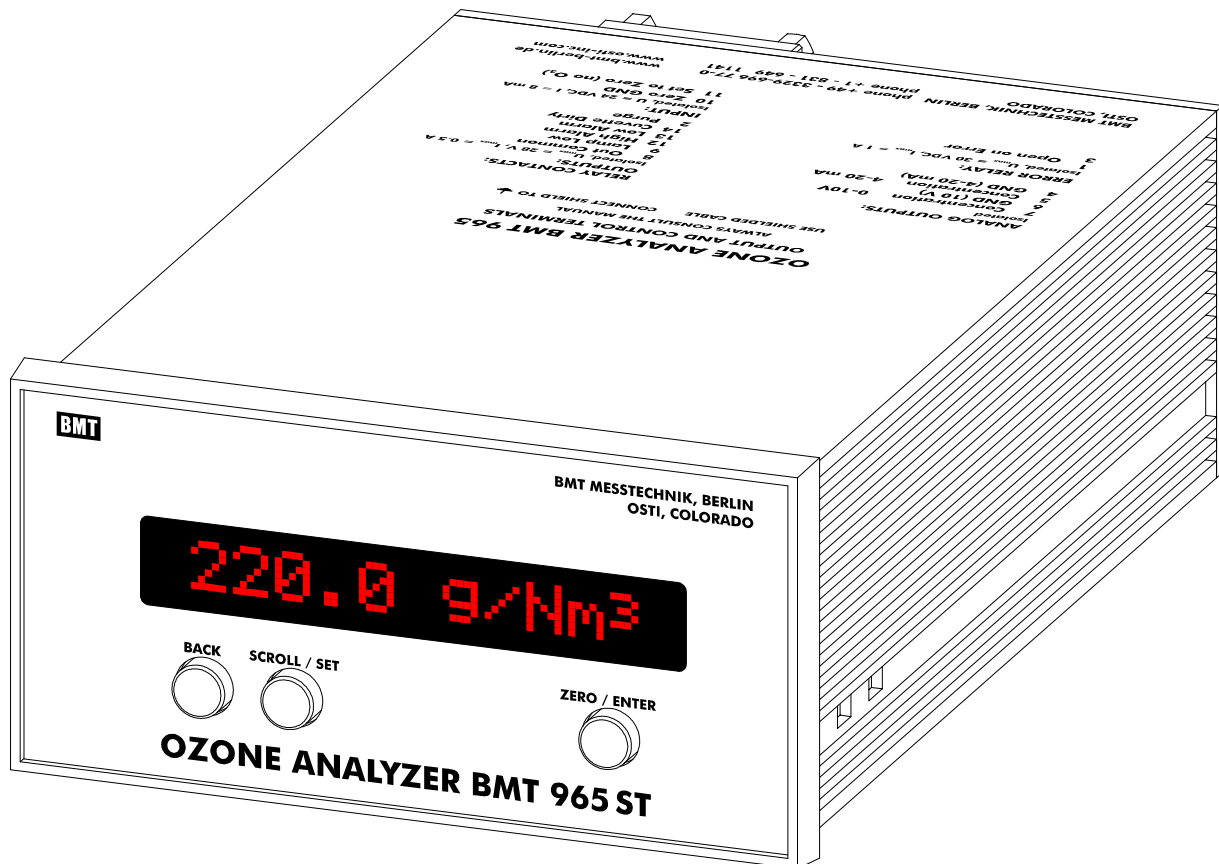# OZONE ANALYZER BMT 965

Manual
(Rev. 01/2024)

M965_001_EN_2024-01-19

OZONE ANALYZER BMT 965

This manual describes the standard version **BMT 965 ST**. For the versions **BMT 965 BT, BMT 965 C, BMT 965 OG, BMT 965 AQ** and **BMT 965 RD**, also refer to the according Appendices at the end of this manual!

Contents

1   General Description

The OZONE ANALYZER BMT 965 is a microprocessor-based dual beam photometer (UV 254 nm) for measuring the ozone content in air or oxygen. To evaluate the ozone content in the sample gas the OZONE ANALYZER BMT 965 measures the UV radiation in the measurement channel, the UV radiation in the reference channel, the temperature and the pressure in the cuvette.

The ozone concentration is displayed in either percent weight of ozone (%wt/wt), grams of ozone per normal cubic meter of sample gas (g/Nm^3) or ppm$_v$ (AQ: g/m^3 or ppm$_w$) on a 16-character alphanumeric display. The concentration unit can be changed during operation. Additional modifiable parameters are, among others:

- Unit of pressure display (selectable: bar, psi, Torr, MPa)

- Alarm parameters (high/low threshold, alarm latching, audible, opening or closing relays)

- Nature of the carrier gas: air or oxygen (incl. PSA)

- Date and time

- RS-232 interface parameters

- Logging parameters

These parameters can be set with the three pushbuttons on the front panel as well as by connecting the serial interface or USB port to a Windows-PC running the program BMT 965 Link, which is supplied with each instrument. Another way of configuring the instrument is to use the so-called Link Mode via the serial or USB interface.

The instrument has a built-in clock with calendar, which is used to provide time stamps for an Event-Log and an Error-Log (e.g. Overrange, Cuvette Dirty) with virtually unlimited capacity on an internal 8 GB SD card. Additionally, concentration data can be logged in configurable time intervals into binary and CSV (Excel) files. The binary logs can be read out and printed via the USB port with the mentioned program BMT 965 Link. Excel can open the CSV concentration log directly on the BMT 965, because the instrument will show up on the PC as an external drive when connected via USB, allowing simple copy action of stored files using Windows Explorer without installing any additional software or drivers.

The USB port supports OTG (On-the-Go) functions, which means that the BMT 965 can be used as a USB device (mass storage and HID) or host (mass storage). This way also a USB flash drive (stick) can be connected to the instrument. Log data from the internal SD card can be copied to the USB flash drive by pressing a single button on the front panel. Firmware updates using a USB flash drive are easily done.

The BMT 965 Cabinet, Off-Gas and AQ versions already have Ethernet hardware, allowing LAN and Internet communication with future firmware upgrades.

2   Cautions & Warnings

The **exclamation point** within an equilateral triangle is intended to alert the user to the presence of important operating and maintenance (servicing) instructions in the literature accompanying the instrument.

The **lightning flash** with arrowhead symbol, within an equilateral triangle is intended to alert the user to the presence of uninsulated "dangerous voltage" within the product's enclosure that may be of sufficient magnitude to constitute a risk of electric shock to persons.

The "**Caution, hot surface**" symbol indicates that the marked item may be hot and should not be touched.

Warning: Ozone is a highly toxic gas. The ozone concentrations measured by the OZONE ANALYZER BMT 965 are above the lethal limit. Appropriate safety devices (ozone detectors) should be used.

Warning: This product relies on the building's installation for short-circuit (overcurrent) protection. Ensure that a fuse or circuit breaker no larger than 15 A at 120 VAC (10 A at 240 VAC) is used on the phase conductor.

Warning: Protection provided by the instrument may be impaired if used in a manner not planned by the manufacturer.

Warning: The installation of the power connector has to be made by a person acquainted with the safety requirements involved. Do not connect or disconnect the voltage-carrying connector!

Warning: The current output (4-20 mA) is an active analog signal transmitter. It must not be connected to an active receiver or power supply!

Warning: Do not use this instrument in a oxygen-enriched atmosphere (fire hazard)! Follow recommended oxygen handling practices.

Warning: Do not apply more than the rated gas pressure (pressure range) to the instrument!

Warning: Make sure that the flow rate is not higher than the range of the flow meter, and the red ruby ball inside the flow meter is not at its upper white stop!

Warning: Disconnect electrical power before opening the cabinet door or the cover.

Warning: The UV radiation power output of the UV lamp is less than 1 Watt. Avoid dismantling of the instrument with mains power applied. The lamp contains 5 milligrams of mercury. Mercury is a poison. Dispose lamp at a waste disposal place which is qualified to handle mercury containing lamps. If you cannot find a respective place, return the lamp to BMT MESSTECHNIK GMBH.

Warning: Before opening the sample gas filter make sure that the sample line does not contain ozone gas, and is not under an overpressure.

Warning: The cables shall only be connected by a person acquainted with the safety requirements involved.

Caution: If the generator feed gas contains nitrogen, connect a tube to the outlet of the ozone destruct to lead away the vent gas. Corrosive nitric acid will be formed when vent gas comes in contact with the moist ambient air.

Caution: High concentration of nitrogen oxides in the sample gas must be avoided. If this could occur e. g. during generator service, sample gas flow to the analyser must be stopped!

Caution: In case the ozone generator is serviced or repaired it is imperative that the ozone analyser is disconnected (the sample gas flow is interrupted). We recommend the installation of a stop cock or shut-off valve for this purpose.

Caution: Before opening the lid of the DH6 electronics, the user should ground himself by touching grounded points in order to prevent damage of the electronics by electrostatic discharge.

Caution: The cuvette must not be flushed with fluids, namely water, for cleaning as this could damage the pressure sensor.

Précautions

Avertissement: *L'ozone est un gaz à forte toxicité. Les concentrations d'ozone mesurées à l'aide de l'analyseur d'ozone BMT 965 vont au-delà de la limite mortelle. C'est pourquoi il convient d'utiliser une technique de sécurité adéquate (détecteur d'ozone).*

Avertissement: *Ce produit présuppose une installation électrique en bâtiment qui assure la protection contre les surintensités et contre les courts-circuits. Assurez-vous que le fusible qui sert à protéger le conducteur de phase ne dépasse pas 15 A pour 120 VCA (10 A pour 240 VCA).*

Avertissement: *La protection fournie par l'instrument peut être compromise si elle est utilisée d'une manière non prévue par le fabricant.*

Avertissement: *Le montage et le branchement au secteur devront être exécutés par une personne spécialement formée à cet effet. Le branchement et le débranchement sous tension sont interdits!*

Avertissement: *La sortie courant (4-20 mA) est un récepteur actif. Elle ne doit pas être connectée avec un récepteur actif ou une source de tension.*

Avertissement: *Ne pas utiliser cet instrument dans une atmosphère enrichie en oxygène (risque d'incendie)! Suivez les recommandations associées à l''utilisation de l'oxygène*

Avertissement: *La pression du gaz à mesurer ne doit pas dépasser la pression nominale (gamme de pression de l'analyseur).*

Avertissement: *Le débit ne doit pas dépasser la gamme de mesure! La boule du débitmètre ne doit pas toucher la butée blanche!*

Avertissement: *Débranchez avant d'ouvrir la porte du cabinet ou le couvercle.*

Avertissement: la puissance de rayonnement de la lampe UV est inférieure à 1 W. Évitez le démontage de l'appareil sous tension. La lampe contient 5 mg de mercure. Le mercure est toxique. Éliminez la lampe auprès d'un centre de traitement des déchets qualifié pour traiter les lampes à base de mercure. Si vous ne parvenez pas à trouver un tel centre, veuillez retourner la lampe à BMT MESSTECHNIK GMBH.

Avertissement: Avant d'ouvrir le filtre du gaz à mesurer, assurez-vous qu'il n'y a pas de surpression dans la conduite du gaz à mesurer et qu'il n'y a pas d'ozone dans le gaz.

Avertissement: Tout cable électrique ne doit être raccordé que par une personne familiarisée avec les exigences de sécurité.

Attention: Connectez un tube à la sortie du catalyseur pour détourner les gaz relâchés dans l'atmosphère en cas que le gaz vecteur du générateur d'ozone soit enrichi d'azote. Acide nitrique corrosif se forme si le gaz qui contient de l'azote entre en contact avec l'air humide de l'environnement.

Attention: Evitez une concentration haute en oxides d'azote dans le circuit gaz. Si cela arrive, par exemple pendant que le générateur d'ozone est en service, le circuit gaz doit être interrompu.

Attention: Rassurez-vous que l'analyseur d'ozone est détaché du système et que le circuit gaz est interrompu, en cas que le générateur d'ozone soit en service ou en panne. C'est pourquoi nous vous recommandons d'installer un robinet d'arrêt ou une valve d'isolement.

Attention: Avant d'enlever le couvercle du refroidisseur /sécheur DH6, reliez-vous à la terre en touchant une surface conductrice reliée à la terre afin d'éviter d'endommager l'électronique par une décharge électrostatique.

Attention: Il ne faut jamais balayer le circuit gaz de l'analyseur avec des liquides, en particulier avec de l'eau, afin de nettoyer la cellule puisque ceci pourra endommager le capteur de pression.

3   Installation and Power Connection

The OZONE ANALYZER BMT 965 is a 144 x 72 mm front panel instrument (according to DIN 61554). For additional information on other variants of the BMT 965 (AQ, Cabinet etc.) consult the appropriate appendix of this manual. The mounting cut-out should be 139 x 67 mm (W x H). Depth is approx. 230 mm. The power line voltage may be 100 to 240 VAC (50 or 60 Hz). All necessary parts needed for installation are supplied with the instrument (e.g. power and signal connectors, mounting brackets, a tool for opening the sample gas filter holder). The serial port cable is a standard RS-232 type and is supplied with every analyser (also with the different models in the Appendix). The USB port is of type Micro-A/B. A cable for connection to a computer and an adapter cable for connecting a USB flash drive come with the instrument.

Do not operate at an elevation higher than 2000 m. Use copper conductors only.

Warning: The installation of the power connector has to be made by a person acquainted with the safety requirements involved. Do not connect or disconnect the voltage-carrying connector!

Warning: This product relies on the building's installation for short-circuit (overcurrent) protection. Ensure that a fuse or circuit breaker no larger than 15 A at 120 VAC (10 A at 240 VAC) is used on the phase conductor.

The power receptacle or the mains socket-outlet the instrument is connected to should be easily accessible for fast interruption of power, or other easily accessible means for switching off power should be provided. This disconnect has to be clearly marked for identification of the instrument.

Optionally the instrument is available in a low voltage version with a voltage range from 12 to 36 VDC (max. power consumption is 15 W).

Mains connector:	left	⏚ Protective Ground	
	middle	mains 'L'	} (100 bis 240 VAC, 50/60 Hz, 15 VA)
	right	mains 'N'	

Alternatively:

DC power connector:	left	⏚ Protective Ground	
	middle	negative	} (12-36 VDC)
	right	positive	

The backplane is shown here:
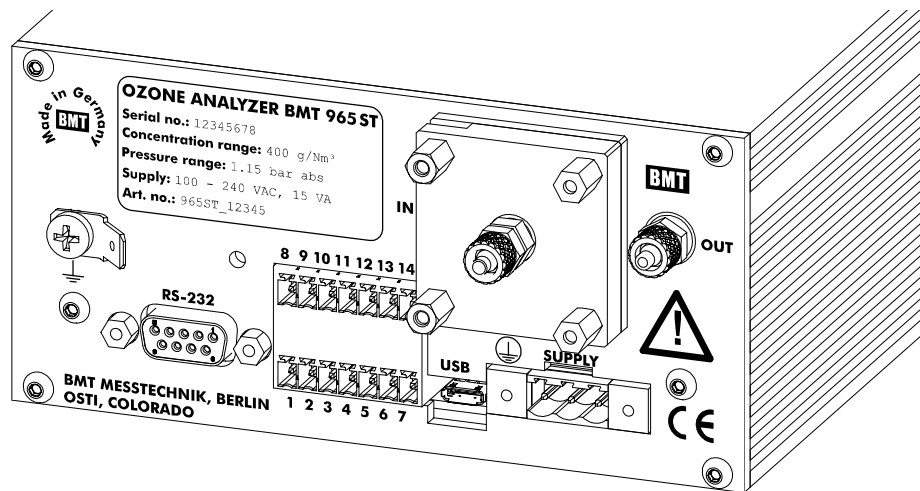
As seen in the backplane the socket for the signal connector has a lower (terminals 1-7) and an upper part (terminals 8-14). Inserting the yellow PCB connector plug belonging to the upper section into the lower one can cause damage to the instrument and must therefore be avoided.

In order to prevent an accidental insertion into the wrong socket, a modification on the terminal no. 5 of both the lower socket and the corresponding plug was made. On terminal no. 5 the socket received a red coding profile whereas the plug was modified by removing the upper fin.

For the sample gas connection 3x5 mm FEP tubing (or 1/8" x 3/16") should be used (which we will supply on request). The sample gas has to be connected via the sample gas filter ("IN"). The time lag of the concentration measurement depends on

a) the flow rate of the sample gas,

b) the length of the tubing to the analyser,

c) the cross section of the tubing (we recommend tubing 3x5 mm, not more!),

d) the time lag of the analyser itself. At the recommended flow rate of 0.2 to 1.0 l/min time lag will be 2 to 0.4 s with a 3x5 mm tubing length of 1 m.

Photometers and Dirt

Using 254 nm UV radiation the ozone photometer "looks" through the gas, or the water, in which the ozone is contained. It looks via two cuvette windows made of fused quartz. When these windows become dirty the instrument cannot distinguish between a reduction of the UV radiation by the ozone present in the cuvette - and the reduction by dirty cuvette windows. The most important rule for operating an ozone photometer is: "The only real enemy of an ozone photometer is dirt!"

Filter holder for BMT 965 ST, BT, etc.

1: fixed part of the holder
2: spacing wire mesh (SS)
3: pre-filter insert
4: spacing wire mesh (SS)
5: O-ring
6: removable part of holder
7: hex nuts
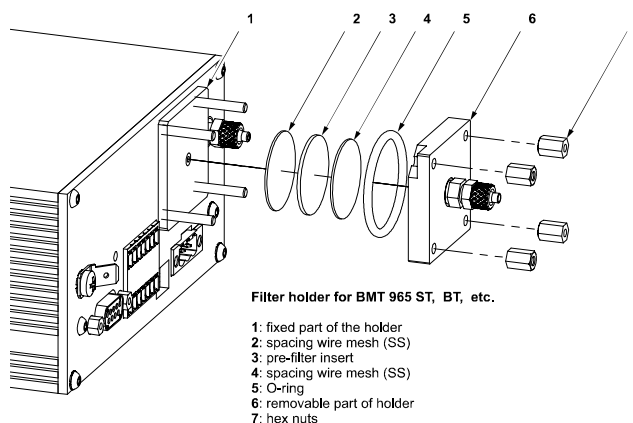
When measuring ozone, namely in an industrial environment, it really pays off to thoroughly protect the ozone analyser from any dirt which might be contained in the ozone sample gas.

BMT ozone analysers for gaseous ozone are equipped with particle filters containing a replaceable filter insert. The filter inserts should from time to time be checked for dirt (see page 52, Maintenance), and be replaced on a regular basis depending on the degree of particle content of the sample gas.

The ozone gas coming from most types of ozone generators contains more or less nitrogen oxides because the oxygen feed gas contains nitrogen, inadvertently, or intentionally. Namely medium sized and big generators are operated with high nitrogen doping. When such generators are serviced without disconnecting the ozone analyser the danger of dirt getting into the analyser is particularly high.

> **Caution**: High concentration of nitrogen oxides in the sample gas must be avoided. If this could occur e.g. during generator service, sample gas flow must be stopped!

The following two drawings show two possible configurations:

VENT mode

OZONE ANALYZER

ozone destruct

(low flow resistance)

vent to ambient

rotameter

throttle

measurement takes place at ambient pressure

"bleed" flow rate depends on system pressure

"bleed" flow 0.1 - 1l/min

system flow

system pressure > ambient pressure

PRESS mode

OZONE ANALYZER

measurement takes place at system pressure

bypass flow rate depends on system flow rate

bypass flow 0.1 - 1l/min

defined flow resistance

system flow

any system pressure

4   Output and Control Terminals

The signal cable should be shielded. The shield should be connected to the protective ground terminal (⏚) of the instrument via an 1/4" FASTON connector. The following table describes the pinout of the signal connector. This is also printed onto the top of the standard instruments:

OZONE ANALYZER BMT 965

OUTPUT AND CONTROL TERMINALS

ALWAYS CONSULT THE MANUAL

USE SHIELDED CABLE   CONNECT SHIELD TO ⏚

ANALOG OUTPUTS:
Isolated
7   Concentration   0-10V
6   GND (10 V)
5   Concentration   4-20 mA
4   GND (4-20 mA)

ERROR RELAY:
Isolated, U_{max} = 30 VDC, I_{max} = 0.5 A
1
3   Open on Error

RELAY CONTACTS:
OUTPUTS:
Isolated, U_{max} = 28 V, I_{max} = 0.5 A
8   Out Common
9   Lamp Low
12   High Alarm
13   Low Alarm
14   Cuvette Dirty
2   Purge

INPUT:
Isolated, U = 24 VDC, I = 8 mA
10   Zero GND
11   Set to Zero (no O_3)

BMT MESSTECHNIK, BERLIN   phone +49 – 3329-696 77-0   www.bmt-berlin.de
OSTI, COLORADO   phone +1 – 831 - 649 1141   www.osti-inc.com

Analog Outputs

The output signals are updated about 10 times per second.

The voltage output is an isolated voltage signal 0 to 10 V, proportional to the concentration (actually this signal swings down to about -0.25 V below zero). Input resistance of the load should be higher than 1 kΩ.

The current output is an isolated current signal 4 to 20 mA, proportional to concentration (with an offset of 4 mA). Input resistance of the load should be less than 600 Ω. The current output provides the energy for the current loop.

> **Warning:** The current output (4-20 mA) is an active analog signal transmitter. It must not be connected to an active receiver or power supply!

Binary Input

The binary input is a control input used to trigger the ZERO function of the OZONE ANALYZER BMT 965. By applying a voltage of typically +24 VDC between pin 11 (+) and pin 10 (-) for about 0.5 seconds the instrument will be zeroed. **The ZERO function may be triggered only after complete purging of the cuvette with filtered air or oxygen** (purging for at least 10 seconds plus delay of the input tubing)!

Input current at the binary input is approx. 8 mA. The input is protected against voltages with wrong polarity.

Binary Outputs

The binary outputs are relay contacts, which are used to signal errors and alarms. An additional contact can be used for the selection of purge gas during automatic zeroing. The common contact of all binary output relays is on pin 8. The following outputs are available:

Pin	Function	Description	see page
9	Lamp Low	Opens when the lamp becomes too weak	32
12	High Alarm	Opens or closes if concentration is above a certain threshold	24
13	Low Alarm	Opens or closes if concentration is below a certain threshold	24
14	Cuvette Dirty	Opens when a dirty cuvette is detected	33
2	Purge	Contact for external pump / solenoid valve	15

The binary output contacts can switch a max. voltage of 28 V and a max. current of 0.5 A. The binary outputs can be used as "high-side switches" (voltage applied to pin 8) or "low-side switches" (pin 8 connected to ground). All outputs are protected by fast blow 1 A fuses. A blown fuse requires the instrument to be sent in for service, so check your installation before operating your system! Further explanations of the different output functions can be found on the pages mentioned.

Error Relay

The error output is an SPST relay contact. In order to prevent a broken wire from remaining undetected, the contact has been designed as opening on error (normally closed ≡ closed if there is no error), see page 32 for more details on error handling. The contact may be loaded with 30 V/0.5 A.

In the warm-up phase and if the instrument is powered off, the error relay is in the error state.

Serial Interface (RS-232)

The bidirectional isolated serial interface is used for communication with a PC or other automation components in an industrial environment.

Connection:

Pin	Function	Description
2	TxD	Data sent
3	RxD	Data received
5	GND	RS-232 ground

Note: The RS-232 GND and isolated analog outputs GND are connected!

The data format used is eight bits, one stop bit, no parity (8N1). See page 25 for configuration of the interface.

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USB-Interface

The USB connector is a Micro-A/B receptacle, conforming to USB OTG (On-The-Go) specifications. The instrument communicates at USB Full Speed (12 Mbit/s) and can serve as device or host on the bus. In host mode only USB flash drives may be connected, no hard drives, because the instrument cannot satisfy the power demand of a hard drive. For host operation, an adapter cable is supplied with the instrument.

5   Switching On the Instrument

After application of the mains voltage the instrument will display the following:

```
BMT965 VX.XX
```

VX.XX denotes the software version. Then concentration and pressure range will be shown, e.g.:

```
R: 200 g/Nm³

PR: 2.5 bar
```

This display is followed by a warm-up period, the length of which is being determined by the state of the lamp and environmental temperature. During warm-up the Error Relay is switched to the error state (contact open). All other relay contacts are open. The analog outputs are set to 10 V and 20 mA respectively. The serial interface (see page 25) puts out max. concentration, actual pressure and the code for the warm-up-state. The time left for change into normal operating mode is displayed and counted down in second intervals. The time period between switching on and normal operating mode can last between 40 s and 120 s. At ambient temperatures less than 15 °C warmup can last up to 240 s. During this time the front panel keys and the zero-input are deactivated.

6   Zeroing the BMT 965

The zero reading of the instrument (the value displayed without any ozone in the cuvette) may undergo slight changes, which among others can be induced by

- namely: soiling of the cuvette
- influence of temperature

In order to compensate these effects BMT MESSTECHNIK recommends zeroing the BMT 965 every 24 hours. Depending on the demands on accuracy and the individual stability of an instrument the time interval between two zeroing actions can be much longer.

It is very important to really make sure that no ozone is present in the cuvette during zeroing! Before zeroing the BMT 965 has to be purged with oxygen or filtered air.

M965_001_EN_2023-11-01

Zeroing can be initiated in the following ways:

- pressing the ZERO button with succeeding confirmation

- driving the Zero-input (Pin 11) with 24 VDC

- via the serial interface in User-Mode by sending the character 'A'

- automatically, time controlled by the BMT 965 internal timer (see page 14, Zeroing)

- via the serial interface in Link-Mode by sending the command *83#3.14159

- from a Windows-PC by using the program BMT 965 Link

The display will show information about zeroing. In each zero cycle the dirtiness of the cuvette is determined. This value is displayed on the front panel and sent via the serial interface. Increased dirtiness will lead to a Dirty Warning or a Dirty Error respectively (see page 33).

During the whole zeroing action the last measured concentration result is used to set the analog outputs to a constant value. The serial interface in User-Mode sends out the last measured concentration and, instead of dirtiness, the string 'AAAA'.

Automatic Zeroing with Control of Purge Gas

Purge gas control can be taken over by the BMT 965. The relay contact Purge (Pin 2) is used for this purpose. This contact (max. 28 V, 0.5 A) can switch an ozone proof solenoid valve to switch from ozone to an ozone free gas like CDA (Compressed Dry Air) or Oxygen. Alternatively, the instrument can be ordered with a built-in Internal Purge Unit. In both cases the parameter **Aut Zero Interval** has to be set to a time interval between 1 hour and 99 hours (either by use of the front panel menu, the program BMT 965 Link or the Link-Mode command *45#). Automatic zeroing will be activated after this time interval. Additional zero cycles can be initiated within this interval by the methods described above, which reset the built in Zero-Timer.

In case **Auto Zero Interval** is set higher than zero (1 to 99 h), there will be an additional automatic zero cycle approx. 15 minutes after each power up. Also, the purge contact is activated on each zeroing cycle (only if Auto Zero Interval > 0 h).

> **Attention:** Activation of the Automatic Zeroing with Control of Purge Gas is meaningful only if the relay contact Purge (pin 2) is used to somehow activate purging of the cuvette in order to remove any ozone or with a built-in Internal Purge Unit.

One complete automatic zero cycle needs 20 seconds. It consists of three phases:

1. purge period, 10 seconds (the instrument displays `Purging...`)

2. zero calculation, 2 seconds (it displays `Zeroing...` and the calculated cuvette dirtiness)

3. waiting period, 8 seconds (it displays `Sampling...`), during which the cuvette is refilled with ozone.

During the complete zeroing period of 20 seconds the analog outputs are set to the stored concentration value measured immediately before the start of the zeroing cycle. In User Mode the RS-232 transmits the same concentration, and 'AAAA' instead of the cuvette's dirtiness.
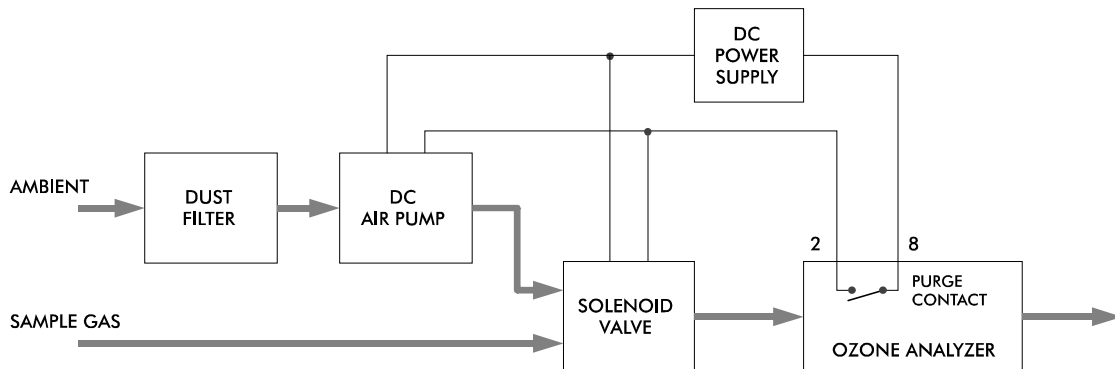
The above setup shows the components needed for automatic zeroing. It is very important to provide automatic switching of purge gas, before the Auto Zero Interval is set to other values than zero hours! Otherwise, the instrument could possibly calculate the zero value with ozone in the cuvette. The Auto Zero Interval is described on page 26.

It should be pointed out, that setting the Auto Zero Interval to zero hours actually means, that the analyser does **not** go through the purge cycle described above and does **not** activate the Purge Control contact! In this case, the user shall never initiate zeroing with ozone in the cuvette. With the option Internal Purge Unit, or in the cabinet version, the analyser takes care about switching to zero gas, itself.

In case the OZONE ANALYZER BMT 965 is equipped with an Internal Purge Unit (solenoid valve and air pump with particle filter) as an option, e.g. in the model BMT 965 BT (see Appendix B) the terminal 2 should not be connected externally.

7   Front Panel Operation

The front panel consists of a 16-character alphanumeric display (LCD with red backlight illumination) and three pushbuttons. The display is updated every 0.3 s.

M965_001_EN_2023-11-01
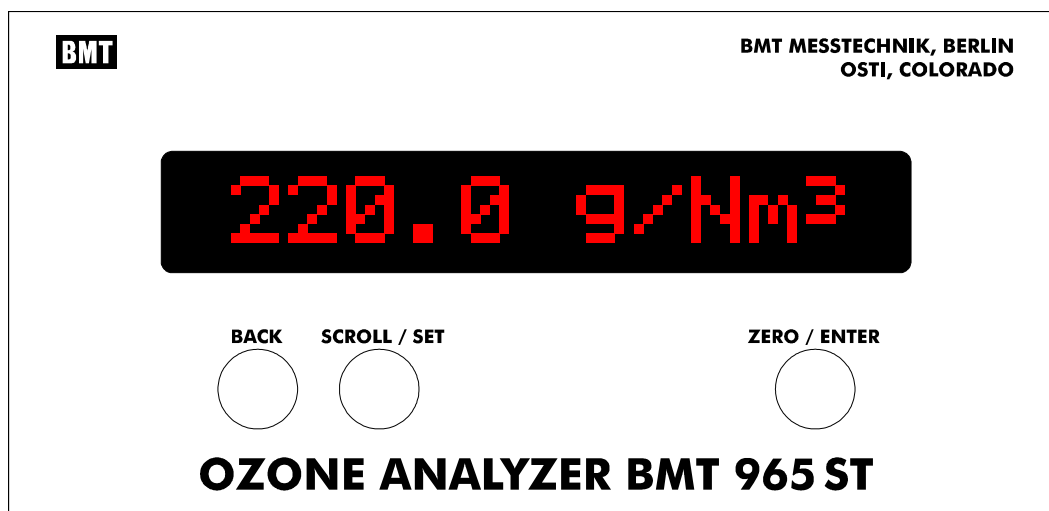
The pushbuttons can be used to perform the following operations:

- Switch to pressure display (and back)

- Zero the BMT 965

- View parameters

- Change parameters

- Confirm file copy or firmware upgrade

The following diagram shows the functions of the main menu:

Main Menu
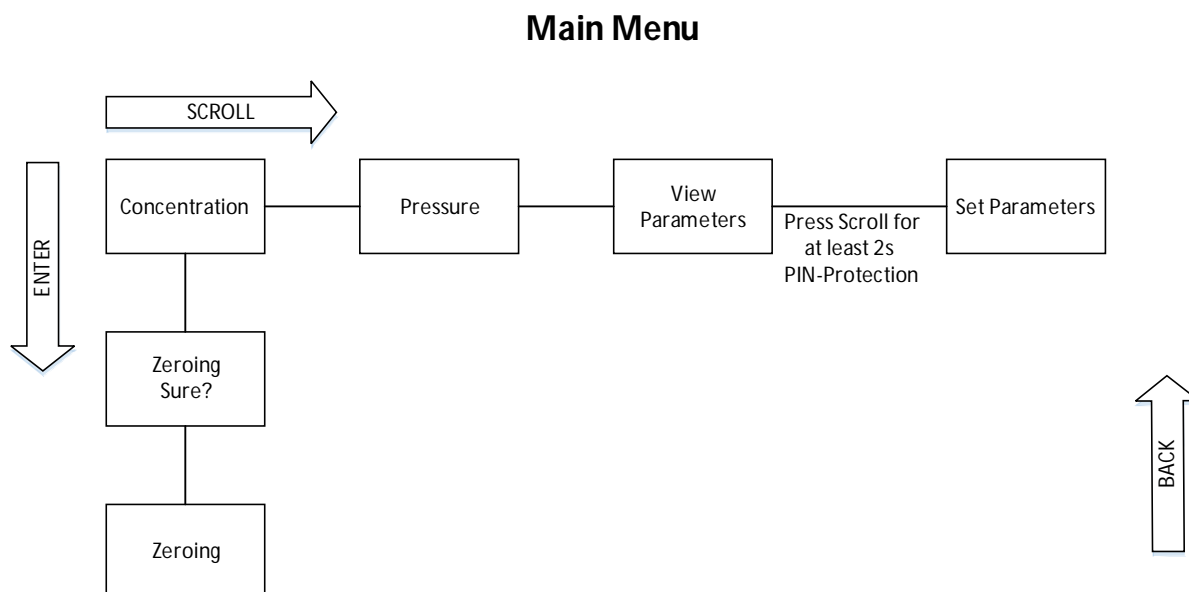
Expressions printed **bold** in the following sections of text always relate to the contents of the instrument menus.

The button SCROLL / SET moves to the right within the menu, the key ZERO / ENTER downwards and the button BACK moves upwards. The SCROLL action will continue on the left side, once it has reached the right side of the diagram. This is also valid for the later explained menus **View Parameters** and **Set Parameters**.

From now on, when relating to the multi-functional keys SCROLL / SET and ZERO / ENTER only the function meant in the context will be mentioned.

Starting with **Concentration** pressing the button SCROLL will lead to **Pressure.** Here the pressure inside the cuvette is displayed and updated every 0.3 s. One further push on SCROLL displays **View Parameters**. After pressing ENTER the parameters can be viewed, but they cannot be changed.

Changing Parameters

If in the menu position **View Parameters** the button SCROLL is pushed briefly, the instrument resumes display of the ozone concentration (Menu position **Concentration**).

> **Note:** In order to move from View Parameters to Set Parameters the SCROLL button has to be held down for at least 2 seconds.

The menu **Set Parameters** is used to change properties of the instrument, like units, alarms etc. In order to protect the instrument and the components connected to it from unqualified handling, the above-mentioned procedure has to be performed. In addition, the instrument configuration can be protected by a 4-digit PIN. This PIN is factory set to 0000, which means that after pressing the SCROLL button for 2 s, properties can be changed freely. The Windows software BMT 965 Link can be used to change this PIN to any other 4-digit number. If the PIN is different from 0000, pressing the SCROLL key for 2 s will lead to the display of:

```
Enter PIN 0000:
```

Only the correct PIN will allow entry to **Set Parameters**, any other number will lead back to the display of ozone concentration.

View Parameters and **Set Parameters** will be described on the following pages. During viewing and setting of parameters the instrument continues measuring, i.e. new measurement results are sent out on the analog outputs and the serial interface continuously.

Zeroing the Instrument from the Front Panel

If ozone concentration is shown on the display and the ZERO button is pushed, the instrument displays the question:

```
Zeroing: Are you sure?
```

Due to the fact that zeroing with ozone would lead to wrong measurement results, this question gives the user the opportunity to stop. This can be done by pressing the button BACK. In case there is really no ozone present in the cuvette, the ZERO button may be pressed again, after which zeroing starts. Further information about zeroing the BMT 965 can be found on page 14.

The Menu View Parameters

In the menu **View Parameters** the configuration of the BMT 965 can be viewed, but it cannot be changed.

View Parameters (1)
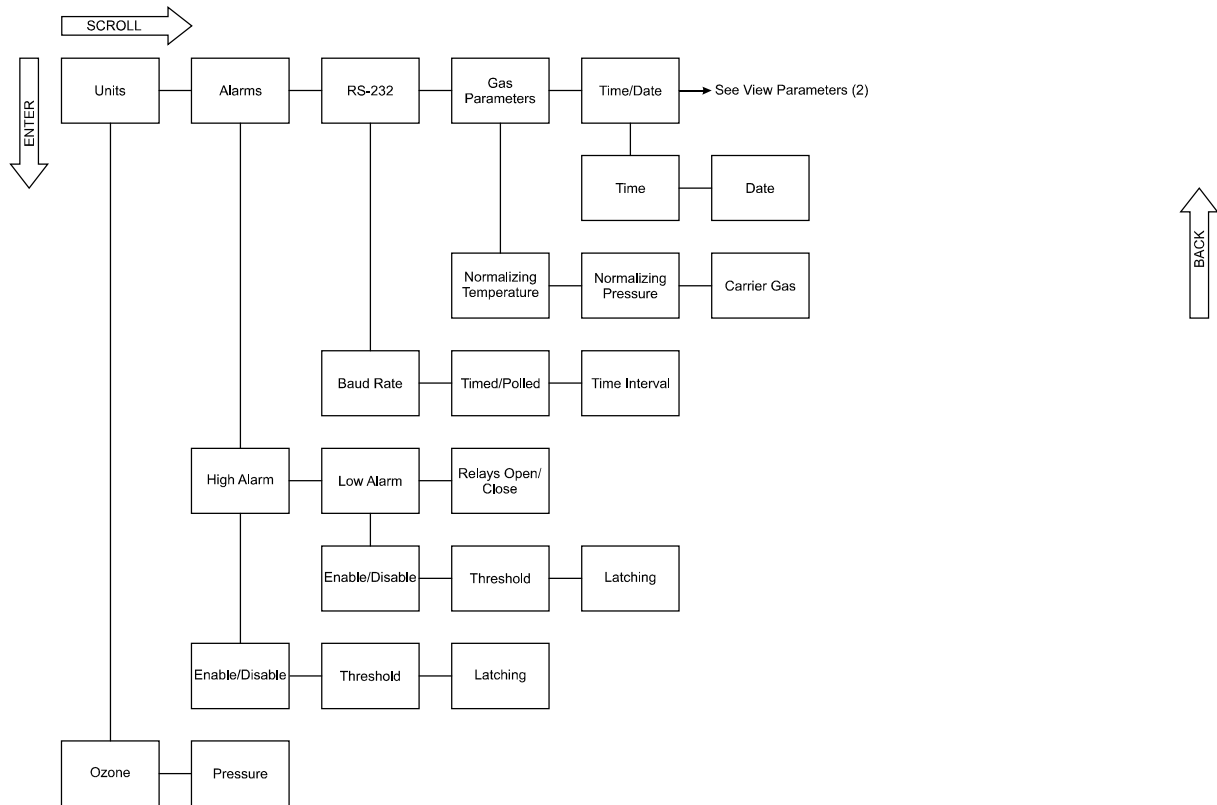
View Parameters (2)
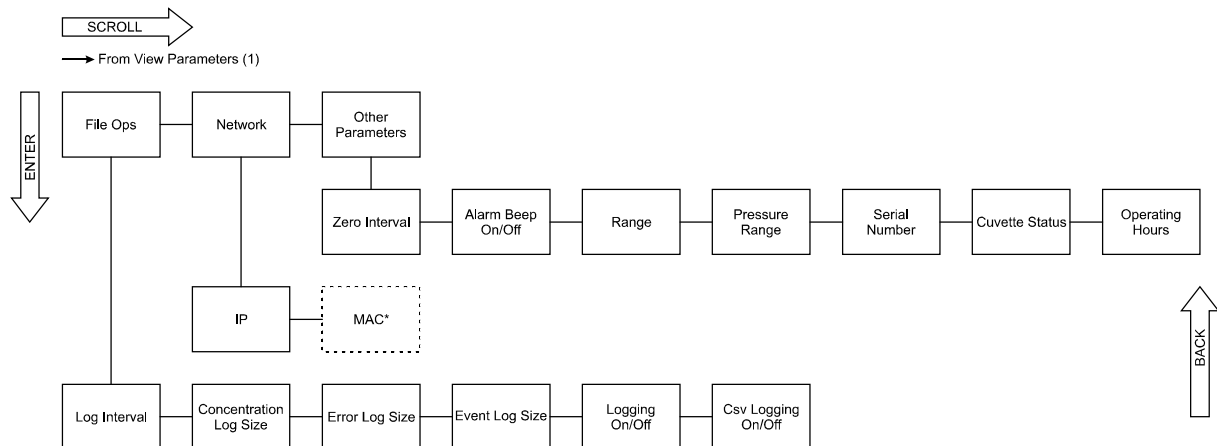
*Available from firmware version 1.05

The following parameters are shown:

- **Units**
  Unit of ozone concentration
  Unit of pressure

- Alarms
  Activation, thresholds, latching, closing or opening of Alarm Relays

- RS-232
  Baud rate, periodic transmission or polling, time interval of periodic transmission

- Gas-Parameters
  Nature of the carrier gas: normalizing conditions, air or oxygen (incl. PSA oxygen)

- Time / Date

- File Operations
  Log time interval, summed size of binary and CSV concentration logs, error, and event logs, logging and CSV logging on or off

- Other Parameters
  Time interval of auto zero, Alarm beep on/off, ozone concentration range, pressure range, serial number, cuvette dirtiness, operating hours

The Menu Set Parameters
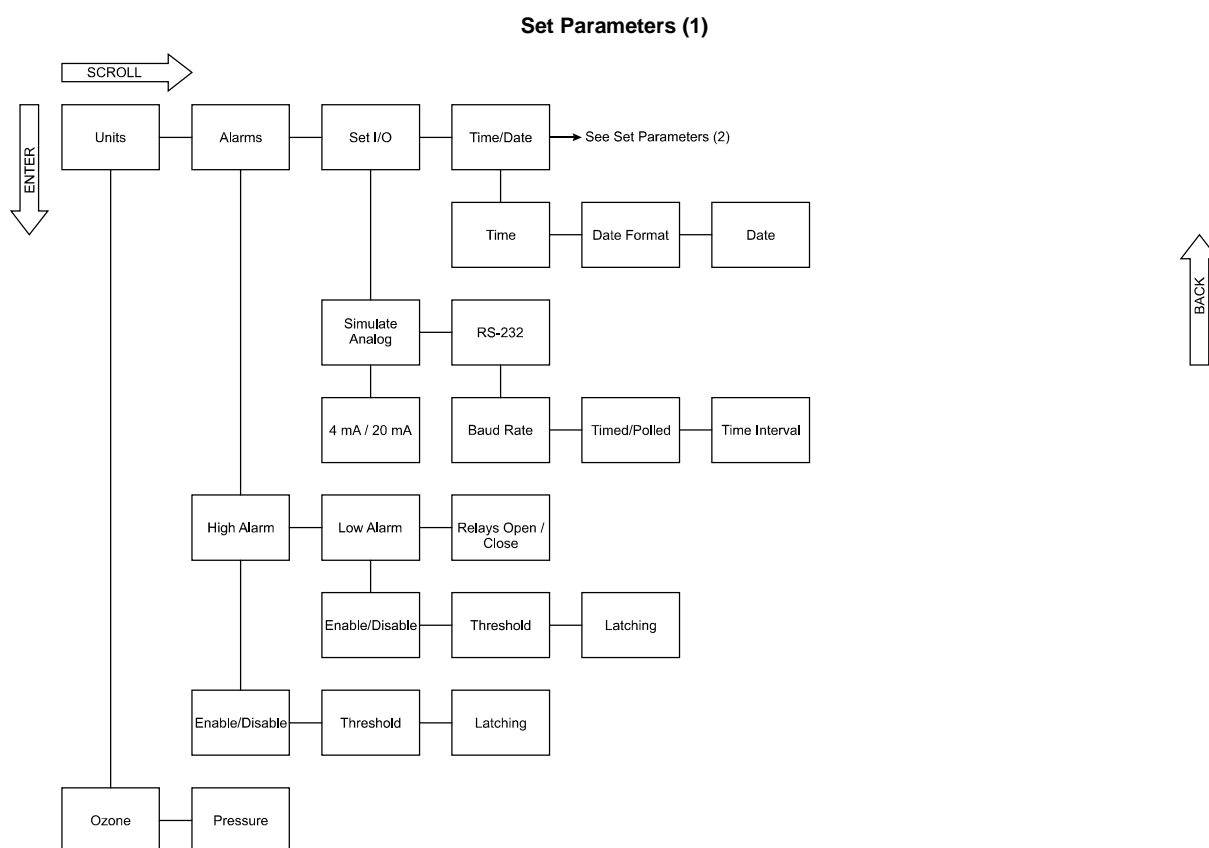
Set Parameters (1)
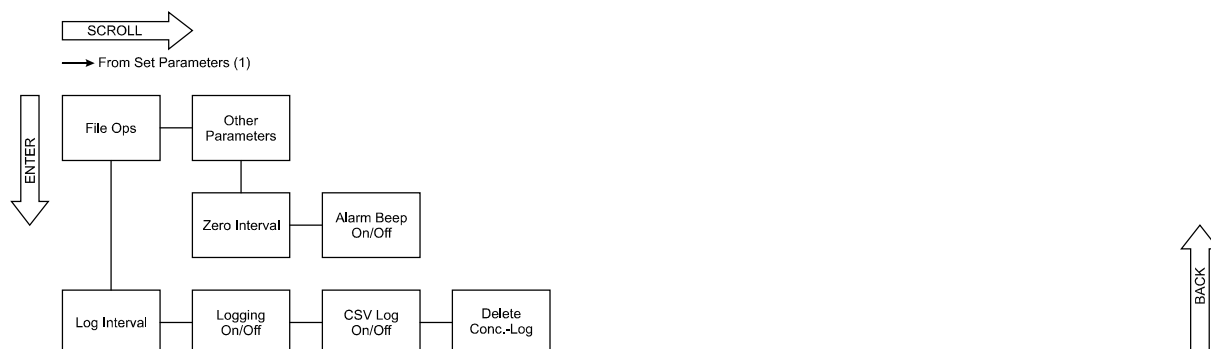
Set Parameters (2)

Note: In order to move from View Parameters to Set Parameters the SCROLL button has to be held down for at least 2 seconds.

The configuration of the BMT 965 can be changed here. The diagram shows the selectable parameters. In order to change a setting, the ENTER button has to be pressed. Logical variables, as e.g. **Enabled/Disabled** are configured with the SET button. Numerical values as e.g. **Threshold** are changed digit by digit. To change a digit, the SET button is used. The digit to be changed is marked by a cursor beneath it. In order to move to the next digit, the ENTER button has to be pressed. The procedure can be stopped at any time by pushing the BACK button. After complete setting of the parameter the ENTER button has to be pressed again, the display

        Saving...

appears for a short time and the parameter is saved. To leave the menu press the back button several times.

This is an example for changing a logical variable: the unit of ozone concentration shall be changed from g/Nm^3 to %wt/wt:

Button	Display
	$0.0 \ g/Nm^3$
SCROLL	1.013 bar
SCROLL	View Parameters
SCROLL (>2 s)	Set Parameters
ENTER	Set Units
ENTER	Set Ozone Unit
ENTER	Ozone: g/Nm^3
SET	Ozone: %wt/wt
ENTER	Saving...
	Ozone: %wt/wt
BACK	Set Ozone Unit
BACK	Set Units
BACK	Set Parameters
BACK	0.00 %wt/wt

One more example: the numerical parameter **High Alarm - Threshold** (determines the threshold, above which a High Alarm occurs) shall be changed from 75 g/Nm^3 to 90 g/Nm^3.

Button	Display
	0.00 g/Nm^3
SCROLL	1.013 bar
SCROLL	View Parameters
SCROLL (> 2s)	Set Parameters
ENTER	Set Units
SCROLL	Set Alarms
ENTER	Set High Alarm
ENTER	Enable/Disable
SCROLL	Set Hi-Threshold
ENTER	Hi:075.0 g/Nm^3
ENTER	Hi:075.0 g/Nm^3
SET	Hi:085.0 g/Nm^3
SET	Hi:095.0 g/Nm^3
ENTER	Hi:095.0 g/Nm^3
SET	Hi:096.0 g/Nm^3
SET	Hi:097.0 g/Nm^3
SET	Hi:098.0 g/Nm^3
SET	Hi:099.0 g/Nm^3
SET	Hi:090.0 g/Nm^3
ENTER	Hi:090.0 g/Nm^3
ENTER	Saving...
	Hi:090.0 g/Nm3
BACK	Set Hi-Threshold
BACK	Set High Alarm
BACK	Set Alarms
BACK	Set Parameters
BACK	0.00 g/Nm^3

On the following pages you can find a detailed description of all configurable parameters. Change of one parameter may lead to the automatic change of other parameters. The stored parameter information is not lost when the instrument is switched off.

Units

Ozone

This will set the unit of ozone concentration. You can choose between:

- g/Nm^3
- % wt/wt (carrier gas oxygen)
- ppm$_v$
- g/m^3 (AQ)
- ppm$_w$ (AQ)

- %wt(air) (carrier gas air)

If the concentration unit is changed the range will change, too:

g/Nm^3 (g/m^3, ppm$_w$)	% wt/wt or %wt(air)	ppm$_v$	Range-ID
2.000	0.1500	1000	1
5.000	0.3500	2500	2
10.00	0.7000	5000	3
20.00	1.500	10000	4
50.00	3.500	25000	5
100.0	7.000	50000	6
150.0	11.00	75000	7
200.0	14.00	100000	8
300.0	20.00	150000	9
400.0	26.00	200000	10
0.750	0.0600	375.0	11
15.00	1.100	7500	12
500.0	31.00	250000	13
600.0	37.00	300000	14
0.500	0.0400	250.0	15

Please bear in mind, that there is a non-linear relationship between g/Nm^3 and ppm$_v$ on one side and %wt/wt resp. %wt(air) on the other side. Also, the full range concentrations are not exactly the same upon switching, as the range limits are rounded values.

Note: Accordingly, the analog outputs may change, when the ozone concentration unit is changed.

Furthermore, the thresholds of High & Low Alarm are recalculated automatically. For a complete list of available ranges, please refer to the latest order sheet.

Pressure

The unit of absolute pressure shown on the display can be changed from bar to psi, Torr or MPa. Here are some examples for recalculation of pressure range when changing the unit:

bar	psi	Torr	MPa
1.15	16.68	863	0.115
1.5	21,76	1125	0.150
2.0	29.02	1500	0.200
2.5	36.27	1875	0.250
3.0	43.52	2250	0.300
3.5	50.78	2625	0.350
4.0	58.03	3000	0.400

For a complete list of available ranges, please refer to the latest order sheet.

Alarms

High-Alarm

This alarm occurs if **Enable/Disable** is activated and the limit stored under **Threshold** is exceeded. In case **Relays Open/Close** is set to Relays Opening, the High-Alarm-Relay opens (default)[1], otherwise it closes. At the same time a High-Alarm-Event is entered into the Event-Log. The display alternates between the measurement result and the message

```
High Alarm!
```

If **Alarm Beep** is activated, there is also an acoustic signal, which may be stopped using the BACK button, if the front panel menu is on its basic level. The BACK button does not clear a latched alarm, though.

If ozone concentration falls below [**Threshold** - 0.002 x range] (hysteresis) the alarm state is ended if **Latching** is set to Not-Latching. The High-Alarm-Relay falls back into its normal state, the error message and the acoustic signal disappear. The end of the alarm state is entered into the Event-Log.

In case **Latching** is activated, the alarm will not go away until it is acknowledged by pressing the ENTER button, even if concentration falls below the programmed threshold. The end of alarm will be entered into the Event-Log when the button is pushed. Also, the button is free for initiating zeroing again.

Low-Alarm

This alarm occurs if **Enable/Disable** is activated and concentration is below the limit stored under **Threshold**. In case **Relays Open/Close** is set to Relays Opening, the Low-Alarm-Relay opens (default)[1], otherwise it closes. At the same time a Low-Alarm-Event is entered into the Event-Log. The display alternates between the measurement result and the message

```
Low Alarm!
```

If **Alarm Beep** is activated, there is also an acoustic signal, which may be stopped using the BACK button, if the front panel menu is on its basic level. The BACK button does not clear a latched alarm, though.

If ozone concentration rises above [**Threshold** + 0.002 x range] (hysteresis) the alarm state is ended if **Latching** is set to Not-Latching. The Low-Alarm-Relay falls back into its normal state, the error message and the acoustic signal disappear. The end of the alarm state is entered into the Event-Log.

In case **Latching** is activated, the alarm will not go away until it is acknowledged by pressing the ENTER button, even if concentration rises above the programmed

---

[1] The default setting for the alarm behaviour has been changed starting from firmware version 1.05. For firmware versions 1.04 and earlier the factory default setting is Relay Closing.

threshold. The end of alarm will be entered into the Event-Log when the button is pushed. Also, the button is free for initiating zeroing again.

Relays Open/Close:

This variable decides if the alarm relays will open or close if an alarm occurs. Relays Opening (default)[1] leads to opening contacts upon reaching the alarm threshold. This menu item influences both alarm relays at the same time.

Input/Output

Simulate Analog Out

For test purposes both analog outputs can be set to their max. (10 V / 20 mA) respectively min. (0 V / 4 mA) values. With the program BMT 965 Link any voltage and current can be put out.

RS-232

This menu item is used to configure the serial interface. The User-**Baud rate** can be set to one of the following values:

- 2400 Baud
- 4800 Baud
- 9600 Baud (default)
- 19200 Baud
- 38400 Baud

The setting of **Timed/Polled** decides, if the output of data on the serial interface is done automatically in a certain time interval (Timed) or if a block of data is sent only on request (character '?', without CR). If the operating mode is set to Timed, a data block is sent every **Time Interval**. Minimum interval is 1 s; max. interval is 99 s. A detailed description of the serial interface can be found on page 13.

Time/Date

Time

Here the time of day is set in the format hh:mm:ss.

Date Format

Display of date can be switched from European (DD.MM.YY, default) to American (MM/DD/YY) notation.

Date

During entry the date will be constantly tested on conformance to the calendar rules, so it is not possible for example to enter the date 29.02.18. In order to make this test possible, first the year, then the month and then the day has to be set.

File Operations

Set Log Interval

Set the time interval in seconds, in which data is written to the concentration log on the internal SD card. Minimum interval is 1 s, and max. interval is 9999 s.

Logging On/Off

Concentration logging can be switched on and off here. An explicit explanation of storage and file handling follows in the next paragraph.

CSV-Log On/Off

If logging is generally on (see above), logging to an Excel-CSV file can be activated here.

Delete Conc.-Log

Both concentration logs can be deleted from the SD card.

Other Parameters

Auto Zero Interval

This variable determines, if and in which time interval (hours) the instrument will perform a (fully) automatic zeroing cycle. If set to zero, there will be no automatic zeroing.

> **Note:** In case the instrument is configured for automatic zeroing care must be taken to supply the purge gas (oxygen or filtered air). The instrument may either be equipped with an external or Internal Purge Unit (solenoid valve and air pump with particle filter, available as an option), or some other means of switching the purge gas supply via the PURGE relay contact has to be provided (see also page 15)

The time interval between two automatic zeroing cycles can be set between 1 and 99 hours. If the instrument is set to automatic zeroing one additional zero cycle is performed 15 min after switching on. A zero triggered manually, via RS-232, USB, or the binary input will also include automatic purge and will reset the interval timer.

Alarm Beep

If this item is set to Enabled, the BMT 965 emits an acoustic signal during Low- or High-Alarms and during error conditions. This beeper may be stopped using the BACK button, if the front panel displays concentrations.

Reset Parameters

This will set all Parameters described above back to factory settings. When pressing ENTER, the instrument displays

```
Are you sure?
```

If ENTER is pressed again, parameters are set as described in the following table:

Parameter	Setting
Ozone Unit	g/Nm^3
Pressure Unit	bar
High Alarm Limit	80 % of Range
High Alarm enabled	No
High Alarm latched	No
Low Alarm Limit	40 % of Range
Low alarm enabled	No
Low Alarm latched	No
Date Format	dd.mm.yy
RS-232 user output	Timed
RS-2323 user output interval	1 s
User Baud Rate	9600 Baud
Alarm Beep	On
Alarm Relays closing	Yes
Purge Time	10 s

8   The Serial Interface

The BMT 965 can be equipped with a bidirectional serial interface as an option. In principle there are two different operating modes: User-Mode and Link-Mode.

In User-Mode all relevant measurement data and status information are sent out in one single line. As inputs only polling of this single line and zeroing are available.

In the more complex Link-Mode it is possible to view and change many parameters interactively.

Data transmission on the serial interface are always ended with a Carriage Return (CR, dec. 13).

User-Mode

If **Timed/Polled** is set to Timed, there is an output every **Time Interval** seconds (s. configuration of the RS-232 on page 25). In case Polled is set, the BMT 965 expects the input of a question mark ('?', without CR), to which it responds with a block of data. User mode data output always follows the format in the following example:

```
26.03.18,12:16:28,154.3 g/Nm3,1.008 bar,00.0,0000
```

Data are separated by commas. Contents of a data block:

- Date (format as set in **Date Format**)

- Time as hh:mm:ss

- Ozone concentration including unit, depending on the setting of **Units-Ozone** (position of decimal point depends on range). During warm-up the range is put out here (max. ozone concentration)

- Pressure inside the cuvette incl. unit, depending on **Units-Pressure**

- Dirtiness of the cuvette in percent (during zeroing this is filled with AAAA)

- 16-Bit status information coded hexadecimal

The 16 bits of the status info have the following meaning:

Bit	Meaning
0 (LSB)	Lamp Low Warning
1	Lamp Low Error
2	Lamp Off Error
3	Dirty Warning
4	Dirty Error
5	Overpressure Error
6	Overrange Error
7	EEPROM Error
8	Zeroing
9	Warmup
10	Lamp High Error
14	Low Alarm
15	High Alarm

Bits 11-13 are not used.

Link-Mode

This mode allows interactive access to measurement results and the change of all parameters also accessible from the front panel. Communication in Link-Mode always obeys the following format. All communication has to be initiated from the outside:

```
*Command Number#[optional parameter]
```

The BMT 965 always responds after completion of the instruction with

```
*Command Number#[optional parameter]
```

The optional parameter can have different decimally coded formats:

- Byte: Range 0 .. 255. Byte is also used for the configuration of binary parameters; in this case Byte can only take the values 0 and 1. If a binary variable is set to 1, the corresponding function or property is activated.

- Short: Range 0 .. 65535

- Word: Range 0 .. 99999999

- Float: Range –9999999 .. 99999999 (floating point number as for example 1.234567, max. 8 characters including the decimal point)

It is very important to wait for confirmation from the BMT 965 once a command is sent. Link-Mode is started by sending the following command:

```
*0#DL4EBY
```

The BMT 965 responds with

```
*0#DL7ZN
```

The User-Mode described above is now deactivated. In order to zero the instrument, the proper Link-Mode command has to be used. The BMT 965 contains a Link-Mode timer. Timeout can be set by a Link-Mode command. This timer is reset by the sending of Link-Mode commands successfully to the BMT 965. The instrument will fall back into User-Mode automatically, if this timer runs out due to Link-Mode commands not being received.

> **Caution:** If the BMT 965 is connected to a programmable component (a PC or a PLC) care has to be taken that the program does not reconfigure the BMT 965 in an endless loop. The internal non-volatile memory will only tolerate a limited (4,000,000) number of write cycles. Reading commands can be used infinitely.

A detailed description of Link-Mode commands can be found inAppendix A. The Windows application BMT 965 Link uses Link Mode and is provided with each analyser.

9   File Operations and the USB Interface

With its internal 8 GB SD card and a Full Speed USB interface supporting device and host mode, the BMT 965 offers various possibilities of logging data, sharing data and upgrading. All methods described in the following sections except Upgrade do not interrupt measurement of ozone. While the instrument is connected to a Windows PC or smartphone, logging to the internal SD card is halted because the external device takes control of the SD card's file system. Logging continues as soon as the USB cable is disconnected. Two USB cables can be found in the instrument accessories: a short USB host adapter, and a longer USB cable.

Connecting a Windows Computer to the BMT 965

When the BMT 965 is connected to a Windows computer via USB for the first time, Windows will configure itself, and then will offer to open a new external USB drive in Windows Explorer. The root folder can contain the following files:

- <Serial number>_Clog.965   Time stamped concentration log
- <Serial number>_Evt.965   Event log
- <Serial number>_Err.965   Error log
- <Serial number>_Dia.965   Diagnostic file
- <Serial number>_Clog.csv   Time stamped Excel-CSV concentration log

The *.965 files are used by the Windows software BMT 965 Link, which comes with the instrument. Concentration logs only exist if logging is enabled. All files can be copied from the instrument, e.g. for the purpose of sending them to the BMT service department for further diagnostic analysis.

Log files can be deleted from the instrument either by selecting the corresponding front panel menu item, or by using Windows Explorer when the BMT 965 is connected to a computer.

Remark: The files <Serial number>_Dia.965 and ID.965 and Error and Event logs should never be deleted. They are needed for diagnostic purposes and should be sent to BMT in case of a service issue.

The BMT 965 drive also contains a folder "Docs", which stores this manual and some technical notes, describing practical uses of the instrument.

Another folder "Run_965Link" contains the communication software BMT 965 Link which allows configuration of the instrument and visualization of the logs described above. To start the software, just double click on L965.exe. The software immediately starts communication with the instrument via USB.

The folder "Setup_965Link" contains a setup program for permanent installation of BMT 965 Link on your computer.

The folder "Teamviewer" holds a portable version of the Teamviewer software. If the connected computer has contact to the Internet, this software in conjunction with BMT 965 Link can be used for remote diagnostics. The screen of the connected computer can be shared with e.g. a BMT service technician. Please call BMT in advance to schedule a Teamviewer session.

Connecting a USB Flash Drive to the BMT 965

Only flash drives (sticks) with a FAT32 file system are supported. If you are not sure, how your drive is formatted, check on a Windows computer: with the drive inserted, right click on it in Windows Explorer to see the properties. You should see FAT32 as the file system. If this is not the case, you can format the drive and choose FAT32 in the process. Be aware, that formatting will erase all data on the drive.

Hint: Flash drives with a capacity larger than 32GB cannot be formatted to FAT32 on a Windows computer using onboard tools, only ExFat or NTFS, which will not work on the BMT 965.

Note: While having a USB host adapter with or without a flash drive or a PC connected to the BMT 965 logging on the SD-card is restricted.

From the accessories, take the USB host adapter and connect it to the USB flash drive. Connect the USB host adapter to the BMT 965. The display will show

    Copy files?

Pressing BACK aborts. If you press ENTER, all log files in internal storage are copied into a folder BMT. If such a folder does not exist, it will be created. Copy progress is shown on the display. Old

files from the same instrument will be overwritten. Additional to copying the logs, a file <Serialnumber>_Sta.965 is created, which contains the latest diagnostic data. At the end, the display shows

```
Copy finished
```

for one second and then goes back to displaying ozone concentration. At this point, remove the host adapter.

Note: Remove the USB host adapter when no longer needed. Always connect and remove the USB host adapter with an inserted flash drive.

If the host adapter is connected without a flash drive, the message

```
Waiting for USB
```

appears after 10 s in the display. After a total of 60 s the message

```
Remove USB OTG
```

appears and SD card logging is activated again.

For instruments without a display (e.g. BMT 965 AQ), the question is omitted and copy starts immediately after insertion of the flash drive. At the end the instrument will emit short beeps five times per second. Then the host adapter should be removed.

Firmware Upgrade

The firmware running on the BMT 965 can be upgraded by connecting a USB flash drive. Firmware upgrades are available for download on the BMT website. The major number of the version information should be identical to the major number of the firmware version running on the instrument. For example, do not try to upgrade an instrument running version 1.45 with version 2.04. The upgrade file is encrypted and it should be copied as downloaded to a folder Upgrade in the BMT folder on the flash drive.

Connect the flash drive as described in the previous section. The instruments checks for upgrades fitting the hardware configuration. If a valid file is found, the display will show

```
Upgrade VX.XX?
```

where X.XX denotes the software version. Pressing BACK will abort, pressing ENTER will continue. Update progress is shown. It can take up to two minutes. When the display shows

```
Remove USB Flash
```

remove the host adapter. As soon as the host adapter is removed, the BMT 965 goes through a restart with warm-up. During warm-up, no measurements are made and outputs are in warm-up state as described in section 5.

For instruments without a display (e.g. BMT 965 AQ), upgrade starts immediately after connection of the host adapter if a valid file is found. At the end of the upgrade, the instrument will beep intermittently five times per second. At this point, remove the host adapter.

> **Caution:** Do not remove the host adapter before being prompted to do so! Do not cut power to the instrument during the upgrade process!

10   Error Handling and Early Warnings

The BMT 965 has diverse possibilities to recognize errors, to signal them and to early-warn against them. Errors and Early Warnings are displayed on the front panel. Depending on the importance of the error, the Error Relay (pins 1 and 3) as well as the Early Warning contacts Lamp Low (Pin 9) or Cuvette Dirty (Pin 14) are activated (opened). Errors and Early Warnings are always accompanied by an acoustic signal. In case the menu on the front panel is on its basic level, the BACK button may be used to stop the beeper.

During warmup the Error Relay is in the error position (open).

Errors and Early Warnings are also sent out over the serial interface (s. p. 13) and are documented in the Error-Log on the SD card. The actual status can be read out in Link-Mode with the command *86#.

The following conditions will lead to warnings respectively errors:

Lamp Low Warning

This warning usually will occur before a Lamp Low Error. The message

```
Warning:Lamp Low
```

is shown alternating between the measurement results. The error contact Lamp Low opens, but the Error Relay stays in its normal state. A Lamp Low Warning should be a hint to the user, that due to aging the UV lamp has become weaker and that at the next opportunity it should be replaced by a new one. Measurement accuracy is not impaired in this state.

Lamp Low Error

Additionally the Error Relay indicates Error. The message

```
Error: Lamp Low
```

is displayed between measurement results. Accuracy can be impaired in this state.

Lamp Off Error

The UV lamp does not work anymore. The message

```
Error: Lamp Off
```

is shown constantly. Both analog outputs are set to their max. values (10 V respectively 20 mA), because the instrument is not able to acquire concentration data without a lamp. Lamp Low contact and Error Relay indicate error.

A possible cause is low temperatures of 15 °C and below during powering up. In this case wait (max. 4 minutes) or switch the analyser off, then on again.

Lamp High Error

In case the lamp becomes too bright for some reason this error is activated. Concentration data are inaccurate. The Error Relay indicates an error. The instrument should be thoroughly checked by BMT MESSTECHNIK (s. also Chapter Troubleshooting).

> **Warning:** The UV radiation power output of the UV lamp is less than 1 Watt. Avoid dismantling of the instrument with mains power applied. The lamp contains significantly less than 5 milligrams of mercury. Mercury is a poison. Dispose lamp at a waste disposal place which is qualified to handle mercury containing lamps. If you cannot find a respective place, return the lamp to BMT.

Cuvette Dirty Warning

In each zeroing the dirtiness of the cuvette is measured and displayed.

```
Warn: Cuv. Dirty
```

is displayed between measurement results, as soon as dirtiness rises above 50%. The contact Cuvette Dirty opens but the Error Relay stays in the normal position. Depending on the kind of soiling accuracy can be impaired already. This warning shall remind the user to have the cuvette cleaned at the next opportunity. In case the instrument is switched off in this state, the Dirty Warning will reappear after switching on again. This warning can only be cleared by zeroing with a cleaned cuvette.

Cuvette Dirty Error

If the dirtiness of the cuvette rises above 60 %

```
Error:Cuv. Dirty
```

is displayed. Additionally, to the contact Cuvette Dirty the Error Relay goes into its error state. Measurement results are inaccurate.

Overpressure

Cuvette pressure is above the allowed maximum pressure (the maximum pressure is defined by the pressure range which is displayed on the front panel during warm-up). The instrument displays

```
Err: Overpress
```

Due to the fact that reliable pressure data are not available, the displayed ozone concentration is wrong. The Error Relay is in its error state.

Overrange

Ozone concentration is above the range of the instrument. An alternating display of

```
Err: Overrange
```

and ozone concentration range is shown. The Error Relay is in its error state. The analog outputs are on their maximum values.

Low Pressure Error

This instrument shows

```
Err: Low Press.
```

This error is shown, if pressure is below 0.2 bar abs. Below this threshold, measurement accuracy is degraded. The Error Relay is set to error.

EEPROM Error

This error shows that there is something wrong with the internal non-volatile memory. Since this memory stores important calibration data, the instrument should be thoroughly checked by BMT MESSTECHNIK (s. also Chapter Troubleshooting). The Error Relay indicates an error.

SD Card Warning

This indicates that an error occurred during a write operation to an internal log. Accuracy is not impaired by this warning, so all outputs remain in the normal position.

11   Event- and Error-Log

These two logs are stored by the BMT 965 on the internal SD card and document important events and errors. Memory capacity is not limited. New entries are appended as they arrive. Both logs can be read out via USB to a computer and can be copied directly to a flash drive.

The program BMT 965 Link can be used to:

- Show logs on a computer which is connected to a BMT 965
- Show logs that were copied to a flash drive or were sent via E-Mail (offline operation)

The name of the logs contains the serial number of the instrument. Each entry in these logs has a time stamp, which means that date and time are recorded with a resolution of 1 s. The user is responsible for setting the internal clock, or comparing its time with local time for correct interpretation of the log entries. Life expectancy of the battery is 10 years or more. An empty battery will only result in erroneous time stamps in the logs.

The Error-Log documents all errors described in chapter Error Handling with date and time. A second entry protocols the end of a particular error.

The Event-Log documents the following events and additional data:

- Switching on of the BMT 965, cuvette pressure at this time
- Switching off of the BMT 965, temperature at switch off
- Zeroing, dirtiness of cuvette in %
- High Alarm, High Alarm Limit
- High Alarm cleared, High Alarm Limit
- Low Alarm, Low Alarm Limit

- Low Alarm cleared, Low Alarm Limit

Error- and Event Log play an important role in troubleshooting.

12 Concentration Logs

Two concentration logs which are stored on the internal SD card can be activated either on the front panel menu or in BMT 965 Link: a binary log and an Excel-compatible CSV-log. Both logs record time stamped concentration values in intervals, which can be set from 1 s to 9999 s. Concentration logs can be deleted either from the front panel menu, within BMT 965 Link, or with the BMT 965 mounted as an external USB drive on a computer with Windows Explorer. The names of the logs contain the serial number of the instrument.

The log interval should be set in a reasonable way. Factors which should be considered when choosing a log interval are:

- Resulting file size (influences download time)

- Recording time (influences download time)

- Gas concentration variation over time (ozone concentration of large generators will usually vary slowly, needing less log entries per time than small lab setups)

- Data volume capacity of software which should work with recorded data (Excel e.g. can only handle 1048576 data points)

USB download speed and copy to USB flash speed are about 700 KB per second. The following table shows some examples of reasonable recording times and log intervals and the corresponding files sizes and download times:

Recording time	Log Interval	Binary File Size [Mbyte]	CSV File Size [Mbyte]	Binary Download Time [s]	CSV Download Time [s]
24 hours	1 s	0.7	2.6	1	3.7
1 week	5 s	0.98	3.64	1.4	5.2
1 month	20 s	1	3.73	1.4	5.3
1 year	1 minute	4.3	15.8	6.1	23
10 years	10 minutes	4.3	15.8	6.1	23
10 years	1 minute	43	158	60	230

The last example would create a file which Excel would not be able to handle.

Caution: Log file size should not exceed 4 GB (max. FAT32 file size). With log interval set to 1 second, this limit would be reached after 17 years for the binary log and after 4.6 years for the CSV-log.

13 The Program BMT 965 Link

On the SD card which is delivered with the instrument you will find the Windows program BMT 965 Link, which is using the Link Mode as described on page 28, and in Appendix A. It has

been designed for Windows XP/Vista/7/8 & 10. For installation of the program, simply unzip the ZIP archive if necessary, and execute the Installer 'setup.exe', then follow the descriptions on screen. See the file readme.txt on the SD card for further information.

For connection with to a computer, a USB cable with a length of 2 m is provided with each analyser. A normal USB cable of a maximum length of 10 m may be used.

Among other features, the software application allows:

- simple configuration of all parameters of the BMT 965. With a few mouse clicks you can view respectively change e.g. the units of ozone concentration and pressure, alarm parameters, properties of the serial interface in User-Mode, characteristics of the carrier gas, date and time and other parameters (serial number, operating hours etc.)

- storing of all modifiable characteristics in files. In order to configure several instruments with the same set of parameters, only the corresponding file has to be loaded.

- downloading and viewing concentration logfiles of selectable measurement results or parameters (e.g., cuvette dirtiness)

- create Diagnostics Reports: view and printout all internal system data (e.g., raw data from the A/D-converter, operating hours)

The main screen shows the basic measurement of the ozone concentration, the pressure measured internally for compensation and cuvette status. From the View menu, you may choose the Parameter window, which shows all custom settings of parameters that may be changed, sorted in tabs named the same as in the front panel menu. As a start, you should check the units used by the analyser, and set the time (built-in real-time clock of the BMT 965) according to the local time in your area. This is the time used in the Error- and Event Log.

Also, in the main menu, you'll find a Monitor window, designed to be enlarged so that you may view the measurements from some distance, and a Diagnostics window, summarizing all raw data mainly needed for troubleshooting by BMT. Other than that, the Error- and Event Log may be loaded from the instrument to the screen via the View menu.

The options in the main menu let you set your preferences concerning the software behaviour itself. For example, you would choose "Print to file" if you are on site with no printer available.

On some screens, you'll find a print function for two different printouts, one summarizing the settings and measurement for documentation, one including internal voltages and values for troubleshooting by BMT. Both should be emailed to us in case of problems. The printouts include both the Error- and Event Log.

The Save and Load functions in the main menu under File are used to save configurations of the BMT 965 onto your PC and load it again at a later time. This helps configuring all analysers with identical settings in multiple locations of one project.

For a more detailed description of the software, please refer to the helpfile (`bmt965.chm`, to be opened with F1 within the program or a double click in the Windows Explorer).

14 Maintenance

Maintenance is limited to a regular check of the sample gas input filter. The pure white material easily displays any dirt (except if it is white). A tool is provided to open the filter holder.

In case the filter insert has been found to be dirty, it should be replaced (spares are supplied). It is in the responsibility of the user to define the interval of this check, which of course depends on the properties of the complete ozone system. It is a good idea to also observe the cuvette dirty value during evaluation.

In case of excessive dirt (e.g., Dirty Warning or Dirty Alarm as described on page 33), the cuvette should be cleaned. We recommend to send in the analyser to the manufacturer or representatives (see chapter Troubleshooting).

> **Caution**: The cuvette must not be flushed with fluids, namely water, for cleaning, as this could damage the pressure sensor.

The UV lamp is the only part of the instrument which undergoes wear. Life expectancy of the lamp is several years. When Lamp Low Warning is activated (see page 32) replacement of the lamp should be planned for the next 4 to 8 weeks. Replacement by the user is possible but we do not recommend it. The instrument should rather be sent back to us for replacement of the UV lamp and for recalibration with the new lamp.

15   Troubleshooting

In case there are warnings, or errors, or when the displayed ozone concentration does not match the expectation you should take advantage of the possibilities of the software **BMT 965 Link** in order to identify possible sources of error. The logging capabilities of the software and the instrument can also be used to detect randomly occurring errors.

In case the BMT 965 has to be sent in for service or repair, you do not need an RMA, **but please provide the following details**:

Hazardous Material Certification:

For the protection of BMT employees we need to know about any possible hazardous contamination outside and inside of our products prior to any repair and service.

Instruments not free of such substances **may be rejected by BMT**.

Type of product:
Serial number(s):

Please describe the status of the returned instrument regarding hazardous substances below:

☐	The product has not been exposed to any hazardous substance at any time
☐	The product has been completely decontaminated and contain no residual hazardous substances
☐	The remaining contamination is not unhealthy, toxic, carcinogenic, radioactive, microbiologic, explosive, corrosive or caustic, it is harmless **and contains** (insert here):

Herewith, I certify that the products being returned to the factory are **free of any hazardous substances**, as stated above:

Undersigned:	Your Company:
Date & Signature:	

The **feed gas** used for the ozone generator is as follows:

☐ Liquid Oxygen	☐ bottled Oxygen	☐ PSA, VPSA	☐ dry air	☐ don't know
☐ N2 or other gas added for performance	☐ analyser does not measure generator output			

Service: Checklist

☐	fill out and sign above Hazardous Material Certification

by all means include in all paperwork accompanying your shipment:

☐   your contact details: delivery & invoicing address, phone number, e-mail address

☐   serial number of the instrument

☐   reason for return:

☐ ship to one of the following addresses:	BMT MESSTECHNIK GmbH Attn.: Service Hamburger Strasse 19 D-14532 Stahnsdorf, Germany	www.bmt-berlin.de service@bmt-berlin.de Tel. +49-3329-696 77-0 Fax +49-3329-696 77-29
For North America, Central America, Pacific Rim:	OSTI Inc. 13511 Northgate Estates Drive, Suite 100, Colorado Springs, CO 80921, USA	www.osti-inc.com service@osti-inc.com Tel. +1-831-649-1141 Fax +1-831-649-1151

16 Specifications

measurement principle	dual-beam UV photometer (254 nm), no moving parts
MTBF	instrument incl. UV lamp 65,000 h, excl. UV lamp 120,000 h
UV lamp	low pressure mercury lamp, long life design, burnt-in for 300 h
display	16-character alphanumeric backlit LCD
concentration ranges	50, 100, 200, 300, 400, 500, 600 g/Nm^3, selectable units g/Nm^3, %wt/wt, %wt(air) & ppm$_v$
optional ranges	2, 5, 10, 20 g/Nm^3, selectable units g/Nm^3, %wt/wt and ppm$_v$
accuracy	after zeroing the max. error is the sum: 0.4 % of measurement + 0.1 % of scale
repeatability error	0.2 % of measurement
response time	0.1 s (analog output), 0.3 s (display)
zero drift	typ. 0.2 % of range per day, after warm-up, non-cumulative
ambient temperature	0 - 50°C (non-condensing)
materials in contact with ozone	quartz (cuvette windows), SS (cuvette, fittings, cuvette spacer), FFPM (window seals), FEP (tubing)
gas ports	for FEP tubing 3x5 mm (1/8" x 3/16"), opt. 1/8" Swagelok, or 4x6 mm. Built-in sample gas filter is standard
recommended flow rate	0.1 to 1 l/min typical
pressure drop	approx. 5 mbar at 0.5 l/min (with sample gas filter)
temperature compens.	is standard
pressure compensation	with built-in cuvette pressure transducer, for ozone measurement at an arbitrary systemic pressure, abs. pressure range 1.15 (optional 1.5 to 4.0 bar abs in steps of 0.5), minimum pressure 0.4 bar abs pressure units selectable: bar, psi, Torr, MPa
signal outputs	concentration 4 - 20 mA (isolated, active) concentration 0 - 10 V (isolated)
concentration alarms	High Alarm, Low Alarm, latching, not latching
control input	set to zero (24 VDC, 8 mA, isolated)
control outputs	relay contacts (28 V, 0.5 A, isolated): Lamp Low Cuvette Dirty High Alarm Low Alarm Purge Control (not available together with internal Purge Unit)
error handling	Error Relay: 30 V, 0.5 A, summarizing instrument failures. Errors: Lamp Low Error, Lamp Off Error, Lamp High Error, Cuvette Dirty Error, Overrange, Overpressure, Low Pressure, EEPROM Error,
early warnings	Lamp Low Warning, Cuvette Dirty Warning, SD Card Warning
memory	8 GB for error and concentration logs
USB interface	USB 2.0 OTG, Full Speed, device: mass storage and HID, host: mass storage
serial interface	RS-232, bidirectional, 2400 - 38400 Baud, isolated (RS-232 GND connected to analog GND)
interface (opt.)	MODBUS/TCP
automatic zeroing	with optional internal purge unit (IPU) or external pump and solenoid valve (not included)
software	BMT 965 Link, instrument configuration and readout of Event, Error and Concentration Logs on a Windows PC
power	wide range input: 100 - 240 VAC, 50/60 Hz, 15 VA optional: 12 – 36 VDC, 15 W
dimensions (W x H x D)	144 x 72 x 230 mm, DIN 61554 (ranges 2 and 5g/Nm^3: 144x144x230)
panel cut-out (W x H)	139 x 67 mm
weight	1.5 kg

Appendix A: Link-Mode Commands

The following table describes all available Link-Mode commands for the serial interface. Commands with question marks retrieve information from the BMT 965.

Caution: This set of commands should only be used by programmers who have a good understanding of the BMT 965 and ozone measurement in general!

Cmd	Meaning	PC->965	965->PC
0	Start Link-Mode	*0#DL4EBY	*0#DL7ZN
2	Ozone Range and Unit? byte1: Range-ID (see table on page 23) byte2: Unit 0: g/Nm^3 1: %wt/wt 2: ppm$_v$ 3: g/m^3 (without pressure and temperature compensation) 4: ppm$_w$ 5: %wt(air)	*2#	*2#byte1, byte2
3	Set ozone unit Meaning of byte: 0: g/Nm^3 1: %wt/wt 2: ppm$_v$ 3: g/m^3 4: ppm$_w$ 5: %wt(air)	*3#byte	*3#
4	Pressure range? float: pressure always in bar byte Multiplier: 0: 1.0 (Unit bar) 1: 14.50778 (Unit psi) 2: 750.0617 (Unit Torr) 3: 0.1 (Unit MPa)	*4#	*4#float,byte
5	Set pressure unit byte: 0: bar 1: psi 2: Torr 3: MPa	*5#byte	*5#
6	Serial number?	*6#	*6#word

Cmd	Meaning		PC->965	965->PC
9	Concentration? float: Concentration byte: Unit: 0: g/Nm^3 1: %wt/wt 2: ppm$_v$ 3: g/m^3 4: ppm$_w$ 5: %wt		*9#	*9#float,byte
10	Pressure? = float * Multiplier float: Pressure always in bar byte Multiplier: 0: 1.0　　　(Unit bar) 1: 14.50778 (Unit psi) 2: 750.0617 (Unit Torr) 3: 0.1　　　(Unit MPa)		*10#	*10#float,byte
11	Temperature? float: in Kelvin		*11#	*11#float
12	Operating hours?		*12#	*12#word
13	High Alarm Parameter? (first retrieve concentration unit) float: Limit in present unit byte1: Enabled byte2: Latching		*13#	*13#float,byte1, byte2
14	Low Alarm Parameter? (first retrieve concentration unit) float: Limit in present unit byte1: Enabled byte2: Latching		*14#	*14#float,byte1, byte2
15	Set High Alarm Limit (first retrieve concentration unit)	(High Limit > Low Limit!)	*15#float	*15#
16	Set Low Alarm Limit (first retrieve concentration unit)	(High Limit > Low Limit!)	*16#float	*16#
17	Set High Alarm Latching byte 1: Latching 0: not Latching		*17#byte	*17#
18	Set Low Alarm Latching byte 1: Latching 0: not Latching		*18#byte	*18#
19	Set High Alarm Enabled byte 1: Enabled 0: not Enabled		*19#byte	*19#
20	Set Low Alarm Enabled byte 1: Enabled 0: not Enabled		*20#byte	*20#
21	Normalizing temperature? float: in Kelvin		*21#	*21#float

| Cmd	Meaning	PC->965	965->PC
23	Normalizing pressure? = float x Multiplier float: Pressure always in bar byte Multiplier: 0: 1.0 (Unit bar) 1: 14.50778 (Unit psi) 2: 750.0617 (Unit Torr) 3: 0.1 (Unit MPa)	*23#	*23#float,byte
29	Time? hh,mm,ss	*29#	*29#byte,byte, byte
30	Set Hour	*30#byte	*30#
31	Set Minute	*31#byte	*31#
32	Set Second	*32#byte	*32#
33	Date Format? 0: DD.MM.YY 1: MM/DD/YY	*33#	*33#byte
34	Set Date Format 0: DD.MM.YY 1: MM/DD/YY	*34#byte	*34#
35	Date? DD,MM,YY	*35#	*35#byte,byte,byte
36	Set Day	*36#byte	*36#
37	Set Month	*37#byte	*37#
38	Set Year (YY)	*38#byte	*38#
39	RS-232 Timed/Polled? 1: Timed 0: Polled	*39#	*39#byte
40	Set RS-232 Timed/Polled 1: Timed 0: Polled	*40#byte	*40#
41	RS-232-Interval? (if Timed) byte: Seconds	*41#	*41#byte
42	Set RS-232-Interval (if Timed) byte: Seconds	*42#byte	*42#
43	Set Analog Output (Simulation) Range 0.0: 0 V/ 4mA... 1.0: 10V /20 mA 2.0: normal operation	*43#float	*43#
44	Autozero Interval? byte: hours if 0: no Autozero	*44#	*44#byte
45	Set Autozero Interval byte: hours if 0: no Autozero	*45#byte	*45#

Cmd	Meaning	PC->965	965->PC
46	Alarm Beep? 1: On 0: Off	*46#	*46#byte
47	Set Alarm Beep 1: On 0: Off	*47#byte	*47#
48	Cuvette Status? float: % Dirty 0: Clean	*48#	*48#float
83	Trigger Zero (Parameter for security) float: Dirty If Autozero Interval > 0, this command will take about 20 s	*83#3.14159	*83#float
85	Firmware-Version?	*85#	*85#float
86	Status (decimally coded, as described in table on page 28, BMT 964-legacy command)	*86#	*86#short
91	Set Link-Mode Timeout (after switching on always 10 s) byte: Seconds	*91#byte	*91#
93	Alarm Relays closing on Alarm? 1: closing 0: opening	*93#	*93#byte
94	Set Alarm Relay Mode 1: closing 0: opening	*94#byte	*94#
95	Set User Baud Rate 0: 2400 1: 4800 2: 9600 3: 19200 4: 38400	*95#byte	*95#
98	Reset all parameters to standard factory setting	*98#	*98#
99	Set PIN (prevents changing parameters) 0: no PIN protection	*99#short (0..9999)	*99#
101	Set Purge Time byte: Seconds (10..100s)	*101#byte	*101#
102	Get Purge Time byte: Seconds	*102#	*102#byte
114	Get Concentration Log Interval short: seconds	*114#	*114#short
115	Set Concentration Log Interval	*115#short	*115#
116	Concentration Log Size (sum of both logs)? word: byte	*116#	*116#word
117	Error Log Size? word: byte	*117#	*117#word
118	Event Log Size? word: byte	*118#	*118#word
119	Delete Binary Concentration Log	*119#	*119#
120	Delete CSV-Concentration Log	*120#	*120#

Cmd	Meaning	PC->965	965->PC
121	Get Errors (full, binary coded): Bit 0: Lamp Low Warning Bit 1: Lamp Low Error Bit 2: Lamp Off Error Bit 3: Cuvette Dirty Warning Bit 4: Cuvette Dirty Error Bit 5: Overpressure Error Bit 6: Overrange Error Bit 7: EEPROM Error Bit 8: Lamp High Error Bit 9: not used Bit 10: not used Bit 11: SD Card Warning Bit 12: Low Concentration Warning Bit 13: High Concentration Warning Bit 14: Low Pressure Error	*121#	*121#word

Appendix B: Bench Top Version BMT 965 BT

General Description

The OZONE ANALYZER BMT 965 BT is the portable version of the standard BMT 965. The instrument is not much bigger than the standard BMT 965. For safety reasons it is powered via a wall mount power supply 24 VDC with wide range power input.
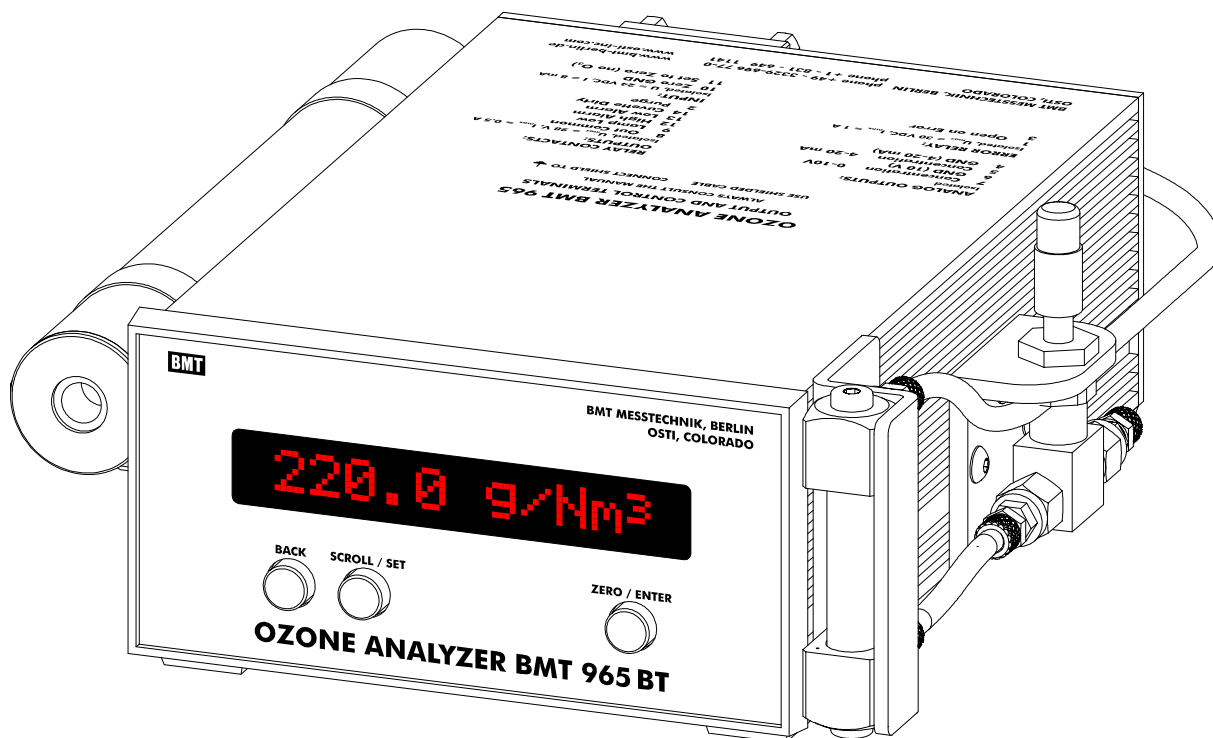
The BT model has a throttle valve and flow meter attached on the right side, and a Catalyzing Cartridge (catalytic ozone destruct) on the left (sample gas outlet).

The sample gas enters the throttle valve through a fitting for 3x5 mm (1/8" x 3/16") FEP tubing, and then via the flow meter enters the BMT 965 through a sample gas filter with a replaceable white filter insert. Upon exiting the analyser, the sample gas passes through the Catalyzing Cartridge where the ozone is destroyed.

Operation

The basic operation of the BMT 965 BT is the same as of the standard BMT 965, see chapters 1 - 14 for more details. Care must be taken using the Catalyzing Cartridge, which may never be exposed to water or humidity, as this might damage the catalysing material. The sample gas filter can only keep dirt from entering the analyser, not humidity.

As an option the OZONE ANALYZER BMT 965 BT may be ordered equipped with the Internal Purge Unit (IPU), which consists of a built-in 3-way solenoid valve plus air pump with particle filter, for fully automatic purging and zeroing the instrument.

This option makes sure, that the cuvette is flushed with ambient filtered air (zero gas) upon activating zeroing, as described on page 15. The pressure head at the outlet of the Catalyzing Cartridge

must not exceed 100 mbar to the ambient. Otherwise, the built-in air pump will not bring the ozone out of the cuvette and false zero readings will be the result.

If the Auto Zero Interval is set to more than zero hours (1 to 99 h), the zeroing is activated by the purge timer, fully automatically. This includes switching to zero gas, zeroing and switching back to the sample gas.

> **Note:** Setting the Auto Zero Interval to zero hours means, that the analyser does **not** go through the automatic purge cycle and does **not** activate the Purge Control contact! In this case, the user must take care to never initiate zeroing with ozone in the cuvette.

The BMT 965 BT may be ordered together with a soft carrying bag for protecting the instrument during transport. The bag has room enough for accessories like filter inserts for the sample gas filter, a tool to open the filter holder and FEP connecting tubing.

For further description of the functions and properties of the bench top version please refer to the main part of the manual.

Specifications (BMT 965 BT only)

concentration ranges	50, 100, 200, 300, 400, 500, 600 g/Nm³, selectable units g/Nm³, %wt/wt, %wt(air) & ppm$_v$
optional ranges	2, 5, 10, 20 g/Nm³, selectable units g/Nm³, %wt/wt, %wt(air) & ppm$_v$
max. inlet pressure	2.5 bar g
max. outlet pressure	1.15 bar abs
ambient temperature	0 - 50°C (non-condensing)
materials in contact with ozone	quartz (cuvette windows), SS (cuvette, fittings, cuvette spacer), FFPM (window seals), FEP (tubing)
gas ports	for FEP tubing 3x5 mm (1/8" x 3/16"), opt. 1/8" Swagelok, or 4x6 mm. Built-in sample gas filter is standard
recommended flow rate	0.1 to 1 l/min typical
pressure drop	approx. 6 mbar at 0.5 l/min, throttle valve fully open
control outputs	relay contacts (28 V, 0.5 A, isolated): Lamp Low Cuvette Dirty High Alarm Low Alarm Purge Control (not available with internal Purge Unit)
error handling	Error Relay: 30 V, 0.5 A, summarizing instrument failures. Errors: Lamp Low Error, Lamp Off Error, Lamp High Error, Cuvette Dirty Error, Overrange, Overpressure, Low Pressure, EEPROM Error
serial interface	RS-232, bidirectional, 2400 - 38400 Baud, isolated (RS-232 GND connected to analog GND)
interface (opt.)	MODBUS/TCP
fully automatic zeroing	with optional internal purge unit (IPU)
power	12-36 VDC, 15 W wall mount power supply 100-240 VAC, 50/60 Hz, included
dimensions (W x H x D)	193 x 82 x 253 mm, DIN 61554 (ranges 2 and 5g/Nm³: 193x152x253)
weight	2.2 kg

General specifications not specific to the BMT 965 BT are found on page 39.

Appendix C: Cabinet Version BMT 965C

General description

The OZONE ANALYZER BMT 965C (cabinet version) is housed in a splash-proof IP 65 (NEMA 4X) aluminium cabinet. It is NRTL safety certified by TUV Rheinland of North America. It is also certified according to IACS E10 and USCG 46 CFR 612.060-30 for operation in ballast water treatment systems on ships. It is equipped with everything necessary for fully automatic stand-alone operation.

Fully automatic means: A purge unit is provided which consists of a three-way solenoid valve, and an air pump (with particle filter), both being controlled by the timer of the analyser. The system automatically purges the cuvette with clean, filtered air, and then zeroes the analyser. The zeroing interval may be chosen between 1 and 99 hours (see page 15).

Stand-alone means: A sample gas filter is provided (external to the cabinet), a throttle valve and a flow meter (behind the front door), and a Catalyzing Cartridge (external). An external Dirt Trap to remove namely fluidic dirt before it can reach the analyser, may be provided on request.
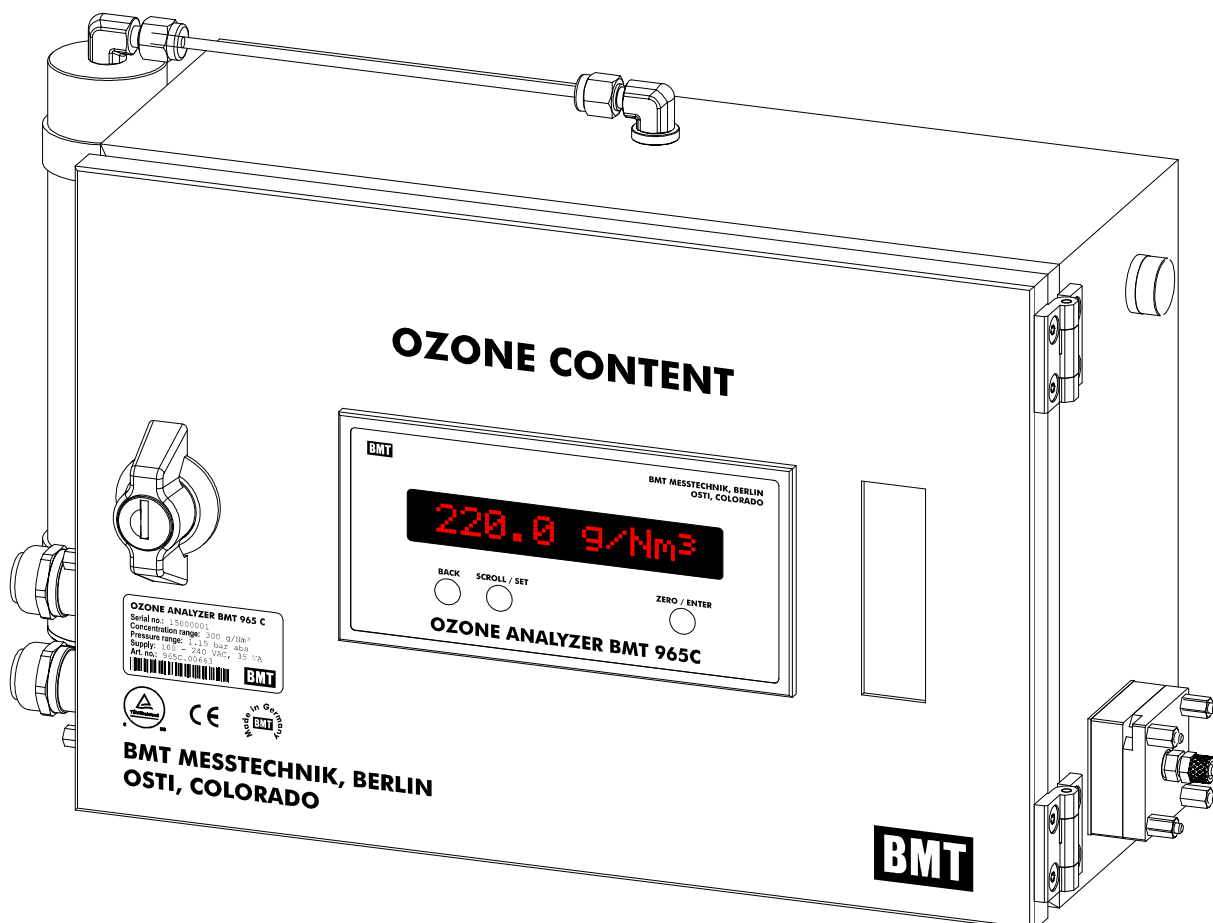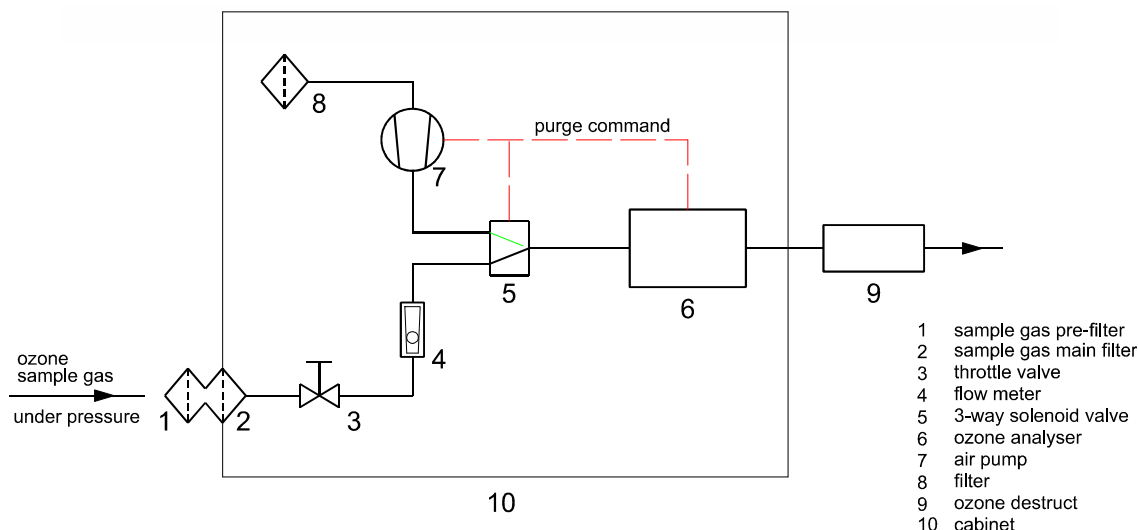

Dimensions of the cabinet are 300 x 200 x 120 mm (W x H x D), the space needed (door open, sample gas tubing and cables connected) is approx. 480 x 240 x 420 mm, and the weight is about 5.5 kg. The cabinet can be wall mounted using the four brackets provided at the rear (four mounting holes are 6 mm ID, spaced 240x225 mm).

For sample gas connection 3x5 mm FEP (or 1/8" x 3/16" FEP) tubing should be used, which will be supplied on request.

> **Warning:** Do not apply more than the rated gas pressure (pressure range) to the instrument!

The Cabinet is also available with fittings for 4x6 mm FEP tubing, or Swagelok fittings (1/8" or 1/4" or 6 mm) at the sample gas inlet. The Catalyzing Cartridge CAT-35 provides a G 1/8 thread (BSPP 1/8") at the outlet, with a fitting for 4x6 mm tubing installed. The power and signal connectors are waterproof.

1	sample gas pre-filter
2	sample gas main filter
3	throttle valve
4	flow meter
5	3-way solenoid valve
6	ozone analyser
7	air pump
8	filter
9	ozone destruct
10	cabinet

The built-in purge unit enables the processor to automatically zero the instrument. This purge unit is only activated with Auto Zero Interval > 0 h.

Automatic zeroing may be initiated in different ways. For a detailed description, see chapter Zeroing on page 14. After approximately 15 minutes of warm-up the first Auto Zero cycle is initiated (assuming the Auto Zero Interval is > 0). After every Auto Zero Interval, the processor starts a zeroing cycle. See page 15 on how to change the Auto Zero Interval. Factory setting is 24 h.

At the start of each zeroing cycle, the last concentration measurement is used to freeze the signal outputs (current and voltage) during the whole cycle. The valve and pump then are activated for about 10 seconds, followed by the zeroing of the analyser (needs about 1 second). After zeroing, the display shows the level of contamination of the cuvette (see page 33). Deactivating the valve and pump allows the ozone gas 10 seconds time to get back into the cuvette before the signal outputs are set to the current concentration values again.

Ozone Destruct

Care must be taken in using the Catalyzing Cartridge, which may never see water or humidity. This might damage the catalyst material. The sample gas filter can only keep dirt from entering the system, but not humidity.

The pressure head at the outlet of the Catalyzing Cartridge must not exceed 100 mbar to the ambient. Otherwise, the built-in air pump will not bring the ozone out of the cuvette and false zero readings will be the result.

> **Caution:** If the generator feed gas contains nitrogen, connect a tube to the outlet of the ozone destruct to lead away the vent gas. Corrosive nitric acid will be formed when vent gas comes in contact with the moist ambient air.

We strongly recommend to lead away the gas exiting the catalytic ozone destruct using PTFE or FEP tubing 1/4" x 5/32"(or 4x6 mm). The Catalyzing Cartridge CAT-35 (left side of the cabinet) has an outlet bore hole with female thread G 1/8 which normally is equipped with a fitting for this kind of tubing. Other types of fitting can be delivered on request or be screwed into the G 1/8 thread by the user.

> **Caution:** In case the ozone generator is serviced or repaired it is imperative that the ozone analyser is disconnected (the sample gas flow is interrupted). We recommend the installation of a stop cock or shut-off valve for this purpose.

We recommend replacement of the catalyst material in the Catalyzing Cartridge once per year in case the oxygen feed gas contains a significant amount of nitrogen or other gases (e.g. PSA oxygen, or oxygen with nitrogen doping). For replacement order "REFILL-35".
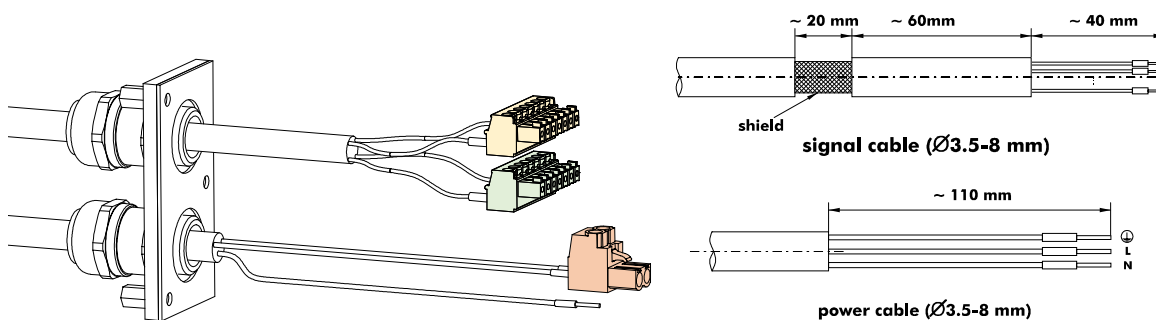
Electric connections

> **Warning:** The cables shall only be connected by a person acquainted with the safety requirements involved.

> **Warning:** This product relies on the building's installation for short-circuit (overcurrent) protection. Ensure that a fuse or circuit breaker no larger than 15 A at 120 VAC (10 A at 240 VAC) is used on the phase conductor.

Do not operate at an elevation higher than 2000 m.

An easily accessible means for switching off power should be provided. This disconnect has to be clearly marked for identification of the instrument. Wire cross section of the power cable shall be between 1.5 mm² and 4 mm² (AWG 16 to AWG 12). Use copper conductors only. The power cable enters the cabinet through a water proof cable gland.

signal cable (∅3.5-8 mm)

power cable (∅3.5-8 mm)

Connect the power carrying wires to the orange two pole female plug labeled "L" and "N" which is provided with the instrument. Attach these wires to each other with a cable tie tightly behind the orange two pole female plug. Connect the protective ground wire (PE) of the cable to the protective ground terminal⏚. Plug the orange two pole female plug with the power carrying wires into the

orange two pole connector on the PCB. Give enough slack on the PE (Protective Ground ⏚) to ensure that, if the strain relief of the cable gland should fail, the power carrying wires are disconnected first.

Function	Description	in/out	Connector	
mains, "N"	100 to 240 VAC, 50/60 Hz, 35 VA	input	orange	right
mains, "L"		input		left
⏚Protective Ground	**yellow-green wire,** to be connected to chassis grounding terminal inside Cabinet			

The signal cable enters the cabinet through a water proof cable gland. It is held by a grounded cable clamp which should have electrical contact to the cable shield. The different wires connect to the two green and yellow PCB connectors, which are plugged into the two-row terminal block.

Connection:

Pin	Function	Description	in/out	Connector
1	Error contact	Opening on any error	output	green
3				
4	Current output	4- 20 mA low	output	
5		4- 20 mA high		
6	Voltage output	0- 10 V low	output	
7		0- 10 V high		
8	Common for output contacts		output	yellow
9	Lamp Low contact	Opening on warning and error	output	
10	Auto Zero input	Low (+24 VDC, 8 mA)	input	
11		High (+24 VDC, 8 mA)		
12	High Alarm contact	Opening or closing (selectable)	output	
13	Low Alarm contact	Opening or closing (selectable)	output	
14	Cuvette Dirty contact	Open on warning and error	output	

The Cabinet features a sealed USB connector. All USB operations described for the standard version can also be performed with the Cabinet.

For service or maintenance, the cable glands may be unscrewed from the housing, and thus allow to electrically disconnect the analyser without disconnecting power and signal connectors from the cable – cables may be fed through the holes together with the connectors.

Two-stage particle filter

The sample gas filter of the BMT 965 C consists of a pre-filter (1 mm porous PTFE, OD 25 mm) and an ultra fine main filter (6 mm porous PTFE, OD 25 mm). The housing is made of stainless steel. The total thickness of this combination creates a significant pressure drop as shown in the following diagram:

BMT 965 C
typical flow rate with pre- and main filter
throttle valve open

typical flow rate [L/min] vs *system pressure [bar gage]*
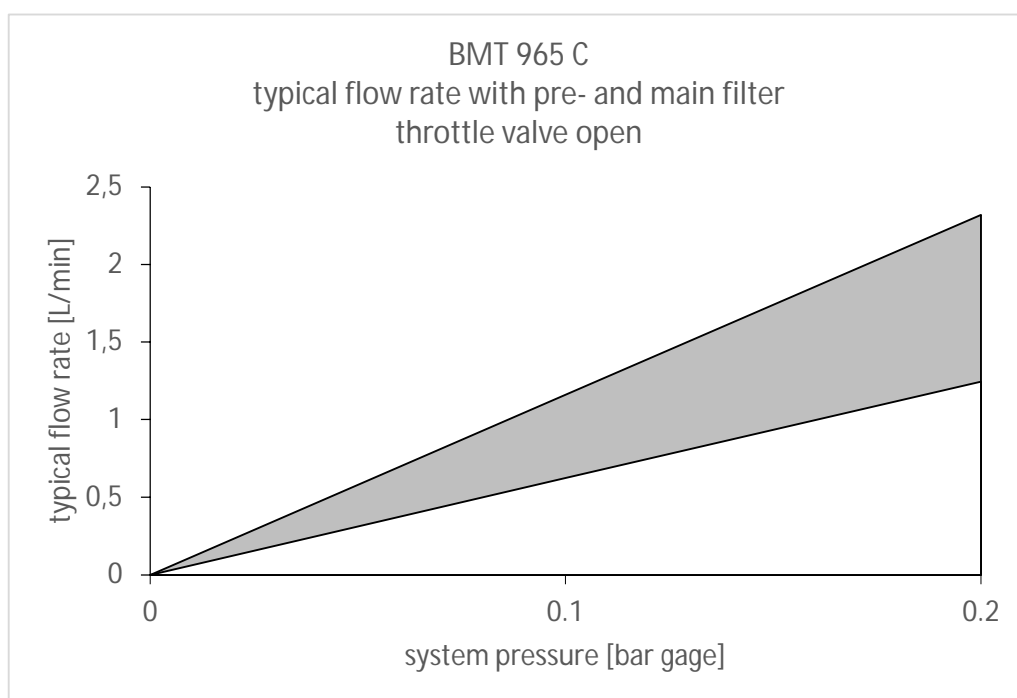
For maintenance on the sample gas filter see chapter Maintenance on the next page.

Operation

The basic operation of the BMT 965 C is the same as of the standard BMT 965, see chapters 1 to 14 for details.

Adjustment of Sample Flow: The sample gas flow rate can be set with the red knob (door open, upper right corner). The recommended flow rate is about 0.5 l/min.

> **Warning:** Make sure that the flow rate is not higher than the range of the flow meter, and the ball inside the flow meter is not at its upper white stop!

> **Warning:** Disconnect electrical power before opening the cabinet door.

If the Auto Zero Interval is set to zero hours, the zeroing is no more automatically activated by the purge timer. It still may be initiated by the various manual zeroing commands described on page 15.

Note: Setting the Auto Zero Interval to zero hours also means, that the analyser does **not** go through the purge cycle and does **not** activate the Purge Unit! In this case, the user shall never initiate zeroing with ozone applied to the inlet of the Cabinet.

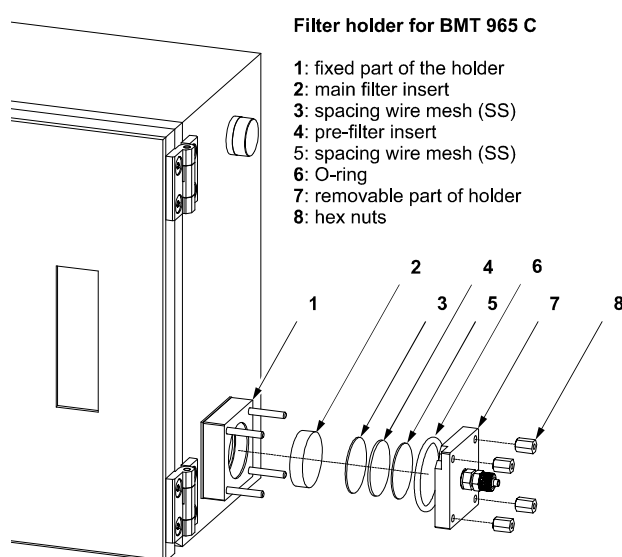Factory default is an Auto Zero Interval of 24 hours.

Maintenance

The only maintenance recommended is checking the sample gas filter inserts on a regular basis. Both inserts, the pre-filter insert and the main filter insert, are of pure-white material which easily shows most kinds of dirt – except if the dirt is white.

Warning: Before opening the sample gas filter make sure that the sample line does not contain ozone gas, and is not under an overpressure.

Under normal circumstances the replacement of the filter inserts will be limited to the exchange of the pre-filter insert, as this holds back most particles. While the filter holder is already open, the main filter insert must be inspected, and the decision for replacement should be based on the contamination found. Spare pre-filter inserts are provided inside of the cabinet. Replacement for the main filter insert is available on request.

The interval of filter insert inspection and replacement has to be evaluated by the user. This interval depends on the degree of dirtiness of the ozone sample gas.

Filter holder for BMT 965 C

1: fixed part of the holder
2: main filter insert
3: spacing wire mesh (SS)
4: pre-filter insert
5: spacing wire mesh (SS)
6: O-ring
7: removable part of holder
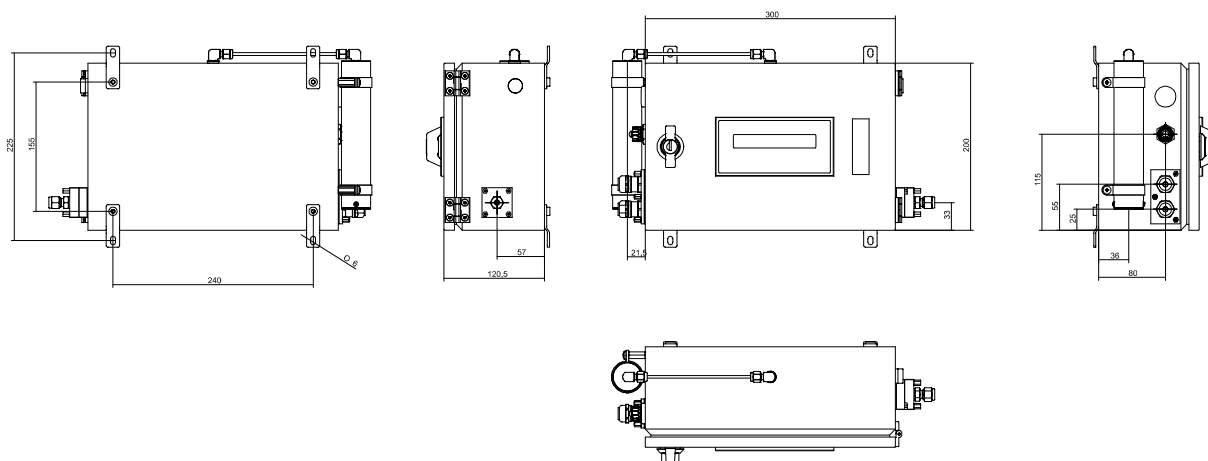**8**: hex nuts

Clean the filter holder and O-ring before re-assembling the filter holder thoroughly, in order to prevent any ozone leaks.

The picture shows the contents of the sample gas filter.

Dimensions

The dimensions of the Cabinet are shown in [mm]:

For further description of the functions and properties of the cabinet version please refer to the main part of the manual.

Specifications (BMT 965 C only)

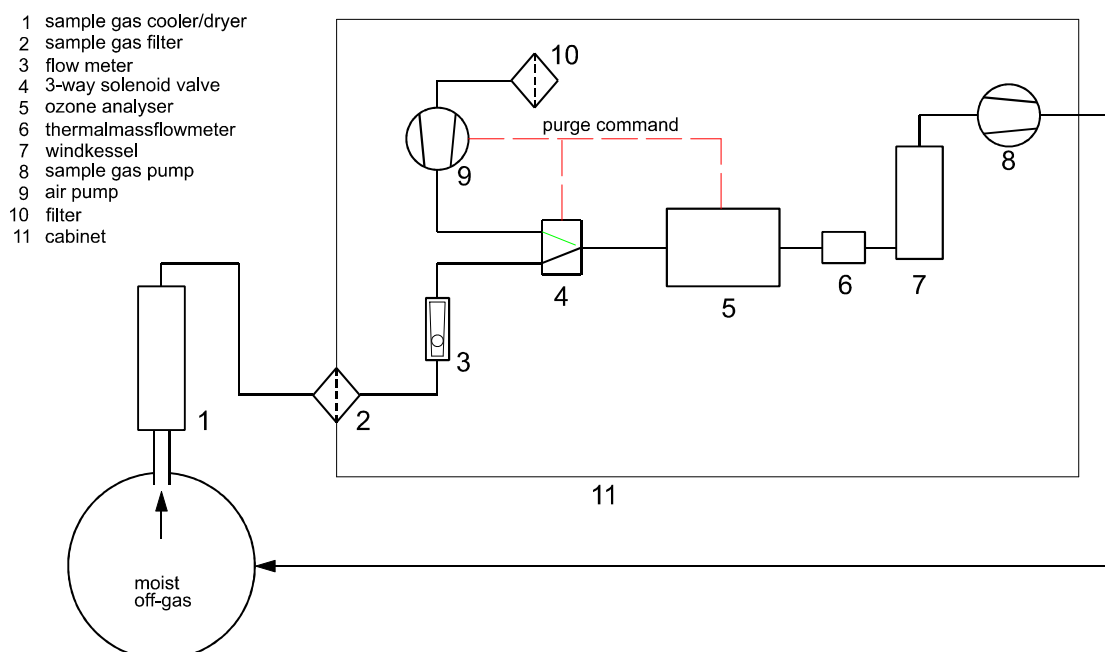| concentration ranges	50, 100, 200, 300, 400, 500, 600 g/Nm³, selectable units g/Nm³, %wt/wt, %wt(air) & ppm$_v$
optional ranges	10, 20 g/Nm³, selectable units g/Nm³, %wt/wt, %wt(air) & ppm$_v$
max. inlet pressure	2.5 bar g
max. outlet pressure	1.15 bar abs
ambient temperature	0 - 55°C (non-condensing)
materials in contact with ozone	quartz (cuvette windows), SS (cuvette, fittings, cuvette spacer), FFPM (window seals), FEP (tubing)
inlet gas port	for FEP tubing 3x5 mm (1/8" x 3/16"), opt. 4x6 mm, or 1/8" or 1/4" or 6 mm Swagelok. Built-in sample gas filter is standard
outlet gas port	for 4x6 mm tubing
recommended flow rate	0.1 to 1 l/min typical
pressure drop	approx. 60 mbar at 0.5 l/min, throttle valve fully open
max. back pressure	100 mbar g
control outputs	relay contacts (28 V, 0.5 A, isolated): Lamp Low Cuvette Dirty High Alarm Low Alarm
error handling	Error Relay: 30 V, 0.5 A, summarizing instrument failures. Errors: Lamp Low Error, Lamp Off Error, Lamp High Error, Cuvette Dirty Error, Overrange, Overpressure, Low Pressure, EEPROM Error,
interface (opt.)	either RS-232, bidirectional, 2400 - 38400 Baud, isolated (RS-232 GND connected to analog GND) or MODBUS/TCP or MODBUS RTU
fully automatic zeroing	internal purge unit is integrated
power	wide range input: 100 - 240 VAC, 50/60 Hz, 35 VA
dimensions (W x H x D)	300 x 200 x 120 mm
weight	3.6 kg
compliance	CE-marked (EMC & safety), cTUVus NRTL-listed (safety), USCG 46 CFR 612.060-30

General specifications not specific to the BMT 965 C are found on page 39.

Appendix D: OZONE-IN-OFF-GAS System

General Overview
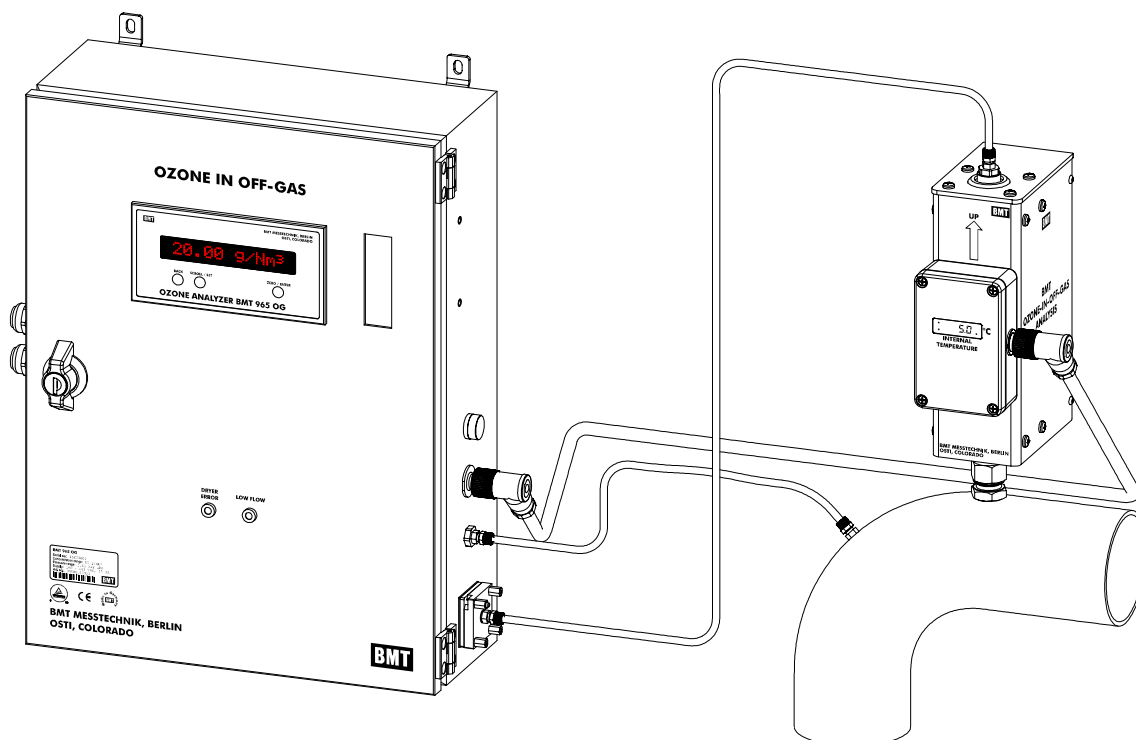
The BMT OZONE-IN-OFF-GAS System is an ozone analysing system for moist off-gases, housed in a splash-proof IP 65 (NEMA 4X) aluminium cabinet. It consists of the Off-Gas Cabinet BMT 965 OG, and the separate Peltier-electric cooler/dryer DH6.

1 sample gas cooler/dryer
2 sample gas filter
3 flow meter
4 3-way solenoid valve
5 ozone analyser
6 thermalmassflowmeter
7 windkessel
8 sample gas pump
9 air pump
10 filter
11 cabinet

The Off-Gas Cabinet contains an OZONE ANALYZER BMT 965, the ozone resistant sample gas pump SGP5, the flow meter FM82, and the DH6 power supply, in a wall mounted aluminum cabinet, 300 x 400 x 120 mm (W x H x D, twice the height of the standard BMT 965C cabinet). The dryer DH6 is mounted upright on top of the reaction vessel, or a large diameter off-gas tube.

Off-Gas Cabinet BMT 965 OG

As the recommended configuration the cabinet contains the UV photometric ozone analyser, a long-life ozone resistant sample gas pump SGP5, the power supply for the external Peltier-electric cooler/dryer DH6, a purge unit (solenoid valve/air pump assembly with particle filter) for fully automatic purging and zeroing the photometer, a sample gas flow meter, thermal mass flow detection and warning (LOW FLOW), and a warning system for the internal temperature of the external cooler (DRYER ERROR).
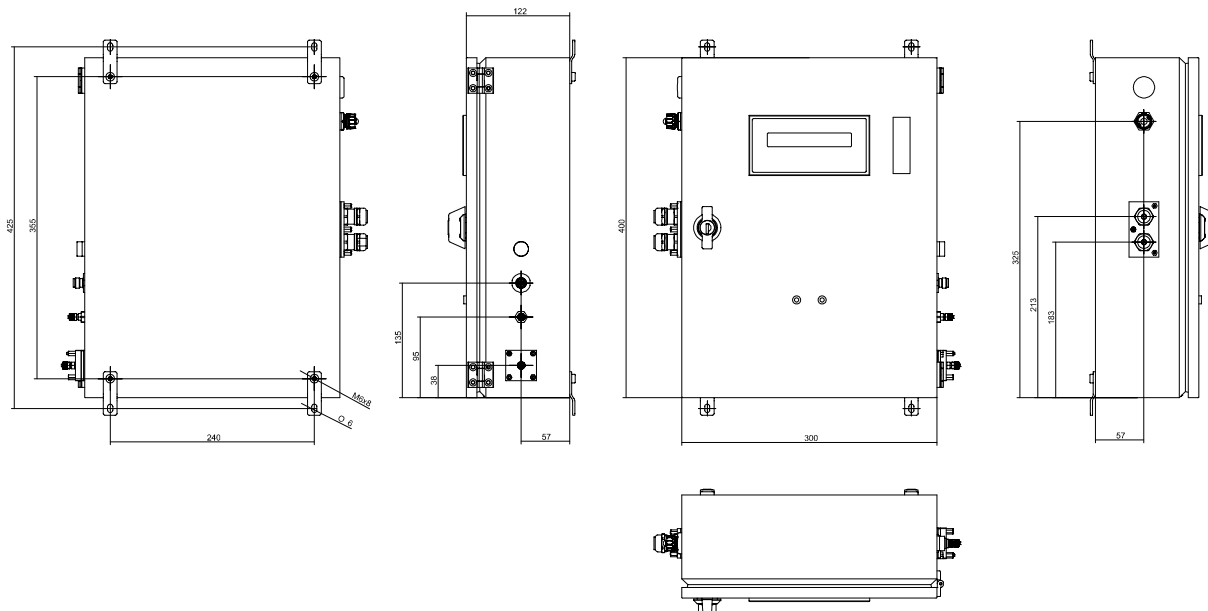
Sample Gas Pump SGP5

The sample gas pump SGP5 is a membrane pump driven by a brushless DC motor. Life expectancy of pump and motor is many years.

The SGP5 may be operated at a maximal system pressure of $\pm$ 100 mbar g. In other words: The internal pressure may not differ from the ambient pressure by more than 100 mbar. Against zero pressure head (differential pressure) the pump moves about 0.5 l/min. At a pressure head of 100 mbar it still can pump 0.35 l/min. But this pump is not a compressor! It is a gas mover.

> **Warning:** Do not apply more than 1 bar g gas pressure to the instrument!
>
> **Avertissement:** Ne pas appliquer une surpression de gaz supérieure à 1 bar sur l'instrument!

Sample Gas Cooler/Dryer DH6

The Peltier-electric dryer DH6 is a flow-through cooling device for removing water vapor from the sample gas, about 64 x 247 x 140 mm (W x H x D) in size. The temperature of the inner surface of the tube is automatically controlled to a temperature which may be set between 1 °C and 15 °C using a screw driver. For details refer to the manual of the DH6.

> **Caution:** Before opening the lid of the DH6 electronics, the user should ground himself by touching grounded points in order to prevent damage of the electronics by electrostatic discharge.

The dryer has to be mounted standing **upright**[2] on one "leg" on top of the reaction vessel, or large diameter off-gas tube.

In case the off-gas is at atmospheric pressure, the "leg" is plugged into an ID 12 mm SS fitting with a PTFE seal. The fitti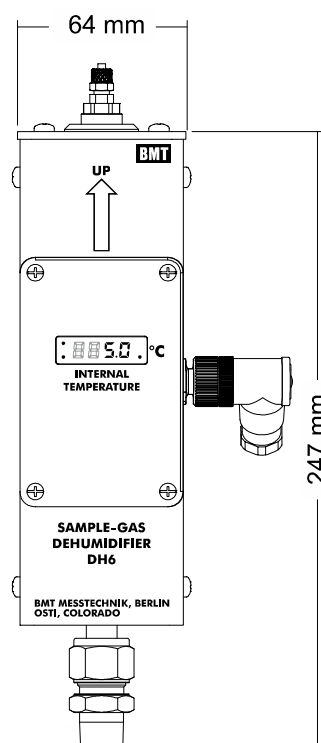ng can be screwed into a 3/8" NPT threaded bore hole, or it can be welded directly into a bore hole 17 mm ID. A PVC plug 12 mm OD is permanently linked to the mounting fitting by a thin SS stranded wire, to tightly close the fitting when the dryer has to be removed for service or repair.
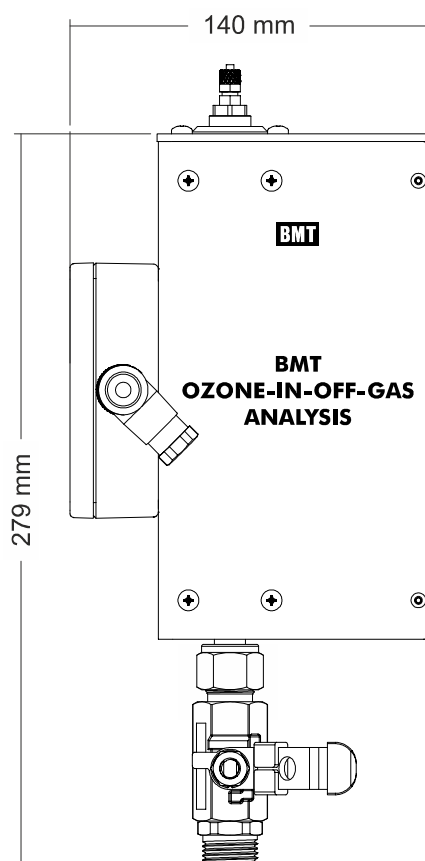
DH6 with SOBV (shut-off ball valve)   DH6

If the off-gas is at an overpressure, or at a slight vacuum, the DH6 should be mounted via a ball valve. The ball valve is screwed into the reactor vessel in a 1/2" NPT threaded bore hole. Welding the ball valve is not recommended.

The DH6 electric cooler/dryer and the analyser cabinet BMT 965 OG are connected by an electric cable, and two FEP tubings 3x5 mm leading the sample gas from the reactor to the analyser for ozone measurement, and leading it back to the reactor after measurement (no critical ozone destruct necessary). The maximum length of the electrical connection between the cabinet and the cooler/dryer is 10 m.

> **Warning**: Before opening the sample gas filter make sure that the sample line does not contain ozone gas, and is not under an overpressure.

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[2] The DH6 must necessarily stand upright because the condensate formed inside the cooler has to flow back into the off-gas system.

In the tubing line from the reactor to the Off-Gas Cabinet an optional Dirt Trap DT 100 can be provided for safety, and to watch the sample gas after its passage through the sample gas cooler/dryer.

Electric Connections

Warning: The cables shall only be connected by a person acquainted with the safety requirements involved.

Warning: This product relies on the building's installation for short-circuit (overcurrent) protection. Ensure that a fuse or circuit breaker no larger than 15 A at 120 VAC (10 A at 240 VAC) is used on the phase conductor.

Do not operate at an elevation higher than 2000 m.

An easily accessible means for switching off power should be provided. This disconnect has to be clearly marked for identification of the instrument.

Wire cross section of the power cable shall be between 1,5 mm² and 4 mm² (AWG 16 to AWG 12). Use copper conductors only. The power cable enters the cabinet through a water proof cable gland. For service or maintenance, the plate holding the cable glands may be unscrewed from the housing, and thus allows to electrically disconnect the analyser from the system without disconnecting power and signal connectors from the cable – cables may be fed through the cabinet's holes together with the connectors.
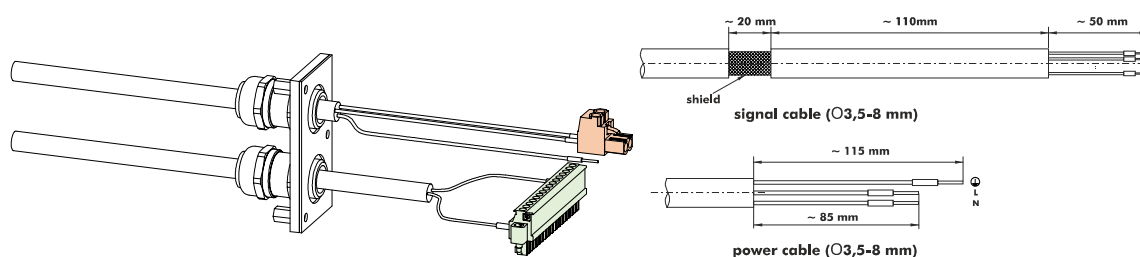
Connect the power carrying wires to the orange two pole female plug labeled "L" and "N" which came with the instrument. Attach these wires to each other with a cable tie tightly behind the orange two pole female plug. Connect the protective conductor (PE) of the cable to the protective conductor terminal ⏚. Plug the orange two pole female plug with the power carrying wires into the orange two pole connector on the PCB. Give enough slack on the PE (Protective Ground ⏚) to ensure that, if the strain relief of the cable gland should fail, the power carrying wires are disconnected first.

Function	Description	in/out	Connector	
mains, "N"	100 to 240 VAC, 50/60 Hz, 35 VA	input	orange	right
mains, "L"		input		left
⏚ Protective Ground	yellow-green wire, to be connected to chassis grounding terminal inside Cabinet			

The signal cable enters the cabinet through a water proof cable gland. The signal cable may be fed through the Cabinet's hole together with the connector. It is held by a grounded cable clamp which should have electrical contact to the cable shield. The different wires connect to the green PCB connector, which is plugged into the green single row terminal block.

Connections:

Pin	Function	Description	in/out
1	Current output	concentration 4- 20 mA	output
2		4- 20 mA GND	
3	Voltage output	concentration 0 – 10 V	output
4		0 – 10 V GND	
5	Auto Zero input	Set to Zero (+24 VDC, 8 mA)	input
6		Zero GND	
7	Error contact	opening on any error	output
8			
10	Common for the following output contacts:		output
9	Dryer Error (DH6) [3]	opening on error	output
11	not connected		
12	Lamp Low contact	opening on warning and error	output
13	Low Limit Alarm contact	opening or closing (selectable)	output
14	High Limit Alarm contact	opening or closing (selectable)	output
15	Cuvette Dirty contact	opening on warning and error	output
16	Low Flow (LFW-2) [2]	opening on warning	output

The Off-Gas Cabinet features a sealed USB connector. All USB operations described for the standard version can also be performed with the Cabinet.

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[3] contact has no function, if option is not installed

Operation

The basic operation of the Off-Gas Cabinet is the same as of the standard BMT 965 ST, see chapters 1 to 14 for details!

Adjustment of Sample Flow: The sample gas flow is produced by the sample gas pump SGP5, and is set in the factory. Corrections may be made by adjusting the trim pot on the pump's electronic board, see graphics under Electric Connections. The recommended flow rate is about 0.5 l/min.

Warning: Make sure that the flow rate is not higher than the range of the flow meter, and the ball inside the flow meter is not at its upper stop!

Warning: Disconnect electrical power before opening the cabinet door.

If the Auto Zero Interval is set to zero hours, the zeroing is not automatically activated by the purge timer, anymore. It still may be initiated by the various manual zeroing commands described on page 15.

Note: Setting the Auto Zero Interval to zero hours also means, that the analyser does not go through the purge cycle and does not activate the Purge Unit! In this case, the user shall never initiate zeroing with ozone applied to the inlet of the Cabinet.

Factory setting of the Auto Zero Interval is 24 hours.

Maintenance

The only maintenance recommended is checking the sample gas filter insert on a regular basis. The filter insert is of pure white material which easily shows most kind of dirt, except if the dirt is white.

Warning: Before opening the sample gas filter, make sure that the sample line does not contain ozone gas, and is not under an overpressure.

The interval of filter insert inspection and replacement has to be evaluated by the user. This interval depends on the degree of dirtiness of the ozone sample gas. Spare filter inserts are provided inside of the cabinet.

For further description of the functions and properties of the cabinet version please refer to the main part of the manual.

Specifications (BMT 965 OG only)

|	
concentration ranges	50, 100 g/Nm^3, selectable units g/Nm^3, %wt/wt, %wt(air), ppm$_v$
optional ranges	5, 10, 20 g/Nm^3, selectable units g/Nm^3, %wt/wt, %wt(air), ppm$_v$
system pressure	within pressure range, max. 100 mbar above or below ambient
ambient temperature	0 – 50°C (main cabinet, non-condensing) 0 – 40°C (dryer DH6, non-condensing)
materials in contact with ozone	quartz (cuvette windows), SS (cuvette, fittings, cuvette spacer), FFPM (window seals), FEP (tubing)
gas ports (main cabinet)	for FEP tubing 3x5 mm (1/8" x 3/16"), opt. 1/8" or 1/4" or 6 mm Swagelok, or 4x6 mm. Built-in sample gas filter is standard
flow rate	factory setting 0.5 l/min
control outputs	relay contacts (28 V, 0.5 A, isolated): Lamp Low Cuvette Dirty High Alarm Low Alarm
error handling	Error Relay: 30 V, 0.5 A, summarizing instrument failures. Warnings and errors: Lamp Low Warning, Lamp Low Error, Lamp Off Error, Lamp High Error. Cuvette Dirty Warning, Cuvette Dirty Error, Overrange, Overpressure, Low Pressure, EEPROM Error, Low Flow (LFW-2)[4], Dryer Error (DH6)[3]
interface (opt.)	either RS-232, bidirectional, 2400 - 38400 Baud, isolated (RS-232 GND connected to analog GND) or MODBUS/TCP or MODBUS RTU
fully automatic zeroing	timer and internal purge unit are integrated
power	wide range input: 100 - 240 VAC, 50/60 Hz, 200 VA
dimensions (W x H x D)	300 x 400 x 120 mm (main cabinet) 64 x 247 x 140 mm (dryer DH6)
weight	6.5 kg (main cabinet) 1.5 kg (dryer DH6)
compliance	CE-marked (EMC & safety), cTUVus NRTL-listed (safety), USCG 46 CFR 612.060-30

General specifications not specific to the BMT 965 OG are found on page 39.

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[4] contact without function if option not installed

Appendix E: DI Water Version BMT 965 AQ

General Description

The OZONE-IN-WATER SENSOR BMT 965 AQ is a UV photometer for the direct measurement of the ozone content of clean, de-ionized water (special version HF for up to 20% hydrofluoric acid, ranges 10 to 150 ppm$_w$). The instrument is based on our OZONE ANALYZER BMT 965ST for the measurement of ozone in gas.
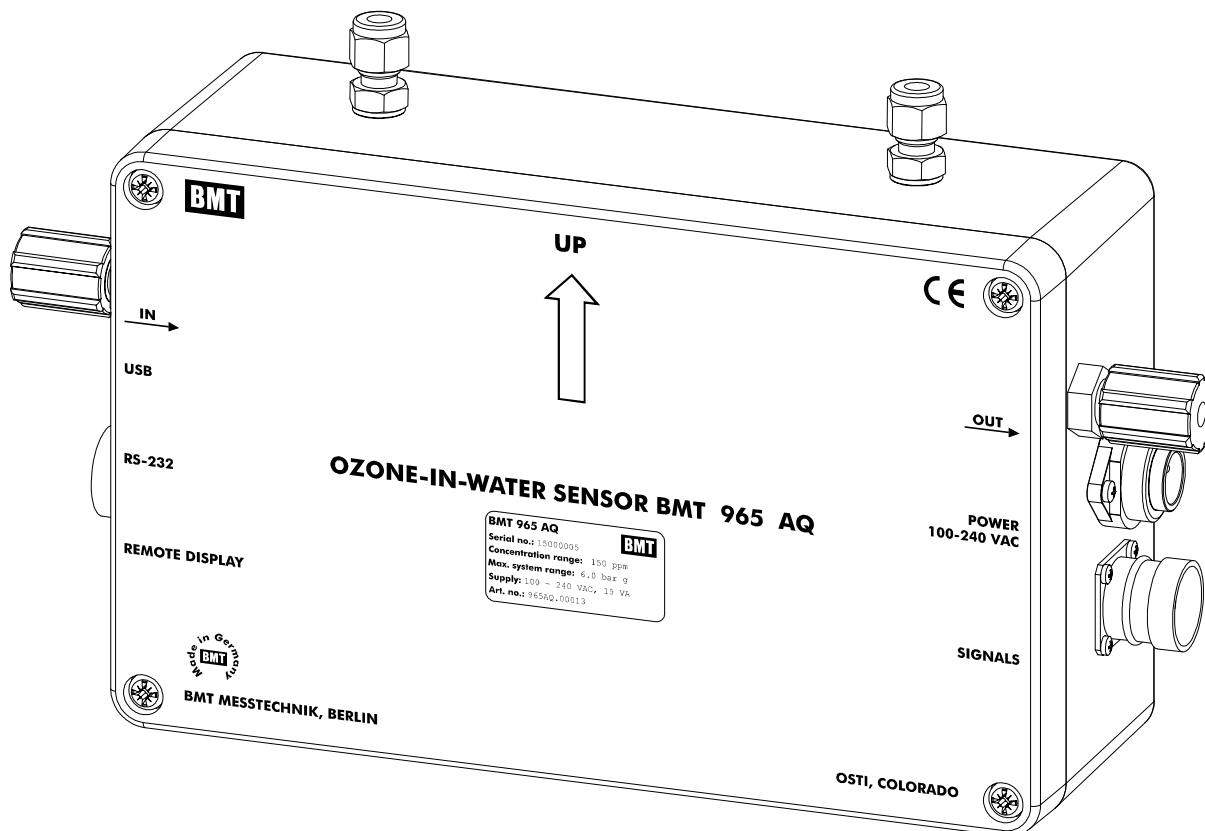
The BMT 965 AQ is a SENSOR because it does not have a display. It is designed to directly be connected to e.g. a workstation via a 4-20 mA, or 0-10 V, signal line. The workstation also has to monitor and control the instrument's functions like auto-zeroing, or possible failure indications. An optional REMOTE DISPLAY BMT 965 RD is available for installations without a workstation (to be specified in the order, needs e.g. BMT 965 AQ/RD, BMT 965 AQ/HF/RD).

The BMT 965 AQ is a splash proof cast aluminium enclosure (IP 65, NEMA 4X) 260 x 160 x 82 mm (W x H x D) with a sea water resistant coating (RAL 5009, azure), and weighs about 3kg. Four mounting brackets are provided for installing the SENSOR where it is needed, e.g. underneath a work bench. Power connector and signal connector are water proof. The cable connecting the Remote Display is supplied with the Display.

The BMT 965 AQ features a sealed USB connector. All USB operations described for the standard version can also be performed with the BMT 965 AQ. If no display is connected, when copying data to a flash drive or upgrading the instrument from a flash drive, the instrument will signal end of copy or upgrade operation by beeping five times per second.

The inlet and outlet fittings are 1/4" PFA Flaretek (for 1/4" OD PFA tubing). A Flarelok version is available. Two additional 1/4" SS Swagelok fittings are provided to flush the inner space of the SENSOR enclosure with dry air, in case the water temperature is below the ambient, to prevent condensation of water vapor on the cooled inner surfaces.

Materials in contact with the ozonized water are only quartz glass, PTFE, FFPM and PFA (sapphire, PTFE, FFPM and PFA in the HF version).

The instrument must be mounted with the arrow on the front panel pointing upwards!

Measurement ranges and associated maximum rated pressure:

BMT 965 AQ	BMT 965 AQ/HF
10 ppm$_w$ (max. 1 bar g)	10 ppm$_w$ (max. 2.5 bar g)
-	20 ppm$_w$ (max. 2.5 bar g)
50 ppm$_w$ (max. 4 bar g)	50 ppm$_w$ (max. 2.5 bar g)
100 ppm$_w$ (max. 4 bar g)	100 ppm$_w$ (max. 2.5 bar g)
150 ppm$_w$ (max. 6 bar g)	150 ppm$_w$ (max. 2.5 bar g)

Some ranges may be ordered compatible with up to 20 % hydrofluoric acid (BMT 965 AQ/HF, see table). Pressure and temperature compensation (which is standard in our gas analysers) is not provided because it is not necessary here. Rated pressure is listed above.

We recommend a water flow rate between 100 and 300 cm^3/min. Pressure head (with 2x50 cm PFA tubing, 4 mm ID, connected to the inlet and outlet fittings) is about 7.5 cm H$_2$O for a flow rate of 100 cm^3/min, 18 cm H$_2$O for 200 cm^3/min, and 33 cm H$_2$O for 300 cm^3/min. The OZONE-IN-WATER SENSOR usually is used as a bypass to a small flow resistance in a large diameter main PFA tubing line. The SENSOR then should be positioned beneath the main tubing to let gas bubbles bypass the SENSOR.

If a throttle (flow resistance) is installed to control the flow rate through the OZONE-IN-WATER SENSOR, this throttle must be positioned behind the sensor (never in front of it!), because gas could bubble out of the water after a pressure drop and disturb the measurement.

When the fluid to be measured is at a temperature lower than the ambient, flushing of the instrument with clean dry air (or nitrogen) is necessary to prevent condensation of water. Flow rate of the dry gas should be about 0.2 l/min.

As long as the cuvette of the SENSOR remains clean, zeroing of the instrument is not necessary for weeks, or even for months. But for safety, zero reading should be checked on a regular basis by applying **water with zero ozone concentration**. For checking zero reading no other method is possible. Zeroing has to be initiated by pressing the push button **ZERO** at the optional REMOTE DISPLAY BMT 965 RD, or via the binary input at pins 5 and 6 of the signal connector, or RS-232, or USB (for details see the main part of the manual). Prior to zeroing the analyser, it has to be assured that the cuvette is filled with water having zero ozone concentration.

In the BMT 965 AQ series of sensors, the isolated signal outputs are tied to Protective Ground by 10 MΩ.

The REMOTE DISPLAY is connected to its own 12-pole connector. The 16-pole Signal Connector is free for access to all signal inputs and outputs. The analyser must be ordered as BMT 965 AQ/RD in order to operate together with a REMOTE DISPLAY.

For further description of the functions and properties of the OZONE-IN-WATER SENSOR BMT 965 AQ refer to the main part of the manual.

Electric connections

Note: The signal connector pinout of the BMT 965 AQ is different to the that of the BMT 965 ST!

Signal connector:
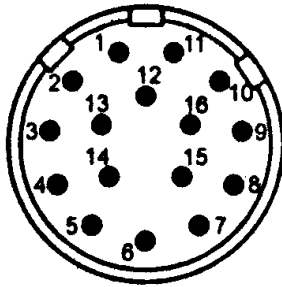
(conn. soldering side)

1	current signal, output	4 - 20 mA high
2	current signal, output	4 - 20 mA low
3	voltage signal, output	0 - 10 V high
4	voltage signal, output	0 - 10 V low
5	Auto Zero, input	high (+24 VDC, 18mA)
6	Auto Zero, input	low
7	Error Contact, output	} open on error
8	Error Contact, output	
9	Purge Control, output	for external pump / solenoid valve
10	Output contacts, Common	for pins 9, 12, 13, 14, 15
11	Cable Shield	
12	Lamp Low, output	open on error
13	Low Limit Alarm, output	opening or closing
14	High Limit Alarm, output	opening or closing
15	Cuvette Dirty, output	open on error
16		not connected

Mains connector:

1	mains	} (100 bis 240 VAC, 50/60 Hz, 15 VA)
2	mains	
3	(free)	
⏚	Protective Ground	

Alternatively:

DC power connector:

1	positive	} (12-36 VDC)
2	negative	
3	(free)	
⏚	Protective Ground	

RS-232 connector:

1	Cable Shield
2	TxD (from BMT 965 AQ)
3	RxD (to BMT 965 AQ)
4	Signal Ground
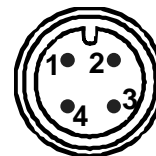
(screw terminal side)

Remote Display: 12-pole connector, only to be connected to BMT Remote Display

Note: The 24V DC version of the BMT 965 AQ is based on the same type of power connector, but with the female connector on the SENSOR side.

Specifications (BMT 965 AQ only)

concentration ranges	AQ: 10, 50, 100, 150 ppm$_w$
	AQ/HF: 10, 20, 50, 100, 150 ppm$_w$
max. pressure, fluid ports	AQ, 10 ppmw: 1 bar g
	AQ, 50 and 100 ppmw: 4 bar g
	AQ, 150 ppmw: 6 bar g
	AQ/HF, all ranges: 2.5 bar g
ambient temperature	0 – 50°C (non-condensing)
materials in contact with ozone	AQ: quartz, PTFE, PFA, FFPM
	AQ/HF: saphhire, PTFE, PFA, FFPM
fluid ports	1/4" Flaretek
recommended flow rate	0.1 - 0.3 l/min typical
pressure drop	approx. 45 mbar at 0.3 l/min
condensate prevention	approx. 0.2 l/min of dry air or nitrogen, connection 1/4" Swagelok
control outputs	relay contacts (28 V, 0.5 A, isolated):
	Lamp Low
	Cuvette Dirty
	High Alarm
	Low Alarm
	Purge Control
error handling	Error Relay: 30 V, 0.5 A, summarizing instrument failures.
	Errors: Lamp Low Error, Lamp Off Error, Lamp High Error, Cuvette Dirty Error, Overrange, Overpressure, Low Pressure, EEPROM Error
interface (opt.)	either RS-232, bidirectional, 2400 - 38400 Baud,
	isolated (RS-232 GND connected to analog GND)
	or MODBUS/TCP
power	wide range input: 100 - 240 VAC, 50/60 Hz, 15 VA
	optional: 12 - 36 VDC, 15 W
dimensions (W x H x D)	260 x 160 x 91 mm
weight	3.0 kg

General specifications not specific to the BMT 965 AQ and BMT 965 AQ/HF are found on page 39.

Appendix F: Remote Display BMT 965 RD

General Description

The different models of the OZONE-IN-WATER SENSOR BMT 965 AQ are available with the display and control panel separated from the analyser, which then is a Sensor with a REMOTE DISPLAY. Both elements are connected with a special cable, 2 or 5 m long, max. cable length is 100 m.

Dimensions of the REMOTE DISPLAY BMT 965 RD are 144 x 72 x 60 mm.

The connecting cable has a special pin-out on a 12-pole connector, and must be ordered with the desired length. Models available as a sensor with REMOTE DISPLAY are: BMT 965 AQ/RD, BMT 965 AQ/HF/RD, BMT 965 AQ-LC/RD. The analyser must be ordered as /RD version in order to operate together with the REMOTE DISPLAY.

The REMOTE DISPLAY BMT 964 RD is fully compatible with the BMT 965 series of analysers. In addition, the REMOTE DISPLAY BMT 965 RD may be used on the BMT 964 series of analysers.

Operation

The Sensor with REMOTE DISPLAY is operated the same way as the standard BMT 965 instrument (see main part of the manual), if it is connected. Connecting the Remote Display during operation of the sensor should be avoided.
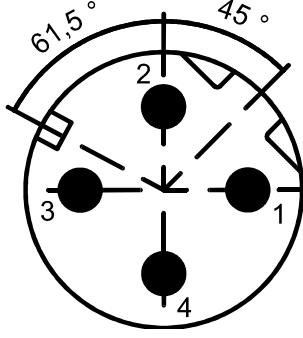
Appendix G: IP-based Communication

Instruments equipped for IP-based communication will support Fast Ethernet (100 Mbit/s) over a four wire twisted pair cable up to a distance of 100 m. The MAC address of the device will be in a range from 70-B3-D5-5D-60-00 to 70-B3-D5-5D-6F-FF, as assigned to BMT MESSTECHNIK by the IEEE. The IP address of the device can be either assigned dynamically by DHCP or it can be configured as a static address.

BMT 965 C / OG / AQ – Installation (M12)

Connection to Ethernet is made with an IP67 M12 connector delivered with the instrument. The used shielded (S/FTP or S/UTP) cable should comply with Ethernet specifications (CAT-5, CAT-6 or CAT-7). Outer diameter should be between 5.5 mm to 8 mm. Max. wire gauge is AWG20 (0.75 mm²). Shield should be connected. Ethernet cables are available with two different colour codes according to TIA/EIA-568, as shown in the following table:

M12-D Male cable connector Pin assignment (plug-in side)	Pin	Signal	EIA/TIA 568A Colour	EIA/TIA 568B Colour
	1	Tx+	white/green	white/orange
	2	Rx+	white/orange	white/green
	3	Tx-	green	orange
	4	Rx-	orange	green

BMT 965 ST / BT – Installation (M8)

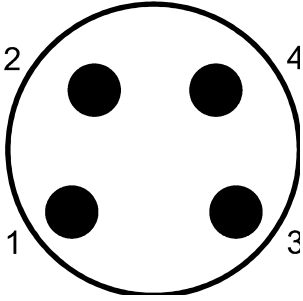Connection to Ethernet is made with an M8 connector delivered with the instrument. The used shielded (S/FTP or S/UTP) cable should comply with Ethernet specifications (CAT-5, CAT-6 or CAT-7). Outer diameter should be between 3.5 mm to 5.5 mm. Max. wire gauge is AWG21 (0.5 mm²). Shield should be connected. Ethernet cables are available with two different colour codes according to TIA/EIA-568, as shown in the following table:

M8-A Male cable connector Pin assignment (plug-in side)	Pin	Signal	EIA/TIA 568A Colour	EIA/TIA 568B Colour
	1	Tx+	white/green	white/orange
	2	Rx+	white/orange	white/green
	3	Rx-	orange	green
	4	Tx-	green	orange

Network Operation

A new BMT 965 comes with its DHCP client enabled. IP address, gateway and netmask will be autoconfigured by the DHCP server on the network, as soon as the instrument is connected or powered on. A BMT 965 with a networking option provides the additional display menu "View Network", where the IP address can be seen. If no DHCP server is found, but the Ethernet link is up, the BMT 965 will use an IP address out of the AutoIP range 169.254.1.0 to 169.254.254.255.

An instrument, which is started up connected to the network, will show its IP address for five seconds during warm up. If the instrument is connected during normal operation, link speed and the IP address will be shown for 10 seconds, replacing the display of ozone concentration.

Static network parameters can be assigned by using the freely available PC program BMT 965 Link. If static parameters are assigned, the DHCP client will be off permanently. BMT 965 Link can also be used to reactivate DHCP.

Note on security: The BMT 965 shall never be exposed directly to the Internet, e.g. by port forwarding through a router. If communication via the Internet is desired, secure methods like encrypted VPN should be used.

Appendix H: MODBUS

The MODBUS protocol is an open, standardized communication protocol which provides a means to monitor and interrogate electronic devices. The device requesting information is the MODBUS client. The devices sending the information are the so-called serves. There can be several servers in a MODBUS network, each one is defined by its own address.

MODBUS enables a SCADA system to have direct access to all relevant parameters (e.g. concentration, pressure, cuvette status) and all alarms of the BMT 965. It is also possible to set some parameters like Low and High Alarm Limits and to execute a zero command. Additionally, Modbus diagnostic information can be requested.

MODBUS RTU

MODBUS RTU (Remote Terminal Unit) is a binary transmission protocol for serial interfaces (RS-232 or RS-485). The BMT 965 C and BMT 965 OG are available with a MODBUS RTU option that implements the common two-wire RS-485 interface with up to 32 nodes. The operation conforms to the document:

> MODBUS Application Protocol Specification, V1.1b[5]
>
> MODBUS Over Serial Line Specification and Implementation Guide, V1.02[5]
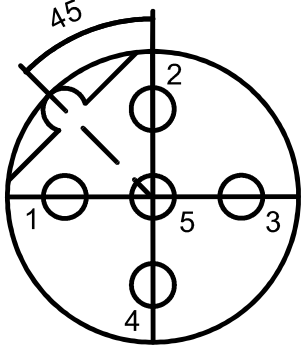
Note: Parallel use of MODBUS RTU and other communication interfaces is allowed.

Installation: A BMT 965 with MODBUS RTU option is equipped with a male 5 pole IP67 M12 connector and the female counterpart for the bus cable is part of the delivered accessories.

The RS-485 interface provides galvanic isolation including transient protection. A shielded three conductor twisted-pair type should be used as bus cable, with an outer diameter (OD) 5 to 8 mm, e.g. Belden 3106A. The maximum cable length that can be connected is determined by various factors (transmission rate, cable type, number of connected devices). With a high-quality cable and proper bus termination (see MODBUS specification) the cable length can be up to 1,000 m, at a transmission rate of 19,200 bit/s.

Connecting the cable shield can be improve noise immunity. If the cable connects distant locations with a potential difference in their mains installation, then unwanted potential equalization current may flow through the shield, making it necessary to connect the cable shield only at one point of the bus.

[5] www.modbus.org

M12-B Female cable connector Pin assignment (plug-in side)	Pin	Signal
	1	NC
	2	NC
	3	0 V Common
	4	Signal A (-)
	5	Signal B (+)

Commissioning: In addition to the front panel menu (`Set I/O - MODBUS Parameters`), BMT offers a freely available PC program (BMT 965 Link) for configuration and diagnostics. The following parameters can be configured and are stored in a non-volatile memory:

Parameter	Factory Default	Range
Baud rate [bit/s]	9600	2400, 4800, 9600, 19200, 38400
Parity	None	none, odd, even
Address	203	1 … 247

MODBUS/TCP

The BMT 965 C, BMT 965 OG, BMT 965 AQ, BMT 965 ST and BMT 965 BT are available with a MODBUS/TCP option. Such an instrument will provide a MODBUS/TCP server, listening on the MODBUS standard port 502. The operation conforms to the document:

MODBUS MESSAGING ON TCP/IP IMPLEMENTATION GUIDE V1.0b[6]

Scan rate should not be faster than 50 ms and response timeout of the client should be set to one second or longer. Only one TCP connection should be open at any time. The client should wait for a response before issuing a new query.

Installation and Commissioning: Refer to Appendix G: IP-based Communication (see page 66)

Attention: M8 interface is provided for BMT 965 ST and BMT 965 BT, M12 interface is provided for BMT 965 C, BMT 965 OG and BMT 965 AQ.

MODBUS Operation and Register

A MODBUS message contains an address, a function code, a register address, user data, and a CRC error checking field. When a MODBUS slave receives a query with its address, it first performs error checking (CRC and Parity check). It will provide an answer if error checks were successful. If not, the query will be ignored.

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[6] www.modbus.org

The instrument will then check query data, and, if invalid data is detected, will respond with a MODBUS Exception.

Caution: Care has to be taken that the MODBUS client does not reconfigure the BMT 965 in an endless loop. The internal non-volatile memory will only tolerate a limited (1,000,000) number of write cycles. Reading commands can be used infinitely.

Function Code: The function code specifies the purpose of the data message and defines the command to be executed by the BMT 965. The following function codes are supported:

Function Code	Definition
01 (0x01)	Read Single Coil
03 (0x03)	Read Holding Registers
04 (0x04) *	Read Input Registers
05 (0x05)	Write Single Coil
06 (0x06) *	Write Single Register
08 (0x08)	Diagnostics
15 (0x0F)	Write Multiple Coils
16 (0x10)	Write Multiple Registers

* This function codes require firmware version 1.05 or higher.

Attention: Please note the differences between the firmware versions. Some functions are only available at Firmware V1.05 and higher.

Exception Code: If the BMT 965 detects an error in the requested message from the client, it returns an exception message. The following exception codes are used:

Exception Code	Definition	Description
01	Illegal Function	The function code received is not supported.
02	Illegal Data Address	The register address received is not a legal address.
03	Illegal Data Value	The value in the data field is not permissible such as that the implied length is incorrect or attempting to write to a read only register.
04	Server Device Failure	An error occurred when processing the request, e.g. illegal parameter. **Note:** The MODBUS standard defines: "An unrecoverable error occurred while the server was attempting to perform the requested action." In this implementation this exception code is also used to convey the client the use of an out-of-range parameter. There is no "unrecoverable error", it merely means that the request was rejected and nothing was changed.

Register Data Types:

Data Type	Description	Range
UINT16	16-bit unsigned integer stored in 1 register, big endian coded	0 … 65535

UINT32	32-bit unsigned integer stored in 2 sequential registers, each big endian coded The lower signification word is hold in the lower register, then the higher significant.	0 … 4 294 967 295
Float32	IEEE-754 encoded 32-bit single precision floating point values stored in 2 sequential registers, each big endian coded. The lower significant word is hold in the lower register, then the higher significant.	-3.4E-38 … +3.4E+38

Register Addressing: The register and coil tables contain the MODBUS notation, where the register addresses are counted starting with 1, that is not the actual content of the data message (starts with 0).

Register Map – FC 03 (0x03), 04 (0x04), 06 (0x06), 16 (0x10)

Reg-ister	Length	Parameter	Data Type	Byte/Word Order	R/W	Unit/Range	Function Code
1	2	Concentration	Float32	Big Endian Low Word Big Endian High Word	R	in set unit	03 (0x03) 04 (0x04) *
3	2	Ozone Range	Float32	Big Endian Low Word Big Endian High Word	R	in set unit	03 (0x03) 04 (0x04) *
5	2	Pressure	Float32	Big Endian Low Word Big Endian High Word	R	in bar absolute	03 (0x03) 04 (0x04) *
7	2	Cuvette Status	Float32	Big Endian Low Word Big Endian High Word	R	dirty value in %	03 (0x03) 04 (0x04) *
9	2	Pressure Range	Float32	Big Endian Low Word Big Endian High Word	R	in bar absolute	03 (0x03) 04 (0x04) *
11	2	Temperature	Float32	Big Endian Low Word Big Endian High Word	R	in Kelvin	03 (0x03) 04 (0x04) *
13	2	Low Alarm Limit	Float32	Big Endian Low Word Big Endian High Word	R/W*	in set unit Note: needs to be lower than current High Alarm Limit	03 (0x03) 04 (0x04) * 16 (0x10) *
15	2	High Alarm Limit	Float32	Big Endian Low Word Big Endian High Word	R/W*	in set unit Note: needs to be higher than current Low Alarm Limit	03 (0x03) 04 (0x04) * 16 (0x10) *
17	2	Molecular weight of carrier gas	Float32	Big Endian Low Word Big Endian High Word	R	---	03 (0x03) 04 (0x04) *
19	2	Firmware Version	Float32	Big Endian Low Word Big Endian High Word	R	---	03 (0x03) 04 (0x04) *
21	2	Operating Hours	UINT32	Big Endian Low Word	R	in hours	03 (0x03) 04 (0x04) *

				Big Endian High Word			
23	2	Serial Number	UINT32	Big Endian Low Word	R	---	03 (0x03) 04 (0x04) *
				Big Endian High Word			
25	1	Ozone Unit	UINT16	Big Endian	R/W*	0: g/Nm3 1: %wt/wt 2: ppm(v) 3: g/m3 (without pressure and temperature compensation) 4: ppm(w) 5: wt (air)	03 (0x03) 04 (0x04) * 06 (0x06) * 16 (0x10) *
26	1	Display Pressure (Front Panel)	UINT16	Big Endian	R	0: bar (1.0) 1: psi (14.50778) 2: Torr (750.0617) 3: MPa (0.1) In parathesis: Multiplier to calculate value in bar	03 (0x03) 04 (0x04) *
27	1	Auto Zero Interval	UINT16	Big Endian	R/W*	[0 … 99] in hours 0: auto zero is disabled	03 (0x03) 04 (0x04) * 06 (0x06) * 16 (0x10) *
28*	1	Zeroing	UINT16	Big Endian	R*/W*	0: inactive 1: active (R) / execute zero (W) Note: Attempting to write register returns exception code 04 for: • Write 0 (inactive) • Write 1 (execute zero) in case of Warming Up or Zeroing	03 (0x03) 04 (0x04) * 06 (0x06) * 16 (0x10) *
29*	1	High/Low Alarm Behaviour	UINT16	Big Endian	R*/W*	Binary coded Bit 2: Low Alarm enabled Bit 3: Low Alarm latched Bit 4: High Alarm enabled Bit 5: High Alarm latched logical 0: inactive logical 1: active	03 (0x03) 04 (0x04) * 06 (0x06) * 16 (0x10) *
30*	2	Device Status	UINT32	Big Endian Low Word Big Endian High Word	R*	Binary coded logical 0: inactive logical 1: active Bit 0: Low Alarm Bit 1: High Alarm Bit 2: Low Alarm enabled Bit 3: Low Alarm Latched Bit 4: High Alarm enabled Bit 5: High Alarm latched Bit 6: Lamp Low Warning Bit 7: Lamp Low Error Bit 8: Lamp Off Error Bit 9: Lamp High Error Bit 10: Cuvette Dirty Warning Bit 11: Cuvette Dirty Error Bit 12: Overrange Error Bit 13: Overpressure Error Bit 14: EEPROM Error Bit 15: Zeroing Bit 16: Warming up Bit 17: SD Card Warning Bit 18: Low Pressure	03 (0x03) 04 (0x04) *

* This function requires firmware version 1.05 or higher.

Register Map – FC 16 (0x10)
For backward compatibility to legacy BMT 964 and BMT 965 V1.04 or below

Reg-ister	Regis-ter Length	Parameter	Data Type	Byte/Word Order	R/W	Unit/Range	Function Code
1	1	Ozone Unit	UNIT16	Big Endian	W	0: g/Nm3 1: %wt/wt 2: ppm(v) 3: g/m3 (without pressure and temperature compensation) 4: ppm(w) 5: wt (air)	16 (0x10)
2	2	Low Alarm Limit	Float32	Big Endian Low Word Big Endian High Word	W	in set unit Note: needs to be lower than current High Alarm Limit	16 (0x10)
4	2	High Alarm Limit	Float32	Big Endian Low Word Big Endian High Word	W	in set unit Note: needs to be higher than current Low Alarm Limit	16 (0x10)
7	1	Auto Zero Inter-vall	UINT16	Big Endian	R	[0 … 99] in hours 0: auto zero is disabled	16 (0x10)

Read Coil Map – FC 01 (0x01)

Coil	Description	Comment
1	Low Alarm	Read Coil (FC 01) is used to request binary status information from the instrument. The query consists of a start coil number (first register to receive data from) and the quantity of bits to read. The least significant bit of the first data byte contains the status of the addressed start coil. The other coils status information follows toward the high-order end of this byte and from low order to high order in subsequent bytes. If the returned coil quantity is not a multiple of eight, the remaining bits in the final byte will be padded with zero. Status information: ON – active – logical 1 OFF – inactive – logical 0
2	High Alarm	
3	Low Alarm Enabled	
4	Low Alarm Latched	
5	High Alarm Enabled	
6	High Alarm Latched	
7	Lamp Low Warning	
8	Lamp Low Error	
9	Lamp Off Error	
10	Lamp High Error	
11	Cuvette Dirty Warning	
12	Cuvette Dirty Error	
13	Overrange Error	
14	Overpressure Error	
15	EEPROM Error	
16	Zeroing	
17	Warming Up	
18	SD Card Warning	
19	Low Press Error	

Write Coil Map – FC 05 (0x05), 16 (0x10)

Coil	Description	Comment
1	Low Alarm Enabled	Write Single Coil (FC 05) is used to force a single output to either ON or OFF. The requested state is specified by a constant: ON – active – data field value 0xFF00 OFF – inactive data field value 0x0000
2	High Alarm Enabled	
3	Low Alarm Latched	

4	High Alarm Enabled	Write Multiple Coils (FC 16) is used to force each coil in a sequence of coils to either ON or OFF. The requested state is specified by contents of the data field.
		ON – active – logical 1 in bit position of the related data field
		OFF – inactive – logical 0 in bit position of the related data field
		Coils are addressed starting at zero – coil number 1 is addressed as 0.
		
		Note: Attempting to write Coil 5 – Execute Zero will return the exception code 04 in case of:
		    (1) Request OFF state or
		    (2) Request ON in case of Warming Up is active or
		    (3) Request ON in case of Zeroing is active

5	Execute Zero	

Diagnostics – FC 08 (0x08)

Coil	Description
0x00	Return Query Data The Data passed in the request is looped back in the response. The entire response message should be identical to the request. **Note:** The data field of the query should be two bytes long.
0x0A	Reset Error Counters
0x0C	Return Bus Communication Error Count Returns the quantity of CRC errors since its last restart. The Reset Error Counters operation or power-on clear this counter.
0x0D	Return Bus Exception Count Returns the quantity of MODBUS exceptions since its last restart. The Reset Error Counters operation or power-on clear this counter.