample compartment and the other hose end into the purge gas inlet for the interferometer and detector compartment. (See fig. 8.)

Warning: When you purge the interferometer and the detector compartment, do not forget to remove the plug from the purge gas outlet. (See fig. 8). Otherwise, overpressure will build up inside the spectrometer during the purging. This may lead to spectrometer damage.

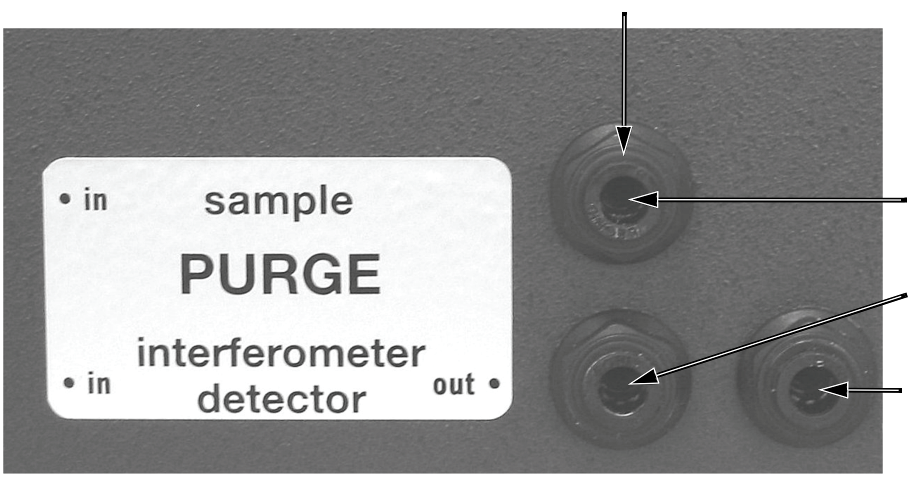


Figure 8: Spectrometer Rear Side - Purge Gas Inlet and Outlet Port (TENSOR 37)

4 OVERVIEW

GENERAL INFORMATION

This chapter describes all relevant external and internal spectrometer components.

Note: The local indications *right* and *left* assume that the operator stands in front of the spectrometer. The indications *forward* and *backward* refer to the spectrometer front side and rear side, respectively.

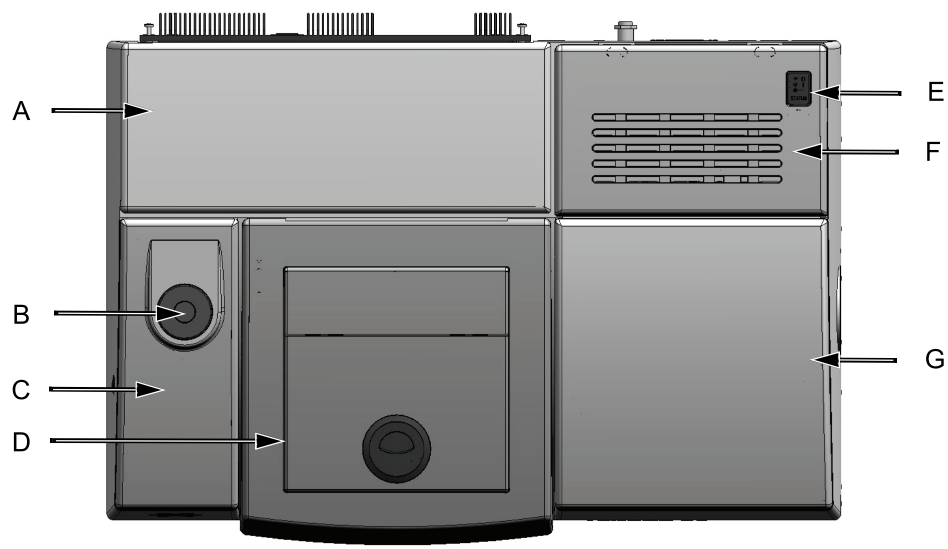


Figure 9: General Overview

Fig. 9	Compartment / External Components
A	Electronics compartment
B	Filler inlet (for filling in liquid nitrogen in case of an optional MCT detector) **Note:** See chapter *Operation*, section *Cooling the MCT Detector*.)
C	Detector compartment
D	Sample compartment
E	Spectrometer display
F	Source/laser compartment
G	Interferometer compartment

All spectrometer compartments are accessible by opening or removing the corresponding cover. All covers are provided with gaskets to prevent air from entering these compartments when they are closed.

SPECTROMETER DISPLAY

The spectrometer diplay (fig. 10) gives a general indication of the water vapor concentration inside the spectrometer, the laser power supply conditions and the general spectrometer status. In case of a spectrometer problem, the spectrometer display facilitates the fault diagnostics. See also chapter *Troubleshooting*.

Figure 10: Spectrometer display

HUMIDITY INDICATOR 

Red - Water vapor concentration inside the spectrometer is too high, i.e. a certain, factory-set limit value is exceeded.

Off - Water vapor concentration inside the spectrometer is OK.

LASER INDICATOR 

Yellow - Laser is in operation. (Laser power supply is OK.)
Off - Laser power supply is interrupted.

STATUS INDICATOR 

Green - Spectrometer is in proper operating condition.

Red - Either there is a spectrometer problem (e.g. laser is out of alignment or IR source is defective) or the spectrometer is still in the initialization phase. (Note: After the spectrometer initialization is completed the indicator turns from red to green.)

SAMPLE COMPARTMENT

The sample compartment can be accessed from the front side as well as from the top side of the spectrometer. You can either turn the whole sample compartment cover upwards (fig. 11a) or open only the top lid using the handle (fig. 11b).

For installing an accessory in the sample compartment or removing it, the whole sample compartment cover needs to turned upwards. For exchanging the sample, it is sufficient to turn only the top lid of the sample compartment cover backwards. In case of an accessory that juts out of the sample compartment, keep the top lid open. (For information about how to install an accessory in the sample compartment refer to chapter *Operation*, section *Placing an Accessory in the Sample Compartment*.)

The sample compartment dimensions are 25cm (w) x 27cm (d) x 16cm (h).

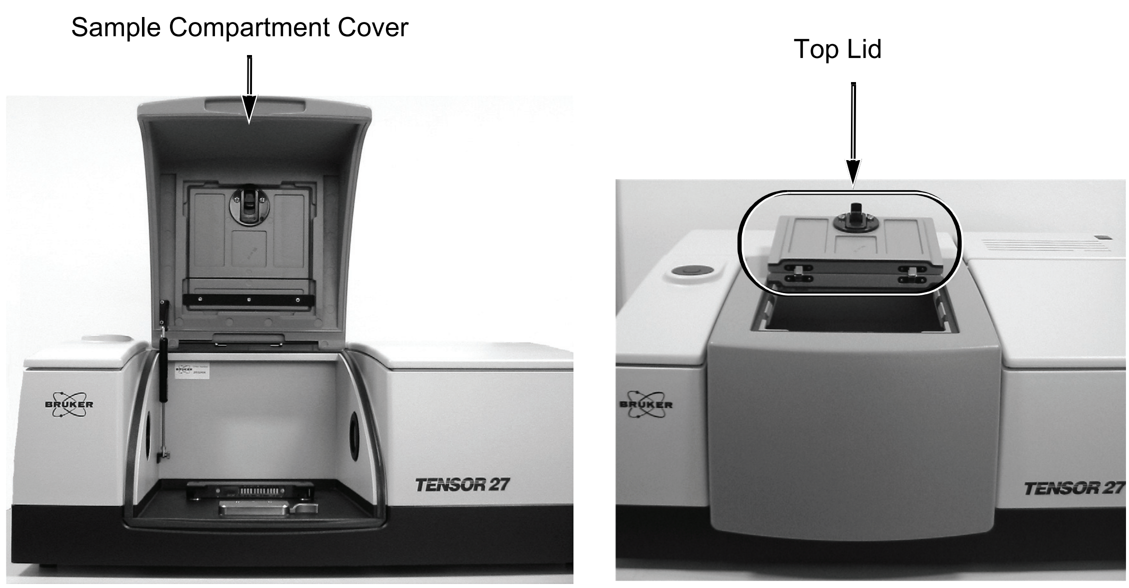


Figure 11: a) Sample compartment completely open b) Sample compartment with open top lid

To install a bulky or special accessory in the sample compartment, you can also remove the complete sample compartment cover by unscrewing the knurled thumb screw (A in fig. 12) and pressing the pins (B in fig. 12) to the center as shown in fig. 12.

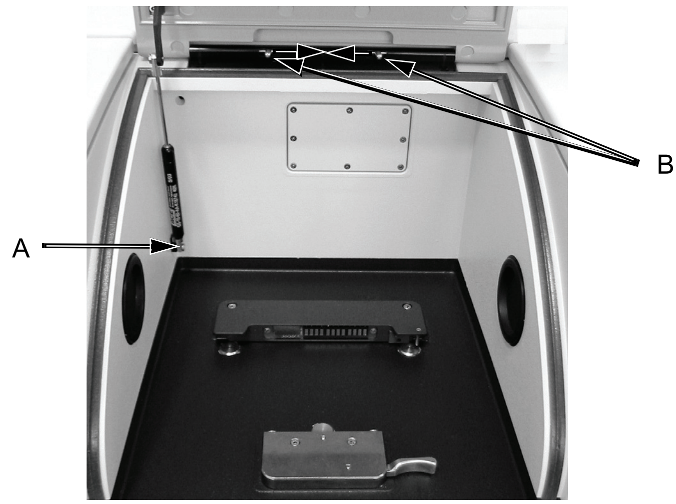


Figure 12: Removing the Sample Compartment Cover

IR BEAM OUTLET PORT

At the right spectrometer side, there is an IR beam outlet port allowing the flange connection of external accessories (e.g. IR microscope or HTS-XT module).

Note: External accessories (e.g. HYPERION microscope) are flange-connected and installed by the Bruker service engineers.

If there is not any accessory flange-connected to the TENSOR spectrometer, the IR beam outlet port is obturated by a blind flange. (See fig. 13.) The blind flange is fixed by a bayonet joint. For removing or installing the blind flange from the IR beam outlet port use the supplied flange tool. (Note: For information about how to use the flange removal tool see chapter *Maintenance and Repair*, section *Replacing a damaged Sample Compartment Window*.)

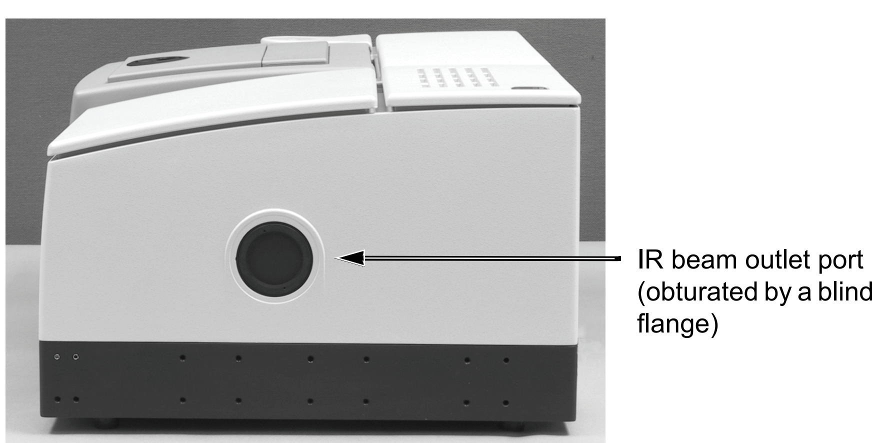


Figure 13: TENSOR - Right side view

SPECTROMETER REAR SIDE

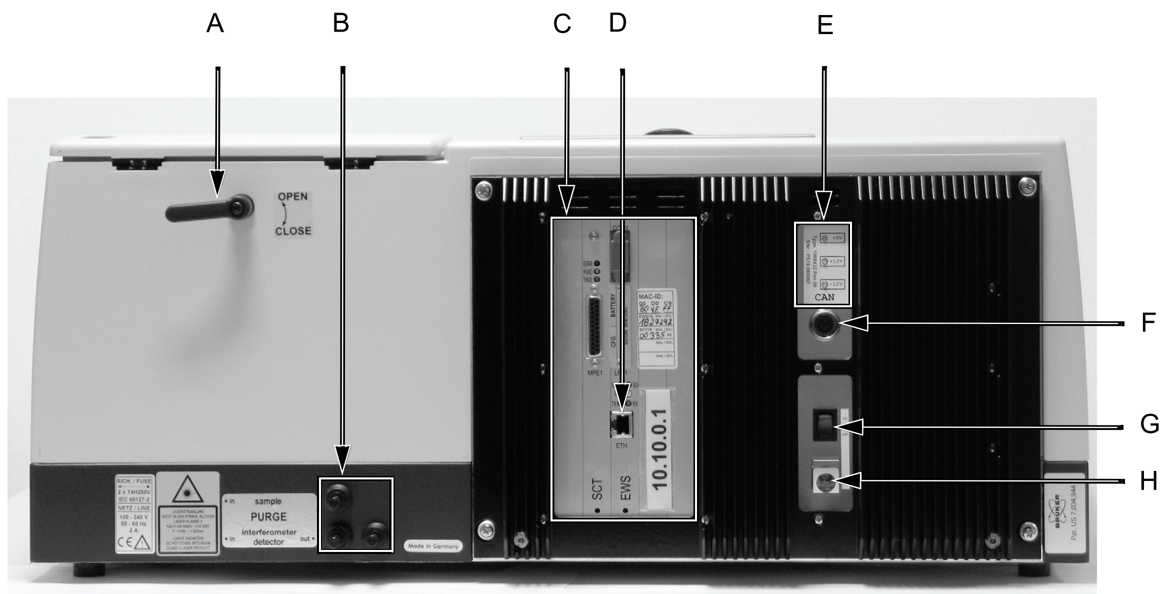


Figure 14: Spectrometer (TENSOR 37) - Rear view

Fig. 14	Components
A	Handle for locking or unlocking the interferometer compartment cover (only in case of TENSOR 37) Handle position OPEN: Interferometer compartment cover is unlocked, i.e. the cover can be removed. Handle position CLOSE: Interferometer compartment cover is locked, i.e. the cover can not be removed.
B	TENSOR 37: 2x Purge gas inlets and 1x outlet TENSOR 27: 1x Purge gas inlet (**Note:** For detailed information refer to chapter *Installation*, section *Connecting TENSOR to the Purge Gas Supply Line*.)
C	Electronics - connector sockets and LEDs (**Note:** For detailed information refer to appendix E.)
D	Ethernet port (for connecting the data cable)
E	Voltage status LEDs
F	CAN bus port
G	On/off switch (for switching the spectrometer on and off)
H	Low-voltage socket (male connector for connecting the low-voltage cable)

TENSOR 27 - OVERVIEW

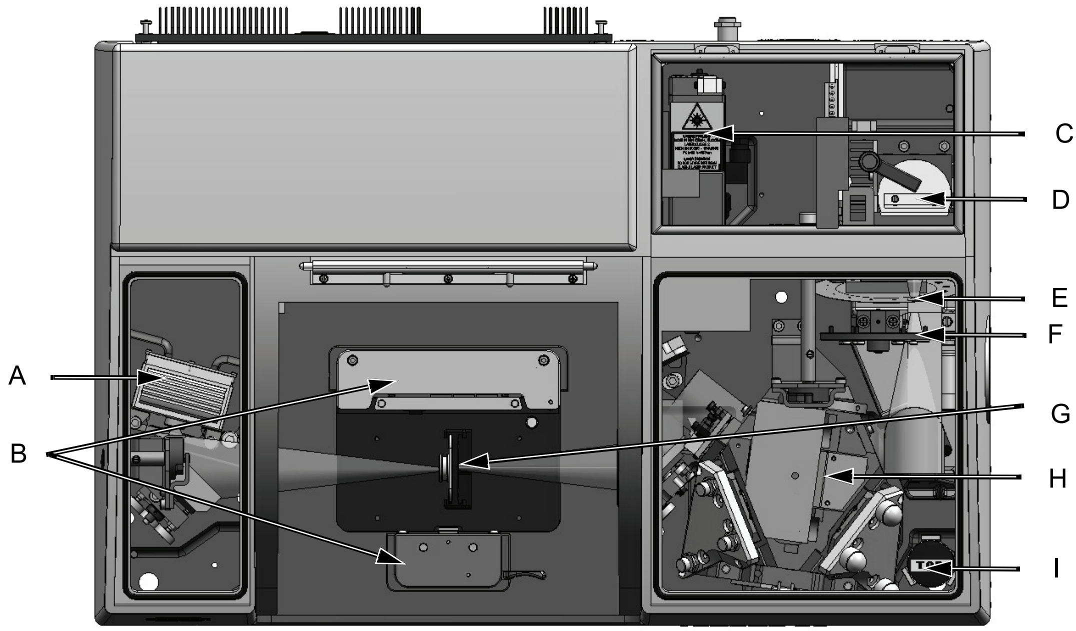


Figure 15: TENSOR 27 - Internal Components

Fig. 15	Component
A	Detector
B	QuickLock mechanism for accessories
C	Laser
D	MIR source (operating position)
E	Aperture wheel
F	Filter wheel (IVU - internal validation unit)
G	Sample holder (standard)
H	Interferometer (including factory-installed beamsplitter)
I	Desiccant cartridge

TENSOR 37 - OVERVIEW

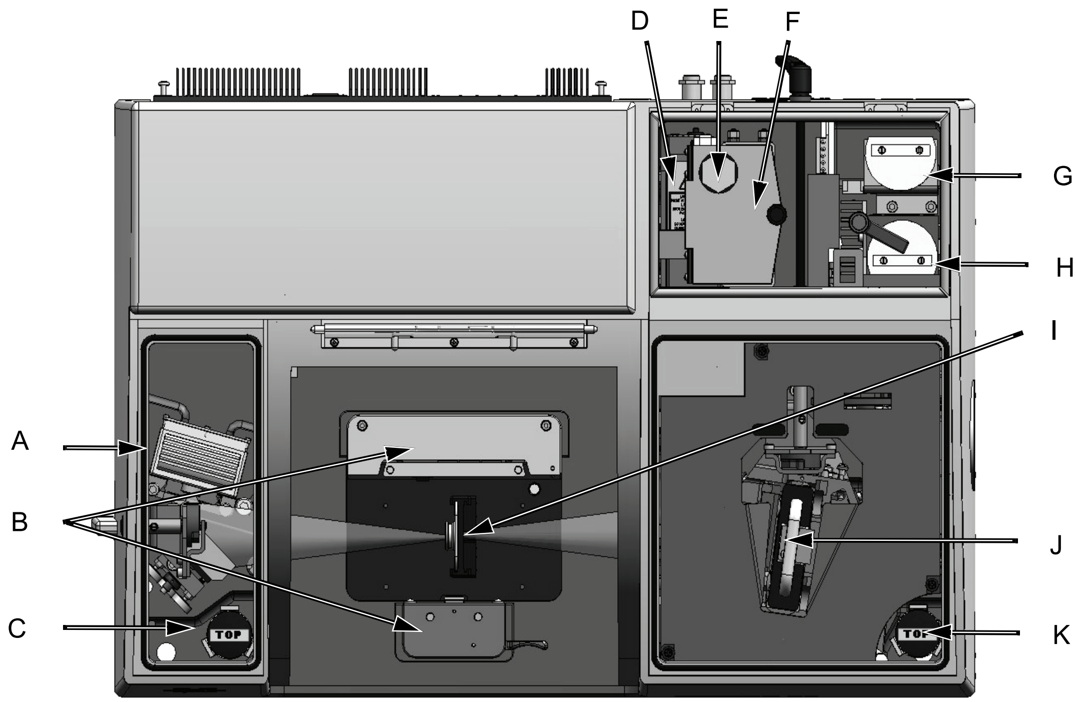


Figure 16: TENSOR 37 - Internal Components

Fig. 16	Component
A	Detector
B	QuickLock mechanism for accessories
C	Desiccant cartridge (in detector compartment)
D	Laser
E	Humidity indicator of desiccant cartridge (in beamsplitter storage box)
F	Beamsplitter storage box
G	IR source (storage position)
H	IR source (operating position)
I	Sample holder (standard)
J	Beamsplitter
K	Desiccant cartridge (in interferometer compartment)

Note: In figure 16, the spectrometer components interferometer, aperture wheel and filter wheel are hidden by the cover. The locations of these components inside the spectrometer are identical to TENSOR 27. See figure 15.

IR SOURCE

TENSOR 27 is provided with only one MIR source (D in fig. 15). The MIR source is a globar (i.e. an U-shaped silicon carbide piece) that emits middle-infrared light.

TENSOR 37 is equipped with both MIR source and NIR source (G and H in fig. 16). The MIR source is a globar (i.e. an U-shaped silicon carbide piece) that emits middle-infrared light. The NIR source is a tungsten halogen lamp and emits near-infrared light.

Note: The source type, you intend to use, has to be installed in the operating position (H in fig. 16). For information about how to exchange the source refer to chapter *Operation*, section *Substituting the Source*.

DETECTOR

By default, both **TENSOR 27** and **TENSOR 37** are equipped with a DLaTGS detector which covers a spectral range from 12,000 to 350cm^{-1}, operates at room temperature and has a sensitivity of D*>4x10^{8}cm Hz$^{1/2}$W^{-1}. In addition, there are optional detectors providing different spectral ranges and sensitivities. All available detectors are mounted on dovetail slides which allow an easy exchange. In addition, all detectors are equipped with an integrated preamplifier and A/D converter that converts the analog signal from the detector directly into a digital signal. This so called DigiTect technology allows for an interference-free signal transmission and ensure a high signal-to-noise-ratio.

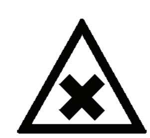
TENSOR 27 - optional detectors

Detector	Spectral Range (cm^{-1})	Sensitivity	Cooling Method
Mid-Infrared			
DLaTGS (Standard)	12,000 - 350	D*>4x10^{8}cm Hz$^{1/2}$W^{-1}	Room temperature
DLaTGS	12,000 - 180	D*>4x10^{8}cm Hz$^{1/2}$W^{-1}	Room temperature
MCT narrow band, with BaF_2 window CAUTION - HARMFUL!	12,000 - 850	D*>4x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
MCT mid band, with ZnSe window CAUTION - TOXIC!	12,000 - 600	D*>2x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled
MCT broad band, with KRS-5 window CAUTION - TOXIC!	12,000 - 420	D*>5x10^{9}cm Hz$^{1/2}$W^{-1}	Liquid N_2 cooled
Photovoltaic MCT, with BaF_2 window CAUTION - HARMFUL!	12,000 - 850	D*>3x10^{10}cm Hz$^{1/2}$ W^{-1}	Liquid N_2 cooled

TENSOR 37 - optional detectors

Detector	Spectral Range (cm^{-1})	Sensitivity	Cooling Method
Mid-Infrared			
DLaTGS	12,000 - 350	$D^* > 4x10^8 cm\ Hz^{1/2} W^{-1}$	Room temperature
DLaTGS	12,000 - 180	$D^* > 4x10^8 cm\ Hz^{1/2} W^{-1}$	Room temperature
MCT narrow band, with BaF_2 window CAUTION - HARMFUL!	12,000 - 850	$D^* > 4x10^{10} cm\ Hz^{1/2}\ W^{-1}$	Liquid N_2 cooled
MCT mid band, with ZnSe window CAUTION - TOXIC!	12,000 - 600	$D^* > 2x10^{10} cm\ Hz^{1/2}\ W^{-1}$	Liquid N_2 cooled
MCT broad band, with KRS-5 window CAUTION - TOXIC!	12,000 - 420	$D^* > 5x10^9 cm\ Hz^{1/2} W^{-1}$	Liquid N_2 cooled
Photovoltaic MCT, with BaF_2 window CAUTION - HARMFUL!	12,000 - 850	$D^* > 3x10^{10} cm\ Hz^{1/2}\ W^{-1}$	Liquid N_2 cooled
Near-Infrared			
InSb	10,000 - 1,850	$D^* > 1.5x10^{11} cm\ Hz^{1/2}\ W^{-1}$	Liquid N_2 cooled
InAs Diode	12,800 - 3,300	$NEP < 1x10^{-12}\ W\ Hz^{-1/2}$	Peltier cooled
InGaAs Diode	12,800 - 5,800	$NEP < 2x10^{-14}\ W\ Hz^{-1/2}$	Room temperature
InGaAs Diode	12,500 - 4,000	$NEP < 2x10^{-13}\ W\ Hz^{-1/2}$	Peltier cooled
InGaAs Diode	12,800 - 5,800	$NEP < 5x10^{-12}\ W\ Hz^{-1/2}$	Room temperature

Warning: Some detectors are equipped with windows of which the material is harmful or (very) toxic. During normal spectrometer operation, these materials do not pose a health risk. However, should these windows break caused by mechanical impact, be extremely careful. Avoid generating dust. These materials are harmful or toxic if swallowed or inhaled. Also avoid skin and eye contact.



BEAMSPLITTER

TENSOR 27

In case of TENSOR 27, the beamsplitter is factory-integrated in the interferometer block, i.e. it can not be replaced by another one. Depending on the ordered spectrometer variant, TENSOR 27 can be equipped with the following beamsplitters:

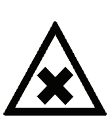
Beamsplitter	Spectral Range (cm^{-1})
Mid-Infrared	
KBr (standard)	7,800 - 370
KBr (broad band)	10,000 - 400
CsI	5,000 - 200
ZnSe („high humidity variant") CAUTION - TOXIC!	5,000 - 500

Warning: The beamsplitter material ZnSe material is toxic. During normal spectrometer operation, it does not pose a health risk. However, should the material break caused by mechanical impact, be extremely careful. Avoid generating dust. The material is toxic if swallowed or inhaled. Also avoid skin and eye contact.

TENSOR 37

In case of TENSOR 37, the beamsplitter can be exchanged by the user. (See chapter *Operation*, section *Substituting the Beamsplitter*. For TENSOR 37, the following beamsplitters are available:

Beamsplitter	Spectral Range (cm^{-1})	Color Coding of the Beamsplitter Handle
Mid-Infrared		
KBr (standard)	7,800 - 370	red
KBr (broad band)	10,000 - 400	red
Near-Infrared		
CaF_2 CAUTION - HARMFUL!	15,500 - 1,200	black
Far-Infrared		
Silicon solid state	600 - 10	nickel-plated
Alignment Tool		
Glass	For alignment purposes only!	nickel-plated



Caution: The beamsplitter material CaF_2 is harmful. During normal spectrometer operation, it does not pose a health risk. However, should the material break caused by mechanical impact, be careful. Avoid generating dust. The material is harmful if swallowed or inhaled. Also avoid skin and eye contact.

SAMPLE COMPARTMENT WINDOWS

In case of **TENSOR 27**, the sample compartment is equipped with one IR-transparent window that separates the sample compartment from the interferometer compartment. The actual window material (KBr or ZnSe or CsI) depends on your TENSOR 27 variant, (See chapter *General*, section *TENSOR 27 Variants*.)

In case of **TENSOR 37**, the sample compartment is equipped with two IR-transparent windows that separate the sample compartment from both the interferometer compartment and the detector compartment. See fig. 17. For TENSOR 37, various window materials are available.

Sample compartment windows

Note: In case of TENSOR 27, there is no window in this place.

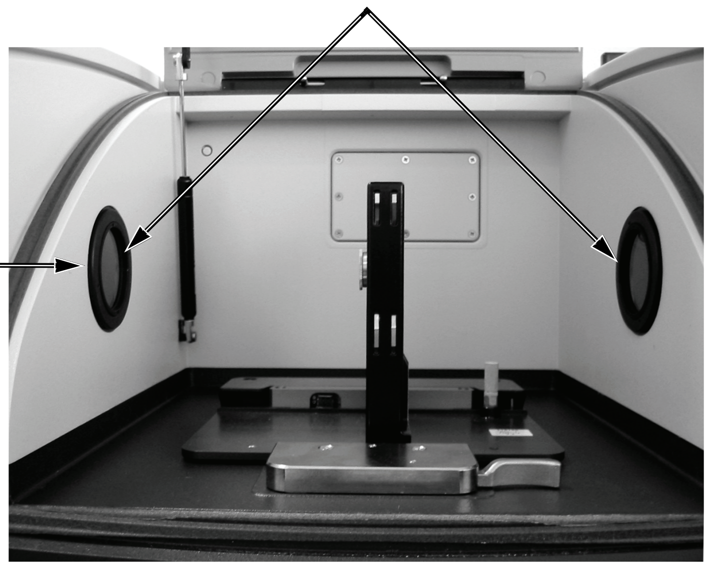


Figure 17: Sample compartment (TENSOR 37)

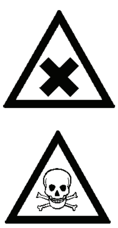
TENSOR 27 and TENSOR 37

The following table lists the optical materials of the available sample compartment windows. (For information about the refraction index and chemical properties of these optical materials refer to appendix A.)

Material	Transmission Range (cm^{-1})*
Quartz (Infrasil), SiO_2	57,000 - 2,800
Calcium Fluoride, CaF_2	66,000 - 1,000
Barium Fluoride, BaF_2 CAUTION - HARMFUL!	50,000 - 800
Sodium Chloride, NaCl	28,000 - 580

Material	Transmission Range (cm^{-1})*
Zinc Selenide, ZnSe CAUTION - TOXIC!	20,000 - 500
Potassium Bromide, KBr	33,000 - 280
Cesium Iodide, CsI CAUTION - HARMFUL!	33,000 - 180
KRS-5 (TIBr/I thallium bromide-iodide) CAUTION - VERY TOXIC!	16,000 - 250
Polyethylene, PE (high density)	600 - 10

* 50% value at a window thickness of 4mm



Warning: Some window materials are harmful or (very) toxic. Observe the safety instructions on the packaging and the safety data sheets attached. Non-observance may cause serious health problems or even death.

LASER

TENSOR is equipped with a HeNe laser (laser class 2). This laser emits red light with a wavelength of 633nm. The rated power output is 1mW. The laser controls the position of the moving interferometer mirrors (also called ’scanner’) and is used to determine the data sampling positions. The monochromatic beam produced by the HeNe laser is modulated by the interferometer to generate a sinusoidal signal.

For information about how to replace a defective laser module refer to chapter *Maintenance and Repair* section *Replacing a defective Laser*.

INTERFEROMETER

TENSOR is equipped with a high stability interferometer with ROCKSOLID permanent alignment. The ROCKSOLID interferometer incorporates dual retroreflecting cube corner mirrors in pendulum arrangement. The high throughput design ensures the highest possible signal-to-noise ratio.

DESICCANT CARTRIDGE

The main purpose of the desiccant cartridge(s) is to keep the water vapor concentration inside the spectrometer low in order to prevent the hygroscopic spectrometer components (e.g. beamsplitter, sample compartment windows) from deteriorating. The desiccant (molecular sieve) binds the air moisture inside the spectrometer.

An additional aspect for the usage of a desiccant is that water vapor in the ambient air may lead to unwanted absorptions that manifest in the spectrum. In the worst case, H_2O absorptions mask the spectral features of the sample in the spectrum. Therefore, it is necessary to reduce the water vapor content in the air inside the spectrometer.

TENSOR 27 is equipped with one desiccant cartridge. The cartridge is situated in the interferometer compartment (I in fig. 15).

TENSOR 37 is equipped with three desiccant cartridges: one cartridge is situated in the detector compartment (C in fig. 16) and one cartridge is situated in the interferometer compartment (K in fig. 16). An additional desiccant cartridge is in the beamsplitter storage box (E in fig. 16). This desiccant cartridge prevents a hygroscopic beamsplitter from deteriorating.

For information on how to replace and regenerate a desiccant cartridge refer to chapter *Maintenance and Repair,* section *Replacing the Cartridge and Regenerating the Desiccant*.

BEAM PATH

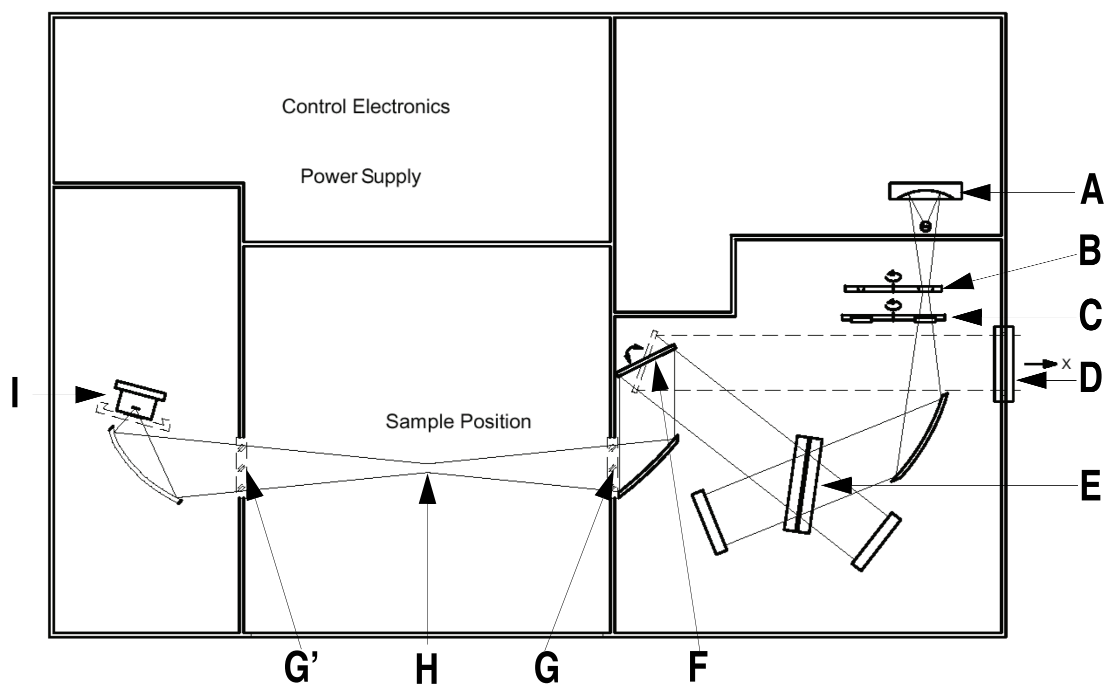


Figure 18: TENSOR - Beam Path

Fig. 18	Component
A	IR source
B	Aperture wheel
C	Filter wheel (IVU - Internal Validation Unit)
D	IR beam outlet port
E	Beamsplitter
F	Switch mirror **Note:** Depending on the position of the switch mirror (F), the IR beam is either directed through the sample compartment (G) or to the IR beam outlet port (D).
G	Sample compartment window
G’	Sample compartment window (only incase of TENSOR 37)
H	Sample
I	Detector

OPERATION

5

GENERAL INFORMATION

This manual is restricted mainly to the spectrometer-related aspects that are relevant to operating the TENSOR spectrometer:

- chronological sequence of the individual operating steps during a measurement (general measurement procedure)
- purging the spectrometer
- extending the spectral range (Only possible in case of TENSOR 37!)
- cooling the MCT detector

Specifying the measurement parameters and starting a measurement as well defining and starting a spectrometer validation test (OQ and PQ) are done exclusively using the spectroscopy software OPUS. For detailed information about these topics refer to the OPUS Reference Manual. The OPUS instructions “Getting Started” explains step by step how to perform the first measurement after the spectrometer has been set up.

General Safety Note

Caution: During the spectrometer operation, the IR source generates heat which is dissipated by the ventilation slots (fig. 19) at the spectrometer top side in order to avoid an excessive temperature increase inside the source/laser compartment and to prevent the source from overheating. Therefore, do NOT cover the ventilation slots to ensure a proper heat dissipation. Failure to do so can lead to spectrometer component damage.

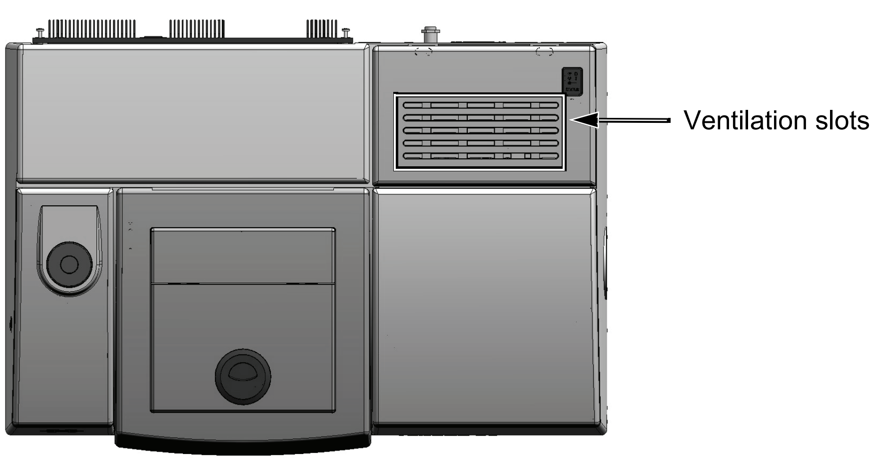


Figure 19: TENSOR - Top view

SWITCHING TENSOR ON OR OFF

For switching on or off the spectrometer, use the on/off switch. The on/off switch is located at the spectrometer rear side. See fig. 20.

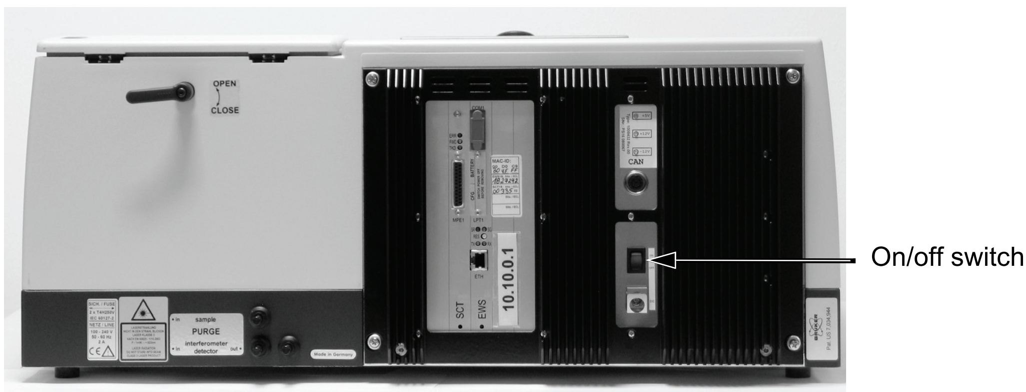


Figure 20: Spectrometer rear side

After having switched on the spectrometer, it starts booting. The initialization takes about 30 seconds. As soon as it is completed successfully, the STATUS indicator lamp (fig. 10) turns from red to green. A green STATUS indicator lamp indicates that the spectrometer is ready for operation.

After having switched on the spectrometer wait at least ten minutes before starting the first measurement. This allows for the electronics and the source to stabilize thermally.

Caution: After having switched off the spectrometer, wait at least 30 seconds before switching the spectrometer on again. This measure avoids peaks in the initial current which could lead to fuse blowing and/or damaging electronic components.

PLACING AN ACCESSORY IN THE SAMPLE COMPARTMENT

General Information

The sample compartment is equipped with a QuickLock mechanism (fig. 21) that allows for an exact and reproducible positioning of all kinds of accessories in the sample compartment, provided that the accessory is mounted on a QuickLock base plate.

The purge gas inlet of QuickLock mechanism (fig. 21) provides for purging the sample compartment with dry air or nitrogen. With installed accessory, the purge gas enters the sample compartment by the purge gas diffusor at the accessory (fig. 22).

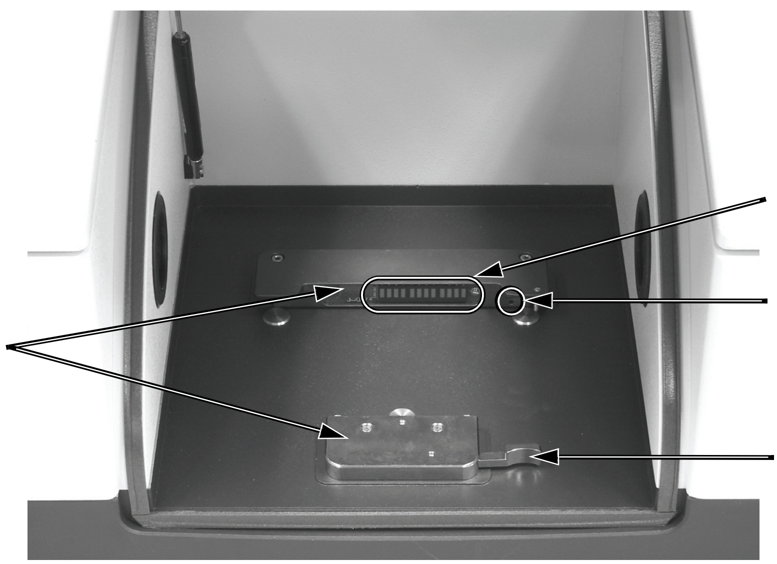


Figure 21: Sample compartment - QuickLock mechanism

Putting an accessory in the sample compartment

1. Put the accessory in the QuickLock mechanism of the sample compartment with the contact strip at the accessory base plate (fig. 22) coming in contact with the contact strip of the QuickLock mechanism in the sample compartment (fig. 21). In doing so, tilt the front side of the accessory base plate slightly upwards. Ensure that the base plate is horizontally aligned to the QuickLock mechanism in the sample compartment.
2. Press the front edge of the accessory base plate downward until it snaps into place. (Hint: To facilitate the insertion of the accessory, press the release lever backwards.)

Due to the contact strips, the electronic connections for AAR (Automatic Accessory Recognition) are established immediately. This is indicated by beep.

As soon as the accessory locks into place, the OPUS function AAR starts and recognizes automatically the accessory in question, provided the AAR function is activated in OPUS. When you place an accessory in the sample compartment for the very first time the OPUS/AAR software cannot recognize it because it is not registered yet. In this case, you are asked by the AAR program to register the new accessory. For detailed information about this software feature refer to the OPUS Reference Manual, manual part OPUS/AAR.

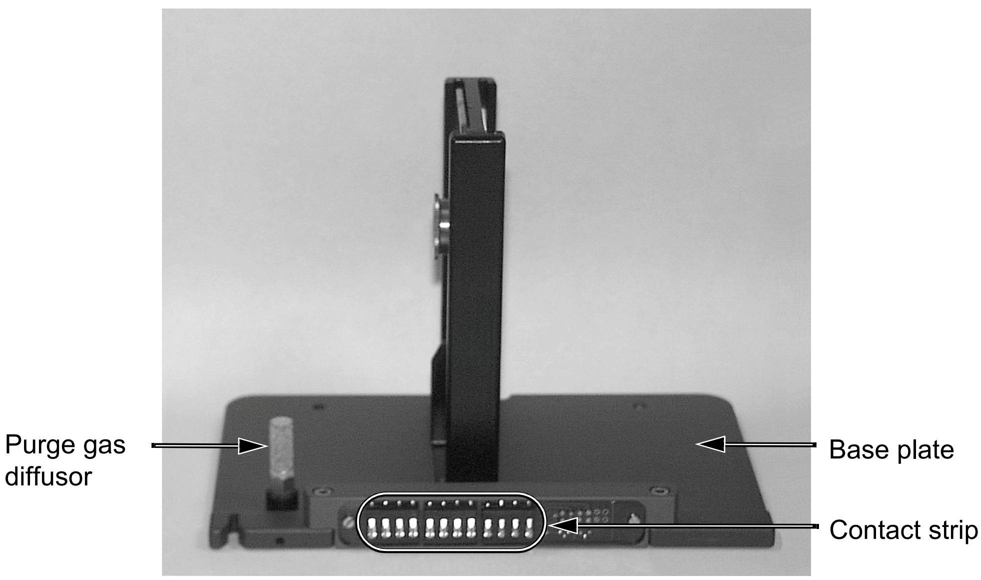


Figure 22: Accessory (rear side) - Sample holder (standard)

Taking an accessory out of the sample compartment

1. Push the QuickLock release lever (fig. 21) backwards.
2. While pushing the QuickLock release lever, lift the front edge of the accessory base plate until the base plate snaps free. Take the accessory carefully out of the QuickLock mechanism to avoid damages to the contact strips!

GENERAL MEASUREMENT PROCEDURE

It is highly recommended to validate the spectrometer performance each day before you start your analytical work by performing a PQ test[1] using OVP[2]. For detailed information about how to validate the spectrometer refer to the OPUS Reference Manual.

1 If you intend to measure the sample using a special accessory[3], place the accessory (without sample!) in the sample compartment. (See the previous section *Placing an Accessory in the Sample Compartment*.) If you intend to measure the sample using the standard sample holder (fig. 22) you can skip this step. (Note: This sample holder is included in the standard delivery scope.)

2 Start OPUS and set the parameters in the *Measurement* dialog window. To do this select in the OPUS *Measure* menu the *Advanced Measurement* function and select or enter the parameter values. (The standard measurement parameter values for a TENSOR spectrometer are listed in appendix C.)

3 If required, purge the spectrometer. (See also the following section.)

4 Acquire a background spectrum (i.e. **without** the sample in the sample compartment) by clicking in OPUS on the *Background Single Channel* button. See fig. 23.

Note: Depending on how you intend to prepare your sample (e.g. KBr pellet, mull or sample solution), it is highly recommended to perform the background measurement with either a pure KBr pellet or the pure nujol or the pure solution placed in the sample position. (For detailed information about sample preparation refer to appendix G.)

The purpose of the background measurement is to detect the influence of the ambient conditions (level of air humidity, temperature etc.), the auxiliary materials (e.g. solutions), that are required for preparing the sample, and the spectrometer itself on the spectroscopic measurement result. After the subsequent sample measurement, OPUS calculates automatically the result sample spectrum by dividing the sample spectrum (SSC[4]) by the background spectrum (RSC[5]). In doing so, those spectral bands, that result from the ambient conditions, auxiliary materials and/or the spectrometer, are eliminated from the result sample spectrum.

1. PQ test - Performance Qualification Test
2. OVP - OPUS Validation Program (It is intended for performing spectrometer validation tests like OQ and PQ.)
3. Bruker offers a wide range of accessories designed for special analytical applications. For detailed information about how to perform a measurement with a particular accessory, refer to the User Instructions delivered with the accessory in question.
4. SSC - Sample Single Channel (data block of the spectrum file in OPUS)
5. RSC - Reference Single Channel (data block of the spectrum file in OPUS)

5 Put the sample in the spectrometer sample compartment. (For information about adequate sample preparation techniques in FT-IR spectroscopy refer to appendix G.)

6 If necessary, purge the spectrometer again.

7 Acquire a sample spectrum by clicking in OPUS on the *Sample Single Channel* button. See fig. 23.

Important: Perform both the background measurement and the sample measurement with the same parameter settings in OPUS. Ensure that for both measurements, the ambient conditions (water vapor concentration, temperature etc.) are identical or at least nearly identical.

Afterwards, OPUS calculates automatically the result sample spectrum by dividing the sample spectrum (acquired in step 7) by the background spectrum (acquired in step 4).

For detailed information about the OPUS functions for data acquisition, manipulation and evaluation refer to the OPUS Reference Manual.

Click on this button to start the background measurement.

Click on this button to start the sample measurement.

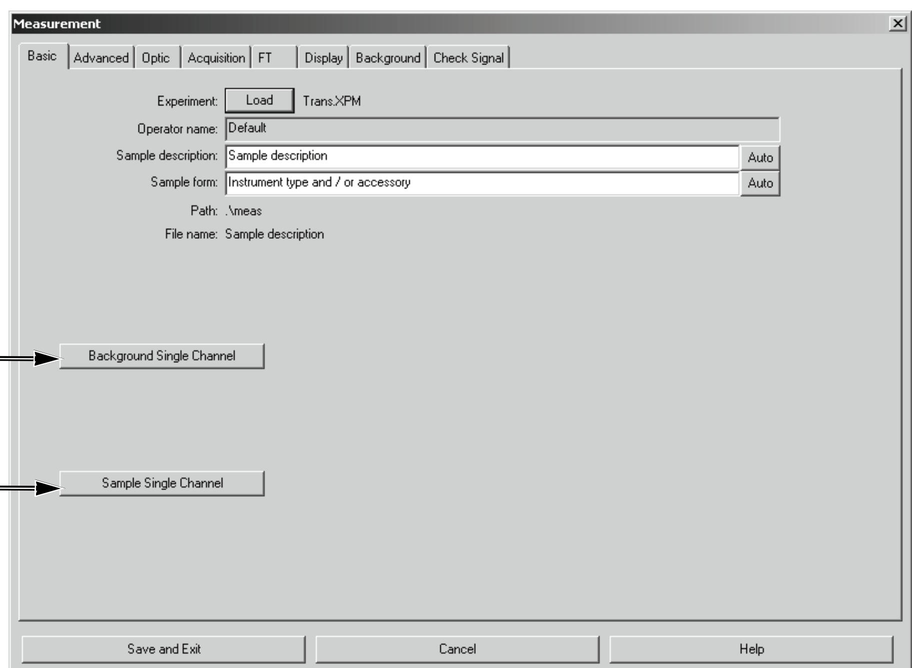


Figure 23: OPUS Measurement dialog window

PURGING THE SPECTROMETER

General Information

In case of TENSOR 27, only the sample compartment can be purged, whereas in case of TENSOR 37, both the sample compartment and the optical bench (i.e. interferometer and the detector compartment) can be purged. (In case of TENSOR 27, purging the detector and interferometer compartment is an optional feature that is available only ex factory.)

Purging the spectrometer with dry air or nitrogen gas reduces the content of unwanted atmospheric interferents like water vapor and carbon dioxide inside the spectrometer significantly. Especially the water vapor in the ambient air absorbs IR radiation. These absorptions are unwanted because they manifest in the spectrum. In the worst case, H_2O bands mask the spectral bands resulting from the sample. Therefore, purging the spectrometer is recommended, especially when you frequently open the compartment covers (e.g. due to a beamsplitter replacement or a sample substitution) or if water vapor concentration is too high.

When you measure with a purged spectrometer, bear in mind the following: After the measurement, OPUS calculates automatically the result sample spectrum by dividing the measured sample spectrum by the background spectrum (measurement without sample). In doing so, the H_2O and CO_2 bands, that result from the ambient air, are eliminated from the result sample spectrum. Consequently, to get a result sample spectrum that is (almost) free of H_2O and CO_2 bands that result from the air inside the spectrometer, it is not necessary to purge the spectrometer over a long period of time because not the absolute concentration of H_2O and CO_2 inside the spectrometer is important but a constant concentration of these gases during both the background and the sample measurement, i.e. the H_2O and CO_2 concentration inside the spectrometer should be (almost) identical during both measurements.

This can be achieved by proceeding as follows: Before starting the background measurement, simulate a sample exchange (with regard to the duration of the open sample compartment) and a spectrometer purging (with regard to the purge duration before the measurement) as you will do it later for the 'real' sample measurement.

For the above mentioned reason, it is not recommended trying to reduce the H_2O and CO_2 content as far as possible by purging the spectrometer for a long period of time before starting the background measurement because the subsequent sample measurement would require the same long purge period before the sample measurement can be started.

Note: Due to the integrated desiccant cartridge(s), purging the spectrometer is not necessarily required. However, it is recommended especially when you frequently open the spectrometer compartment. Purging with dry air or nitrogen reduces the water vapor concentration inside the spectrometer within a shorter time than a desiccant cartridge can do. Consequently, purging reduces the waiting time until optimal air conditions inside the spectrometer are reached again.

Purge Gas Requirements

Purge the spectrometer for example with dry air or low pressure nitrogen. Provide the following purge gas conditions:

- Oil-free, dust-free and dry air or nitrogen gas with a dew point < -40°C (This corresponds to a degree of dryness of 128ppm humidity.)
- Maximum pressure of 2 bar (29 psi)
- Controllable flow rate (When the spectrometer is purged continuously the recommended flow rate is 200 liters/hour. Make sure that the flow rate does not exceed 500liters/hour.)

Warning: Do not use flammable gases for purging the spectrometer. Some spectrometer components become very hot during operation. If flammable gases come in contact with hot components there will be the risk of fire and/or explosion!

EXTENDING THE SPECTRAL RANGE

The spectral range in which a spectrometer is capable of detecting a signal is determined by the optical components source, beamsplitter, sample compartment windows and detector. Consequently, extending the spectral range involves the substitution of these components. For information about how to substitute these optical components refer to the corresponding sections in this chapter.

In case of **TENSOR 27**, a spectral range extension is not possible. The actual spectral range depends in the spectrometer variant in question. See chapter *General*, section *TENSOR 27 Variants.* In case of **TENSOR 37**, the user can extend the standard spectral range (7,500 - 370cm^{-1}) to 15,000 - 50cm^{-1} by substituting the relevant optical components. (The spectral ranges of the available beamsplitters, detectors and sample compartment windows are listed in the corresponding sections in chapter *Overview*.)

Important: Make sure that the spectral ranges of the installed optical components correspond with each other!

The optical components source, beamsplitter and detector are electronically coded enabling the spectrometer firmware to recognize automatically the type of source, beamsplitter and detector that are actually installed. The information about the installed components is passed on to the spectroscopy software OPUS. This feature is called ACR (Automatic Component Recognition). Its purpose is to prevent you from selecting a wrong component in OPUS when you set up a measurement experiment. (A wrongly selected component is indicated in OPUS by a red colored entry field of the corresponding drop-down list. See also the OPUS Reference Manual.)

Note: After having replaced the above listed optical components, it is highly recommended to validate the spectrometer performance by performing a PQ test using OVP. (See OPUS Reference Manual.)

SUBSTITUTING THE SOURCE

General Information

The replacement procedure described below is identical for both IR source types (MIR and NIR). All sources are pre-aligned, i.e. after the installation, realignment is not required.

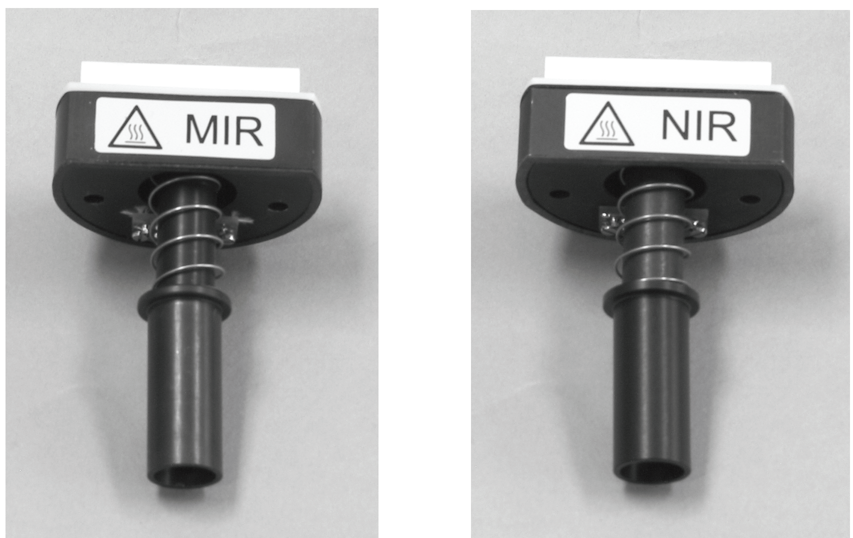


Figure 24: Available IR sources types (NIR source only for TENSOR 37)

Substitution Procedure

1 **Switch off the spectrometer:** See chapter *Operation*, section *Switching TENSOR on or off*.

2 **Open the source/laser compartment:** Press on the spot of the source/ laser compartment cover shown in fig. 25a and turn the cover upwards.

Caution: During the spectrometer operation, the IR source becomes very hot. Avoid any skin contact. Risk of skin burn! Wait until the source has cooled down sufficiently before you remove it.

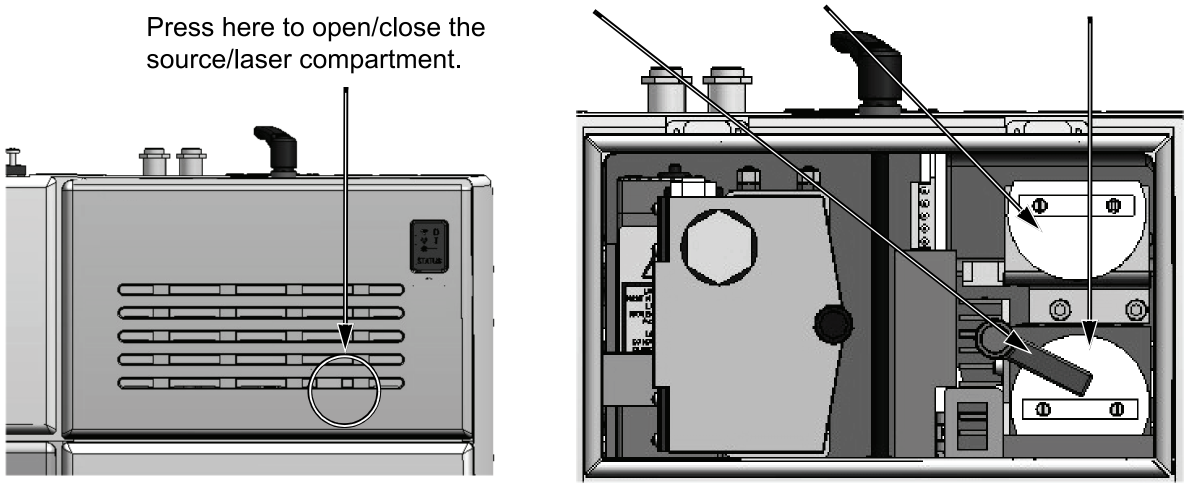


Figure 25: a) Source/Laser compartment (closed) b) Source/Laser compartment open (TENSOR 37)

3 **Remove the source:** Loosen the knurled thumb screw of the clamping bar (approximately one turn). (See fig. 25b.) Press the source downwards while rotating the clamping bar aside. Take the source out of the holder.

4 **Install the source:** Take the provided NIR (or MIR) source out of the storage position holder and insert it in the operating position holder. Ensure that the two pins of the holder engage in the holes of the source. While pressing the source downwards, rotate the clamping bar over the source. Tighten the knurled thumb screw of the clamping bar (about one turn).

5 **Store the source that is currently not in use:** Insert the source that is currently not in use in the storage position holder. (See fig. 25b.)

6 **Close the source/laser compartment:** Shut the source/laser compartment and press on the spot of the cover shown in fig. 25a.

7 **Switch on the spectrometer:** See chapter *Operation*, section *Switching TENSOR on or off*.

8 **Check the signal intensity** using the OPUS software. (See section *Checking the Signal* below in this chapter.)

SUBSTITUTING THE BEAMSPLITTER

General Information

A beamsplitter substitution is possible only with **TENSOR 37**. The available beamsplitters are listed in chapter *Overview*, section *Beamsplitter*.

Handling Instructions

Caution: The beamsplitter is a very delicate component. Handle it with utmost care and observe the following handling instructions to ensure a long service life.

- Do not touch the optical material of the beamsplitter as this can damage it irreversibly. Take hold of the beamsplitter only by the handle (fig. 26).
- The optical material of some beamsplitters are hygroscopic. Never expose them to humidity or water vapor. Store the beamsplitter in a dry and sealed container (e.g. in the beamsplitter storage box of the source/laser compartment, see fig. 28b).
- Do not try to loosen or fasten the screws as this will impair the optical quality of the beamsplitter.
- Do not try to clean the optical material of the beamsplitter as this will definitively damage the beamsplitter irreversibly.
- Do not expose the beamsplitter (especially KBr beamsplitters) to temperature changes.

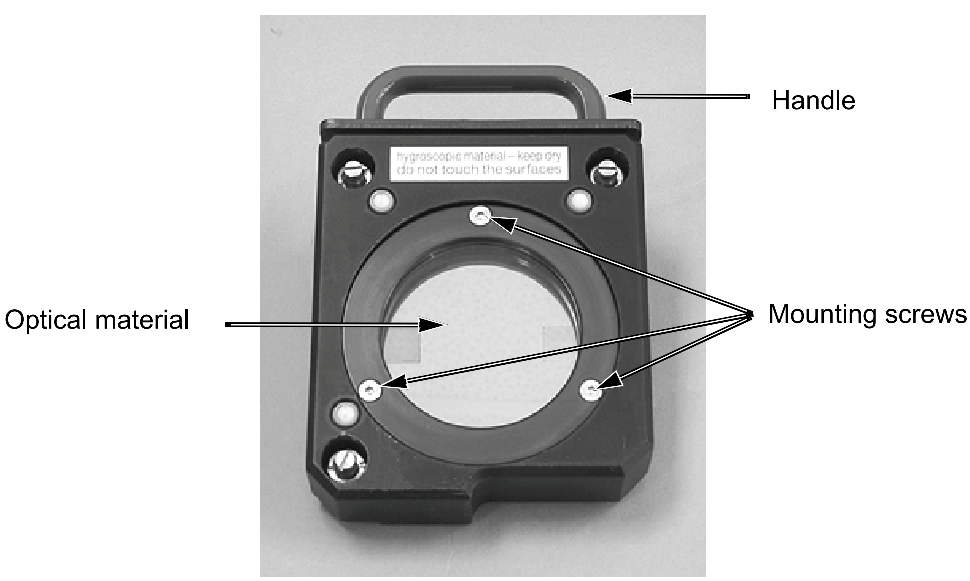


Figure 26: Beamsplitter

Substitution Procedure

The beamsplitter currently in use is situated in the interferometer compartment.

1 **Open the interferometer compartment:** Turn the handle (fig. 27a) at the spectrometer rear side to the OPEN position and take off the interferometer compartment cover.

2 **Unlock the beamsplitter:** Move the lever (fig. 27b) in the unlocked (OPEN) position.

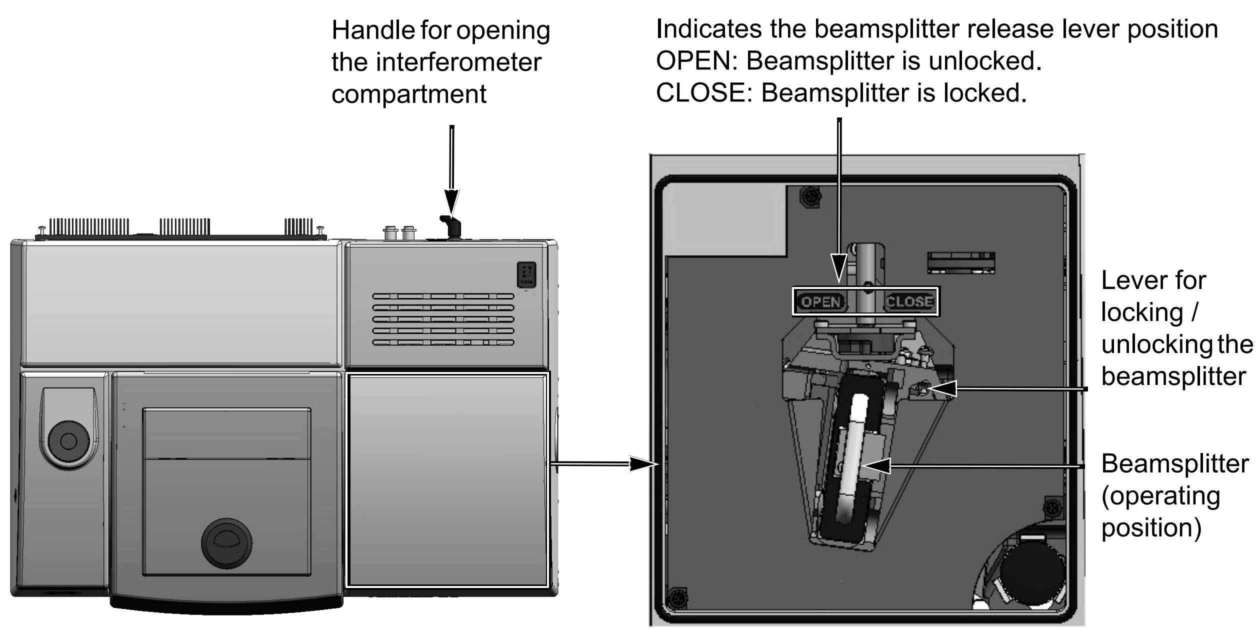


Figure 27: a) Location of the interferometer compartment b) Open interferometer compartment (TENSOR 37)

3 **Take out the beamsplitter:** Pull the beamsplitter straight upwards without catching an edge.

The exchange beamsplitter is either in the storage box which is situated in the source/ laser compartment of the spectrometer (fig. 28a) or in another airtight storage box (outside the spectrometer).

4 **Take the beamsplitter out of the storage box in the spectrometer:** Open the source compartment by pressing on the spot of the cover shown in fig. 28a and turning the cover upwards. Loosen the knurled thumb screw of the beamsplitter storage box (fig. 28b) and open the box. Take the beam-splitter out of the storage box.

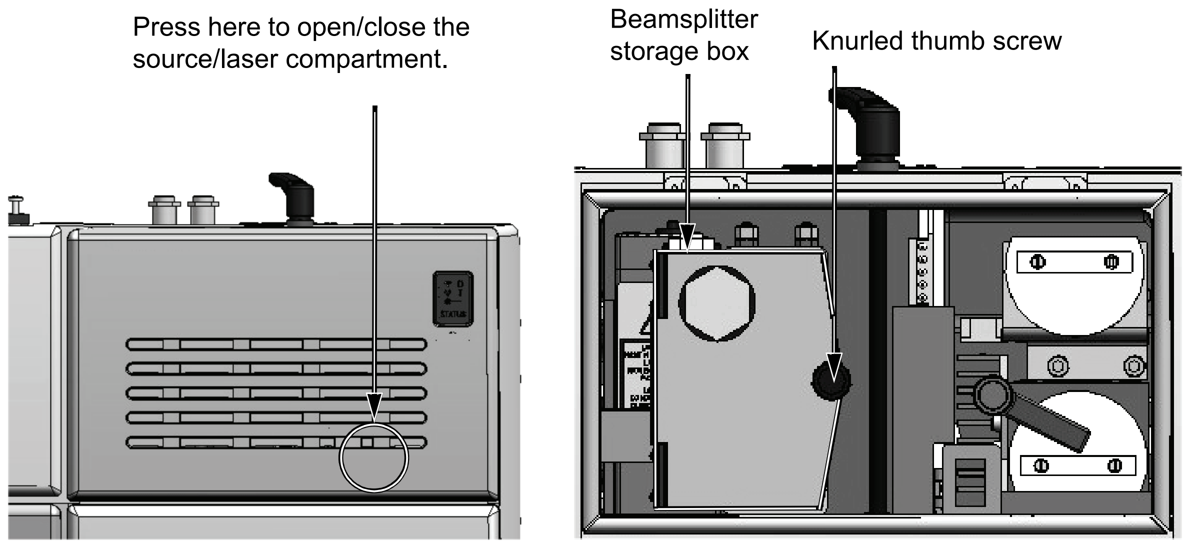


Figure 28: a) Source/Laser compartment (closed) b) Beamsplitter storage box (only in case of TENSOR 37)

5 **Insert the beamsplitter:** Insert the beamsplitter in the holder (operating position) with the electrical contacts facing to the right. (See fig. 27b.) Press the beamsplitter right down.

6 **Lock the beamsplitter:** Move the lever (fig. 27b) into the locked (CLOSE) position. (A precise locking mechanism fixes the beamsplitter automatically at the exact position, i.e. a realignment is not required.)

Note: A beep indicates that the beamsplitter has been recognized by the spectrometer firmware.

7 **Close the interferometer compartment:** Put the cover on the compartment and latch the cover by turning the handle at the spectrometer rear side to the CLOSE position. (See fig. 27a.)

8 **Store the beamsplitter that is not in use under dry conditions:** Store the beamsplitter that is currently not in use either in the storage box which is situated in the source/ laser compartment of the spectrometer (fig. 28a) or in another airtight storage box (outside the spectrometer). **Storage box in the spectrometer:** Put the beamsplitter in the storage box, close the storage box and fasten the knurled thumb screw. Shut the source/laser compartment and press on the spot of the cover shown in fig. 28a.

9 **Check the signal intensity** using the OPUS software. (See section *Checking the Signal* below in this chapter.)

SUBSTITUTING THE DETECTOR

General Information

A detector substitution is possible with both **TENSOR 27** and **TENSOR 37**.

For **TENSOR 27**, several optional MCT detectors for measurements in the MIR range but with different spectral ranges are available. See chapter *Overview*, section *Detector*.

For **TENSOR 37**, several optional detectors for measurements in the MIR and NIR range and with different spectral ranges are available. See chapter *Overview*, section *Detector*.

The substitution procedure described below is identical for both TENSOR 27 and TENSOR 37 and for all detectors. The dovetail detector mounting facilitates the substitution, a re-alignment is not necessary.

Substitution Procedure

1 **Open the detector compartment:** The detector compartment cover is secured by a Allen screw that is located at the left spectrometer side and covered by a cap. (See fig. 29a.) Remove this cap and loosen the Allen screw (approx. half a turn) using a Allen wrench (6mm). Take off the detector compartment cover.

2 **Remove the detector:** The detector is secured by an Allen screw (fig. 29b and fig. 29c). Loosen that screw using the long end of the Allen wrench (6mm). Pull the detector straight upwards out of the dovetail guide.

Caution: Remove the detector with care in order not to damage the mirror.

3 **Install the exchange detector:** Insert the detector precisely into the dovetail guide and press the detector right down. Fasten the Allen screw (figure 29) that secures the detector using the long end of the Allen wrench (6mm).

Note: A beep indicates that the detector has been recognized by the spectrometer firmware.

4 **Close the detector compartment:** Put the cover on the detector compartment and secure it by fastening the Allen screw at the left spectrometer side. Reinstall the covering cap.

5 **Check the signal intensity** using the OPUS software. (See section *Checking the Signal* below in this chapter.)

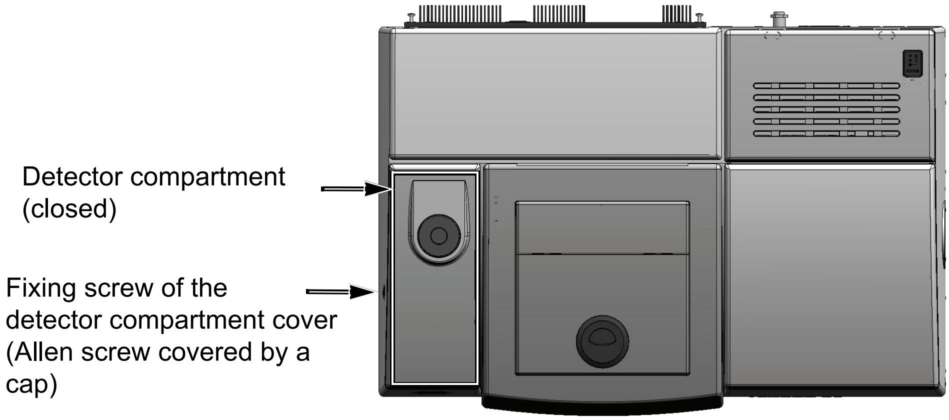


Figure 29: a) Top view - Location of the detector compartment

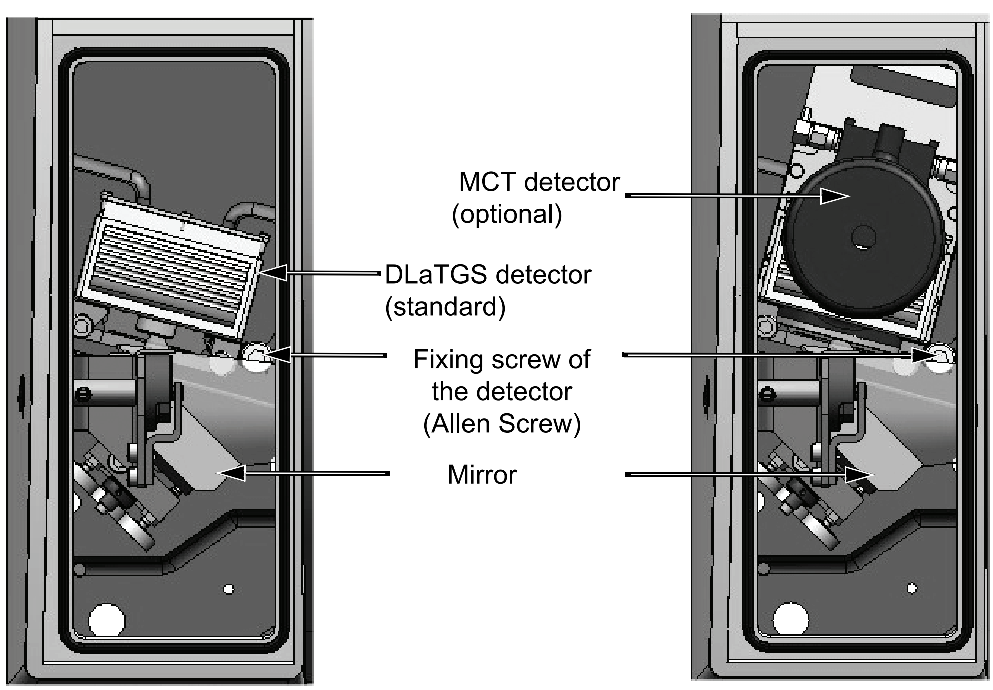


Figure 29: b) Open detector compartment with standard DLaTGS detector

Figure 29: c) Open detector compartment with optional MCT detector

SUBSTITUTING THE SAMPLE COMPARTMENT WINDOWS

General Information

For information about the available sample compartment windows including their transmission range and refraction index see chapter *Overview*, section *Sample Compartment Windows*.

Only when you intend to measure in the far infrared region a replacement of the sample compartment windows is required from a technical point of view. In this case, windows made of polyethylene need to be installed. All other available windows cover both the near and the mid infrared region, i.e. replacing the windows is not necessarily required.

Handling Instructions

Observe the following handling instructions:

- The windows are very fragile. Handle them with care because they crack easily under the influence of mechanical pressure.
- Contaminations in the window surface can decrease the infrared transparency significantly. Therefore, do not touch the window surface. **Because most of the window materials are hygroscopic and/or harmful or toxic we strongly advise you against trying to clean the windows!**

Safety Notes

Warning: Some window materials are harmful or (very) toxic. (See the table in chapter *Overview*, section *Sample Compartment Windows*.) Observe the safety instructions on the packaging, and the safety data sheets attached. Non-observance may cause (serious) health problems or even death.

During normal spectrometer operation according to the instructions, the harmful or toxic window materials do not pose any health risk. However, should such a window break, be extremely careful. **Avoid generating dust!**

Substitution Procedure

Note: In case you want to replace the window(s) for the purpose of extending the spectral range you only need to replace the window assembly as a whole. Whereas, in case you have to replace a damaged or opaque window the window assembly also needs to be disassembled. See chapter *Maintenance and Repair*, section *Replacing a damaged Sample Compartment Window*.

1 **Remove the window assembly:** Insert the pins of the flange tool into the corresponding holes of the window assembly. (See fig. 30.) Rotate the flange tool about a quarter turn counterclockwise and remove the complete window assembly from the sample compartment wall.

2 **Reinstall the window assembly:** Insert the pins of the flange tool into the corresponding holes of the window assembly. (See fig. 30.) Attach the window assembly to the lock ring in the sample compartment wall and rotate the flange tool about a quarter turn clockwise.

Important: All sample compartment windows are wedge-shaped. To ensure maximum signal intensity, the correct orientation of the installed windows is of crucial importance. Due to the bayonet mount, there are four possible window installation positions. Find out the optimum installation position by trial and error while checking the signal intensity in OPUS. (See the following section *Checking the Signal*.)

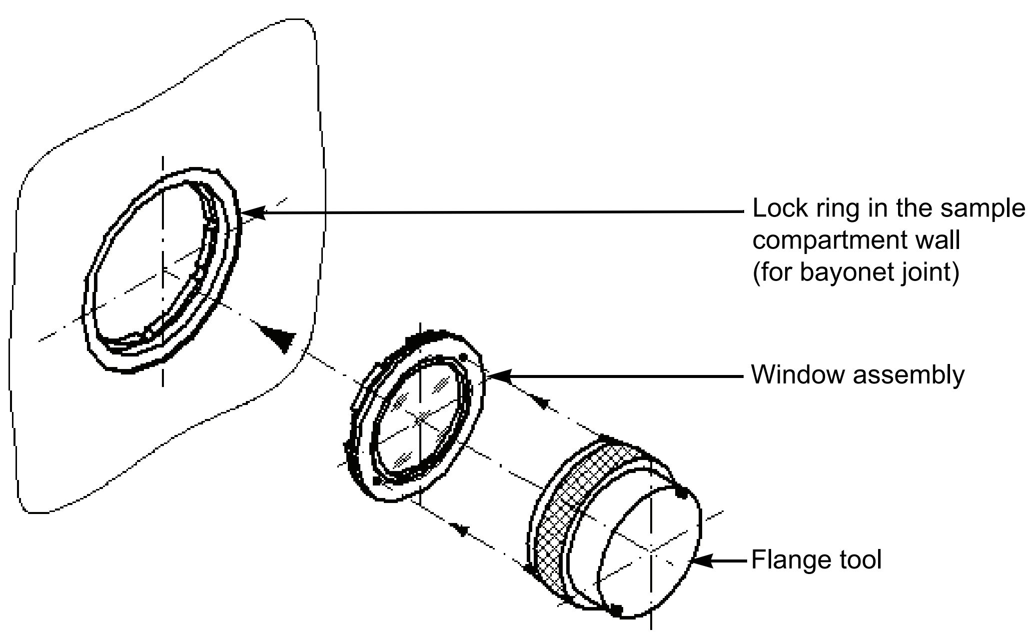


Figure 30: Removing / reinstalling the window assembly

CHECKING THE SIGNAL

General Information

Especially after you have replaced a spectrometer component (source, laser beamsplitter, detector), it is advisable to check whether a signal is detected and to check the signal intensity (signal amplitude).

Procedure

1. Make sure that there is not any accessory and/or sample in the spectrometer sample compartment.
2. Open OPUS.
3. Select in the *Measure* menu the *Advance Measurement* function.
4. Click in the *Measurement* dialog window on the *Check Signal* tab.
5. Make sure that the *Interferogram* option button is activated. (See fig. 31.)

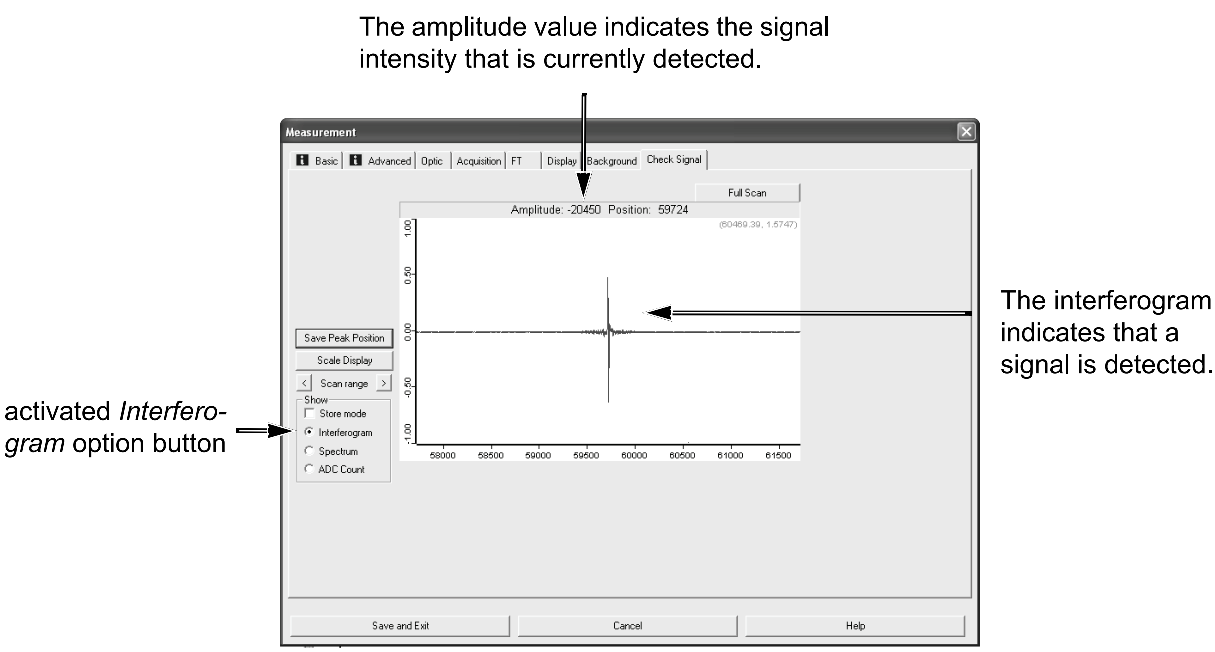
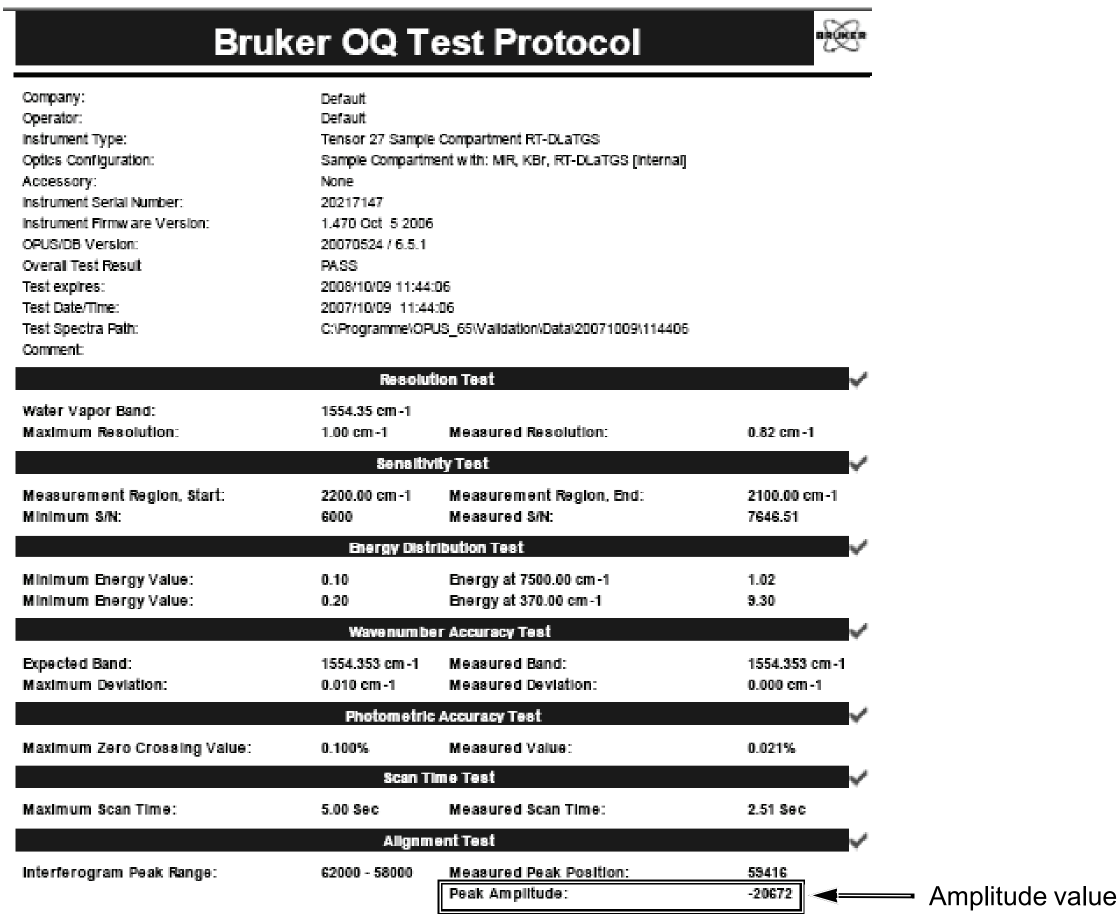


Figure 31: OPUS Dialog Window - Measurement

For verifying the currently detected signal intensity, compare the amplitude valve displayed in OPUS (fig. 31) with the amplitude value stated in the supplied OQ test protocol[1] (fig 32).



Bruker OQ Test Protocol

Company:	Default
Operator:	Default
Instrument Type:	Tensor 27 Sample Compartment RT-DLaTGS
Optics Configuration:	Sample Compartment with: MIR, KBr, RT-DLaTGS [internal]
Accessory:	None
Instrument Serial Number:	20217147
Instrument Firmware Version:	1.470 Oct 5 2006
OPUS/DB Version:	20070524 / 6.5.1
Overall Test Result	PASS
Test expires:	2008/10/09 11:44:06
Test Date/Time:	2007/10/09 11:44:06
Test Spectra Path:	C:\Programme\OPUS_65\Validation\Data\20071009\114406
Comment:	

Resolution Test			
Water Vapor Band:	1554.35 cm-1		
Maximum Resolution:	1.00 cm-1	Measured Resolution:	0.82 cm-1
Sensitivity Test			
Measurement Region, Start:	2200.00 cm-1	Measurement Region, End:	2100.00 cm-1
Minimum S/N:	6000	Measured S/N:	7646.51
Energy Distribution Test			
Minimum Energy Value:	0.10	Energy at 7500.00 cm-1	1.02
Minimum Energy Value:	0.20	Energy at 370.00 cm-1	9.30
Wavenumber Accuracy Test			
Expected Band:	1554.353 cm-1	Measured Band:	1554.353 cm-1
Maximum Deviation:	0.010 cm-1	Measured Deviation:	0.000 cm-1
Photometric Accuracy Test			
Maximum Zero Crossing Value:	0.100%	Measured Value:	0.021%
Scan Time Test			
Maximum Scan Time:	5.00 Sec	Measured Scan Time:	2.51 Sec
Alignment Test			
Interferogram Peak Range:	62000 - 58000	Measured Peak Position:	59416
		Peak Amplitude:	-20672

Figure 32: OQ Test Protocol

If there is not any signal detected or if the amplitude value displayed in OPUS (fig. 31) deviates significantly from amplitude value of the supplied OQ test protocol (fig. 32) check the installation of the spectrometer component(s) you have replaced before.

See also chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *No signal is detected or the signal intensity is too low.*

1. The supplied OQ test protocol documents the result of a factory-performed OQ test. The test has been performed with your spectrometer being optimally adjusted. You will find the OQ test protocol in the Bruker folder supplied with the spectrometer.

COOLING THE MCT DETECTOR

General Information

For both TENSOR 27 and TENSOR 37, optional MCT detectors are available. See chapter *Overview*, section *Detector*.

The operating temperature of the MCT detectors is significantly below room temperature. To achieve the required operating temperature, liquid nitrogen needs to be filled in the detector. The hold time indicates how long the cooling effect of the liquid nitrogen lasts, i.e. to ensure an optimum signal detection, the MCT detector needs to be filled with liquid nitrogen in regular intervals. The available MCT detectors have different nominal hold times: 8, 12, or 24 hours.

Indications of a weakened or disappeared cooling effect are a low signal intensity or no signal detection. (See section *Checking the Signal* above in this chapter.) In case no signal is detected the OPUS status lamp turns to red. This problem is also indicated by the following instrument status message in OPUS: *Detector not ready*. See chapter *Troubleshooting*.

Note: If the actual hold time of the MCT detector is considerably shorter than the nominal hold time the MCT detector dewar needs to be evacuated. See chapter *Maintenance and Repair*, section *Evacuating a MCT Detector Dewar*.

To fill the detector dewar with liquid nitrogen you need neither to remove the detector nor even open the detector compartment. The supplied funnel facilitates the filling in of liquid nitrogen in the MCT detector dewar. (See figure 34b.) The delivery scope of a MCT detector includes a funnel, an overflow protection device and a plug.

Detector Compartment Cover Preparation Procedure

If the MCT detector has been delivered together with the spectrometer, the detector compartment cover is already prepared for the funnel insertion. If the MCT detector has been ordered at a later date you need to prepare the cover as described below.

The filling hole in the detector compartment cover (B in fig. 9) is intended to accommodate the funnel, i.e. the MCT detector can be filled with liquid nitrogen without the need to remove the detector compartment cover. Upon delivery, this hole is closed by a plug.

1. The detector compartment cover is secured by an Allen screw that is located at the left spectrometer side and covered by a cap. (See fig. 29a.) Remove this cap and loosen the Allen screw (approx. half a turn) using a Allen wrench (6mm).
2. Take off the detector compartment cover and turn it upside down.
3. Screw off the knurled thumb screw, remove the two washers and take the plug out of the filling hole. (See fig. 33.)
4. Put the cover on the detector compartment and secure it by fastening the Allen screw at the left spectrometer side. (See fig. 29a.)
5. First insert the overflow protection device into the filling hole and then the plug. See fig. 34a.

The purpose of the overflow protection device is to prevent liquid nitrogen from overflowing onto the detector compartment cover as the cooled liquid nitrogen can cause cracks in the cover. Despite the installed overflow protection device, always fill in the liquid nitrogen carefully! The plug is intended for closing the filling hole in order to prevent particles and small objects from falling into the detector dewar. Remove this plug only when the MCT detector needs to be cooled with liquid nitrogen. After you have finished filling in liquid nitrogen remove the funnel and reinsert the plug.

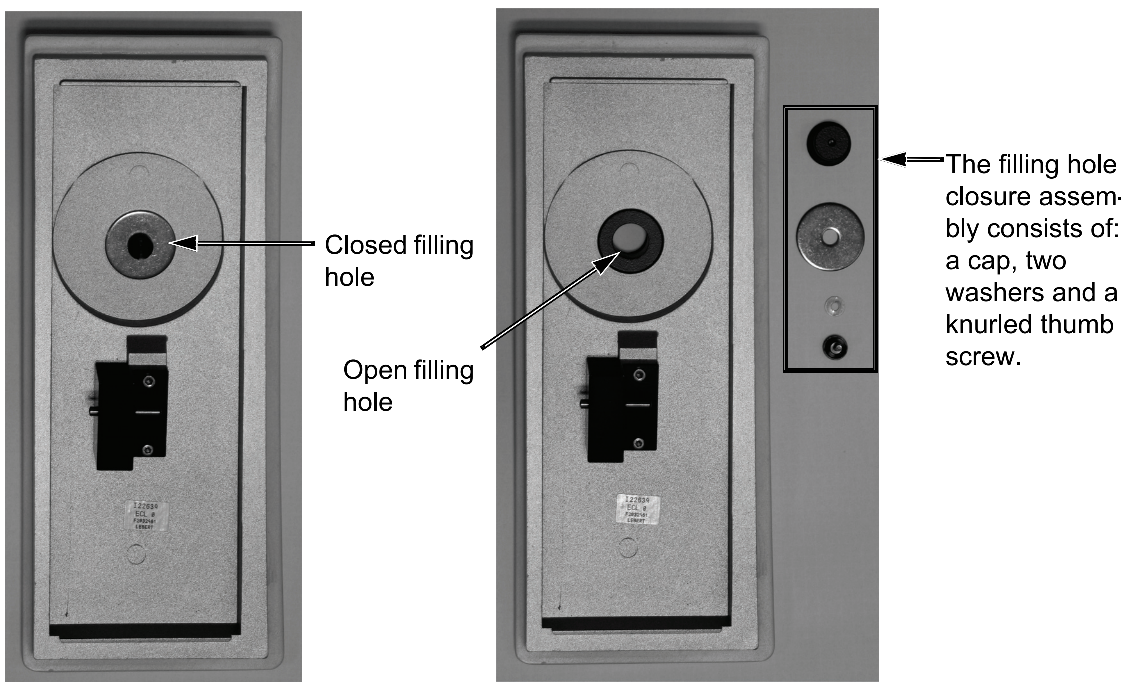


Figure 33: Detector compartment cover (bottom side)

Safety Notes

MCT detectors have to be cooled with liquid nitrogen. The temperature of liquid nitrogen is minus 196°C (minus 320.8°F). Therefore, handling liquid nitrogen requires the observance of the following safety notes:

Warning: Handle liquid nitrogen always with utmost care. Due to its extremely low temperature, skin contact can cause severe frostbites! Also the gases escaping from the liquid nitrogen are extremely cold and can cause frostbite. The delicate eye tissue can be damaged if exposed to this cold gas even for a short time. Protect your eyes by wearing a face shield or safety goggles! Note that goggles without side shields do not provide adequate protection!

Warning: High nitrogen gas concentrations in an enclosed area can cause asphyxiation! Use liquid nitrogen only in well-ventilated areas. Nitrogen gas is colorless, odorless and tasteless. Therefore, it can not be detected by human senses and will be inhaled as if it were normal air.

MCT Detector Cooling Procedure

1 Remove the plug (fig. 34a) from the filling hole on the detector compartment cover and insert the supplied funnel instead (fig. 34b).

Figure 34: a) Detector compartment cover b) Filling liquid N_2 in the MCT detector dewar

2 Slowly fill in liquid nitrogen. Avoid spilling the liquid on the housing. At first the liquid nitrogen evaporates and streams out again.

Warning: Liquid nitrogen boils and splashes when it is filled a warm container. Especially at the beginning, when the temperature difference between the detector dewar and the liquid nitrogen is still very large, the liquid nitrogen may squirt out forcefully due to the boiling delay. Therefore, fill in the liquid nitrogen slowly to minimize boiling and splashing. Stand clear of boiling and splashing liquid nitrogen and its issuing gas! Be aware that during the entire filling process, liquid nitrogen can squirt out of the detector dewar from time to time.

3 Wait until the funnel is empty before refilling. When the liquid nitrogen stops streaming out the detector dewar has reached liquid nitrogen temperature. Then, fill the funnel again with liquid nitrogen.

4 Repeat this procedure until the detector dewar has been filled to maximum. (As a rough rule of thumb for the standard MCT detector: the maximum dewar capacity is about the quantity of two to three funnel fillings. Note that the first two funnel filling will evaporate almost completely.) Avoid overfilling. In this case the liquid flows out of the filling port.

5 After having filled in sufficient liquid nitrogen, remove the funnel and insert the plug in the filling hole instead.

6 Wait about 20 minutes before starting the measurement to allow the detector to stabilize.

MAINTENANCE AND REPAIR

6

GENERAL INFORMATION

The TENSOR spectrometer is a low-maintenance instrument. Replacing the desiccant cartridges and evacuating the (optional) MCT detector dewar are the only maintenance works that need to be performed at certain intervals to ensure optimum spectrometer performance.

Repair works are required only if a spectrometer component is defect. The user can replace the following components: source, laser, sample compartment windows, beamsplitter and detector. (Note: For information about how to replace a beamsplitter and a detector refer to the corresponding sections in chapter *Operation*. A beamsplitter substitution is possible only with **TENSOR 37**.)

Perform only the maintenance and repair works that are described in this manual. Adhere strictly to the described procedures and observe the relevant safety precautions. Otherwise, Bruker does not assume any liability if personal injury and/or spectrometer damage occur. Maintenance and repair works that are not described in this manual should only be performed by Bruker service personnel. (For service addresses and telephone numbers refer to appendix H.)

Performing an OQ Test[1] using OVP[2]

After the replacement of a defective optical component[3] (source, laser, beamsplitter or detector), it is highly recommended to perform an OQ test to ensure that the spectrometer achieves the specified parameter values[4]. (For information about how to perform an OQ test refer to the OPUS Reference Manual.)

Note: If the OQ test fails, refer to chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *A validation test failed*.

1. OQ test - Operational Qualification Test
2. OVP - OPUS Validation Program (It is intended for performing spectrometer validation tests like OQ and PQ.)
3. Perform the OQ test only after the replacement of a defective component, but NOT after the substitution of a optical component for the purpose of extending the spectral range, for example.
4. In the course of the OQ test, the following parameters are tested: resolution, sensitivity, energy distribution, wavenumber accuracy, photometric accuracy, scan time, peak position and peak amplitude.

Electrostatic Discharge

Caution: Avoid electrostatic discharges (ESD) to prevent ESD-sensitive electronic components from being damaged.

Electronic components (like semiconductor chips and boards) are very susceptible to electrostatic discharge caused by the operator. Even the slightest electrostatic discharge that is imperceptible to the operator can damage electronic components. Therefore, it is crucial importance that you are connected to ground with respect to the spectrometer before you touch any electronic component inside the spectrometer.

Electrical grounding can be accomplished either by using a grounding wrist strap or touching a grounded object (e.g. radiator). The grounding wrist strap is the most effective (and preferred) grounding method.

REPLACING THE CARTRIDGE AND REGENERATING THE DESICCANT

General Information

The desiccant (molecular sieve) is in a cartridge. The molecular sieve adsorbs the water vapor of the ambient air. A saturated molecular sieve can be regenerated repeatedly by heating.

TENSOR 27 is equipped with one desiccant cartridge. The cartridge is situated in the interferometer compartment. (See fig. 35a.) **TENSOR 37** is equipped with three desiccant cartridges: one cartridge is situated in the detector compartment and one cartridge is situated in the interferometer compartment. (See fig. 35b.) An additional desiccant cartridge is in the beamsplitter storage box. This desiccant cartridge prevents a hygroscopic beamsplitter from deteriorating.

The desiccant cartridges in the detector compartment and the interferometer compartment should be replaced approx. every six months or at least when the corresponding humidity indicator on the spectrometer top side (fig. 10) lights red. The desiccant cartridge in the beamsplitter storage box (only in case of TENSOR 37) has its own humidity indicator. (See fig. 35b.) When the field *50* (max. field *60*) of the humidity indicator has turned from blue to pink this desiccant cartridge needs to be replaced.

You can either regenerate the desiccant (as described below in this section) and reuse it or order a new desiccant cartridge. (For the order number refer to appendix B.)

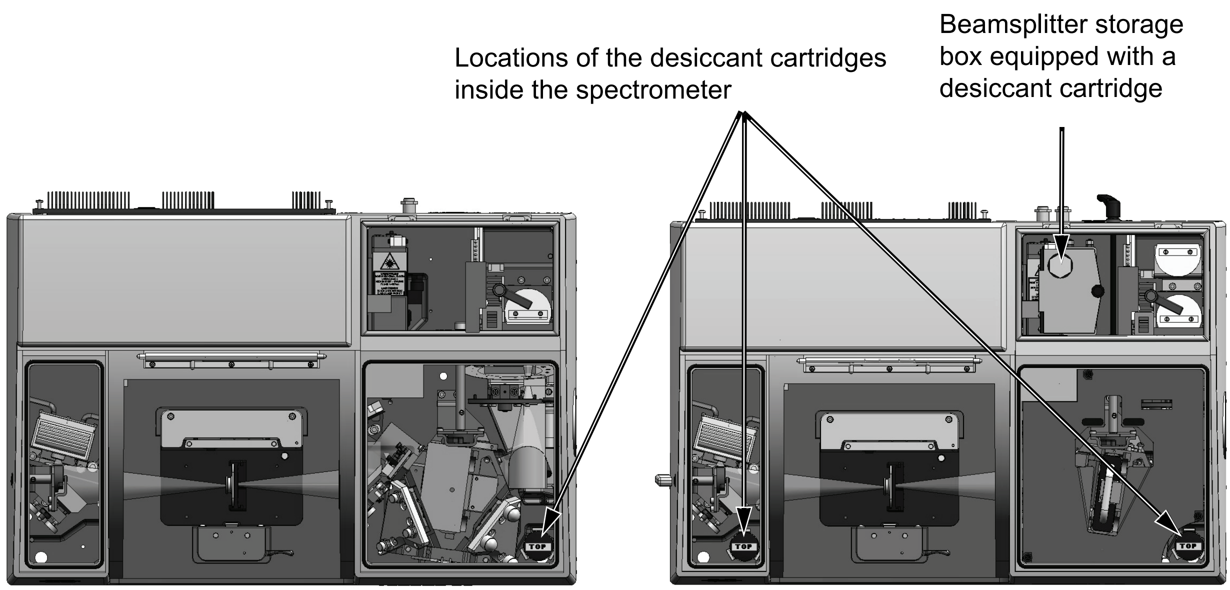


Figure 35: a) TENSOR 27 b) TENSOR 37

Replacement Procedure of the Desiccant Cartridge in the Detector Compartment

TENSOR 37

1 **Open the detector compartment:** The detector compartment cover is secured by an Allen screw that is located at the left spectrometer side and covered by a cap. (See fig. 36a.) Remove this plug and loosen the Allen screw (approx. half a turn) using a Allen wrench (6mm). Take off the detector compartment cover.

2 **Replace the desiccant cartridge:** Pull the desiccant cartridge out of the holder. Insert a new or regenerated desiccant cartridge into the holder. Ensure that the cartridge top side (with the label 'TOP') is upturned. (See fig. 36b.)

3 **Close the detector compartment:** Put the cover on the detector compartment and secure it by fastening the Allen screw. Reinstall the cap. (See fig. 36a.)

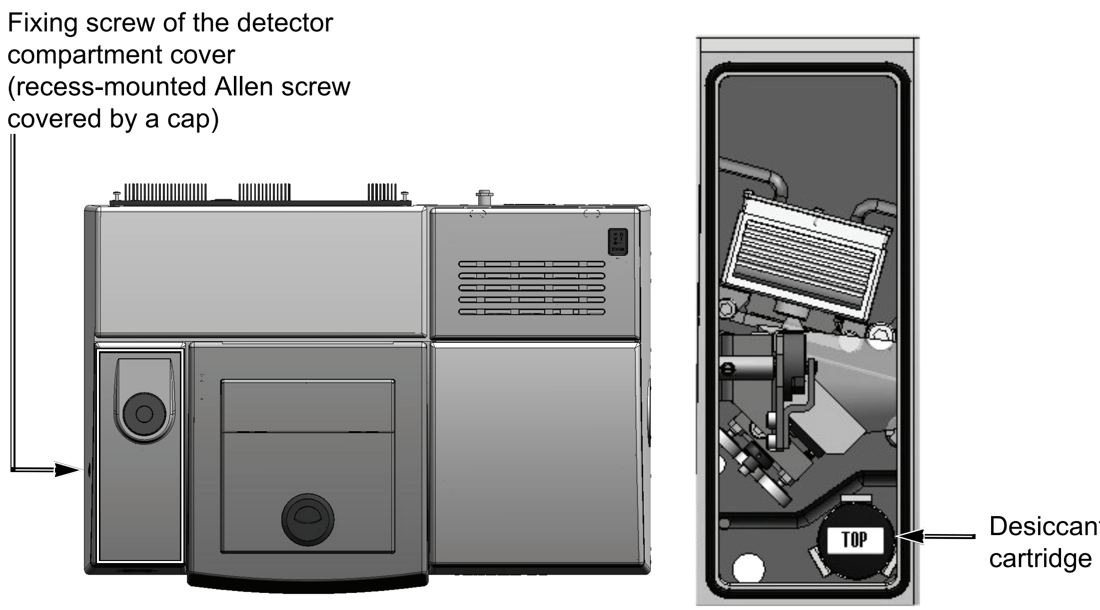


Figure 36: a) TENSOR - Top view b) Open detector compartment

Replacement Procedure of the Desiccant Cartridge in the Interferometer Compartment:

TENSOR 27

The interferometer compartment cover is latched. The Allen screw for unlatching / latching the interferometer compartment cover is in the source/laser compartment. (See fig. 37b.) This means, in order to be able to open the interferometer compartment you first have to open the source/laser compartment.

1 **Open the source/laser compartment:** Press on the spot of the source/laser compartment cover shown in fig. 37a and turn the cover upwards.

2 **Open the interferometer compartment:** Unlatch the interferometer compartment cover by loosening the Allen screw (fig. 37b) using an Allen wrench (size 6mm). (A quarter turn to a half turn is sufficient.) Take off the interferometer compartment cover.

3 **Replace the desiccant cartridge:** Pull the desiccant cartridge out of the holder. Insert a new or regenerated desiccant cartridge into the holder. Ensure that the cartridge top side (with the label ’TOP’) is upturned. (See fig. 36b.)

4 **Close the interferometer compartment:** Put the cover onto the interferometer compartment and latch the cover by fastening the Allen screw. See fig. 37b.)

5 **Close the source/laser compartment:** Shut the source/laser compartment and press on the spot of the cover shown in fig. 37a.

Figure 37: a) Closed source/laser compartment b) Open source/laser compartment

TENSOR 37

1. **Open the interferometer compartment:** Unlatch the interferometer compartment cover using the handle at the spectrometer rear side (A in fig. 14). Turn the handle to the OPEN position. Remove the interferometer compartment cover.
2. **Replace the desiccant cartridge:** Pull the desiccant cartridge out of the holder. Insert a new or regenerated desiccant cartridge into the holder. Ensure that the cartridge top side (with the label 'TOP') is upturned.
3. **Close the interferometer compartment:** Put the cover onto the interferometer compartment and latch the cover by turning the handle (A in fig. 14) to the CLOSE position.

Replacement Procedure of the Desiccant Cartridge in the in the Beamsplitter Storage Box

The storage box for the unused beamsplitter is in the source/laser compartment. See fig. 38b.

1. **Open the source/laser compartment:** Press on the spot of the source/laser compartment cover shown in fig. 38a and turn the cover upwards.
2. **Open the beamsplitter storage box:** Loosen the knurled thumb screw (fig. 38b) of the beamsplitter storage box and open the box.

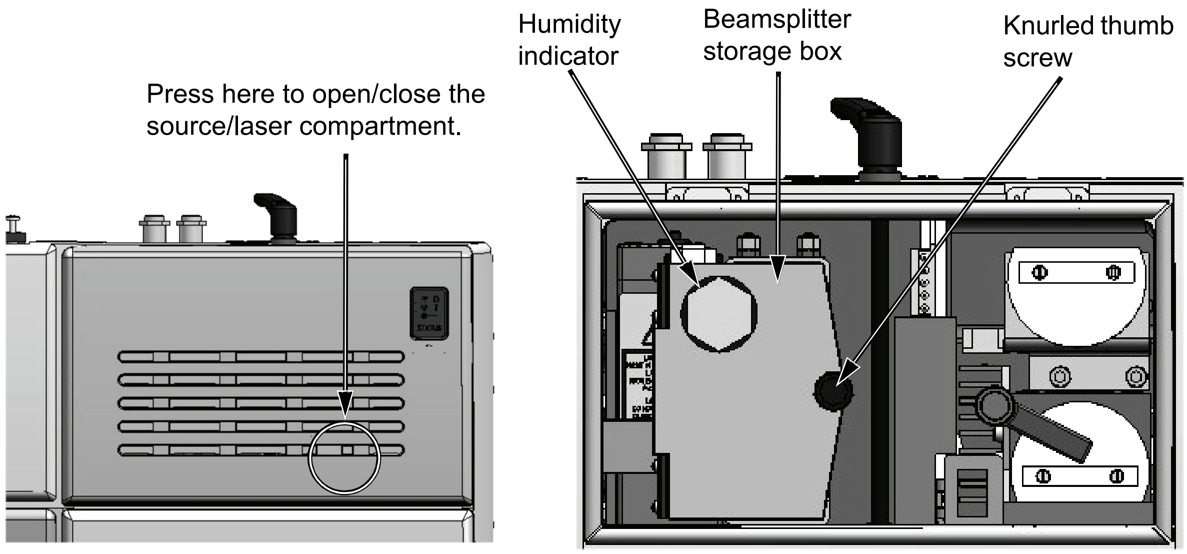


Figure 38: a) Source/Laser compartment (closed) b) Source/Laser compartment open (TENSOR 37)

3 **Replace the desiccant cartridge** by a new or regenerated one.

4 **Close the beamsplitter storage box** and fasten the knurled thumb screw (fig. 38b).

5 **Close the source/laser compartment:** Shut the source/laser compartment and press on the spot of the cover shown in fig 38a.

Regeneration Procedure of the Desiccant

1 Pull off the top cap (with the label 'TOP') from the cartridge.

2 Empty the desiccant (molecular sieve) into a container that can withstand high temperatures (at least 150 °C).

3 Put the container in a oven for at least 24 hours at a temperature of 150°C.

4 Refill the regenerated desiccant in the cartridge and close the cartridge again using the cap.

Storage Notes

- **To maintain the serviceableness of the desiccant during the storage period, store a new or regenerated cartridge always in a dry environment!**
- Store a regenerated desiccant cartridge in a dry environment (e.g. in an excicator or in an dry and airtight sealed container) until it is reused in the spectrometer.

EVACUATING A MCT DETECTOR DEWAR

General Information

The operating temperature of the MCT detectors is significantly below room temperature. To achieve the required operating temperature, liquid nitrogen needs to be filled in the MCT detector. The available MCT detectors have different nominal hold times[1]: 8, 12 or 24 hours. To provide for the longest possible hold time, most MCT detectors are integrated in an evacuable dewar (except for permanently sealed detectors). The actual hold time strongly depends on the quality of the vacuum in the detector dewar.

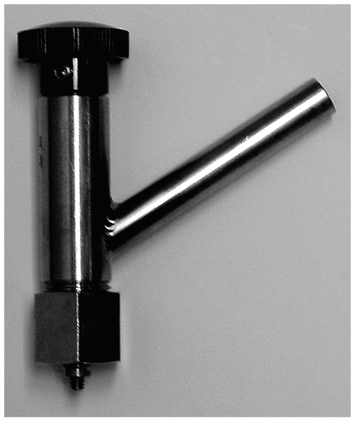
If the actual hold time decreases considerably with regard to the nominal hold time the detector dewar needs to be evacuated. Another indication that a dewar evacuation is required is a failed *Ice Band Test*[2]. The existence of condensation water on the detector outside indicates that the dewar must be evacuated soon. If the MCT detector outside is iced the detector dewar must be evacuated immediately. For evacuating the dewar, the detector must be removed from the spectrometer.

Required evacuating Equipment

- Vacuum pump (turbo molecular pump or oil-free high-vacuum pump that is capable of generating a vacuum of at least < 10^{-5}mbar)
- Adapter for connecting the vacuum pump to the MCT detector dewar
- Shut-off valve
- 2x flexible metal hose

Note: The above listed evacuating equipment is NOT included in the standard delivery scope of the MCT detector. But Bruker offers suitable evacuating equipment (part number S105-V2, D126 and I10290). Alternatively, Bruker also offers the service of evacuating the MCT detector dewar (part number SD128). This option requires you to remove the MCT detector from the spectrometer and to send the complete MCT detector in to Bruker.

1. The hold time indicates how long the cooling effect of the liquid nitrogen lasts.
2. The *Ice Band Test* checks whether there is a thin ice layer on the detector element. This in turn is an indication of the vacuum quality in the MCT detector dewar. The ice band test is part of the PQ test protocol. For detailed information, refer to the OPUS Reference Manual.



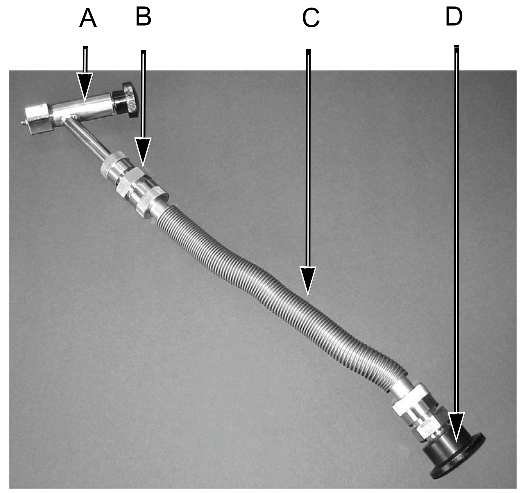


Figure 39: a) Adapter b) Adapter with flexible Metal Hose and Flange

Fig. 39	Component
A	Connecting adapter (for connecting the vacuum pump to the detector dewar)
B	Flange
C	Flexible metal hose
D	NW 25 flange (for connecting to the vacuum pump)

Evacuation Procedure

Note: Before starting to evacuate the MCT detector dewar, make sure that the dewar does not contain any more liquid nitrogen and that the detector has warmed up to room temperature. Note that the detector warming-up from operating temperature to room temperature takes at least 3 hours after the residual liquid nitrogen has been emptied.

1. Remove the MCT detector from the spectrometer. See chapter *Operation*, section *Substituting the Detector*.
2. Connect the adapter to the vacuum pump by flanging a flexible metal hose to the connecting piece of the adapter (E in fig. 41) to the vacuum pump. See fig. 39a. (Note: The connecting piece of the adapter has an OD of 9.7mm.) In addition, install a shut-off valve between adapter and vacuum pump.
3. Make sure whether the shut-off valve is closed. Switch on the vacuum pump. Leave the pump running until it has reached its operating temperature.
4. Inspect the O-ring inside the adapter (C in fig. 41) for signs of wear.

Note: The O-ring inside the adapter is a wearing part that needs to be replaced after 4 or 5 evacuations at maximum.

5 Remove the cap from the connection nozzle of the detector. (See fig. 40a.)

6 Pull the adapter knob (G in fig. 41) to the open position and loosen the coupling nut (A in fig. 41).

7 Push the adapter carefully over the connection nozzle of detector dewar and fasten the coupling nut (A in fig. 41) hand-tight while holding the adapter and the detector as shown in fig. 40b. (A hand-tight tightening of the coupling nut is sufficient.)

Note: Hold the adapter and the detector always as shown in fig. 40b when you have to carry out the following tasks: opening and closing the evacuation valve by pushing or pulling the adapter knob (step 8, 12, 14 and 17), screwing the threaded adapter rod in or out of the connection thread of the dewar evacuation valve (step 11 and 15) and loosening the coupling nut (step 18).

8 Push the adapter knob (G in fig. 41) in the closed position until the threaded rod (D in fig. 41) of the adapter is in contact with the sealing plug of the dewar evacuation valve.

9 Before you begin to evacuate the detector dewar, check the connections for leak tightness by evacuating the section between vacuum pump and detector at first. To do this, open the shut-off valve. If a vacuum of 10^{-4}mbar is generated within a few minutes it is an indication of the leak tightness of this section.

10 Close the shut-off valve again.

11 Screw the threaded rod of the adapter (D in fig. 41) in the connection thread of dewar evacuation valve by turning the adapter knob (G in fig. 41) clockwise; 2 to 3 rotations are sufficient. **Attention: In case of more than 2 or 3 knob rotations there is a risk that the threaded connection becomes inseparable! That means the threaded rod of the adapter cannot be screwed out of the connection thread of the dewar evacuation valve again.**

12 Pull the knob (G in fig. 41) to the open position in order to open the dewar evacuation valve.

13 Begin to evacuate the detector dewar by opening the shut-off valve.

Note: We recommend an evacuation time of at least 3 days to allow for generating an optimal vacuum inside the dewar. The final pressure in the detector dewar should be less than 10^{-5} mbar.

14 When the optimal vacuum is achieved, close the dewar evacuation valve by pushing the adapter knob (G in fig. 41) to the closed position. Press the adapter knob firmly to the stop position to ensure that the dewar evacuation valve is sealed air-tightly.

15 Screw the threaded rod of the adapter (D in fig. 41) out of the connection thread of the dewar evacuation valve by rotating the adapter knob (G in fig. 41) several turns counterclockwise until you sense that the threaded adapter rod and the connection thread of the dewar evacuation valve are not joint any more. Be careful in order to prevent an unintentional opening of the evacuation valve and consequently to prevent the detector dewar from being vented again.

16 Vent the section between vacuum pump and adapter.

17 Pull the knob (G in fig. 41) to the open position. **Attention: Make sure that the sealing plug of the evacuation valve is NOT pulled out! This may occur when you have screwed the threaded adapter rod too far in the connection thread of the dewar evacuation valve. (See step 10.) In this case repeat the dewar evacuation. If you do not succeed in closing the evacuation valve at all you have to send the detector in to Bruker.**

18 Loosen the coupling nut (A in fig. 41) and remove the adapter from the connection nozzle of the detector dewar.

19 Reinstall the MCT detector in the spectrometer. See chapter *Operation*, section *Substituting the Detector*.

Note: If a tiny amount of air should unawares get into the detector dewar during the evacuation procedure (e.g. when you close the evacuation valve) you can perform measurements with this MCT detector for the moment but after a relatively short period of time you have to repeat the detector evacuation.

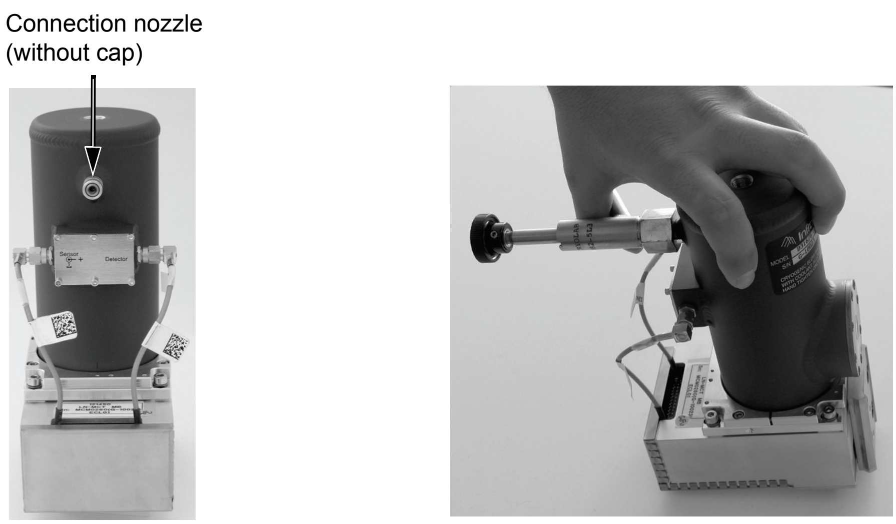


Figure 40: a) MCT detector

b) How to hold the MCT detector when oping or closing the dewar evacuation valve

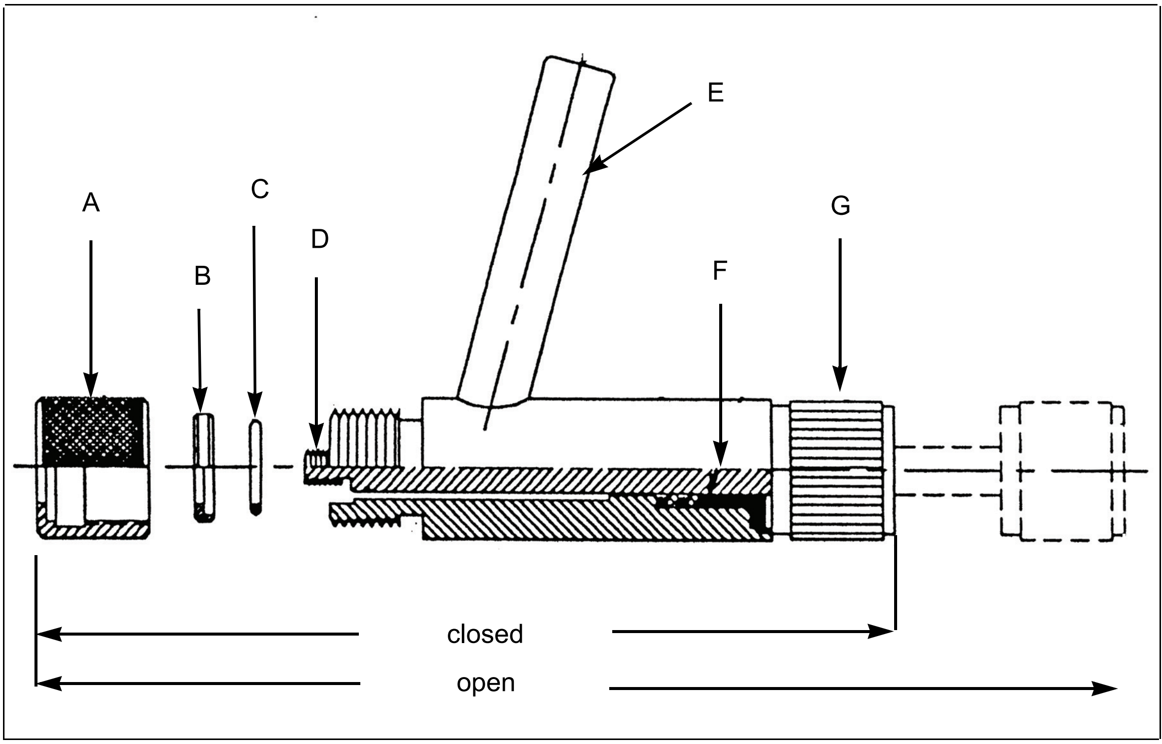


Figure 41: Adapter - Cross Section

Fig. 41	Component
A	Coupling nut
B	O-ring retainer
C	O-ring
D	Threaded rod (to remove the valve closure of the detector dewar)
E	Connecting piece for vacuum pump (OD = 9,7mm)
F	Washer and O-ring packing
G	Adapter knob

REPLACING A DEFECTIVE LASER

General Information

An indication of a defective laser is, for example, a red STATUS indicator (fig. 10) and/ or a failed PQ test. For information about a detailed fault diagnosis, refer to chapter *Troubleshooting*, section *Fault Diagnosis*.

The replacement laser module consists of the laser tube and the laser power supply unit (fig. 44), i.e. in case of a defective laser you have to replace the complete laser module. (For the order number of the replacement laser refer to appendix B.)

Safety Notes

The installed HeNe laser emits red light with a wavelength of 633nm. The rated power output is 1mW. According to EN 60825-1/10.2003, the installed HeNe laser is laser class 2 product. Laser class 2 means that the accessible laser radiation can cause eye injuries. Therefore, when replacing the laser, observe the following safety notes:

Caution: Do not stare into the beam! A long-standing exposure to laser class 2 radiation can lead eye injuries.

Always switch off the spectrometer and disconnect the power plug before beginning the laser removal. Be aware of the fact that the laser is active as soon as the spectrometer is switched on.

Do not put the spectrometer into operation if the covers are removed or if they show signs of damage.

Replacement Procedure

The laser module is situated in the source/laser compartment.

1. **Switch off the spectrometer.** (See chapter *Operation*, section *Switching TENSOR on or off*.) **Interrupt the mains power supply**. Unplug the power cable.
2. **Open the source/laser compartment:** Press on the spot of the source/ laser compartment cover shown in fig. 42a and turn the cover upwards.
3. **Remove the beamsplitter storage box (only in case of TENSOR 37):** Pull the beamsplitter storage box (fig. 42b) out of the holder to gain access to the laser module.

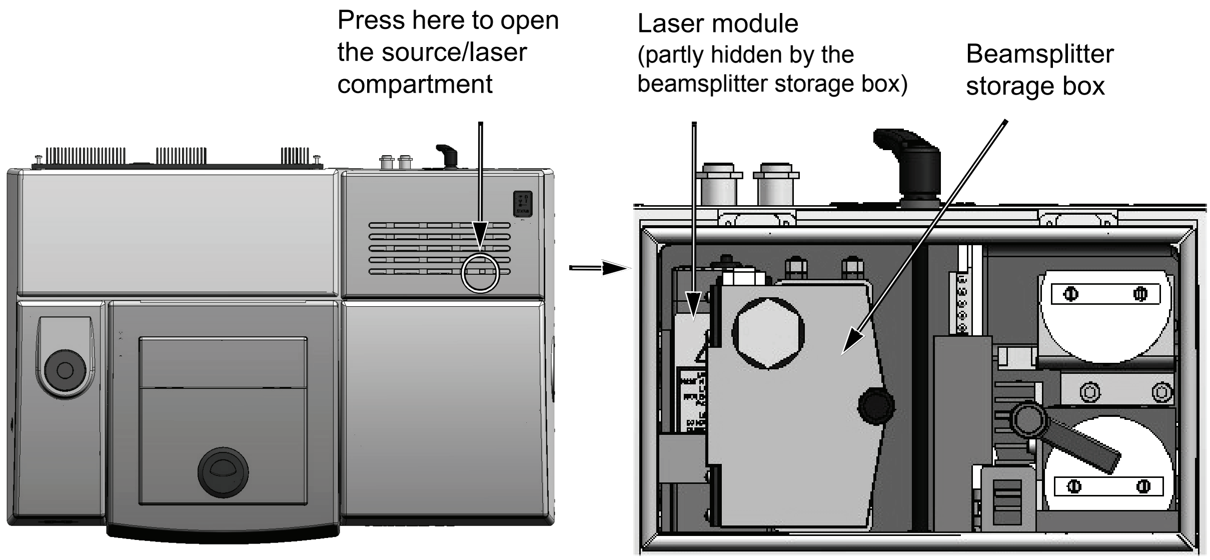


Figure 42: a) TENSOR top view b) Open source/laser compartment (TENSOR 37)

4 **Remove the laser module:** Loosen the Allen screw (A in fig. 43) and rotate the holding plate (B in fig. 43) aside. Take the laser module out of the holder. But be aware of the fact that the laser module is still connected to the supply cable!

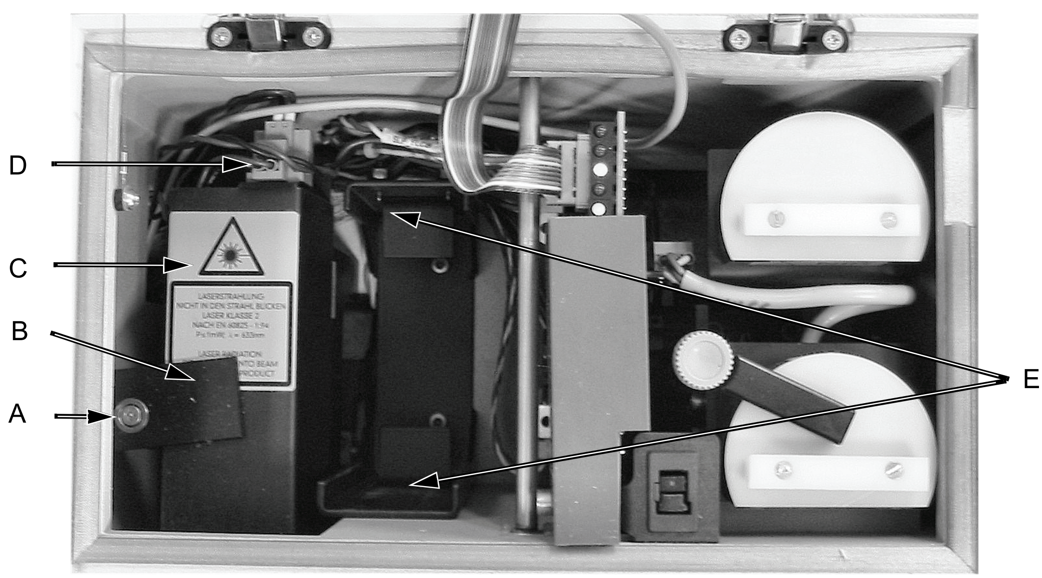


Figure 43: Location of the Laser Module

5 **Unplug the laser supply cable:** Loosen the two slotted screws (fig. 44) and unplug the supply cable.

6 **Connect the replacement laser:** Connect the supply cable to the replacement laser module and fasten the two slotted screws (fig. 44).

Figure 44: Laser module

7 **Install the replacement laser:** Insert the laser module in the holder. **Make sure that the laser rests on the holder bottom in a plane manner to ensure the correct orientation of the laser beam!** Rotate the holding plate (B in fig. 43) in place and fasten the Allen screw (A in fig. 43).

8 **Reinstall the beamsplitter storage box (only in case of TENSOR 37):** Insert the beamsplitter storage box in the holder (E in fig. 43).

9 **Close the source/laser compartment:** Shut the source/laser compartment and press on the spot of the cover shown in fig 42a.

10 **Connect the spectrometer power cord to the mains socket outlet and switch on the spectrometer.** (See chapter *Operation*, section *Switching TENSOR on or off*.)

Note: If the laser is properly installed the laser indicator (fig. 10) on the spectrometer top side lights yellow after a few seconds. If this is not the case the laser power supply cable is not connected correctly. Solve this problem. See step 6.

Note: During the spectrometer initialization, the STATUS indicator (fig. 10) lights red. After approx. 30 seconds it turns to green indicating that the spectrometer is ready for operation. If the STATUS indicator remains red the laser module is not installed correctly, i.e. the laser does not rest on the holder bottom in a plane manner. Correct the laser installation. See step 7.

11 **Check the signal:** Check whether a signal is detected using the OPUS software. And check the current signal intensity (amplitude value). See chapter *Operation*, section *Checking the Signal*.)

12 **Reset the laser operating hour meter:** Click in OPUS either on the status light or select in the *Measure* menu the *Optics Diagnostics* function. The *Instrument Status* window opens. Click on the *HeNe laser* icon and then on the *Service Info* button. The laser diagnostics page opens. (See fig. 45.) Click on the *Reset* button.

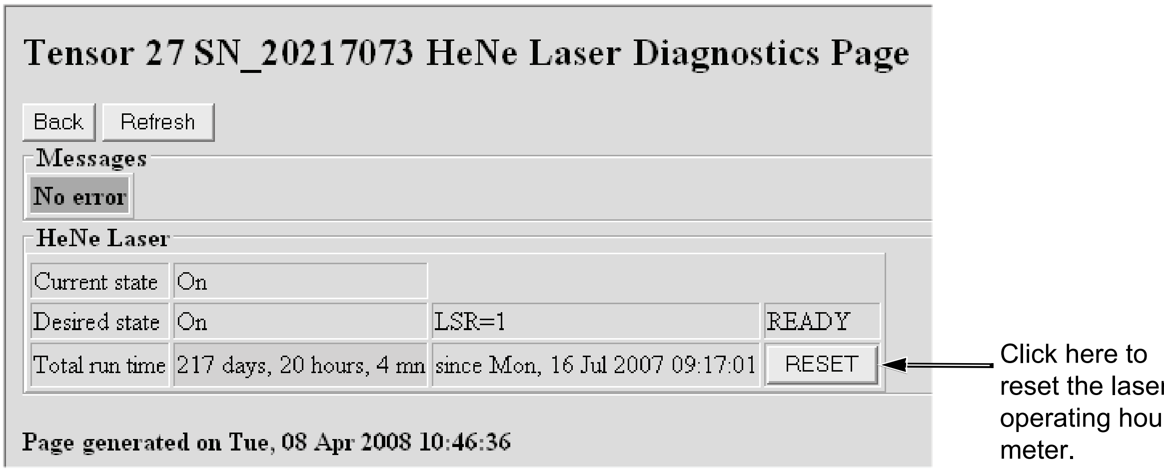


Figure 45: Laser Diagnostics Page

13 **Measure the laser wavenumber (LWN) and validate the spectrometer:** Open OPUS, measure the LWN and perform an OQ test using OVP. (For detailed information refer to the OPUS Reference Manual.)

Note: If the OQ test fails, refer to chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *A validation test failed*.

REPLACING A DEFECTIVE SOURCE

General Information

An indication of a defective source is, for example, a red STATUS indicator (fig. 10) and/or a failed PQ test. For information about a detailed fault diagnosis, refer to chapter *Troubleshooting*, section *Fault Diagnosis*.

For the order number of the replacement laser refer to appendix B.

Replacement Procedure

- The source replacement procedure is described in chapter *Operation*, section *Substituting the Source*. The procedure is identical for both IR source types (MIR and NIR).

After the replacement of a defective source, the following steps are required in addition:

- **Reset the source operating hour meter:** Either click in OPUS on the status light or select in the *Measure* menu the *Optics Diagnostics* function. The *Instrument Status* window opens. Click on the source icon and then on the *Service Info* button. The source diagnostics page opens. (See fig. 46.) Click on the *Reset* button.

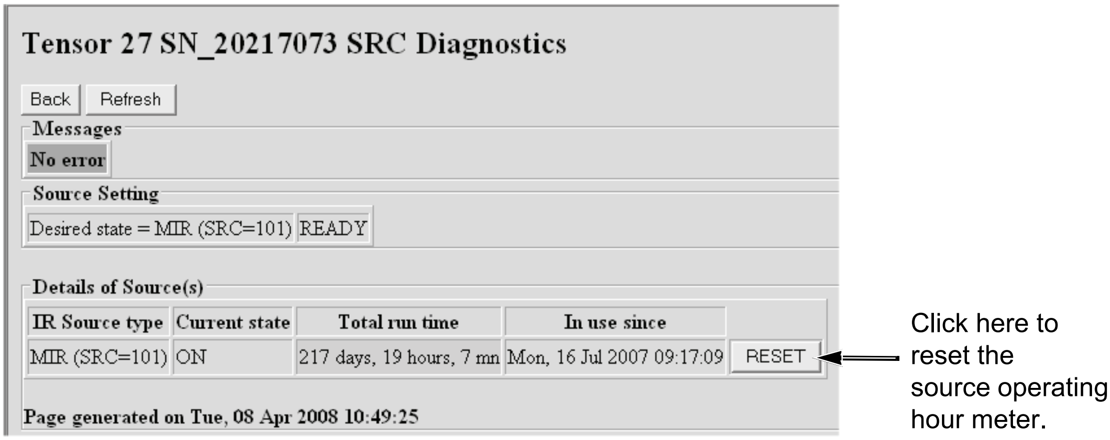


Figure 46: Source Diagnostics Page

- **Validate the spectrometer:** Open OPUS and perform an OQ test using OVP. (For detailed information refer to the OPUS Reference Manual.)

Note: If the OQ test fails, refer to chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *A validation test failed*.

REPLACING A DAMAGED SAMPLE COMPARTMENT WINDOW

General Information

A sample compartment window needs to be replaced if it is dirty and/or in case of cracking. Moreover, hygroscopic windows can become opaque in the course of time. The opacity of a window can reach such a degree that the transparency (infrared transmittance) is reduced significantly. In this case, the sample compartment window needs to be replaced as well.

For the order number of the available replacement windows refer to appendix B.

Handling Instructions

Observe the following handling instructions:

- The windows are very fragile. Handle them with care because they crack easily under the influence of mechanical pressure.
- Contaminations on the window surface can decrease the infrared transparency significantly. Therefore, do not touch the window surface. **Because most of the window materials are hygroscopic and/or harmful or toxic we strongly advise you against trying to clean the windows!**

Safety Notes

Warning: Some window materials are harmful or (very) toxic. (See the table in chapter *Overview*, section *Sample Compartment Windows*.) Observe the safety instructions on the packaging, and the safety data sheets attached. Non-observance may cause (serious) health problems or even death.

During normal spectrometer operation according to the instructions, the harmful or toxic window materials do not pose any health risk. However, should such a window break, be extremely careful. **Avoid generating dust!**

Replacement Procedure

1 **Remove the window assembly:** Insert the pins of the flange tool into the corresponding holes of the window assembly. (See fig. 47.) Rotate the flange tool about a quarter turn counterclockwise and remove the complete window assembly from the sample compartment wall.

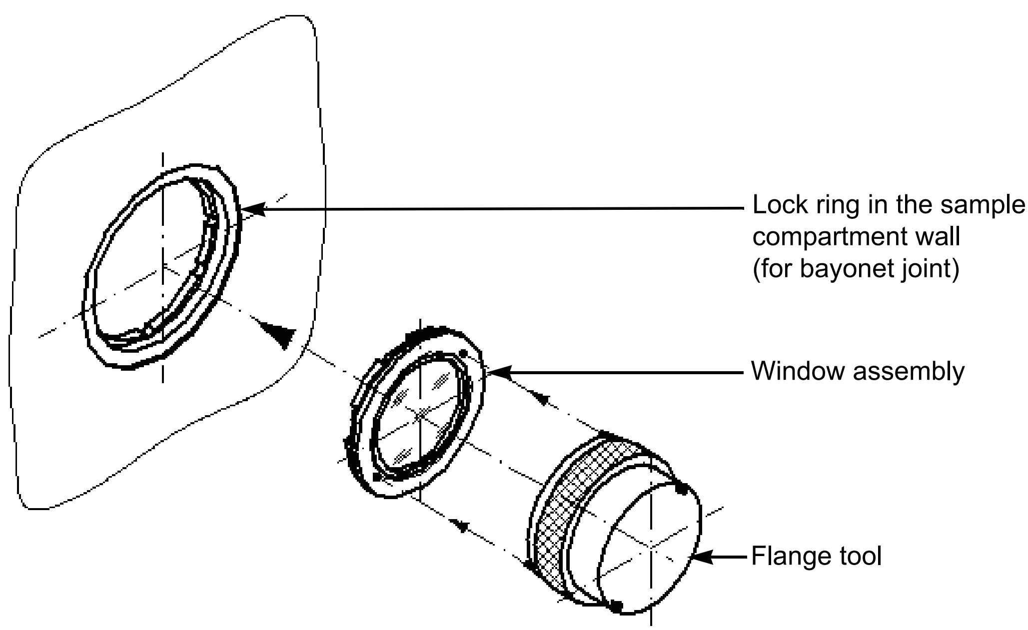


Figure 47: Removing / reinstalling the window assembly

2 **Disassemble the window assembly:** Put the window assembly on an even surface with the retainer ring (fig. 48) pointing upwards. Insert the corresponding pins of the flange tool into the holes of the window assembly retainer ring and rotate the flange tool counterclockwise. Disassemble the window assembly.

3 **Replace the window.**

4 **Reassemble the window assembly:** Re-assemble the window assembly. Insert the pins of the flange tool into the holes of the retainer ring of the window assembly and rotate the flange tool clockwise. (See fig. 48.)

5 **Reinstall the window assembly:** Insert the pins of the flange tool into the corresponding holes of the window assembly. (See fig. 47.) Attach the window assembly to the lock ring in the sample compartment wall and rotate the flange tool about a quarter turn clockwise.

Important: All sample compartment windows are wedge-shaped. To ensure maximum signal intensity, the correct orientation of the installed windows is of crucial importance. Due to the bayonet mount, there are four possible window installation positions. Find out the optimum installation position by trial and error while checking the signal intensity in OPUS. (See chapter *Operation* section *Checking the Signal*.)

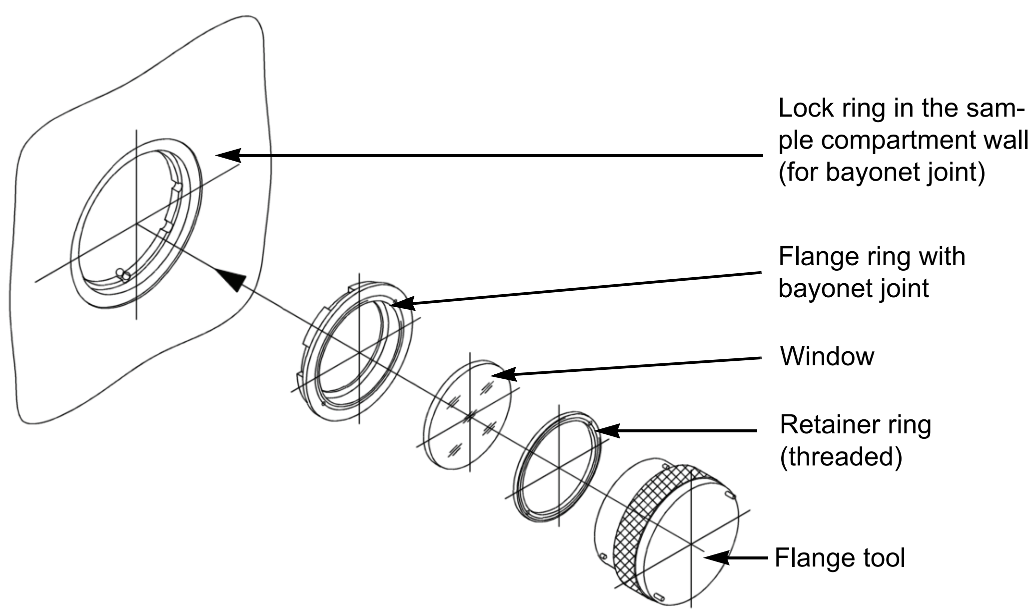


Figure 48: Exploded drawing of the window assembly plus flange tool

CLEANING

Only the outer surface of the spectrometer can be cleaned with a dry or damp cloth. Do not use detergents with organic solvents, acid or base!

Warning: Do not clean the spectrometer interior. This may lead to serious spectrometer damage. Do not try to clean a mirror surface! Even the usage of a cleaning cloth especially intended for cleaning optical lenses will irreversibly damage the mirror surface. So in case of a polluted mirror surface, contact the Bruker Service.

TROUBLESHOOTING

7

GENERAL INFORMATION

This chapter deals mainly with the most common spectrometer problems that may occur as experience has shown. It provides information about possible causes of the problem and presents solutions for troubleshooting. If the solutions listed in this chapter do not eliminate your spectrometer fault contact the Bruker service. (For service addresses and telephone numbers refer to appendix H.)

Depending on how a spectrometer problem becomes apparent, they are divided in the following categories:

- Spectrometer problem indicated by the spectrometer display
- Spectrometer problem indicated by an instrument status message in OPUS
- Spectrometer problem indicated by one of the various diagnostic LEDs at the spectrometer rear side (e.g. ERR LED, voltage status LEDs)
- No communication between spectrometer and computer
- No signal is detected or signal intensity is too low. (See chapter *Operation*, section *Checking the Signal*.)
- A validation test (e.g. PQ test) has failed.

The available diagnostic means (e.g. spectrometer display, instrument status messages in OPUS, diagnostics pages of the spectrometer firmware) enable the operator to identify many spectrometer problems, or at least to narrow down a problem. (The available diagnostic means are described in the following section.) In addition, there is the possibility of a remote fault diagnosis by the Bruker service. See section *Fault Diagnosis*, subsection *Remote Fault Diagnosis*.

Due to easy-to-replace spectrometer components, the operator can solve many problems himself. The holders and/or locking mechanisms for the spectrometer components source, beamsplitter and detector ensure a correct installation position of these components, i.e. after the replacement of these components, a realignment is not required.

FAULT DIAGNOSIS

For a systematic spectrometer fault diagnosis, the following diagnostic means are available:

- Spectrometer display on the spectrometer top side (See fig. 49.)
- OPUS dialog window *Instrument Status* (See fig. 50.)
- Instrument status message in OPUS (See fig. 51.)
- Diagnostics pages of the spectrometer firmware for the following spectrometer components: laser, source, interferometer[1], electronic, automation and detector (See fig. 52 to fig. 57.)
- Several diagnostic LEDs at the spectrometer rear side (See fig. 58a and fig. 58b.)

Spectrometer Display

The spectrometer display gives an indication of:

- the water vapor concentration inside the spectrometer,
- the power supply status of the laser and
- the general spectrometer status.

Figure 49: Spectrometer display

Humidity Indicator 

Red - Water vapor concentration inside the spectrometer is too high.
Off - Water vapor concentration inside the spectrometer is OK.

1. The terms *Interferometer* and *Scanner* are used synonymously.

Laser Indicator 

Yellow - Laser is in operation. (Laser power supply is OK.)

Off - Laser power supply is interrupted.

Status Indicator STATUS

Green - Spectrometer is in proper operating condition.

Red - Either there is a spectrometer problem (e.g. laser is out of alignment or IR source is defective) or the spectrometer is still in the initialization phase. (Note: After the spectrometer initialization is completed successfully, the status indicator turns from red to green.)

OPUS Dialog Window *Instrument Status*

The OPUS dialog window *Instrument Status* allows you to find out which spectrometer component has caused the problem or whether a validation test[1] has expired or failed. To perform a fault diagnosis, proceed as follows:

1 Either click on the OPUS status light or select in the OPUS *Measure* menu the *Optics Diagnostics* function. The following dialog window opens:

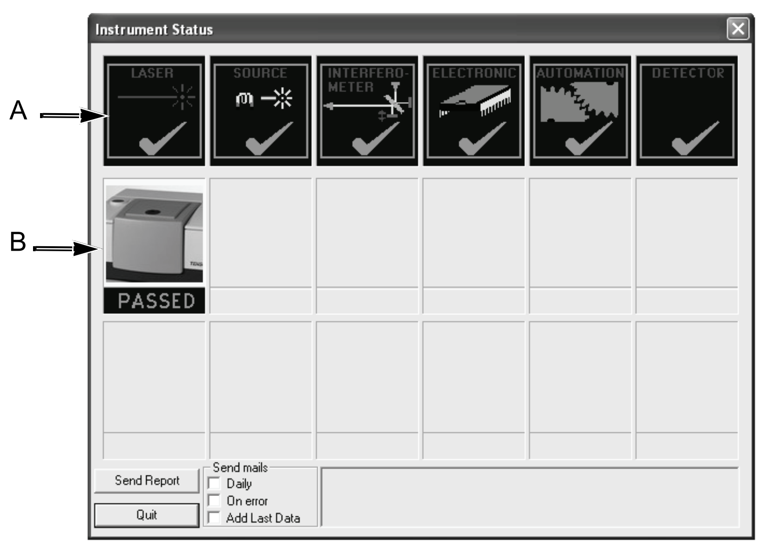
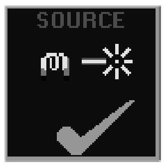
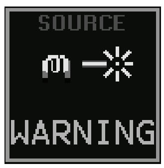
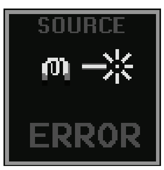


Figure 50: Optics Diagnostics - Instrument Status dialog

1. 'Validation test' is a collective term for all tests (e.g. OQ - Operational Qualification, PQ - Performance Qualification) that can be performed with OVP in order to validate the spectrometer. OVP (OPUS Validation Program) is part of OPUS. The general purpose of these validation tests is to check whether the spectrometer system achieves the specified performance or not. For information about OVP refer to the OPUS Reference Manual.

A The first row of icons refers to the spectrometer components like source, laser, interferometer etc. The components can take on the following states:

	**Green check mark:** Component is okay.
	**WARNING (light blue):** The exact meaning of a warning depends on the component in question. For example, in case of the source, a warning means: • End of the specified lifetime of the component is nearly reached. In this case, measuring is still possible.
	**ERROR (rot):** Component is defective. In this case, measuring is no longer possible.

B The second row of icons refers to the test channel(s) that have been set up using OVP. For these test channels, the following validation test results or validity states can be displayed:

	**PASSED (green):** Validation test passed. Test is still valid.
	**EXPIRED (light blue):** The validity period of the validation test has expired. What to do in this case? Perform the validation test in question. (See OPUS Reference Manual.)
	**FAILED (red):** Validation test failed. What to do in this case? Try to find out the cause of a failed validation test by performing a systematic fault diagnosis. Solve the problem and then repeat the validation test in question.

2 If a spectrometer component has the status WARNING or ERROR click on the respective icon in the first row of the *Instrument Status* dialog. The *Instrument Status Message* dialog opens. (See fig. 51.)

Instrument Status Messages in OPUS

Some spectrometer problems are indicated additionally by a corresponding instrument status message displayed in OPUS. (See the following figure. In this example, the instrument status message points to a source problem.)

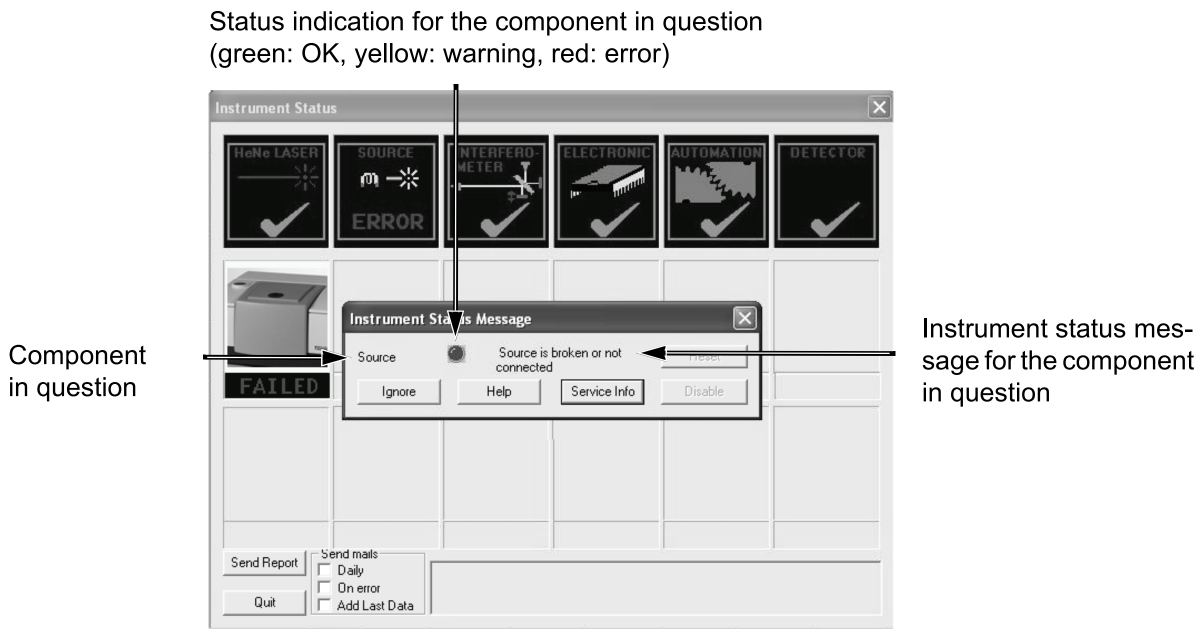


Figure 51: Instrument status message in OPUS

Diagnostics Pages of the Spectrometer Firmware

When you click on the *Service Info* button (fig. 51), the diagnostics page for the component in question opens. The diagnostics pages of the spectrometer firmware contain all relevant information about the current operating state of the respective spectrometer component. In the following figures, the information relevant to fault diagnostics are highlighted by a rectangle.

The following figures (fig. 52 to fig. 57) show the diagnostics pages of the following spectrometer components:

- HeNe-Laser (HeNe-Laser Diagnostics Page)
- Source (SCR Diagnostics)
- Interferometer (Scanner Diagnostics)
- Electronic (Instrument Ready Diagnostics)
- Automation (Automation units Diagnostics)
- Detector (DTC Diagnostics)

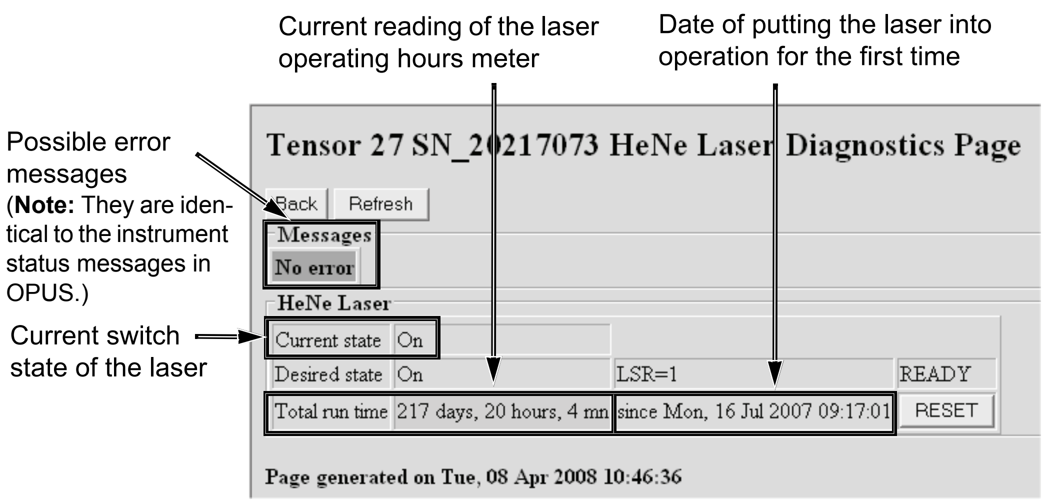


Figure 52: Laser diagnostics page

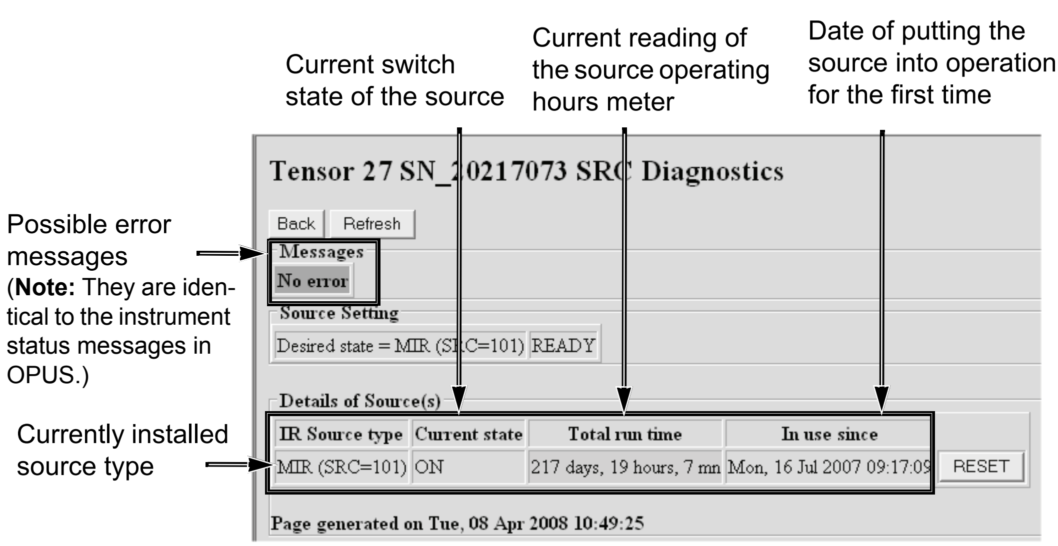


Figure 53: Source diagnostics page

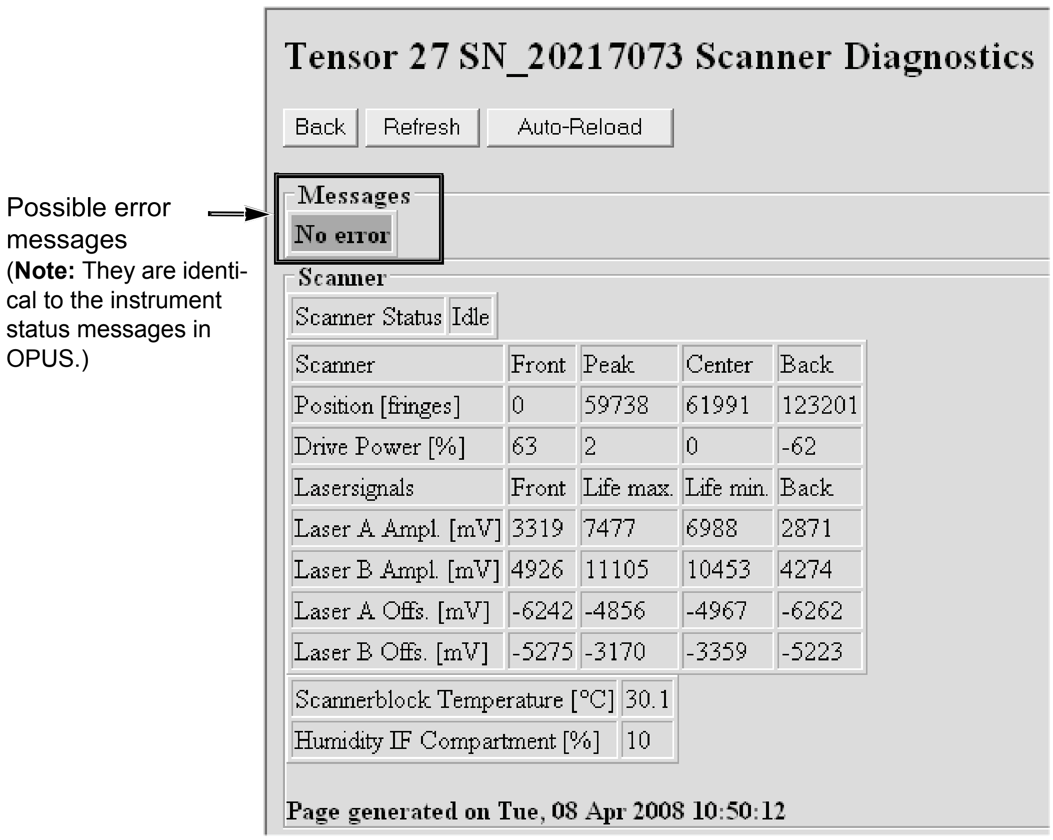


Figure 54: Scanner diagnostics page

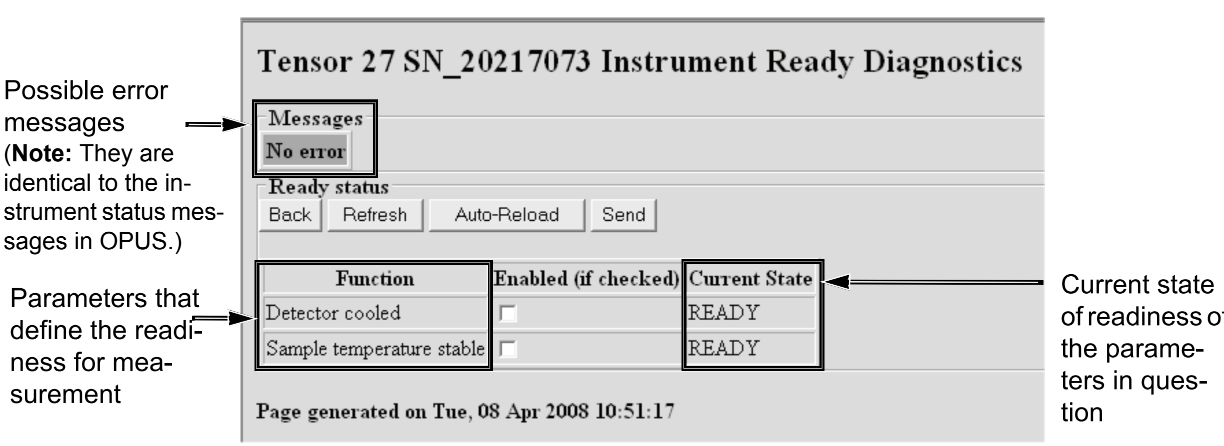


Figure 55: Electronics diagnostics page

Possible error messages
(**Note:** They are identical to the instrument status messages in OPUS.)

Tensor 27 SN_20217073 Automation units Diagnostics

Back | Refresh | Auto-Reload

Messages
No error

CAN Devices

Mot Number	Hex Address	Type	Used in	Current Pos	Timeout	Status Ready	Error	Running	Initialized	Connected	Firmware version
14	0x8E00	Sample Changer	SNR	0	15						
15	0x8F00	Motor		0	15						
16	0x9000	Sample Changer	SNR	0	15						
17	0x9100	Motor		0	15						
38	0xA600	Motor		0	20						
39	0xA700	Motor		0	10						
48	0xB000	Motor		2	120						
49	0xB100	Motor		0	30						
56	0xB800	Motor		2	30						
58	0xBA00	Motor		0	60						
59	0xBB00	Motor		0	60						
52	0xB400	Motor		0	10						
53	0xB500	Motor		0	10						
62	0xBE00	Motor		0	60						
216	0x5800	Optical filter (11)	OPF	0	10	READY			X	X	58
218	0x5A00	Measurement Channel (11)	CHN	0	10				X		58
219	0x5B00	Purge Valve (11)	PVV	1	1	READY			X	X	58
220	0x5C00	Aperture (11)	APT	361	10	READY			X	X	58
6160	0x20C0	CAN-ADI Digout		0	5						
7160	0x20E0	CAN-ADI Digin		0	5						
2162	0x2240	CAN-ADI ADC 1		0	5						
3162	0x2260	CAN-ADI ADC 2		0	5						
4162	0x2280	CAN-ADI DAC 1		0	5						
5162	0x22A0	CAN-ADI DAC 2		0	5						
6162	0x22C0	CAN-ADI Digout		0	5						
7162	0x22E0	CAN-ADI Digin		0	5						

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Figure 56: Automation diagnostics page

Possible error messages
(**Note:** They are identical to the instrument status messages in OPUS.)

Tensor 27 SN_20217073 DTC Diagnostics

Back | Refresh | Auto-Reload

Messages
No error

RT-DLaTGS [Internal]

Detector selected	YES	DTC=0x4020	PIC Vers 2.7	SNo. DTR2711	ECL07
Ana15 board settings	MUX=IR	TRW=OFF	HPF=OFF	GNS=16	SG2=1
Preamp board status	READY	PreampPower=ON	PGN=0 (0..0)		
Detector properties	Range: 180..10000wn	Vels: 400..10000..20000 Hz	NL coef: 0wn, 1.000	Recov. time: 3s	
	Gains: 1.0/1.0/1.0/1.0	Delays: 7500/7500/7500/7500ns	Error Level: No Error Messages		

Humidity Detector Compartment [%]	10

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Figure 57: Detector diagnostics page

Several diagnostic LEDs

At the spectrometer rear side, there are the following diagnostic LEDs:

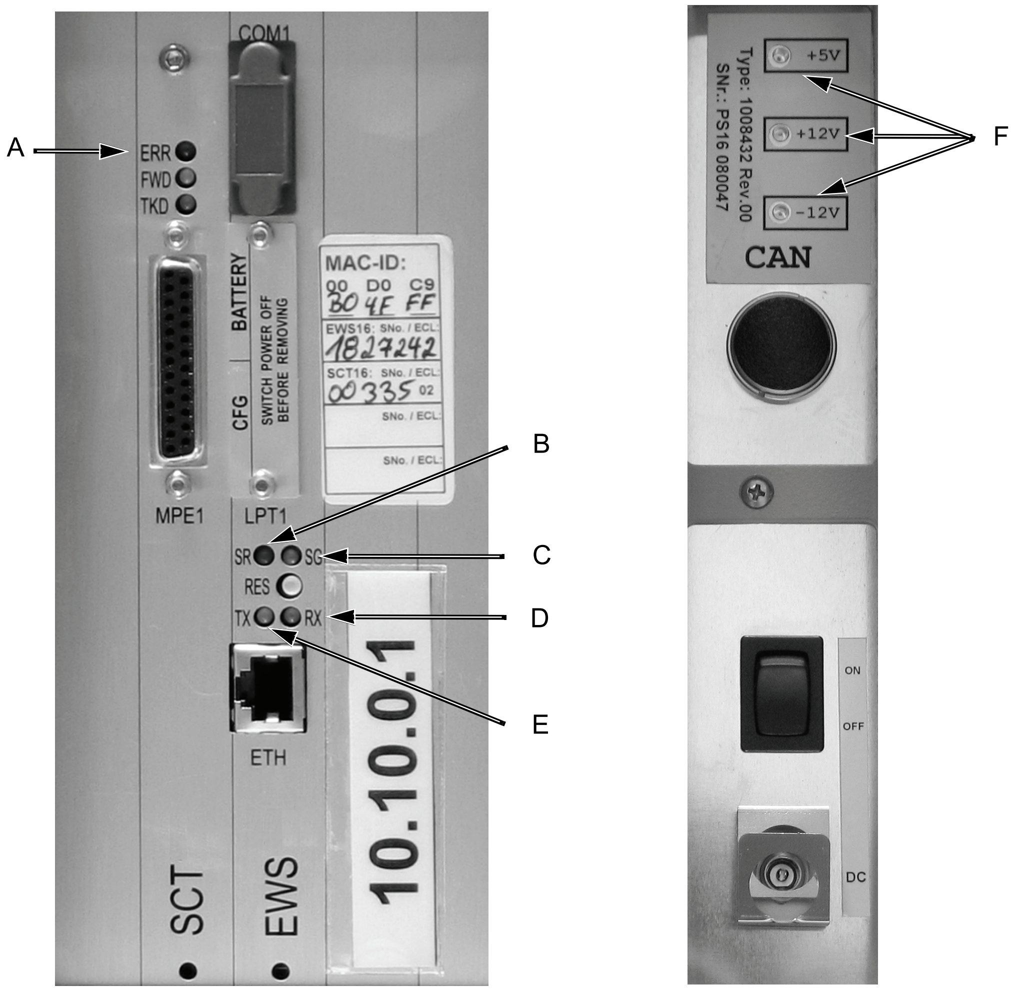


Figure 58: Connector panels for electronics and electricity (spectrometer rear side, detail views)

Figure 58	Component	Explanation
A	ERR LED (red)	A red ERR LED indicates an interferometer error (e.g. a missing laser signal, a beamsplitter problem). As long as this LED lights, measurement is not possible.
B and C	SR LED (red) and SG LED (green)	These two LEDs indicate the internal operating state of the spectrometer communication processor. (The abbreviation SR stands for ’Status Red’ and SG for ’Status Green’.)

Figure 58	Component	Explanation
D and E	RX LED (green) and TX LED (yellow)	These LEDs indicate the data transfer direction between spectrometer and PC. In case of the stand-alone operation, the green RX LED signals that the spectrometer receives data. In case the spectrometer is connected to an Ethernet network, the green RX LED indicates that a data packet is transmitted on the Ethernet. (This does not necessarily mean that the data packet is destined for the spectrometer!) The yellow TX LED lights when the spectrometer transmits a data packet, i.e. the spectrometer is accessed by a computer. **Note:** The abbreviation RX stands for ’transmit data’ and TX stands for ’receive data’. You can use these LEDs to test the communication between spectrometer and PC.
F	Voltage status LEDs	The voltage status are labeled +5V, +12V and -12V. They indicate the state of the secondary voltages of the electronics unit.

General information about how to diagnose a fault

In many cases, a problem caused by a spectrometer component, that is either defective or not properly installed or not in operating condition, becomes apparent in several different ways. For example:

- You have started a measurement but OPUS does not display any measurement result. (Reason: OPUS did not start the measurement at all.)
- No signal detection. (See chapter *Operation*, section *Checking the Signal*.)
- You have started a validation test but OVP does not display a PQ or OQ test protocol. (Reason: OVP did not start the validation test at all.)

To find out the concrete cause of a spectrometer problem, it is advisable to narrow down the trouble source in a systematic way. We recommend the following fault diagnosis procedure:

- First check whether the status indicator at the spectrometer (fig. 49) or the status lamp in OPUS indicate a spectrometer problem. (Are they red?)
- If so, open the OPUS dialog window *Instrument Status* and check whether there is a component having the status WARNING or ERROR. (See fig. 50.)
- If so, look up whether an instrument status message is displayed in OPUS. (See fig. 51.) For information about the meaning of the instrument status messages refer to section *Problem - Possible Cause - Solution*, subsection *Spectrometer problem indicated by an instrument status message in OPUS*.)
- For more information about the component in question, open the corresponding diagnostic page of the spectrometer firmware and try to find a hint for the cause of the spectrometer problem. (See fig. 52 to fig. 57.)

For information about how to eliminate a certain fault refer to the following section *Problem - Possible Cause - Solution*. If the solutions listed in this do not eliminate a fault contact the Bruker service. (See appendix H.)

Remote Fault Diagnosis

Remote fault diagnosis means that you send a complete spectrometer status report - a so called 'Full Report' - by e-mail to Bruker. This report enables a Bruker service technician to perform a first remote fault diagnostics.

Depending on whether your spectrometer is connected to a network or network computer (see fig. 5 and fig. 6) or a stand-alone computer (see fig. 4), the procedure for sending the report is different.

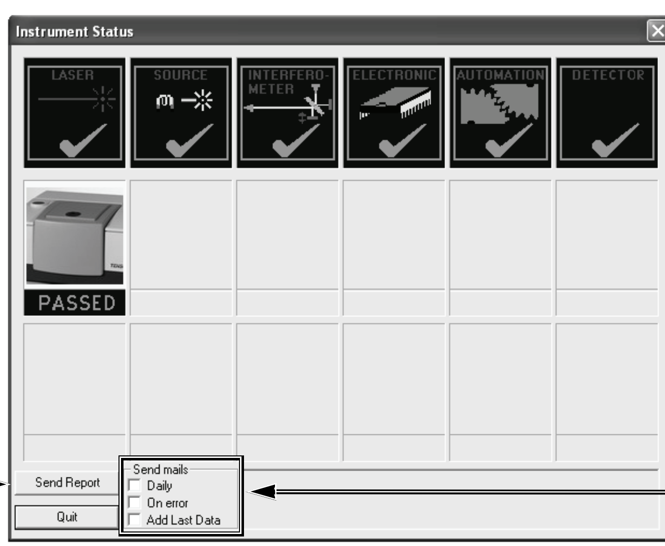
If your spectrometer is connected to a network or network computer ....

With OPUS version 6 or higher, it is possible to send the full report by e-mail to Bruker with just the click of a button. Proceed as follows:

1. Click on the OPUS status light. (Note: The status light is in the lower right corner of the OPUS interface.)
2. The *Instrument Status* dialog window opens. Click on the *Send Report* button. (See fig. 59.) As a result of this, the report is sent automatically by e-mail to *opusreports@brukeroptics.de*.

Note: The usage of this function requires an e-mail program installed on the network computer and a set-up mail account.

Click here to send the Full Report to the Bruker.



Note: In addition, you can define conditions for sending the full report automatically.

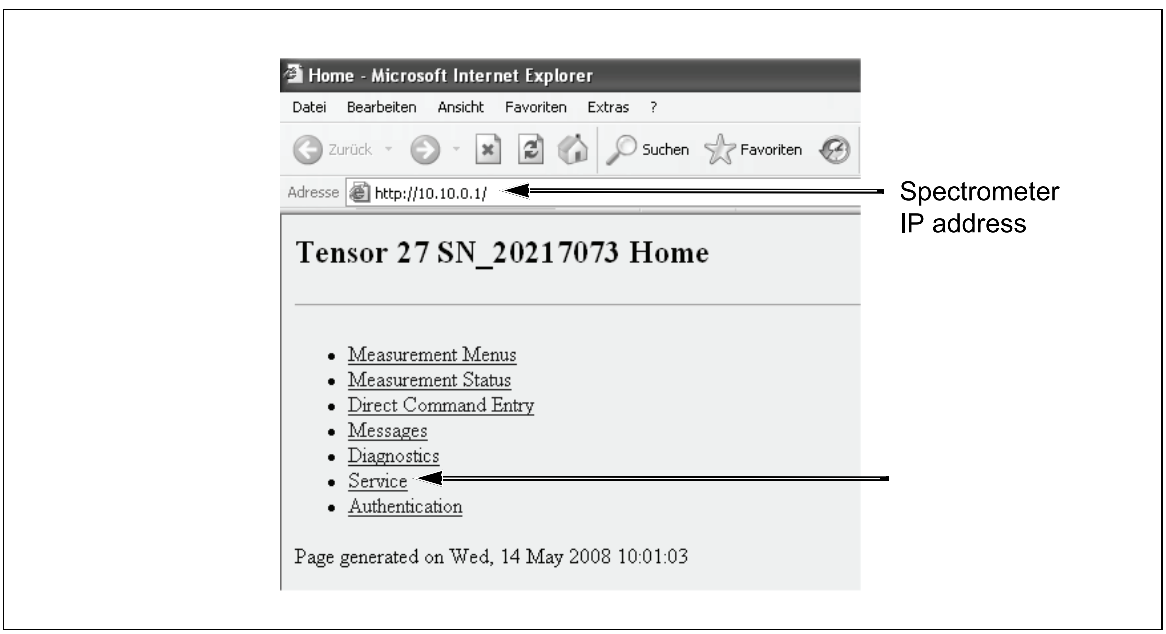
Figure 59: Optics Diagnostics - Instrument Status dialog

If your spectrometer is connected to a stand-alone computer, proceed as follows:

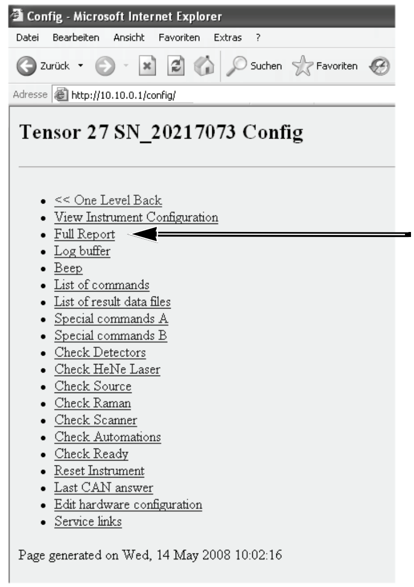
1. Generate a full report manually and save it. (See description below.)
2. Transfer the full report file to a network computer. (Note: The network computer requires an e-mail program and a set-up mail account.)
3. Send the full report by e-mail as an attached file to *opusreports@brukeroptics.de*.

Generating and saving a Full Report

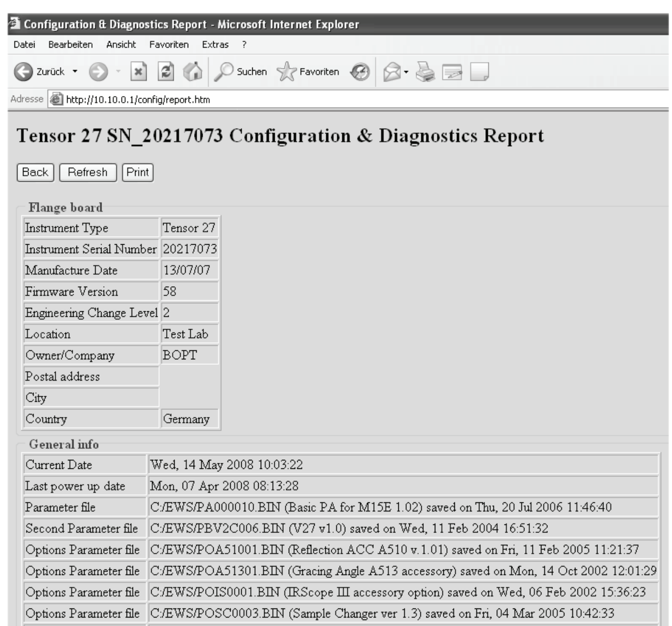
1. Open the web browser and enter the spectrometer IP address into the address field of the web browser. See the following figure. (Note: In case of the stand-alone configuration, the default spectrometer IP address is *http://10.10.0.1*.) The following page appears:



2. Click on *Service*. The following page appears:



3 Click on *Full Report*. The following page appears.



4 Save the full report by selecting in the web browser menu *File* the function *Save as*. Note: Save the full report as **.htm* file for sending it as an e-mail attachment.

Note: It is highly recommended to save the full report instantly after a spectrometer problem or failure has occurred. Otherwise, important information may be overwritten by newer ones.

PROBLEM - POSSIBLE CAUSE - SOLUTION

Starting from how a certain problem can become apparent (e.g. a red status LED, no signal detection), this section provides information about possible causes of a problem as well as solutions troubleshooting. If the solutions listed in this section do not eliminate your spectrometer fault contact the Bruker service. (For service addresses and telephone numbers refer to appendix H.

A problem indicated by the spectrometer display

Red humidity indicator

Possible causes	Solutions
Water vapor concentration inside the interferometer and/or detector compartment is too high.	In general, the following actions can solve the problem: • Purging the spectrometer with dry air or nitrogen gas. See chapter *Operation*, section *Purging the Spectrometer*. **Note:** For information about how to install a purge gas connection refer to chapter *Installation*. • Replacing the saturated cartridge(s) by new or regenerated cartridge(s). See chapter *Maintenance and Repair*, section *Replacing the Cartridge and Regenerating the Desiccant*. **Note:** If the desiccant is saturated and cannot absorb any further water vapor the cartridge needs to be replaced. Generally, the cartridges should be replaced about every 6 months. **Note:** Either regenerate the desiccant and reuse it or order replacement cartridges and replace the cartridge(s). For the order number refer to appendix B. **TENSOR 27:** Note that in case of TENSOR 27, the detector compartment is not equipped with a desiccant cartridge. The water vapor concentration in this compartment can by reduced only by purging the sample compartment with dry air because there is no window separating the sample compartment from the detector compartment. The water vapor concentration in the interferometer compartment can by reduced only by a desiccant cartridge. By default, TENSOR 27 is not designed for purging the interferometer compartment. **TENSOR 37:** In both compartments, the water vapor concentration can be reduced by purging as well as using a desiccant cartridge.

Laser indicator is off

Possible causes	Solutions
Spectrometer is still initializing, i.e. there is no spectrometer problem.)	Wait until the spectrometer has completed the initialization successfully.
Laser power supply is interrupted.	Check whether the supply cable of the laser module is connected and the green plugs are secured properly. See chapter *Maintenance and Repair*, section *Replacing a defective Laser.*

Red status indicator

A red STATUS LED indicates a spectrometer problem which can be caused by a number of spectrometer components (e.g. laser, source, detector). In this case it is highly recommended to open the OPUS dialog window *Instrument Status* (fig. 50) in order to be able to narrow down the problem.

Possible causes	Solutions
Spectrometer is still initializing. (In this case, there is no spectrometer problem.)	Wait until the spectrometer has completed the initialization successfully. (Note: As soon as the spectrometer initialization is completed successfully, the STATUS indicator turns from red to green.)
If the **laser** is the cause of the problem either: • the laser beam is blocked or • the laser is not installed properly or • the laser is defective.	**Blocked laser beam:** Contact the Bruker service. (See appendix H.) **Improperly installed laser:** Check whether the laser rests on the holder bottom in a plane manner. (See chapter *Maintenance and Repair*, section *Replacing a defective Laser*.) **Defective laser:** Order a replacement laser module. (For the order number refer to appendix B.) Replace the defective laser module. See chapter *Maintenance and Repair*, section *Replacing a defective Laser.*
If the **source** is the cause of the problem either: • there is no source installed in the operating position or • the source is not installed properly or • the source is defective. **Note**: This problem is indicated by the instrument status message *Source is broken or not connected*. (See fig. 51.)	**Missing source:** Install a source in the operating position. See chapter *Operation*, section *Substituting the Source*. **Improperly installed source:** Check whether the source is installed properly. See chapter *Operation*, section *Substituting the Source*. **Defective source:** Order a replacement source. (For the order number refer to appendix B.) Replace the defective source. See chapter *Maintenance and Repair*, section *Replacing a defective Source*.

Possible causes	Solutions
If the **detector** is the cause of the problem: • either the detector is not installed correctly or **Note**: This problem is indicated by the instrument status message *Device not connected. No analog board selected*. • the MCT detector is not cooled down to its operating temperature. **Note**: This problem is indicated by the instrument status message *Detector not ready*.	**Improperly installed detector:** Check whether the detector is installed correctly. (See chapter *Operation*, section *Substituting the Detector*.) **MCT detector temperature is too high:** Fill liquid nitrogen into the MCT detector dewar. (See chapter *Operation*, section *Cooling the MCT Detector*.)
If the **interferometer** is the cause of the problem there are a number of possible causes. For example: • Beamsplitter is not locked (only in case of TENSOR 37). • **Note**: This problem is indicated by the instrument status message *BMS door is open*.	**Unlocked beamsplitter:** Lock the beamsplitter by putting the lever in the position CLOSE. (See chapter *Operation*, section *Substituting the Beamsplitter*.) **In case of a different cause**, try to narrow down the trouble source by consulting the *Scanner Diagnostics Page* (fig. 54). If you can not solve the problem contact the Bruker service. (See appendix H.)
If the **electronics** is the cause of the problem the electronics unit is defective or there is a short circuit, for example.	Check whether the voltage status LEDs (labeled +5V, +12V and -12V) at the spectrometer rear side are on. (See also section *Spectrometer problem indicated by the voltage status LEDs* below in this chapter.) In case of a defective power supply unit contact the Bruker service. (See appendix H.)
If the **automation** is the cause of the problem there are a number of possible causes.	To narrow down the cause of the problem, open the *Automation Diagnostics Page* (fig. 56) in OPUS. See also section *Spectrometer problem indicated by an instrument status message in OPUS* below in this chapter; instrument status messages regarding the automation. If you can not solve the problem contact the Bruker service. (See appendix H.)

Spectrometer problem indicated by an instrument status message in OPUS

Instrument status message regarding the laser

Instrument status message	Possible causes	Solutions
HeNe laser is off or no laser signal.	Laser is not installed correctly **OR** laser power supply is interrupted **OR** laser is defective.	Check whether the laser rests on the holder bottom in a plane manner. See chapter *Maintenance and Repair*, section *Replacing a defective Laser*. Check whether the supply cable of the laser module is connected and the green plugs are secured properly. See chapter *Maintenance and Repair*, section *Replacing a defective Laser.* Order a replacement laser module. (For the order number refer to appendix B.) Replace the defective laser module. See chapter *Maintenance and Repair*, section *Replacing a defective Laser*.
End of average lifetime is nearly reached, spare part will be required.	The end of the specified lifetime of the laser is nearly reached.	Order a replacement laser module. (For the order number refer to appendix B.) Replace the defective laser module. See chapter *Maintenance and Repair*, section *Replacing a defective Laser*. **Note:** Despite this warning message, measuring is still possible. To turn the OPUS status light green again click on the *Ignore* button in the *Instrument Status Message* dialog (fig. 51). **Note:** This instrument status message will be repeated in certain intervals until the laser module has been replaced.

Instrument status message regarding the source

Instrument status message	Possible causes	Solutions
Source is broken or not connected.	There is no source installed in the operating position or the source is not installed properly. **OR** Source is defective (e.g. burnt out).	Install the source properly. See chapter *Operation*, section *Substituting the Source*. Order a replacement source. (For the order number refer to appendix B.) Replace the defective source. See chapter *Maintenance and Repair*, section *Replacing a defective Source*.
End of average lifetime is nearly reached, spare part will be required.	The end of the specified lifetime of the source is nearly reached.	Order a replacement source. (For the order number refer to appendix B.) Replace the defective source. See chapter *Maintenance and Repair*, section *Replacing a defective Source*. **Note:** Despite this warning message, measuring is still possible. To turn the OPUS status light green again click on the *Ignore* button in the *Instrument Status Message* dialog (fig. 51). **Note:** This instrument status message will be repeated in certain intervals until you have replaced the source.

Instrument status message regarding the interferometer

Instrument status message	Possible causes	Solutions
Scanner initialization mode.	This message appears only if you try to start a measurement while the spectrometer is still initializing. **Note:** Also other instrument status messages can be displayed. As in this case there is not a spectrometer problem you can ignore them.	Before starting a measurement, wait until the spectrometer has completed the initialization successfully. (Note: As soon as the spectrometer initialization is completed successfully, the STATUS indicator turns from red to green.)

Instrument status message	Possible causes	Solutions
BMS door is open. **Note:** This message can appear only in case of **TENSOR 37**.	Beamsplitter is not locked, i.e. the beam-splitter lever is in the position OPEN.	Lock the beamsplitter by putting the lever in the position CLOSE. (See chapter *Operation*, section *Substituting the Beamsplitter*.)
Laser-A timing error / Laser-B timing error **OR** Laser-A modulation too small / Laser-B modulation too small **OR** Laser signals modulation too small **OR** Laser period too slow or modulation too small	Interferometer is out of adjustment caused by strong shocks, for example.	Contact the Bruker service. (See appendix H.)

Instrument status message regarding the detector

Instrument status message	Possible causes	Solutions
Detector not ready.	MCT detector temperature is too high.	Fill liquid nitrogen into the MCT detector. (See chapter *Operation*, section *Cooling the MCT Detector*.)
Device not connected. No analog board selected. **OR** No analog board found.	Detector is not installed.	Install the detector. (See chapter *Operation*, section *Substituting the Detector*.)

If an instrument status message appears which is not listed in the above tables contact the Bruker service. See appendix H.

Spectrometer problem indicated by the voltage status LEDs

All voltage status LEDs are Off

Possible causes	Solutions
Spectrometer is off.	Switch on the spectrometer. (See chapter *Operation*, section *Switching TENSOR on or off*.)
Power cord and /or low-voltage cable are not connected.	Connect the cables properly. (See chapter *Installation*, section *Connecting TENSOR to Power Supply*.)
No voltage is applied.	Check whether the proper voltage is applied at the mains socket outlet to which the spectrometer is connected. (See chapter *Installation*, section *Site Requirements*.)
Short circuit in the power supply unit	Interrupt the mains power supply immediately! If there are external accessory and/or components connected to the CAN bus port or any other spectrometer port, disconnect them. Then reconnect the spectrometer to the mains supply. If this action solves the problem the external circuitry has caused the short circuit. Otherwise, it is an internal problem of the spectrometer electronics. Contact the Bruker service. (See appendix H.)
Defective external power supply unit.	If the power supply LEDs do not light correctly, probably the external power supply unit needs to be replaced. If LEDs do not light at all, contact the Bruker service. (See appendix H.)

One voltage status LED is off

Possible causes	Solutions
An external accessory / component causes a short circuit.	Switch off the spectrometer and disconnect all externally connected accessories and/or components from the CAN bus port or any other port at the spectrometer rear side. Then switch on the spectrometer. (See also chapter *Operation*, section *Switching TENSOR on or off*.)
Temporary short circuit	Switch off the spectrometer, wait about 30 seconds and switch it on again. (See also chapter *Operation*, section *Switching TENSOR on or off*.)

Possible causes	Solutions
A defective LED.	In this case there is no spectrometer malfunction and the spectrometer operates properly. Only the defective LED needs to be replaced.

A spectrometer problem indicated by a red ERR LED

Generally, a red ERR LED indicates a scanner problem, i.e. all components (e.g. laser, beamsplitter) and/or conditions that are involved in the scanner functioning can cause a red ERR LED.

Possible causes	Solutions
If the **laser** is the cause of the problem either: • the laser beam is blocked or • the laser power supply is interrupted or • the laser is not installed properly or • the laser is defective.	**Blocked laser beam:** Contact the Bruker service. (See appendix H.) **Interrupted laser power supply:** Check whether the supply cable of the laser module is connected and the green plugs are secured properly. (See chapter *Maintenance and Repair*, section *Replacing a defective Laser.)* **Improperly installed laser:** Check whether the laser rests on the holder bottom in a plane manner. (See chapter *Maintenance and Repair*, section *Replacing a defective Laser*.) **Defective laser:** Order a replacement laser module. (For the order number refer to appendix B.) Replace the defective laser module. (See chapter *Maintenance and Repair*, section *Replacing a defective Laser.)*
Shocks or other strong mechanical impacts have caused a permanent optics misalignment.	Contact the Bruker service. (See appendix H.)
TENSOR 37 only In case the beamsplitter is the cause of the problem either: • no beamsplitter is installed or • the beamsplitter is not locked, i.e. the beamsplitter lever is in the position OPEN. **Note**: These problems are indicated by the instrument status message *BMS door is open.* **Both TENSOR versions** • The beamsplitter is damaged or has become opaque.	**Missing beamsplitter:** Install a beamsplitter. (See chapter *Operation*, section *Substituting the Beamsplitter*.) **Improperly installed beamsplitter:** Lock the beamsplitter by putting the lever in the position CLOSE. (See chapter *Operation*, section *Substituting the Beamsplitter*.) **Damaged beamsplitter:** Probably you need to order a replacement beamsplitter. Replace the beamsplitter. (See chapter *Operation*, section *Substituting the Beamsplitter*.) **Note:** In case of **TENSOR 27**, you can neither inspect visually the beamsplitter nor substitute this component due to the interferometer design. But if you assume that the beamsplitter is the cause of the problem contact the Bruker service. (See appendix H.)

The SR LED lights permanently

As long as the SR LED lights, the spectrometer is busy and not available for communication.

Possible causes	**Solutions**
Spectrometer is still in the initialization phase. (In this case, there is no spectrometer problem.)	Wait until the spectrometer has completed the initialization successfully. (Note: As soon as the spectrometer initialization is completed successfully, the STATUS indicator turns from red to green.)
Spectrometer control hangs.	Reset the spectrometer using the reset button (J in fig. 68) at the spectrometer rear side and wait for initialization to terminate. If this action does not solve the problem, contact the Bruker service. (See appendix H.)

No communication between spectrometer and computer

In case of communication problems, the troubleshooting procedure depends on the connection variant. (See chapter *Installation*, section *Connecting TENSOR to a PC*.)

The direction of the data transfer is indicated by the LEDs RX and TX at the spectrometer rear side. The TX LED lights during the spectrometer sends data and the RX LED lights during the spectrometer receives data.

The green RX LED does not light at all

This indicates a problem with regard to the physical connection between the spectrometer and the PC or the network.

Possible causes	**Solutions**
With regard to the existing connection variant, the wrong data cable type is used.	The data cable type (cross-over or straight), which has to be used, depends on the realized connection variant. (For information about which data cable type has to be used for which connection variant, see chapter *Installation*, section *Connecting TENSOR to a PC*, subsection *General Information*.) Procure a data cable of the correct type. Replace the data cable.
Data cable connector is loose.	Check both data cable connectors for tight fit, i.e. at the Ethernet port (E in fig. 68) at the spectrometer rear side and the RJ45 socket at the PC. Connect the data cable properly.
Data cable is damaged.	Check the data cable for damages. If it shows signs of damages, replace it.

Possible causes	Solutions
Spectrometer does not start up.	Check whether the spectrometer is connected to a mains socket outlet. (See chapter *Installation*, section *Connecting TENSOR to Power Supply*.) Check whether the mains supply meets the requirements. (See chapter *Installation*, section *Site Requirements*, subsection *Power Supply*.) Check whether the spectrometer is switched on. (See chapter *Operation*, section *Switching TENSOR on or off*.) If these actions do not solve the problem contact the Bruker service. (See appendix H.)

During the connection establishment the green RX LED lights but the yellow TX LED does not.

This indicates that there is no logical connection between the spectrometer and network or computer.

Possible causes	Solutions
With regard to the realized connection variant, the wrong IP address has been assigned to the spectrometer. **Note:** The correct spectrometer IP address depends on the existing connection variant. (See chapter *Installation*, section *Connecting TENSOR to a PC*, subsection *Network Addresses*.)	Assign the correct IP address to the spectrometer. (See chapter *Installation*, section *Connecting TENSOR to a PC*, subsection *Assigning Network Address to the Spectrometer*.)
TCP/IP settings mismatch between spectrometer and computer/network.	Refer to the documentation of the operating system Windows.

Hint: If you do not succeed in solving the communication problem between spectrometer and PC, consult your network administrator. To provide the network administrator with the relevant information, proceed as follows:

1. Click in the Window desktop on the *Start* button.
2. Select *Run*.
3. Enter *cmd* and click *OK*.
4. Enter *route print* and press the ENTER key.
5. Then, enter *ipconfig/all* and press the ENTER key again.
6. Take a screenshot of the dialog (fig. 60) and provide it for your network administrator.

Figure 60: Useful information for solving the communication problem between PC and spectrometer

No signal is detected or the signal intensity is too low.

Provided that the spectrometer and the PC are properly connected and switched on and the computer can access the spectrometer, this problem can have the following possible causes:

Possible Causes	Solutions
Beam path is blocked.	Check whether the IR beam is blocked in the sample compartment by an accessory or a sample or another object. Remove the sample / object and check the signal again.
Source is switched off (i.e. the source parameter in OPUS is set to *Off*).	Switch on the source by selecting in the OPUS *Measure* menu the *Set Measurement Parameters* function. Click in the *Measurement* dialog on the *Optic* tab and select in the *Source Setting* drop-down list the option *MIR* (in case of MIR source) or *NIR* (in case of NIR source). Exit the dialog by clicking on the *Save and exit* button.
In case of a MCT detector or a thermoelectrically cooled detector, the detector temperature is too high. **Note**: This problem is indicated by the instrument status message *Detector not ready.*	**MCT detector:** Fill liquid nitrogen into the MCT detector. (See chapter *Operation*, section *Cooling the MCT Detector.*) **Thermoelectrically cooled detector:** Contact the Bruker service. (See appendix H.)

Possible Causes	Solutions
Detector is not or not properly installed. **Note**: This problem is indicated by the instrument status message *Device not connected. No analog board selected*.	Install the detector properly. (See chapter *Operation*, section *Substituting the Detector*.)
Source is not or not properly installed or it is defective. **Note**: These problems are indicated by the instrument status message *Source is broken or not connected.*	Install the source properly. (See chapter *Operation Substituting the Source*.) If the source is defective, order a replacement source. (For the order number refer to appendix B.) Replace the defective source. (See chapter *Maintenance and Repair*, section *Replacing a defective Source*.)
TENSOR 37 only No beamsplitter is installed or the beamsplitter is not locked, i.e. the beamsplitter lever is in the position OPEN. **Note**: These problems are indicated by the instrument status message *BMS door is open.*	Install a beamsplitter. Lock the beamsplitter by putting the lever in the position CLOSE. (See chapter *Operation*, section *Substituting the Beamsplitter*.)
The beamsplitter is damaged or has become opaque.	**TENSOR 27:** The beamsplitter is factory-installed, i.e. you can neither inspect visually the beamsplitter nor substitute it due to the interferometer design. But if you assume that the beamsplitter is the cause of the problem contact the Bruker service. (See appendix H.) **TENSOR 37:** Order a new beamsplitter and replace it. (See chapter *Operation*, section *Substituting the Beamsplitter*.)
The laser is defective. **Note**: This problem is indicated by the instrument status message *HeNe laser is off or no laser signal.*	Order a replacement laser module. (For the order number refer to appendix B.) Replace the defective laser module. (See chapter *Maintenance and Repair*, section *Replacing a defective Laser.)*
Detector oversaturation or A/D converter overflow	Either reduce the source intensity by using a smaller aperture or reduce the gain settings. **Note:** Both parameters (aperture and gain) are set in the OPUS dialog *Measurement*. See the OPUS Reference Manual.
A temporary or permanent optics misalignment caused by strong shock.	Put the spectrometer on a vibration-free surface. In case of a temporary optics misalignment, this action can solve the problem. If this action does not solve the problem contact the Bruker service. (See appendix H.)
Defective power supply unit.	Check the voltage status LEDs at the spectrometer rear side. If none of the LEDs lights, the power supply unit probably needs to be replaced. Contact the Bruker service. (See appendix H.)

A validation test failed

'Validation test' is a collective term for all tests (e.g. OQ test[1], PQ test[2]) that can be performed with OVP[3] for the purpose of the spectrometer validation[4]. (For detailed information about OVP refer to the OPUS Reference Manual.)

Possible causes	Solutions
During the validation test measurements, an object (e.g. a sample) in the sample compartment has blocked the IR beam.	Take the sample/object out of the sample compartment and repeat the validation test.
Source performance has decreased significantly because the end of its service lifetime is nearly reached. **Note**: This problem is indicated by the instrument status message *End of average lifetime is nearly reached, spare part will be required.*	Order a replacement source. (For the order number refer to appendix B.) Replace the defective source. (See chapter *Maintenance and Repair*, section *Replacing a defective Source*.) Afterwards, repeat the validation test. **Note:** To find out of which component - either laser or source - the end of the average lifetime is nearly reached, open in OPUS the *Instrument Status* dialog window. (See fig. 50.) The component in question has the status WARNING.)
Sample compartment windows are dirty or damaged. Moreover, hygroscopic windows can become opaque in the course of time. The opacity of a window can reach such a degree that the transparency (infrared transmittance) is reduced significantly.	Order new windows. (For the order number refer to appendix B.) Replace them. (See chapter *Maintenance and Repair*, section *Replacing a damaged Sample Compartment Window*.) Afterwards, repeat the validation test.
Beamsplitter is dirty or damaged. Moreover the hygroscopic beamsplitter can become significantly opaque in the course of time.	**TENSOR 27:** The beamsplitter is factory-installed, i.e. you can neither inspect visually the beamsplitter nor substitute it due to the interferometer design. But if you assume that the beamsplitter is the cause of the problem contact the Bruker service. (See appendix H.) **TENSOR 37:** Order a new beamsplitter and replace it. (See chapter *Operation*, section *Substituting the Beamsplitter*.) Afterwards, repeat the validation test.

1. OQ- Operational Qualification (Normally, this test should be performed once a year or at least after the replacement of an optical spectrometer component.)
2. PQ - Performance Qualification (Normally, this test should be perform each day before you start your analytical work and after the replacement of an optical spectrometer component for the purpose of extending the spectral range.
3. OVP - OPUS Validation Program
4. Validating the spectrometer means to check whether the spectrometer system achieves the specified performance parameter values. The spectrometer validation ensures that the measurement results delivered by a validated spectrometer system are correct.

Possible causes	**Solutions**
The spectral ranges of the installed optical components source, beam-splitter, detector and sample compartment windows do not match.	Find out the spectral ranges of the installed optical components. (Note: The spectral ranges of the available optical components are listed in the corresponding sections of chapter *Overview*.) Depending on the spectral range you intend to use, replace the corresponding component(s). (For information about the replacement procedure, refer to the corresponding sections of chapter *Operation*.) Make sure that the spectral ranges of the installed optical components source, beamsplitter, detector and sample compartment windows match. Afterwards, repeat the validation test.
The test channel configuration (source, beamsplitter and detector) set up in OVP deviates from the actually installed components.	Either modify the test channel configuration in OVP or replace the spectrometer component(s) in question. (For information about the replacement procedure, refer to the corresponding sections of chapter *Operation*.) Afterwards, repeat the validation test.
In case of a MCT detector or a thermoelectrically cooled detector, the detector temperature is too high. **Note**: This problem is indicated by the instrument status message *Detector not ready*.	**MCT detector:** Fill liquid nitrogen into the MCT detector. (See chapter *Operation*, section *Cooling the MCT Detector*.) **Thermoelectrically cooled detector:** Contact the Bruker service. (See appendix H.)
MCT detector: In the course of time, the quality of the vacuum in the detector dewar has degraded significantly. **Note:** This problem becomes apparent by a failed *Ice Band Test*. This test is part of the PQ test protocol. **Note:** An additional indication of a degraded vacuum is condensation water or ice on the MCT detector outside.	Evacuate the MCT detector dewar. (See chapter *Maintenance and Repair*, section *Evacuating a MCT Detector Dewar*.) Afterwards, repeat the validation test.
Peak position of the interferogram has shifted (along the wavenumber axis).	Save the new peak position using the OPUS software. Proceed as follows: Select in the *Measure* menu the *Advance Measurement* function, click on the *Check Signal* tab. (Ensure that the option button *Interferogram* is activated.) If the peak position is constant save it by clicking on the *Save Peak Position* button. Afterwards, repeat the validation test.

Possible causes	**Solutions**
Water vapor concentration inside the spectrometer is too high, i.e. the water vapor concentration has exceeded as certain limit value. **Note:** This problem becomes apparent by a failed *Water Vapor Test*. This test is part of the OQ test protocol. **Note:** An additional indication of this kind of problem is a red humidity indicator at the spectrometer top side. See fig. 49.	In general, the following actions can solve the problem: • Purging the spectrometer with dry air or nitrogen gas. See chapter *Operation*, section *Purging the Spectrometer*. **Note:** For information about how to install a purge gas connection refer to chapter *Installation*. • Replacing the saturated cartridge(s) by new or regenerated cartridge(s). See chapter *Maintenance and Repair*, section *Replacing the Cartridge and Regenerating the Desiccant*. **Note:** If the desiccant is saturated and cannot absorb any further water vapor the cartridge needs to be replaced. Generally, the cartridges should be replaced about every 6 months. **Note:** Either regenerate the desiccant and reuse it or order replacement cartridges and replace the cartridge(s). For the order number refer to appendix B. **TENSOR 27:** Note that in case of TENSOR 27, the detector compartment is not equipped with a desiccant cartridge. The water vapor concentration in this compartment can by reduced only by purging the sample compartment with dry air because there is no window separating the sample compartment from the detector compartment. The water vapor concentration in the interferometer compartment can by reduced only by a desiccant cartridge. By default, TENSOR 27 is not designed for purging the interferometer compartment. **TENSOR 37:** In both compartments, the water vapor concentration can be reduced by purging as well as using a desiccant cartridge. Afterwards, repeat the validation test.
If a failed validation test has a different cause (e.g. detector sensitivity has weakened or optics is out of adjustment due to shock etc.) ...	... contact the Bruker service. (See appendix H.)

SPECIFICATIONS

A

Feature	TENSOR 27	Description / TENSOR 37
Weight	approx. 37kg (The exact weight depends on the spectrometer configuration.)	
Dimensions	67cm (W) x 44cm (D) x 28cm (H)	
Power Consumption	24 VDC ± 10%; 3.75 A; max. 90 W SELV with functional earthing by the negative terminal	
Spectral Range	**standard:** 8,000 to 340cm^{-1} with standard KBr beamsplitter	**standard:** 8,000 to 350cm^{-1} with standard KBr beamsplitter
	optional: • 11,000 to 350cm^{-1}, with broadband KBr beamsplitter • 5,000 to 210cm^{-1} with CsI optics • 6,000 to 500cm^{-1} with “High Humidity” ZnSe optics	**optional:** • 15,000 to 50cm^{-1} (For extending the spectral rage, a number of manually exchangeable MIR, NIR and FIR beamsplitters are available.)
Resolution	Better than 0.9cm^{-1}, optional better than 0.4cm^{-1}	Better than 0.6cm^{-1}, optional better than 0.3cm^{-1}
Wavenumber Accuracy	Better than 0.01cm^{-1} @ 2,000cm^{-1}	
Photometric Accuracy	Better than 0.1% T	
Detector	**standard:** High sensitivity DLaTGS with KBr window	
	Optional: various detectors for measurements in the MIR region	**Optional:** various detectors for measurements in the MIR, NIR and FIR region
Laser	**TENSOR 27** is a laser class 1 product containing a laser class 2 laser according to EN 60825-1/10.2003. Divergence angle: 1.77 mrad ± 5%	**TENSOR 37** is a laser class 2 product containing a laser class 2 laser according to EN 60825-1/10.2003. Divergence angle: 1.77 mrad ± 5%

Feature	TENSOR 27	Description TENSOR 37
Sample Compartment	25.5cm x 27cm x 16cm The sample compartment is purgeable. **TENSOR 27:** The sample compartment is separated from the interferometer compartment by one KBr window. **TENSOR 37:** The sample compartment is separated from the optical bench by two KBr window.	
Interferometer	ROCKSOLID interferometer ensures high stability and permanent alignment.	
Scan Velocity	**standard:** 3 velocities; 1.6 - 12.7mm/sec opd **optional:** 5 velocities;1.6 - 51mm/sec opd	**standard:** 5 velocities;1.6 - 51mm/sec opd
Electronics	Microprocessor controlled optics bench with digital speed control, system diagnostics, advanced system check, 24 bit-100kHz A/D converter with 24 bit dynamic range.	
Environmental Conditions	Operational temperature range: 18 - 35°C (64 - 95°F) Temperature variation (during measurement): max. 1°C Humidity (non condensing): ≤ 80% (relative humidity) Installation site: in a closed room, max. 2000m above sea level Overvoltage category: II Degree of pollution: 2	

Optical materials

The spectrometer is equipped with components (e.g. beamsplitter, sample compartment window, detector) in which optical material is incorporated. The following table lists all available optical materials including their transmission range, refraction index and chemical properties.

Material	Transmission Range (cm^{-1})*	Refraction Index n (at 2000cm^{-1})	Chemical Properties
Quartz (Infrasil), SiO_2	57,000 - 2,800	1.46	Insoluble in water; soluble in HF
Calcium Fluoride, CaF_2	66,000 - 1,000	1.40	Insoluble in water; resistant to most acids and bases; soluble in NH_4 salts
Barium Fluoride, BaF_2 CAUTION - HARMFUL!	50,000 - 800	1.45	Low water solubility; soluble in acid and NH_4Cl
Sodium Chloride, NaCl	28,000 - 580	1.50	Hygroscopic; slightly soluble in alcohol and NH_3

Material	Transmission Range (cm^{-1})*	Refraction Index n (at $2000 cm^{-1}$)	Chemical Properties
Zinc Selenide, ZnSe CAUTION - TOXIC!	20,000 - 500	2.43	Soluble in strong acids and in HNO_3
Potassium Bromide, KBr	33,000 - 280	1.54	Soluble in water, alcohol, and glycerine; hygroscopic
Cesium Iodide, CsI CAUTION - HARMFUL!	33,000 - 180	1.74	Soluble in water and alcohol; hygroscopic
KRS-5 (TIBr/I thallium bromide-iodide) CAUTION - VERY TOXIC!	16,000 - 250	2.38	Soluble in warm water and bases; insoluble in acids
Polyethylene PE (high density)	600 - 10	1.52	Resistant to most solvents

* 50% value at a window thickness of 4mm

Warning: Some window materials are harmful or (very) toxic. Observe the safety instructions on the packaging and the safety data sheets attached. Non-observance may cause serious health problems or even death.

A SPECIFICATIONS

REPLACEMENT PARTS

B

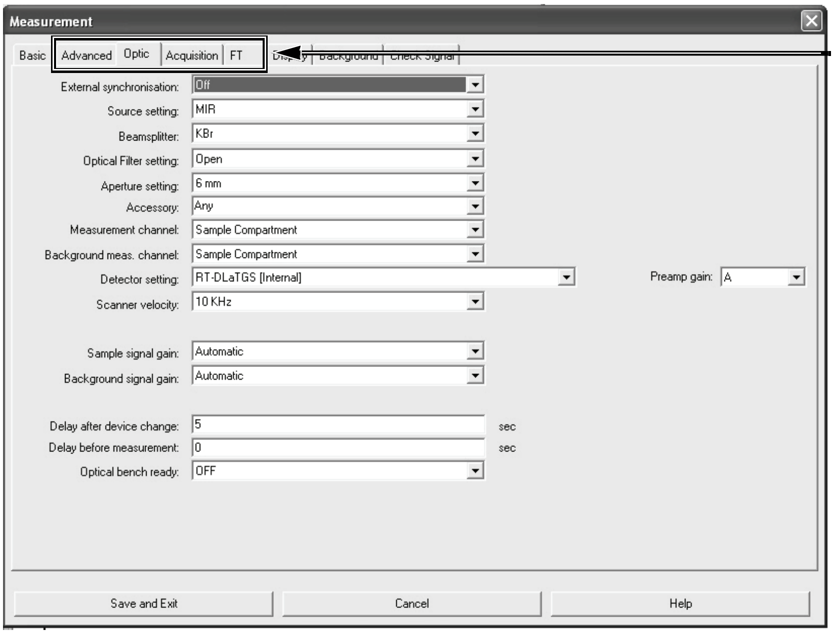
Order number	Replacement part
Q328/7	MIR source
Q428/7	NIR source (only in case of TENSOR 37)
Q101/B	Laser module
S119/B	Desiccant cartridge (2x)
F173-1	Quartz window (wedge-shaped, 35 x 5mm)
F173-11	ZnSe window (wedge-shaped, 35 x 2mm)
F173-17	BaF_2 window (wedge-shaped, 35 x 3mm)
F173-3	CaF_2 window (wedge-shaped, 35 x 4mm)
F173-5	KBr window (wedge-shaped, 35 x 4mm)
F173-7	CsI window (wedge-shaped, 35 x 5mm)
F173-9	Polyethylene window (wedge-shaped, 35 x 4 mm)

For measurement accessories visit us at www.brukeroptics.com.

MEASUREMENT PARAMETERS

C

Before starting a measurement, you have to enter adequate parameter values and select the corresponding parameter setting options. To do this, select in the OPUS *Measure* menu the *Advanced Measurement* function and enter the corresponding parameter values. (See also OPUS Reference Manual.)



On these pages of the dialog window *Measurement*, you have to enter the parameter values. (See the following table.)

Figure 61: OPUS dialog window - Measurement

Especially the optics parameter values and settings depend on the spectrometer configuration in question. Note that the following table lists only the parameter values and settings for the standard spectrometer configuration. (Standard spectrometer configuration means that the spectrometer is equipped with a MIR source, the standard KBr beamsplitter, KBr sample compartment windows and the standard DLaTGS detector.)

Advanced Parameters	Parameter Value
Resolution	4
Save data from	4000 cm^{-1} to 400 cm^{-1}
Result spectrum	Transmittance
Data blocks to be saved	Transmittance, Single Channel, Background
Optics Parameters	**Parameter Value**
Source setting	MIR
Beamsplitter	KBr
Optical filter setting[a]	Open
Aperture setting[b]	6 mm
Measurement channel	Sample Compartment
Detector setting	RT-DLATGS
Scanner velocity	10 kHz
Acquisition Parameters	**Parameter Value**
Wanted high frequency limit	8000
Wanted low frequency limit	0
High Pass filter	Open
Low Pass filter	10 kHz
Acquisition mode	Double Sided, Forward-Backward
Correlation mode	OFF
FT Parameters	**Parameter Value**
Phase resolution	16
Phase Correction mode	Mertz
Apodization function	Blackman-Harris 3-Term
Zerofilling factor	2

a. Note: The available optical filter options (e.g. NG11, polystyrene) are used for OQ and PQ tests only. When such a test is running, the correct filter is moved automatically in the beampath, i.e. it does not need to be selected explicitly by the user. Normally, these optical filters are not intended for spectroscopic measurements. For this reason, select by default the optical filter setting *Open* when defining the measurement parameters. Note: There are vacant filter wheel positions which can be equipped with optional filters (filter diameter: 25mm), if desired. They can be used for customer-specific applications.

b. By default, the aperture wheel has 12 occupied positions which allow for the following aperture settings: 0.25, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 5, 6, and 8mm. The optimal aperture setting depends mainly on the detector and the source which are currently used and on whether the measurement is to be performed using a special accessory or not. As a rough guideline: The more sensitive a detector is the smaller the aperture should be (e.g. MCT: ca. 2mm). In case of an accessory having a small measurement spot, select a small aperture (e.g. A518, reflection unit, grazing incidence 80°: < 1mm). Note: In addition to the 12 default aperture wheel positions, there are four vacant aperture wheel positions which can be equipped with customer-specific apertures, if desired. These optional aperture settings are selectable by direct commands.

Note: The parameter values and settings listed above are for measurements in transmittance using the standard spectrometer configuration. These parameter values and setting are in the supplied experiment file *MIR_TR.XPM*. By default, this file is saved under *OPUS path\XPM*. When you load this experiment file in the OPUS *Measurement* dialog window (see fig. 62) the above listed parameter values and settings are selected automatically.

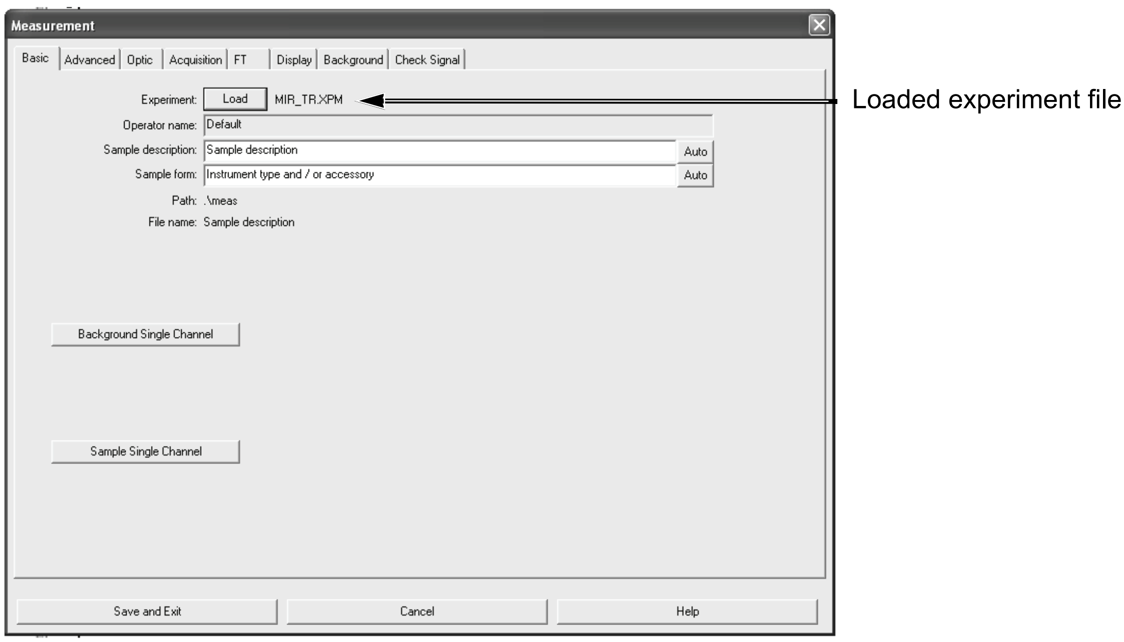


Figure 62: Loading an experiment file

DIMENSIONAL DRAWINGS

D

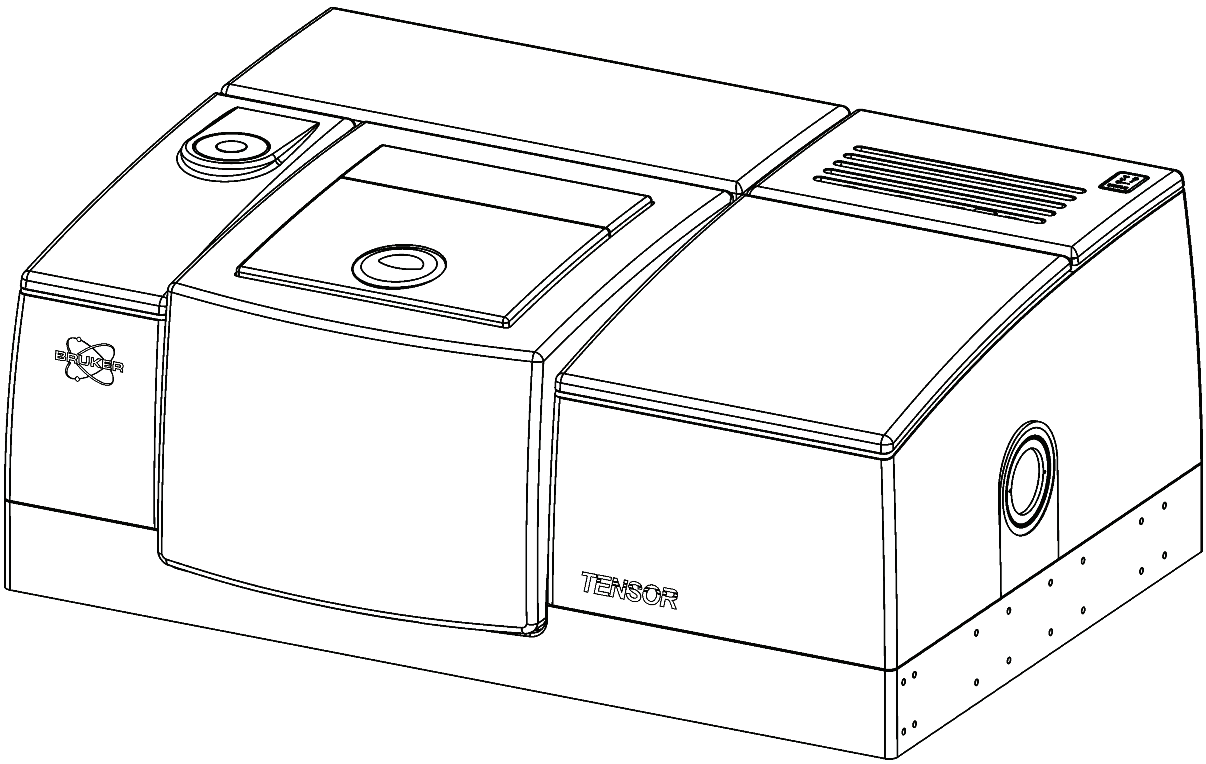


Figure 63: TENSOR - Isometric View

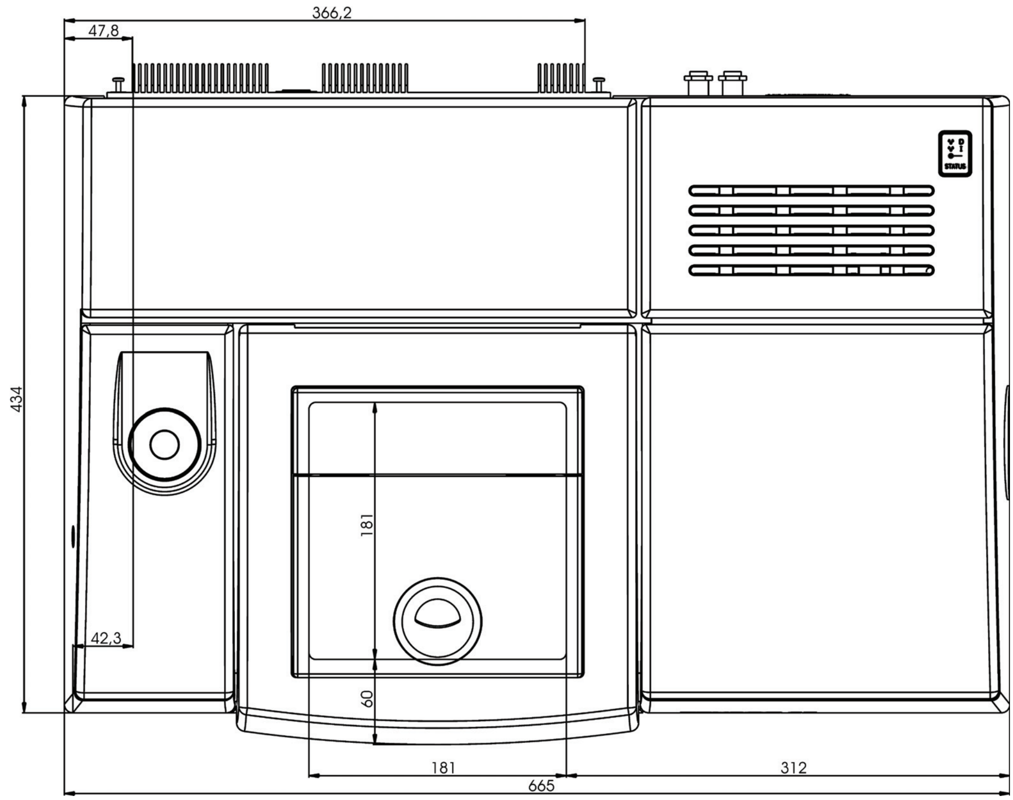


Figure 64: TENSOR - Top View

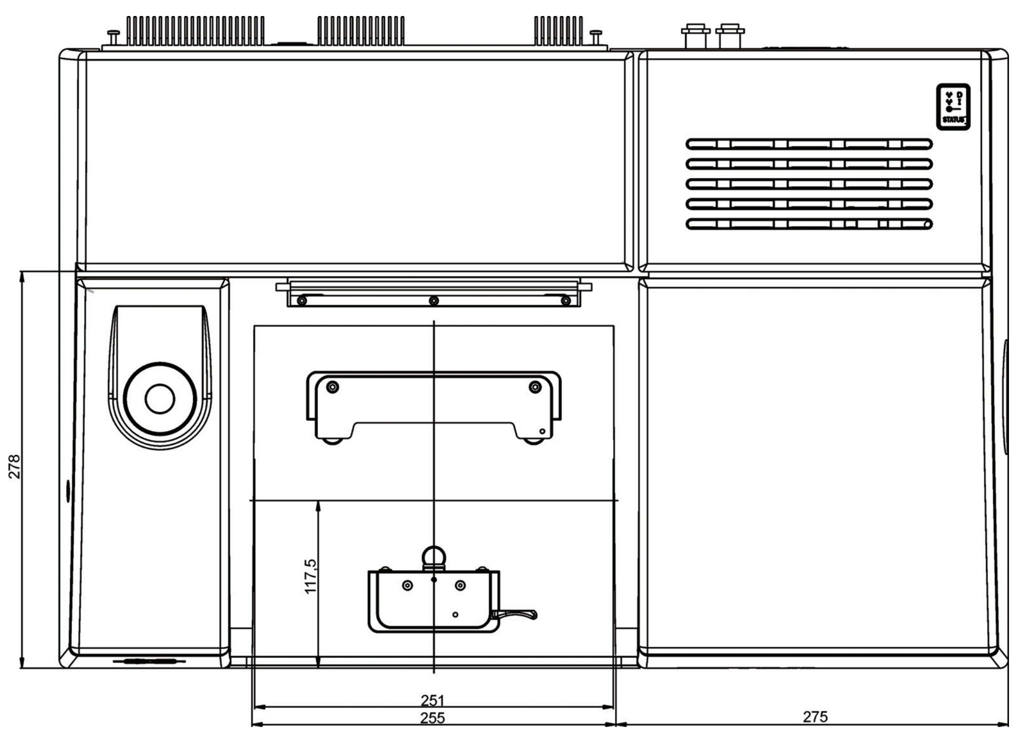


Figure 65: TENSOR - Top View Showing Sample Compartment Dimensions

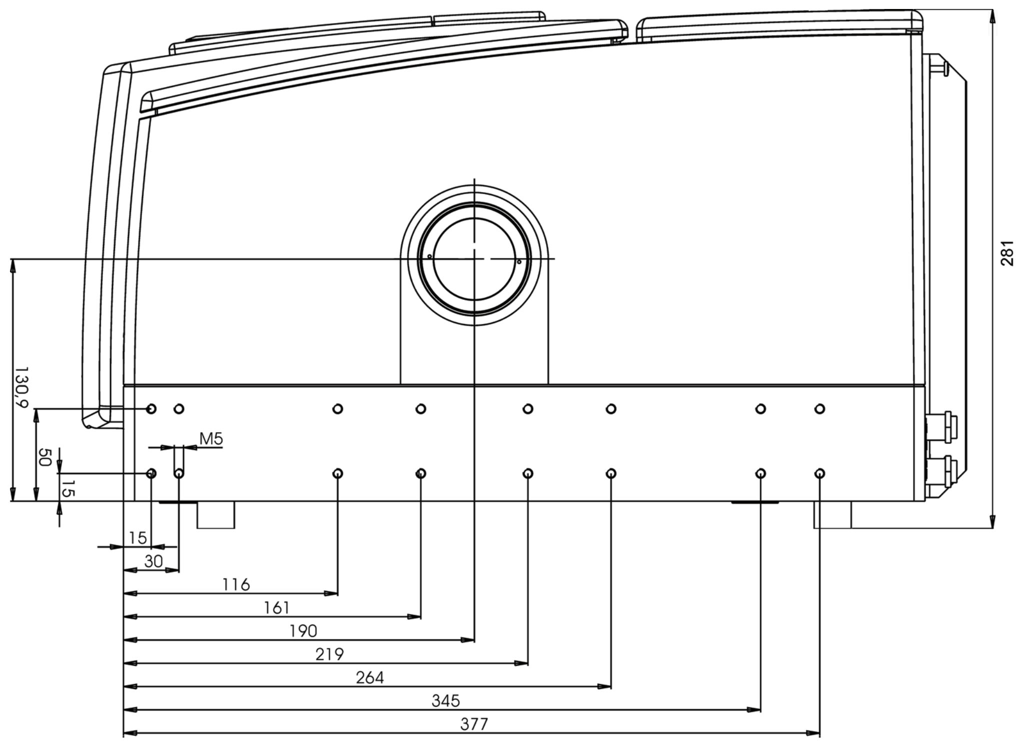


Figure 66: TENSOR - Right Side View

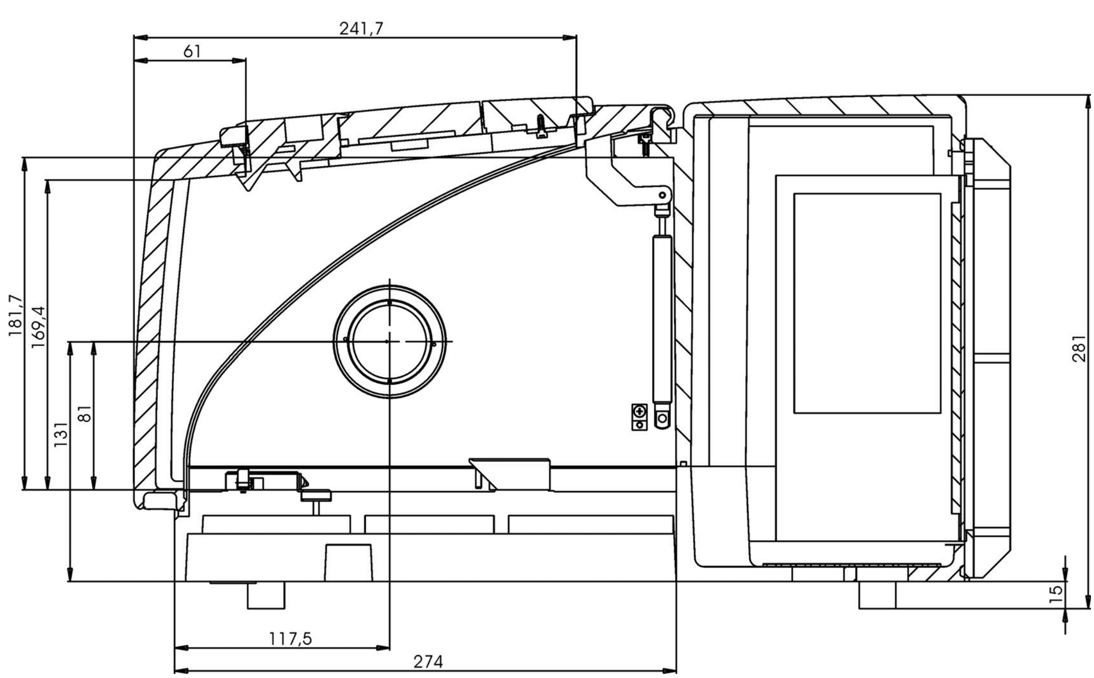


Figure 67: TENSOR - Right Side View Showing Sample Compartment Dimensions

Electronics and Power Supply

E

Connector Panel of the Electronics

The connector panel of the electronics unit at the spectrometer rear side includes cable connections (e.g. Ethernet connection) and LEDs. The LEDs serve for instrument diagnostics purposes. Each LED indicates a specific operating state (e.g. interferometer mirror movement, data transfer).

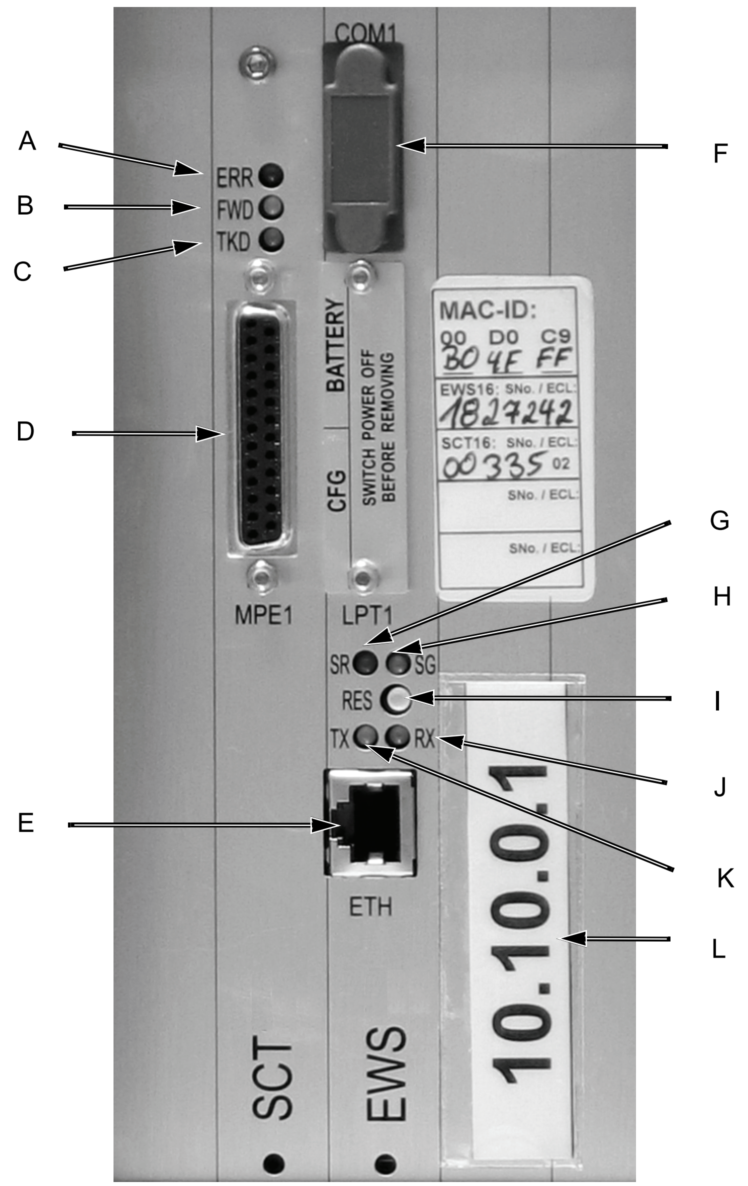


Figure 68: Connector panel of the electronics unit

Figure 68	Component	Explanation
A	ERR LED (red)	A red ERR LED indicates an interferometer error (e.g. a missing laser signal). As long as this LED lights, data acquisition is not possible. See chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *A spectrometer problem indicated by a red ERR LED*.
B	FWD LED (yellow)	This LED indicates the current interferometer mirror movement. As long as the interferometer mirror moves forward this LED lights. During the backward movement the LED does not light. Thus, the LED flashes in the rhythm of the interferometer mirror forward and backward movement. This rhythm depends on the chosen measurement parameters (e.g. resolution and velocity). (The abbreviation FWD stands for ’forward’.)
C	TKD LED (green)	This LED indicates that the interferometer mirror is within the data acquisition range. Typically, it flashes with twice the frequency and synchronous to the FWD LED. During data acquisition the light intensity changes to bright green. (The abbreviation TKD stands for ’take data’.)
D	MPE 1 port	It is a versatile port to connect external optical modules and detectors. It includes a complete CAN bus, transmits all required remote trigger signals and establishes a complete connection to DDC (Digital Detector Connection) compatible detectors.
E	ETH port (Ethernet port)	This port is used to connect the spectrometer to a PC or to a network (Ethernet standard 10/100Base-T). For detailed information refer to chapter *Installation*, section *Connecting TENSOR to a PC*. The ETH port is designed for RJ-45 plugs and complies with the 10/100Base-T Ethernet standard.
F	COM1 port	This port is technically similar to a conventional, PC-compatible serial port, however, it does not have the complete functionality like serial port of a PC. It is only used for special applications.

Figure 68	Component	Explanation
G and H	SR LED (red) and SG LED (green)	These two LEDs indicate the internal operating state of the spectrometer communication processor. (The abbreviation SR stands for 'Status Red' and SG for 'Status Green'.) See also chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *The SR LED lights permanently*.
I	RES (reset button)	Pressing this button longer than 1 second resets the spectrometer without the need to turn it off. The effect is identical to switching the spectrometer off and on again. In addition, this button can be used to assign an IP address to the spectrometer. Refer to chapter *Installation*, section *Connecting TENSOR to a PC*.
J and K	RX LED (green) and TX LED (yellow)	These LEDs indicate the data transfer direction between spectrometer and PC. In case of the stand-alone configuration, the green RX LED signals that the spectrometer receives data. In case the spectrometer is connected to an Ethernet network, the green RX LED indicates that a data packet is transmitted on the Ethernet (This does not necessarily mean that the data packet is destined for the spectrometer!) The yellow TX LED lights when the spectrometer transmits a data packet, i.e. the spectrometer is accessed by a computer. **Note:** The abbreviation RX stands for 'transmit data' and TX stands for 'receive data'. You can use these LEDs to test the operational reliability of the Ethernet connection. In case of communication problems see chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *No communication between spectrometer and computer*.
L	Spectrometer IP address	For detailed information about the spectrometer IP address refer to chapter *Installation*, section *Connecting TENSOR to a PC*, subsection *Network Addresses*.

Line-powered accessories connected to the spectrometer interfaces like RS232 (serial) or Ethernet have to have special electrical disconnecting features. The electric circuits of these interfaces have to comply with SELV circuit (Safety Extra Low Voltage circuit) requirements, and still even if the connection has already been realized. Typically, this is achieved when SELV circuits are connected to each other. In general, the interface requirements are met if the accessories comply with the regulations outlined in EN 61010 (safety regulations for laboratory equipment) or EN 60950 (safety regulations for information technology facilities).

CONNECTOR PANEL FOR POWER SUPPLY

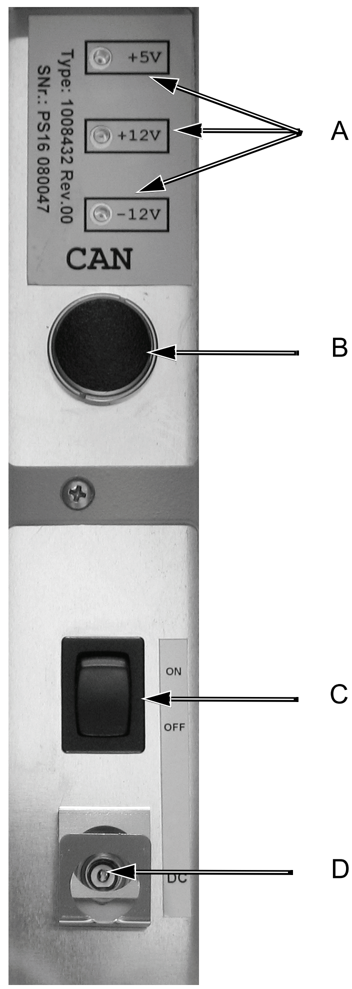


Figure 69: Connector panel for power supply

Figure 69	Component	Explanation
A	Voltage status LEDs (+5V, +12V, -12V)	These LEDs indicate the state of the secondary voltages of the electronics unit. **Note:** A dark power supply LED indicates a major electronics problem. (See chapter *Troubleshooting*, section *Problem - Possible Cause - Solution*, subsection *Spectrometer problem indicated by the voltage status LEDs*.)

Figure 69	Component	Explanation
B	CAN bus port	The CAN bus connector is primarily used to connect external automated units (e.g. sample changer, moving mirror unit, etc.) to the spectrometer. The CAN bus also provides power to these units. Thus, most external units can be operated without connecting them to the power supply. Furthermore, the CAN bus can be used as a communication link to control these external units via the spectrometer. (The abbreviation CAN stands for Controller Area Network.)
C	On/off switch	This switch is used to switch the spectrometer on and off. (See chapter *Operation*, section *Switching TENSOR on or off*.) This switch interrupts the primary voltage supply.
D	Low-voltage socket (male connector)	The low-voltage socket is used to connect the low-voltage cable of the external power supply unit to spectrometer. For detailed information see chapter *Installation*, section *Connecting TENSOR to Power Supply*.

F

FIRMWARE UPDATE

GENERAL INFORMATION

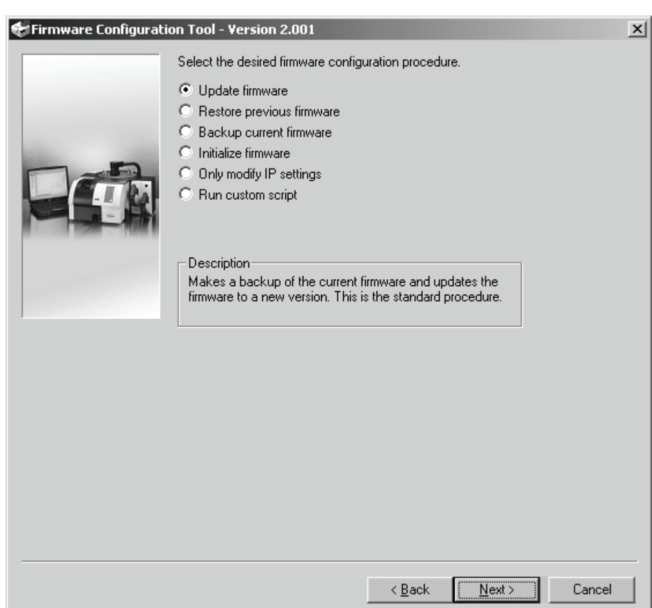
The spectrometer firmware needs to be updated in order to make new features (e.g. a higher scanner velocity) available. It is updated using the FCONF program (Firmware Configuration Tool). This program performs automatically all the necessary actions.

The FCONF program facilitates:

- updating the firmware,
- restoring a previous firmware version,
- backing up the current firmware version,
- initializing the firmware (For service purposes only!),
- modifying IP settings (See chapter *Installation*, section *Connecting TENSOR to a PC*, subsection *Assigning Network Address to the Spectrometer*.),
- running a custom script (For service purposes only!).

Firmware updates are typically delivered on CD or by e-mail. If the firmware update has been delivered on a CD start the FCONF program directly from the CD by double-clicking on the *fconf.exe* file and proceed as described below. If the firmware update has been delivered via e-mail, store the delivered files into a temporary directory, start the FCONF program by double-clicking on the *fconf.exe* file and proceed as described below.

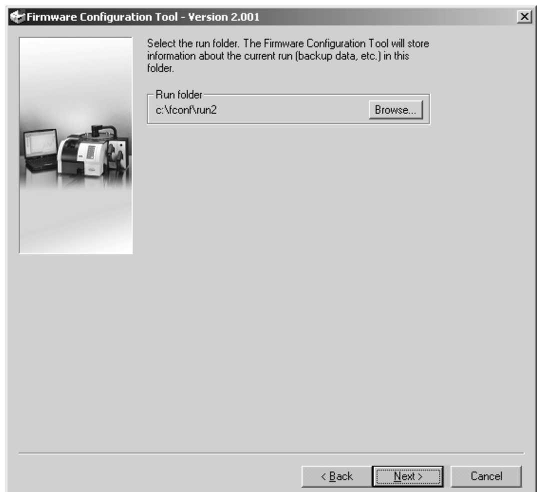
After having double-clicked on the *fconf.exe* file, the following window appears:



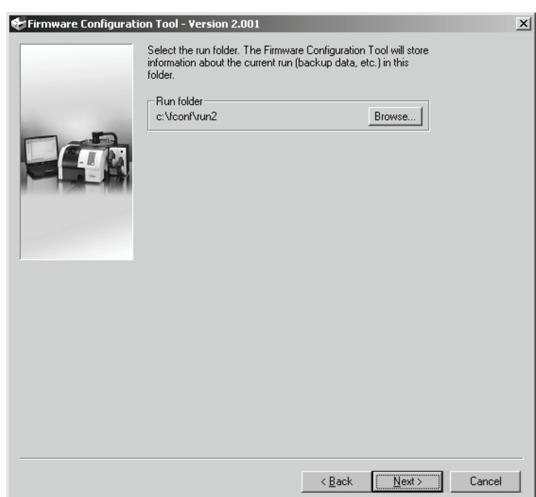
UPDATING THE FIRMWARE

To update the firmware, proceed as follows:

- Activate the *Update firmware* option button and click on the *Next* button. The following window appears:



- If there is no reason why another directory (run folder) than the displayed default directory should be specified, accept the default directory by clicking on the *Next* button. The following window appears:



- In this window you have to specify the spectrometer of which the firmware is to be updated. To do this, activate the *Enter custom address* option button and enter the corresponding IP address in dotted notation.

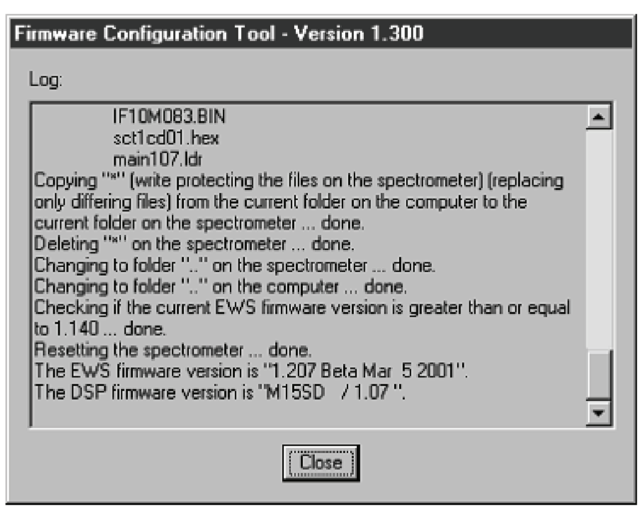
Note: In case of a stand-alone operated instrument, the default IP address is 10.10.0.1. If the spectrometer is integrated into a network and therefore the operating company has assigned a different than the default IP address you will find it at the spectrometer rear side. In this case, it is the operating company's duty to inscribe the IP address on the provided label at the spectrometer rear side.

- After having entered the IP address, check whether the intended spectrometer is addressed by clicking on the *Beep* button. The addressed spectrometer will beep shortly three times.
- Click on the *Next* button. The following window will appear:

- Press the *Finish* button to start the update procedure.

Note: The update procedure may take several minutes, depending on the available bandwidth and the amount of files to be updated.

During the update procedure, a log window is displayed showing all actions performed by the FCONF program. (The log-file is stored in the same directory as the backup files.)



At the end of the update procedure, the FCONF program resets the spectrometer (telling it in the log window: *Resetting the spectrometer... done.*). After a successful spectrometer initialization, the firmware version is displayed in the log window.

After the firmware updating has been completed successfully, the following message appears:

- Click on the *OK* button of the message window and on the *Close* button of the log window.

Note: The delivered Firmware update performs automatically all the actions necessary to properly replace the existing firmware version by the new one. It also generates automatically backup information to allow the restoration of the previous firmware version, in case the new firmware version does not ensure a trouble-free operation. For information on how to restore a previous firmware version refer to the next section.

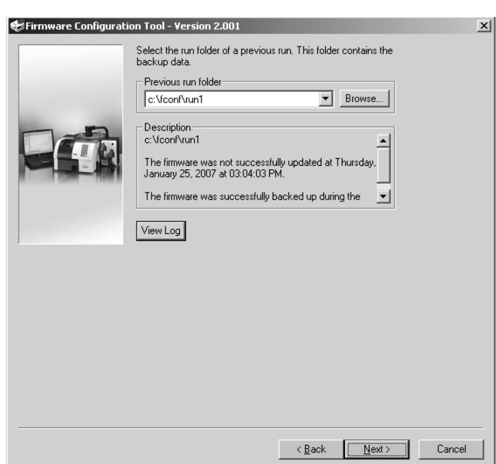
Note: In case of error during the update procedure, the FCONF program terminates the procedure and proposes to restore the previous firmware version.

RESTORING A PREVIOUS FIRMWARE VERSION

Restoring a previous firmware version is only possible if an update has been performed from that PC before.

To restore the previous firmware version, proceed as follows:

- Activate the *Restore previous firmware* option button and click on the *Next* button. The following window appears:



- The FCONF program asks you to select the directory containing the backup information of the last firmware version (previous run folder). By default, this directory is displayed automatically.

Note: If you click on the *View Log* button a log window appears displaying detailed information about the last update including errors, warnings or other irregularities.

- Press on the *Next* button.
- In the next window you are asked to specify a directory for the backup files of the restoration procedure. It is recommended to accept the directory proposed by the FCONF program.
- The rest of the restoration procedure is identical to the update procedure described above.

BACKING UP THE CURRENT FIRMWARE VERSION

To backup the current firmware version, proceed as follows:

- Activate the *Backup current firmware* option button and click on the *Next* button.
- The following backup procedure is identical to the update procedure described above.

Sample Preparation

G

GENERAL INFORMATION

Proper sample preparation is crucial to obtain good and meaningful spectra. This section describes several sample preparation technique that cover a wide range of samples. It will give you some help in choosing the most suitable sample preparation technique for a given sample.

The adequate sample preparation technique depends on the state of aggregation and the spectral absorptivity of the sample. Regardless of the state of aggregation, the sample material has to be homogeneous because variations in concentration or composition within the sample area to be analyzed can result in misleading or erroneous data. Sometimes the trial-and-error procedure is required to obtain an acceptable spectrum.

State of Aggregation

Depending on the state of aggregation of the sample, there are different sample preparation and measurement techniques. If you have to analyze a solid sample you can either prepare a solution, a Nujol mull or a KBr pellet. Liquid samples can be analyzed either as a thin film between plates or in a liquid cell. Gaseous samples require dedicated cells with different path lengths.

Absorptivity

The absorptivity of the sample is a critical factor in choosing a suitable sample preparation method. To get a meaningful spectrum of a strongly absorbing sample, the sample has to be either:

- very thin or
- diluted by a solvent or powder that is not strongly absorbing.

According to Lambert-Beer Law, the absorbance (i.e. peak intensity) in an absorbance spectrum is directly proportional to the component concentration in the sample, path-length of the sample and the absorptivity.

$$A = \varepsilon b C$$

Symbol	Description	Typical Units
A	Absorbance at a given wavelength	None
ε	Molar absorptivity (a proportionality constant)	$l \cdot mol^{-1} \cdot cm^{-1}$
b	Pathlength of the sample (cell length for samples in a cell or sample thickness for films, pressed pellets)	cm
C	Component concentration in the sample	mol/l)

If the absorbance *A* (i.e. peak intensity) is too strong, decrease the sample concentration *C* by diluting it or diminish the pathlength *b* by reducing the sample thickness. If the absorbance *A* (i.e. peak intensity) is too weak, increase the sample concentration *C* or the pathlength *b* correspondingly to obtain a reasonable peak intensity.

To find out whether a sample is strongly absorbing in the wavelength range of interest or not you have to acquire a test transmission spectrum. The figure below shows a transmission spectrum of a strongly absorbing sample.

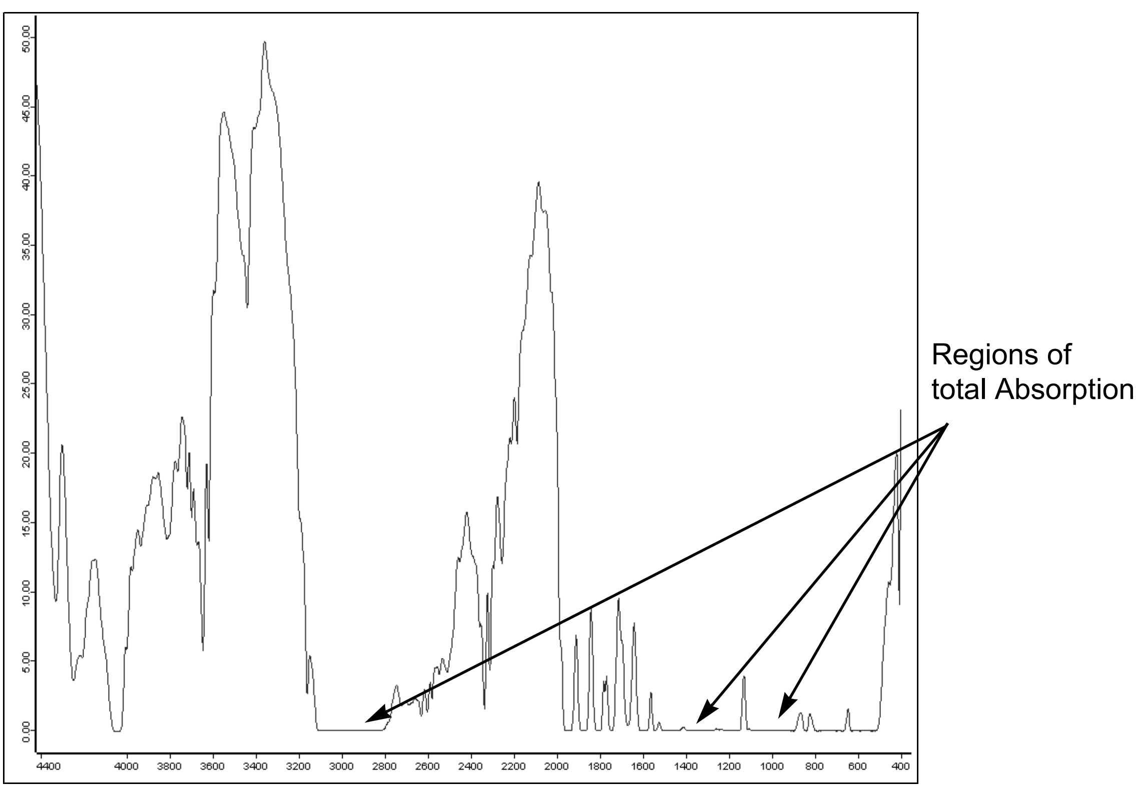


Figure 70: Transmission Spectrum of a strongly absorbing Sample

SAMPLE PREPARATION TECHNIQUES

There is a large number of possible sample preparation techniques. For lack of space, however, not all possible techniques can be described in detail in this chapter. Therefore, we restrict our explanations only to the most common techniques. (For more detailed information about this topic refer to the relevant specialist literature[1].) Moreover, we give you a general guideline for choosing the adequate sample preparation technique.

To find the most adequate method we recommend trying several sample preparation techniques and acquiring spectral data. On the basis of these data, you can assess which sample preparation technique is the most suitable one for your application. In case of doubt ask your application specialist.

Some of the most common sample preparation techniques are:

- No sample preparation (e.g. self supporting film or measurement using a micro-ATR accessory)
- Thin film of liquid sample solution between two IR-transparent[2] plates
- Preparing a solution
- Preparing a Nujol mull[3]
- Pressing a KBr pellet
- Liquid cell and gas cell

Note: Most of the described sample preparation techniques involve the use of hygroscopic materials (such as NaCl or KBr), i.e. if these materials come in contact with water or alcoholic solvents, they begin to dissolve or become cloudy and thus, impair the measurement results. Therefore, avoid all sources of water and even alcohols (ethanol and methanol).

No Sample Preparation

The easiest samples to analyze are film and polymer samples with a thickness of less than approx. 100 micrometers. They can be simply placed in a magnetic holder and immediately scanned. The same procedure can be used for samples which can be sliced to an appropriate thickness.

A large number of solid and liquid samples can also be analyzed without requiring a preparation using a micro-ATR accessory. Attenuated Total Reflectance (ATR) units are a very versatile accessory for FT-IR measurements. In many cases, the micro-ATR unit can be used for liquid and semi-liquid materials instead of the constant path transmission cells and the salt plates. In addition, this measurement accessory can also be used

1. e.g. Günzler, Helmut / Gremlich, Hans-Ulrich (2002): IR Spectroscopy - An Introduction. Weinheim: WILEY-VCH Verlag.
2. i.e. IR-transparent within the frequency range of interest
3. A mull is a mixture (more precisely a suspension) of two substances, one of which (i.e. the sample) is finely divided and dispersed in the other (e.g. the paraffin oil Nujol).

for analyzing polymer films, pastes and powders. Due to the reproducible effective path-length, they are well suited for both qualitative and quantitative analyses. Depending on the sample material and the objective of the analysis, there are different ATR-crystal materials (e.g. ZnS, ZnSe, Ge and diamond). The sample penetration depth ranges between 0.1 and 2µm and depends on the wavelength, the refractive index of the ATR-crystal material and the incidence angle of the beam. (For more information about attenuated total reflectance refer to the respective specialist literature.)

Thin Film between two Plates

Preparing a thin film of a liquid sample between two IR-transparent plates is an easy sample preparation method. Choose this method if your sample is either a liquid or an oil. An advantage of this method is that only a small amount of the sample is required.

- Apply a drop of the sample on one of the plates using a pipet.
- Place a second plate on the top and make a quarter turn to obtain a nice even film of the liquid sample. Sandwich the plates carefully together to remove all air bubbles. Note that these plates are very fragile and can break easily. (The space between the two plates is very small (typically < 0.01mm).
- If the sample amount proved to be too much, separate the plates, wipe one side clean and fit the plates together again.
- Slot the plates in the sample holder of the spectrometer and start the measurement.

Note: The plates (made of NaCl or KBr) are extremely moisture sensitive. Therefore, do not use samples that contain water, keep the plates always dry, clean them only with chloroform or high purity acetone and polish them carefully after each use. In the course of time they will absorb moisture from the atmosphere and deteriorate. Therefore, proper storage (e.g. in an exicator) is extremely important.

Solid Sample as Solution

Use this sample preparation method if your sample is a soluble solid (e.g. a soluble powder). To obtain an IR spectrum, you have to prepare a concentrated solution of your sample using a suitable solvent. The concentration of the solution needed for a good spectrum depends on the sample.

- Dissolve the sample or sample powder in a solvent and apply the sample solution between two support plates, as described above. Depending on the available amount of sample material you can either apply a small amount of your sample powder directly on the plate and add one drop of the solution or dissolve the sample in a test tube and apply the solution with a pipet on the plate.
- A second variant is to apply the sample solution on an IR-transparent plate and allow the solvent to evaporate leaving a thin sample film on the plate. Then, slot the plate in the sample holder of the spectrometer and start the measurement.

- A third variant is to fill the sample solution in a liquid cell and acquire a sample spectrum. To acquire a background spectrum measure the liquid cell containing only the solvent. The volumes of these liquid cells are between 0.1 and 1ml. Microcells with a much lower capacity are also available.
- Do not forget to acquire a background spectrum from the solvent as well.

Note: The plates (made of NaCl or KBr) are extremely moisture sensitive. (See above.)

The major problem in preparing a solution is choosing an appropriate solvent. Most solvents have a strong absorptivity and so their absorption bands will superimpose those of the solute. Therefore, you have to ensure that the used solvent is not strongly absorbing in the wavelength range of interest. Use only spectrophotometrically pure solvents and solvents that are not infrared active in the spectral region of interest.

No solvent is perfect but if some information about the sample is known, the solvent can be chosen accordingly. Commonly used solvents are carbon tetrachloride, carbon disulphide, chloroform, cyclohexane, acetonitrile, and tetrachloroethylene. Never use water as solvent because, firstly, it will dissolve the salt plates and secondly, it exhibits a broad OH-peak. Consult the relevant reference books for the absorptivity of the various solvents.

Preparing a Mull

This sample preparation method is suitable if the solid sample can be ground into fine particles but a suitable solvent is not available. In this case the sample powder is suspended in a mulling agent (i.e. a liquid in that the solid is not soluble). A suitable mulling agent is Nujol, a paraffin oil, which is transparent in the infrared region, except for narrow bands at 2900, 1450 and 1375cm^{-1}. (An alternative mulling agent, which does not absorb in these regions, is a perfluorokerosene, such as Fluorolube.)

The advantage of this technique is that it is a relatively quick and simple procedure. The disadvantage is the interference resulting from the absorption bands of the mulling agent. (Both Nujol and Fluorolube have characteristic spectral features and in most cases have to be used as a pair in order to generate a complete MIR spectrum. Nujol is used below 1330cm^{-1}, Fluorolube above 1330cm^{-1}.)

- Put a small amount of your solid sample in an agate mortar.
- Grind the sample thoroughly into fine powder (particles smaller than 500 mesh) using a pestle.

Note: A common mistake when preparing a Nujol mull is to spend too little time grinding the powder. Note that a mull prepared from a coarsely ground solid will yield only a poorly resolved spectrum. Grinding the sample into very fine particles is also important to reduce light scattering and salt plate scratching.

- Add 1 or 2 drops of Nujol. Be careful not to add too much Nujol.
- Mix the ground sample with the mulling agent until a uniform paste with a vaseline-like consistency is formed.
- Apply some mull on the surface of a NaCl plate using a suitable tool (e.g. a small spatula or a rubber policeman). Be careful not to scratch the plate.
- Place the second plate over the mull. To ensure an even and thin sample thickness between the plates, rotate and press the plates together in order to squeeze out the excess of the paste. Exclude also air bubbles.
- Slot the plates in the plate holder installed in the spectrometer sample compartment and start the measurement.
- Do not forget to acquire also a background spectrum of the pur Nujol.

Pressing a KBr Pellet

This sample preparation technique is very suitable for solid samples in terms of the information yield from an IR spectrum because KBr is significantly more IR transparent than most solvents or Nujol oil. KBr has no absorption in the region 4000cm^{-1} to 250cm^{-1} so that a good sample spectrum (i.e. a spectrum that does not contain spectral information about the dispersing agent) is obtained.

The success of this technique strongly depends on the grain size of the ground sample. Grind the sample as fine as possible (particle size of at least 200 mesh, better 500 mesh) to minimize the infrared light scattering on the particle surface, also called Christiansen effect. This effect is caused by a refraction index mismatch between the salt (KBr) and the sample powder that leads to reflections at the salt-sample interface. Therefore, proper grinding is required to ensure a good contact between KBr and sample powder and to minimize the portion of the reflected light.

Another important factor in this technique is to keep everything moisture free as the KBr material is hygroscopic. To prevent the KBr material from absorbing moisture, keep the KBr material and the die in a drying oven at a temperature of 50 to 60°C. Failure to do so will result in cloudy pellets that yield distorted spectra. A correctly prepared KBr pellet will be transparent to IR light.

To sum it up, the KBr-pellet technique yields good quality spectra with a wide spectral range and no interfering peaks. Disadvantages include tedious and time consuming sample preparation and cleanup, interference of water bands (3,960 to 3,480cm^{-1} and 1,950 to 1,300cm^{-1} and below 500cm^{-1}) and in same cases structural changes caused by high pressure applied to the KBr/sample mix.

- Put a small amount of the sample in an agate mortar and grind it up as fine as possible.
- Add a spatula full of oven-dry KBr material to the ground sample and mix it until a uniform mixture is obtained. Do not grind the mixture as this may increase the absorption of water by KBr.

Note: A common mistake is to use to much sample. The concentration of the sample in KBr should be in the range of 0.2% to 1% (i.e. typically a 300:1 dilution by mass).

- Transfer the mixture into a die of a hydraulic or hand press and subject it to very high pressure (ca. 20,000 psi) for a few minutes (2 to 5 minutes). The result should be a translucent pellet with an ideal thickness of 0.5 to 1mm.
- Carefully remove the pellet from the die, place it in the pellet holder and put the pellet holder in the spectrometer sample compartment.

Note: The KBr pellet is very hygroscopic and fragile. Handle it with care and use gloves to avoid contact with moisture from your hands. Measure the KBr pellet immediately after removing it from the press as the pellet will fairly rapidly begin to absorb moisture from the air and becomes cloudy.

Liquid Cell

Liquid cells produce excellent results for most liquids. Especially for liquid samples that are very volatile, using a liquid cell is highly recommended. A liquid cell consists of two IR transparent windows with a precision spacer in between. One of the windows has two drilled holes for the introduction and evacuation of the liquid. A large number of cell options are available including permanently sealed cells, demountable cells with different window material and a wide selection of spacers.

Note: Take into consideration that KBr is hygroscopic and the pathlength of the KBr cell will change when exposed to a 'wet' sample (this may affect quantitative results). In addition, water will reduce the cell throughput by clouding the windows. Note that many liquid cells contribute a fringe pattern to the spectrum. Matching the refraction index of the window material with that of the sample can minimize this effect.

Gas Cell

To obtain an infrared spectrum of a gaseous sample a gas cell with windows at each end is required. It is important to select a suitable window material (e.g. KBr, NaCl, or CaF_2) that does not absorb infrared light. The cell usually has an inlet and outlet port with a tap to facilitate the filling with the gas to be analyzed. Simple demountable cells (50 mm to 100 mm) are recommended for samples in a 5 - 10% concentration range. For diluted samples (ppm to ppb concentrations) a long path cell should be used. The long path cell reflects the IR beam several times through the sample using a set of mirrors positioned on the opposite ends of the cell. Note that the cell thickness, the pressure of the gas (proportional to concentration) inside the cell, and the molar absorptivity determine the peak intensity.

SERVICE ADDRESSES

H

Bruker Optik has an international network of branch offices and representations to ensure worldwide a competent customer service. Below the addresses of the Bruker headquarters are listed.

For a complete list with the addresses and telephone numbers of the Bruker branch offices and representations worldwide refer to the internet: **http://www.brukeroptics.com/offices.html**

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ir_service@brukeroptics.de

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No responsibility can be taken for the correctness of this information. Subject to change.

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BRUKER

FT-IR
FT-NIR
FT-Raman
BioMed
TD-NMR
Software

EC-DECLARATION OF CONFORMITY

The undersigned, representing the following manufacturer

Manufacturer: BRUKER OPTIK GMBH
Address: D-76275 Ettlingen, Rudolf-Plank-Straße 27

herewith declares that the product

Product identification: **Tensor 27**

is in conformity with the provisions of the following EC directive(s)
(including all applicable amendments)

Reference no.	Title
73/23/EWG	Directive of the commission from February 19th, 1973 (Low Voltage Directive)
89/336/EWG	Directive of the commission from May 3rd, 1989 (Electromagnetic Interference Directive)
92/31/EWG	Directive of the commission from April 28th, 1992 (Amendment Electromagnetic Interference)
93/68/EWG	Directive of the commission from July 22nd, 1993 (Amendment Electromagnetic Interference/Low Voltage Directive)
98/13/EG	Directive of the commission from February 12th, 1998 (Amendment Electromagnetic Interference)

and that the standards and / or technical specifications referenced overleaf have been applied.

Last two digits of the year in which the CE marking was affixed: 04
(when compliance with the provisions of the Low Voltage Directive 73/23/EWG is declared)

Ettlingen .... June 7, 2004 ....

(Place) (Date)

....

(Signature)

Dr. Arno Simon, Development Manager

....

(Name and function of the signatory empowered to bind the manufacturer or his authorized representative)

Page 1 of 2 of EC-Declaration of Conformity of **Tensor 27**

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Commerzbank Karlsruhe Nr. 242 706 000, BLZ 660 400 18
USt-IdNr. DE812440710 · Steuer-Nr. 31190 39703 Finanzamt Ettlingen

Optics

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References of standards and/or technical specifications applied for this declaration of conformity, or parts thereof :

Harmonized standards:

No.	Issue	Title	Parts(1)
EN 61326:1997 +A1:1998+A2:2001	March 2002	Electrical equipment for measurement, control and laboratory use – EMC requirements	1
EN 61000-3-2:2000 +Corrigendum 1	December 2001	Electromagnetic compatibility; Part 3-2: Limits - Limits for harmonic current emissions	3-2
EN 61000-3-3:1995 +Corrigendum:1997+ A1:2001	May 2002	Electromagnetic compatibility; Part 3-3: Limits - Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16A	3-3
EN 61010-1:2001 (2nd Edition)	August 2002	Safety requirements for electrical equipment for measurement, control and laboratory use; Part 1: General requirements	1
EN 60825-1:1994+ A1:2002 + A2:2001	October 2003	Safety of laser products; Part 1: Equipment classification, requirements and user`s guide	1

Other standards and/or technical specifications:

No.	Issue	Title	Parts (1)

Other technical solutions, the details of which are included in the technical documentation or the technical construction file: ....

Other references or information required by the applicable EC directive(s):

....

(1) Where appropriate, the applicable parts or clauses of the standard or the technical specification shall be referenced.

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Sitz der Gesellschaft ist Ettlingen HRB 2608E, Geschäftsführer: Dipl.-Phys. Jürgen Gast, Dr. Dieter Schmalbein, Dr. Arno Simon
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Optics

FT-IR
FT-NIR
FT-Raman
BioMed
TD-NMR
Software

EC-DECLARATION OF CONFORMITY

The undersigned, representing the following manufacturer

Manufacturer: BRUKER OPTIK GMBH
Address: D-76275 Ettlingen, Rudolf-Plank-Straße 27

herewith declares that the product

Product identification: **Tensor 37**

is in conformity with the provisions of the following EC directive(s)
(including all applicable amendments)

Reference no.	Title
73/23/EWG	Directive of the commission from February 19th, 1973 (Low Voltage Directive)
89/336/EWG	Directive of the commission from May 3rd, 1989 (Electromagnetic Interference Directive)
92/31/EWG	Directive of the commission from April 28th, 1992 (Amendment Electromagnetic Interference)
93/68/EWG	Directive of the commission from July 22nd, 1993 (Amendment Electromagnetic Interference/Low Voltage Directive)
98/13/EG	Directive of the commission from February 12th, 1998 (Amendment Electromagnetic Interference)

and that the standards and / or technical specifications referenced overleaf have been applied.

Last two digits of the year in which the CE marking was affixed: 04
(when compliance with the provisions of the Low Voltage Directive 73/23/EWG is declared)

Ettlingen .... June 7, 2004
(Place) (Date)

A. Simon
....
(Signature)

Dr. Arno Simon, Development Manager
....
(Name and function of the signatory empowered to bind the manufacturer or his authorized representative)

Page 1 of 2 of EC-Declaration of Conformity of **Tensor 37**

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References of standards and/or technical specifications applied for this declaration of conformity, or parts thereof :

Harmonized standards:

No.	Issue	Title	Parts(1)
EN 61326:1997 +A1:1998+A2:2001	March 2002	Electrical equipment for measurement, control and laboratory use – EMC requirements	1
EN 61000-3-2:2000 +Corrigendum 1	December 2001	Electromagnetic compatibility; Part 3-2: Limits - Limits for harmonic current emissions	3-2
EN 61000-3-3:1995 +Corrigendum:1997+ A1:2001	May 2002	Electromagnetic compatibility; Part 3-3: Limits - Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current ≤16A	3-3
EN 61010-1:2001 (2nd Edition)	August 2002	Safety requirements for electrical equipment for measurement, control and laboratory use; Part 1: General requirements	1
EN 60825-1:1994+ A1:2002 + A2:2001	October 2003	Safety of laser products; Part 1: Equipment classification, requirements and user`s guide	1

Other standards and/or technical specifications:

No.	Issue	Title	Parts (1)

Other technical solutions, the details of which are included in the technical documentation or the technical construction file: ....

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