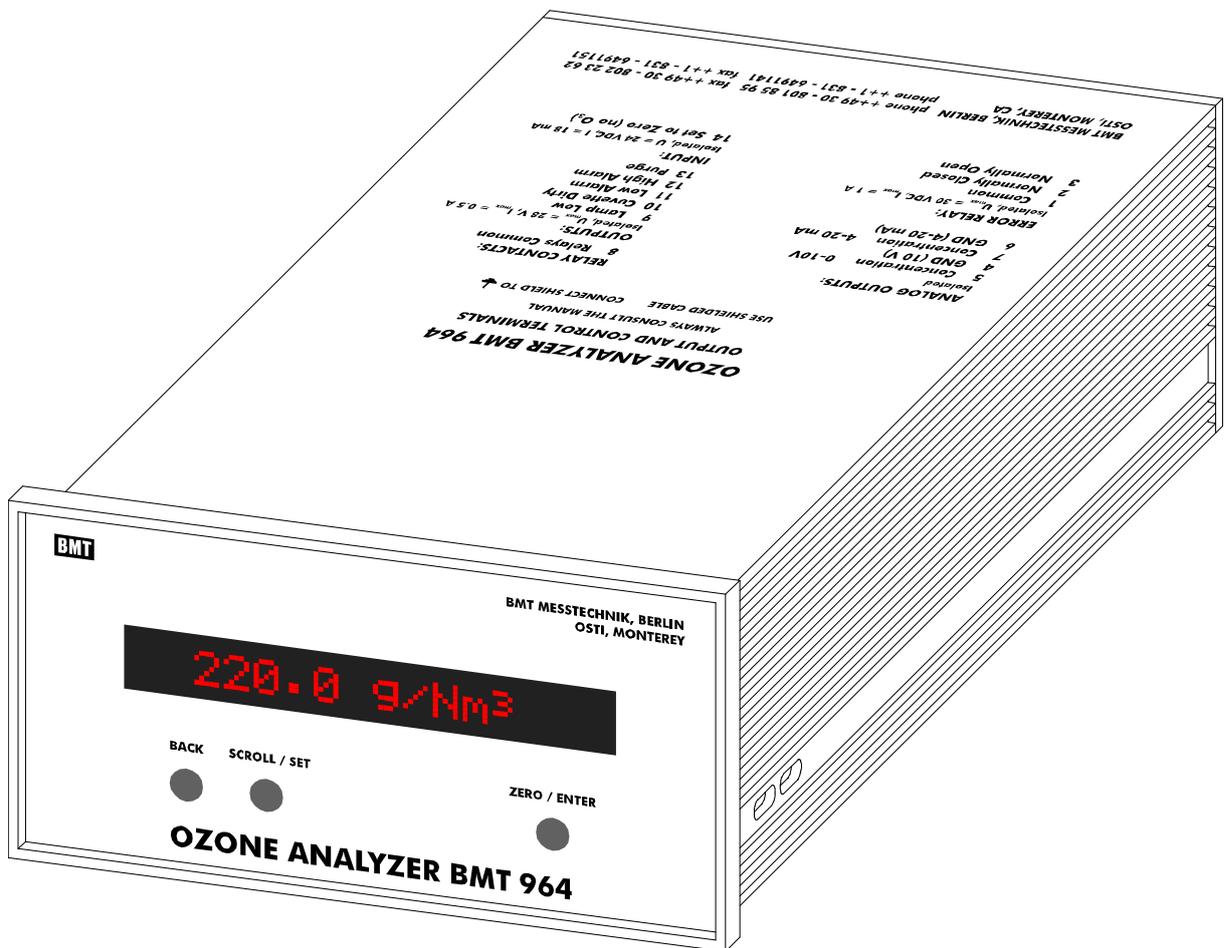


# OZONE ANALYZER BMT 964

## Manual

Rev. 04/2021



# OZONE ANALYZER BMT 964

This manual describes the standard version BMT 964. For the versions **BMT 964 BT**, **BMT 964 C**, **OFF-GAS System**, **BMT 964 AQ** and **BMT 964 RD**, also refer to the according Appendices at the end of this manual !

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## 1 General Description

The OZONE ANALYZER BMT 964 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 964 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<sup>3</sup>) or ppm<sub>v</sub> (AQ: g/m<sup>3</sup> or ppm) 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

These parameters can be set with the three pushbuttons on the front panel as well as by connecting the serial interface to a Windows-PC running the program BMT 964 Link, which is supplied with each instrument. Another way of configuring the instrument is to use the so-called Link Mode via the serial interface.

The instrument has a built-in clock with calendar, which is used to provide time stamps for an Event-Log (48 entries, e.g. zeroing, alarms) and an Error-Log (16 entries, e.g. Overrange, Cuvette Dirty). These logs can be read out and printed via the serial interface with the mentioned program BMT 964 Link.

## 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 964 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.

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

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

**Warning:** Do not apply more than 2.5 barg gas pressure to the instrument! The maximum for the Off-Gas version BMT 964 OG is 1 barg.

**Warning:** Make sure that the flow rate is not higher than 0.8 l/min, 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.

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

**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:** 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.

**Précaution:**

**Avertissement :** L'ozone est un gaz à forte toxicité. Les concentrations d'ozone mesurées à l'aide de l'analyseur d'ozone BMT 964 vont au-delà de la limite mortelle. C'est pourquoi il convient d'utiliser une technique de sécurité adéquate (détecteur d'ozone).

**Attention :** 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 !

**Attention :** Ce produit est soumis à l'emploi d'un fusible de surintensité dans le bâtiment. Vérifiez que le fusible de la phase utilisée ne dépasse pas 15 A pour 120 VCA (10 A pour 240 VCA).

**Attention :** 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 2,5 bar de surpression.

**Avertissement :** Le débit ne doit pas dépasser 0,8 l/min ! La boule rouge du débitmètre ne doit pas toucher la butée blanche !

**Avertissement :** Débranchez avant d'ouvrir la porte.

**Avertissement :** Avant d'ouvrir le filtre du gaz à mesurer, assurez-vous que dans la conduite du gaz à mesurer il n'y a pas d'ozone sous pression.

### 3 Installation and Power Connection

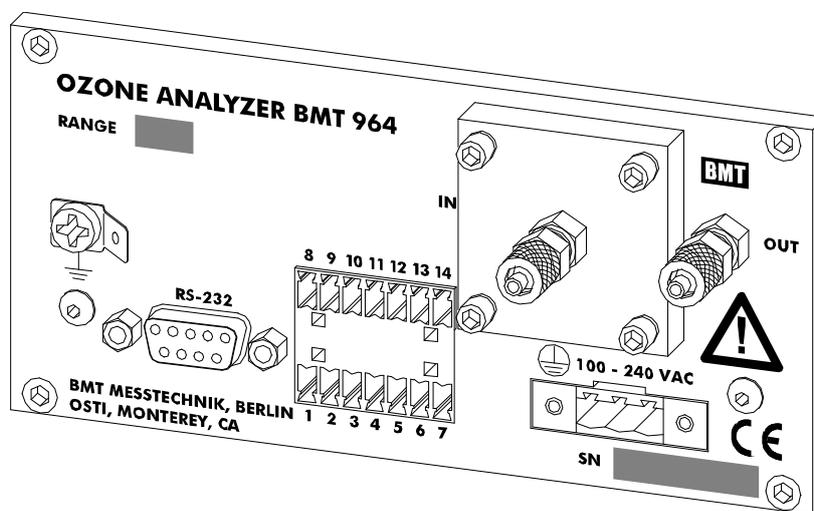
The OZONE ANALYZER BMT 964 is a 144 x 72 mm front panel instrument (according to DIN 43700). The mounting cut-out should be 139 x 67 mm (W x H). Depth is approx. 230 mm. The power line voltage may be 100 to 240 VAC (50 or 60 Hz). All necessary parts needed for installation are supplied with the instrument (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 installation of the power connector has to be made by a person acquainted with the safety problems 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 means for switching off power should be provided.

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). The backplane is shown here:



For the sample gas connection 3 x 5 mm PTFE tubing (or FEP tubing 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 analyzer,
- c) the cross section of the tubing (we recommend tubing 3 x 5 mm, not more!),
- d) the time lag of the analyzer itself. At the recommended flow rate of .2 to 1 l/min time lag will be 2 to 0.4 s with a 3 x 5 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!"

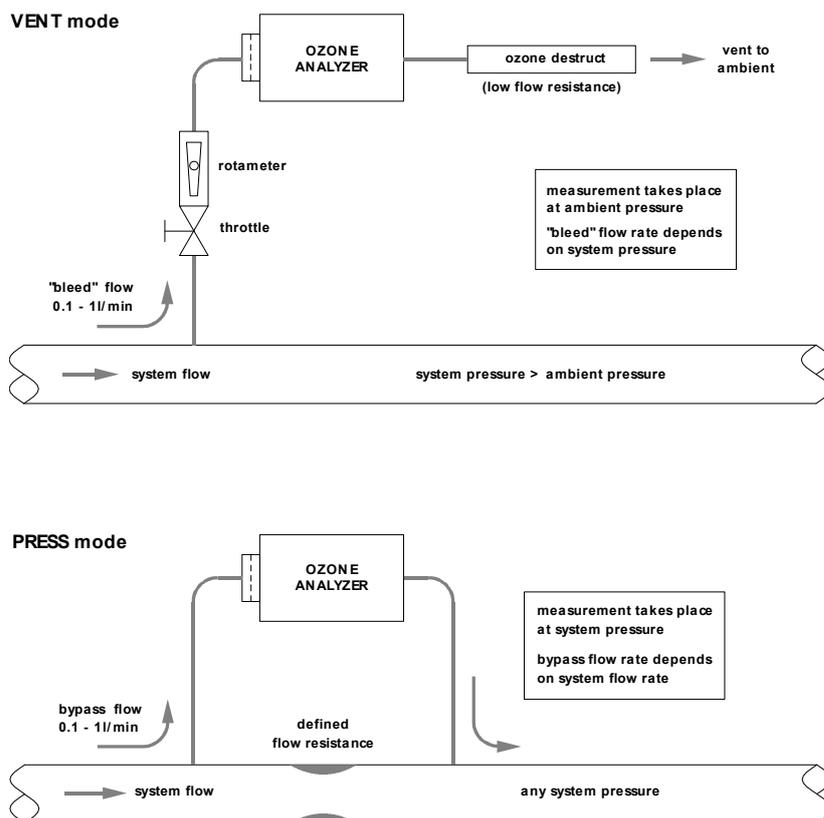
When measuring ozone, namely in an industrial environment, it really pays off to thoroughly protect the ozone analyser from any dirt which might be contained in the ozone sample gas.

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 29, 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:



## 4 Output and Control Terminals

All signal leads should be shielded. The shield should be connected to the ground terminal ( $\perp$ ) of the instrument via an 1/4" FASTON connector. The following table describes the signal connector and is also printed onto the top of the standard instrument.

### Analog Outputs

The output signals are updated about 25 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 k $\Omega$ .

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  $\Omega$  (optional 1350  $\Omega$ ). The current output provides the energy for the current loop.

**Attention:** The current output must not be connected to an external power supply!

## OZONE ANALYZER BMT 964

### OUTPUT AND CONTROL TERMINALS

ALWAYS CONSULT THE MANUAL

USE SHIELDED CABLE    CONNECT SHIELD TO  $\perp$

#### 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,  $I_{max} = 1$  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,  $I = 18$  mA

- 10 Zero GND
- 11 Set to Zero (no O<sub>3</sub>)

BMT MESSTECHNIK, BERLIN    phone ++ 49 30 - 801 85 95    fax ++ 49 30 - 802 23 62  
 OSTI, MONTEREY, CA    phone ++ 1 - 831 - 6491141    fax ++ 1 - 831 - 6491151

### Binary Input

The binary input is used to trigger the ZERO function of the OZONE ANALYZER BMT 964. By applying a voltage of typ. +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. 18 mA. The input is protected against voltages with wrong polarity.

## Binary Outputs

Pin	Function	Description	see page
9	Lamp Low	Opens when the lamp becomes too weak	25
12	High Alarm	Opens or closes if concentration is above a certain threshold	25
13	Low Alarm	Opens or closes if concentration is below a certain threshold	25
14	Cuvette Dirty	Opens when a dirty cuvette is detected	26
2	Purge	Contact for external pump / solenoid valve	23

The binary outputs are relay contacts, which are used to signal errors and alarms. An additional contact is 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:

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). 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  $\equiv$  closed if there is no error), see page 25 for more details on error handling. The contact may be loaded with 30V/1A. The error output is isolated to the binary outputs mentioned above.

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 stopbit, no parity (8N1). See page 19 for configuration of the interface.

## 5 Switching On the Instrument

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

BMT964 VX.XX

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

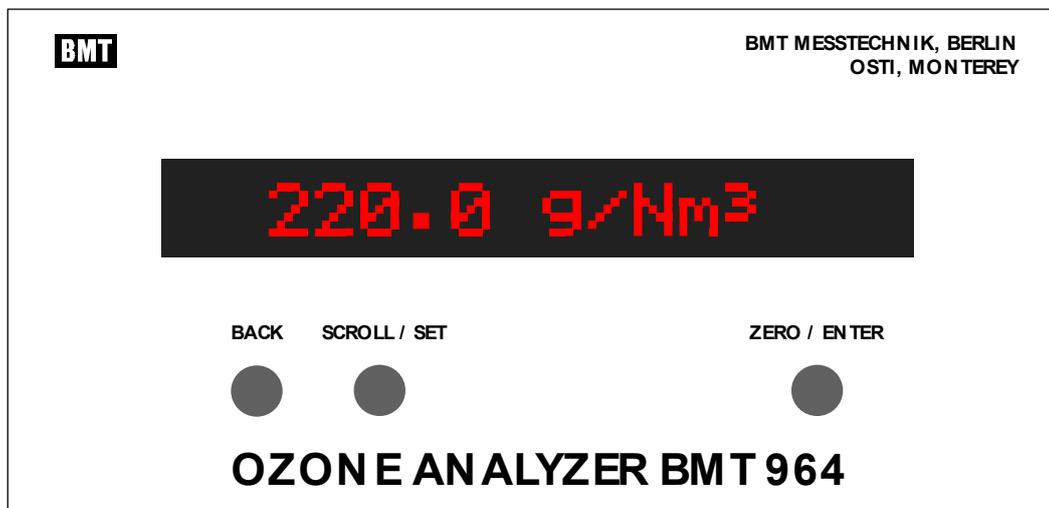
R: 200 g/Nm<sup>3</sup>

PR: 2.5 bar

This display is followed by a warmup period, the length of which is being determined by the state of the lamp. During warmup the Error Relay is switched to error. All other relay contacts are open. The analog outputs put out 10 V and 20 mA respectively. The serial interface (see page 19) puts out max. concentration, actual pressure and the code for the warmup-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. During this time the front panel keys and the zero-input are deactivated.

## 6 Front Panel Operation

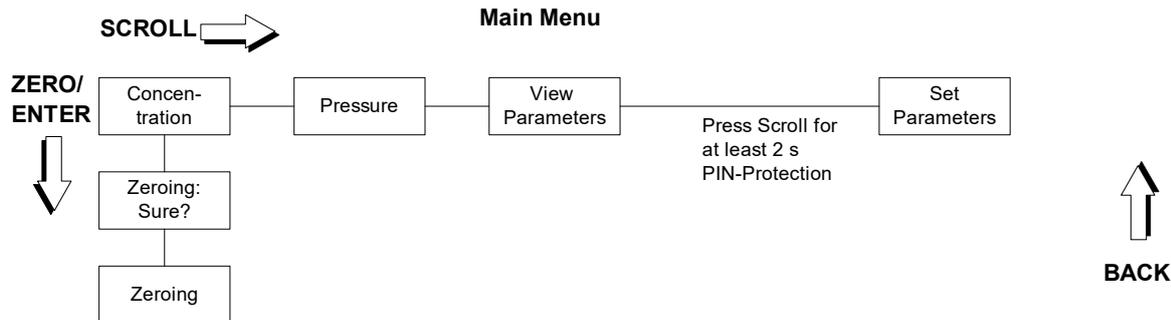
The front panel consists of a 16-character alphanumeric display (LCD with red backlight illumination) and three pushbuttons. The display will be updated every 0.3 s.



The pushbuttons can be used to perform the following operations:

- Switch to pressure display
- Zero the BMT 964
- View parameters
- Change the parameters

The following diagram shows the functions of the 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**).

**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 964 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

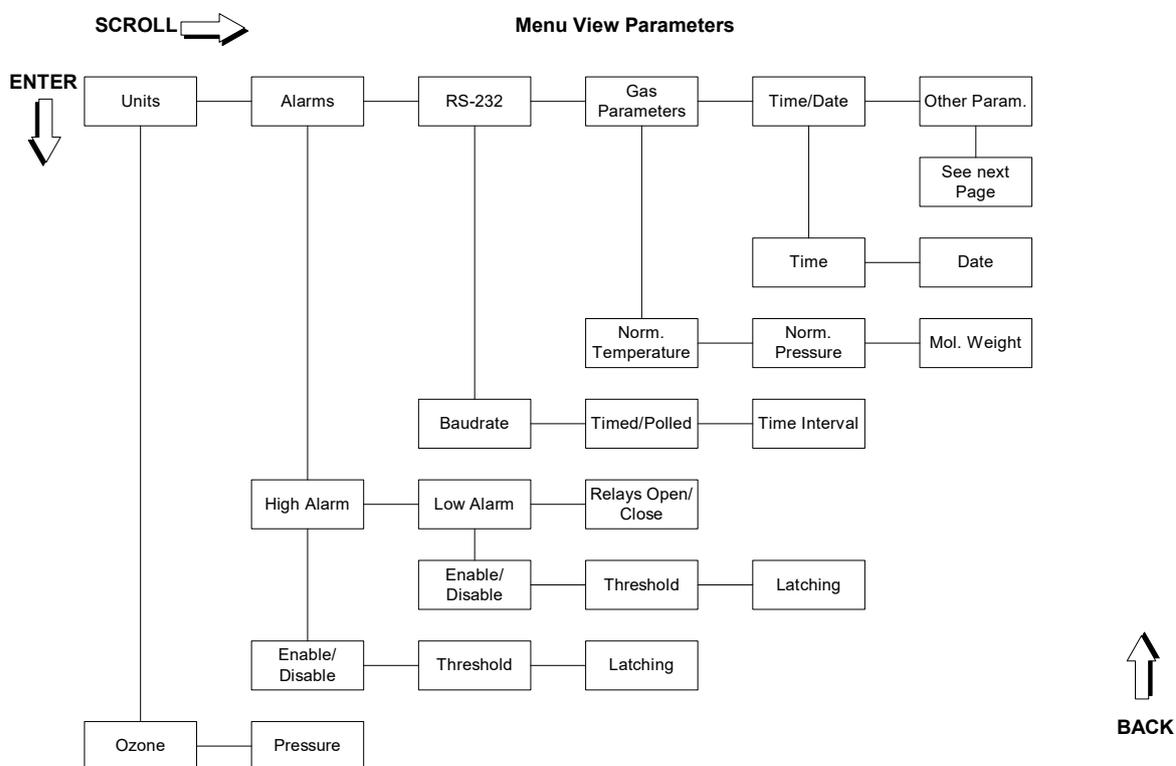
If ozone concentration is shown on the display and the ZERO button is pushed, the instrument displays the question:

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 964 can be found on page 23.

## The Menu View Parameters

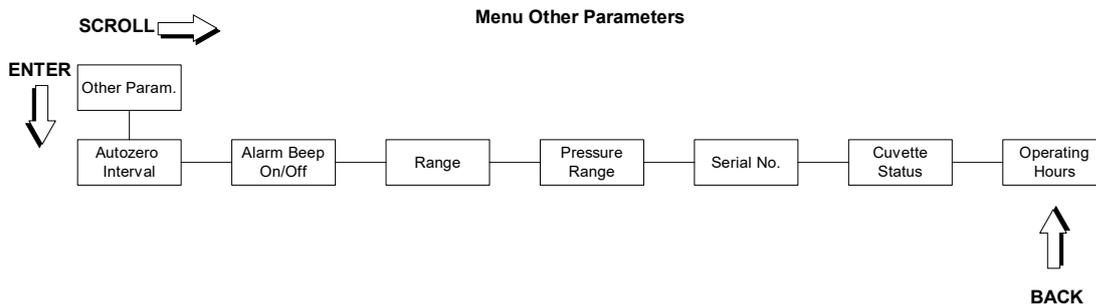
In the menu **View Parameters** the configuration of the BMT 964 can be viewed, but it cannot be changed.



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: air or oxygen (incl. PSA oxygen)
- Time / Date

The meaning of these parameters is explained in greater detail on the following pages. An additional point in the menu **View Parameters** is **Other Parameters**:

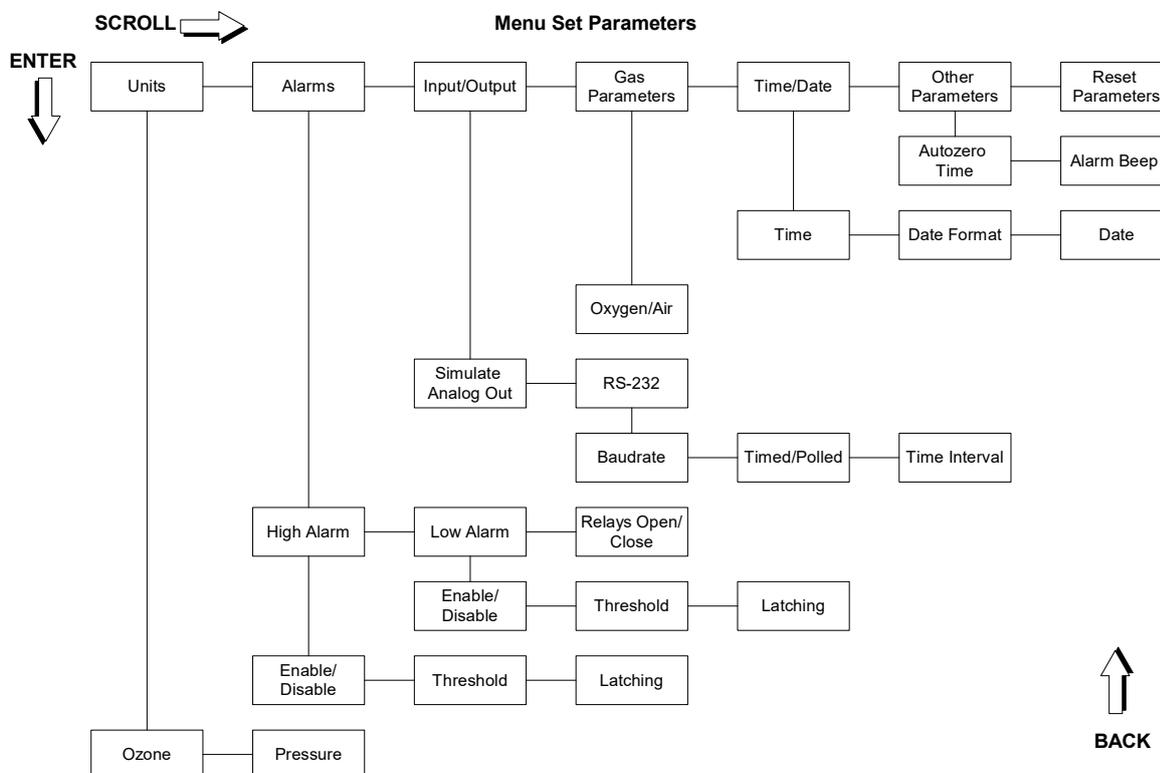


**Autozero Interval** and **Alarm Beep On/Off** are also explained on page 20. The other elements of the menu cannot be changed.

Explanations:

- **Range:** max. ozone concentration
- **Pressure Range:** max. pressure
- **Serial No.:** the serial number
- **Cuvette Status:** shows dirtyness of the cuvette in %
- **Operating Hours:** since calibration

### The Menu Set Parameters



**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 964 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<sup>3</sup> to %wt/wt:

Button	Display
	0.0 g/Nm <sup>3</sup>
SCROLL	1.013 bar
SCROLL	View Parameters
SCROLL (>2 s)	Set Parameters
ENTER	Set Units
ENTER	Set Ozone Unit
ENTER	Ozone: g/Nm <sup>3</sup>
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<sup>3</sup> to 90 g/Nm<sup>3</sup>.

Button	Display
	0.00 g/Nm <sup>3</sup>
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 <sup>3</sup>
ENTER	Hi:075.0 g/Nm <sup>3</sup>
SET	Hi:085.0 g/Nm <sup>3</sup>
SET	Hi:095.0 g/Nm <sup>3</sup>
ENTER	Hi:095.0 g/Nm <sup>3</sup>
SET	Hi:096.0 g/Nm <sup>3</sup>
SET	Hi:097.0 g/Nm <sup>3</sup>
SET	Hi:098.0 g/Nm <sup>3</sup>
SET	Hi:099.0 g/Nm <sup>3</sup>
SET	Hi:090.0 g/Nm <sup>3</sup>
ENTER	Hi:090.0 g/Nm <sup>3</sup>
ENTER	Saving...
	Hi:090.0 g/Nm <sup>3</sup>
BACK	Set Hi-Threshold
BACK	Set High Alarm
BACK	Set Alarms
BACK	Set Parameters
BACK	0.00 g/Nm <sup>3</sup>

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<sup>3</sup>
- % wt/wt
- ppm<sub>v</sub>
- g/m<sup>3</sup> (AQ)
- ppm (AQ)

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

g/Nm <sup>3</sup>	% wt/wt	ppm <sub>v</sub>	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

<b>g/Nm<sup>3</sup></b>	<b>% wt/wt</b>	<b>ppm<sub>v</sub></b>	<b>Range-ID</b>
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<sup>3</sup> and ppm<sub>v</sub> on one side and %wt/wt on the other side. Also, the full range concentrations are not exactly the same upon switching, as the range limits are rounded values.

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 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:

<b>bar</b>	<b>psi</b>	<b>Torr</b>	<b>MPa</b>
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 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 Closing, the High-Alarm-Relay closes (default), otherwise it opens. 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 key, 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 mentioned 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 Closing, the Low-Alarm-Relay closes (default), otherwise it opens. 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 key, 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 mentioned 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 Closing (default) leads to closing 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 964 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 10.

## Gas Parameters

**Warning:** A change of this parameter will influence measurement results!

### Molecular Weight

When using the BMT 964 it is important to give the instrument information about the carrier gas. Two different carrier gases can be chosen:

- Oxygen, or oxygen from PSA, molecular weight 31.9988
- Air (molecular weight 29.0)

If the customer does not specify a particular molecular weight when ordering, it will be set to oxygen.

## 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) 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 e.g. to enter the date 29.02.01. In order to make this test possible, first the year, then the month and then the day has to be set.

## Other Parameters

### Autozero Interval

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

**Caution:** 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 23).

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 or the binary input will reset the interval timer.

### Alarm Beep

If this item is set to Enabled, the BMT 964 emits an acoustic signal during Low- or High-Alarms. This beeper may be stopped using the BACK button, if the front panel menu is on its basic level.

## 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 <sup>3</sup>
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

Normalizing Temperature	273.15 K
Normalizing Pressure	1.01325 bar
Molecular weight of carrier gas	Oxygen
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 Relais closing	Yes

## 7 The Serial Interface

The BMT 964 has a bidirectional serial interface. 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 p. 19). In case Polled is set, the BMT 964 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:

```
26.03.01,12:16:28,154.3 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 warmup the range is put out here (max. ozone concentration)
- Pressure inside the cuvette incl. unit, depending on **Units-Pressure**
- Dirtyness of the cuvette in percent (during zeroing this is filled with AAAA)
- 16-Bit status information coded hexadecimally

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 964 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.
- Word: Range 0 .. 65535
- Long: Range 0 .. 99999999
- Float: Range -9999999 .. 99999999 (floating point number as e.g. 1.234567, max. 8 characters including the decimal point)

It is very important to wait for confirmation from the BMT 964 once a command is sent. Link-Mode is started by sending the following command:

\*0#DL4EBY

The BMT 964 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 964 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 to the BMT 964. 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 964 is connected to a programmable component (a PC or a PLC) care has to be taken that the program does not reconfigure the BMT 964 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.

A detailed description of Link-Mode commands can be found in Appendix A.

## 8 Zeroing the BMT 964

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
- aging of the UV-lamp
- influence of temperature

In order to compensate these effects BMT MESSTECHNIK recommends zeroing the BMT 964 every 24 hours. Depending on the demands on accuracy and 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 964 has to be purged with oxygen or filtered air.

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 964 internal timer (see page 23)
- via the serial interface in Link-Mode by sending the command \*83#3.14159
- from a Windows-PC by using the program BMT 964 Link

The display will show information about zeroing. In each zero cycle the dirtytness of the cuvette is determined. This value is displayed on the front panel and sent via the serial interface. Increased dirtytness will lead to a Dirty Warning or a Dirty Error respectively (see page 26).

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 dirtytness, the string 'AAAA'.

### Automatic Zeroing with Control of Purge Gas

Purge gas control can be taken over by the BMT 964. The relay contact Purge (Pin 2) is used for this purpose. This contact (max. 28V, 0.5A) can switch e.g. a BMT Purge Unit PUDC2, which consists of a solenoid valve and a small air pump with dust filter. An external 24 VDC power supply is necessary to power the PUDC2. Alternatively, the instrument can be ordered with a built-in Internal Purge Unit. In both cases the parameter **Autozero 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 964 Link or the Link-Mode command \*45#). Automatic zeroing will be activated after this

time interval. Additional automatic zero cycles can be initiated within this interval, which reset the built in Zero-Timer.

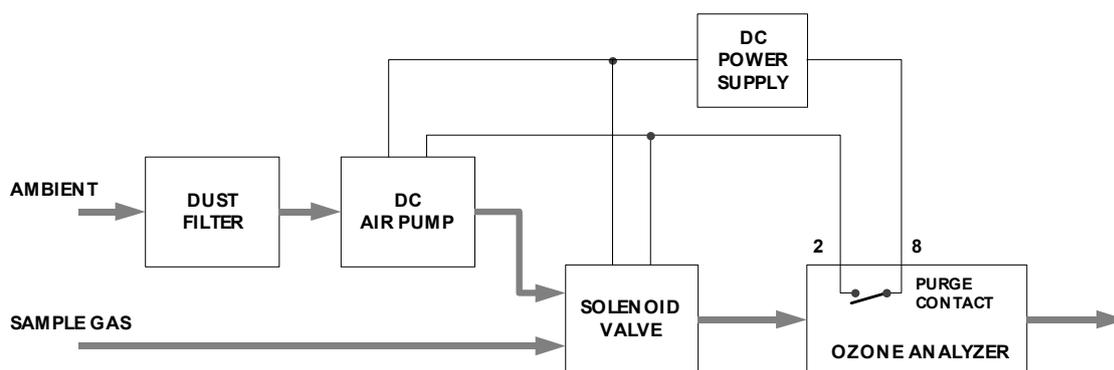
In case **Autozero Interval** is set higher than zero (1 to 99h), there will be an additional automatic zero cycle approx. 15 minutes after each power up. Also, the purge contact is activated on each zeroing cycle (only if Autozero Interval > 0h).

**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.

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 dirtyness)
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 the User Mode the RS-232 transmits the same concentration, and 'AAAA' instead of the cuvette's dirtyness.



The above setup shows the components needed for automatic zeroing. It is very important to provide automatic switching of purge gas, before the Autozero Interval is set to other values than zero hours! Otherwise, the instrument could possibly calculate the zero value with ozone in the cuvette. The Autozero Interval is described on page 20.

It should be pointed out, that setting the Autozero Interval to zero hours actually means, that the analyzer 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 analyzer takes care about switching to zero gas, itself.

In case the OZONE ANALYZER BMT 964 is equipped with an Internal Purge Unit (solenoid valve and air pump with particle filter) as an option, e.g. in the model BMT 964 BT (see Appendix B) the terminal 2 may not be connected externally because it is already connected to the internal 5 VDC power supply!

## 9 Use of the Limit-Alarms

The BMT 964 supplies two Limit-Alarms. These alarms are given if concentration rises above (High Alarm) or falls below (Low Alarm) a certain threshold level. On every triggering of an alarm, the corresponding contact of its Alarm Relay opens or closes (Pin 12, Pin 13). By default, the relays close. This can be changed with the parameter **Relays Open/Close**. If **Alarm Beep** is activated, an acoustic signal will be sent out with the alarm. Alarm activation and alarm clearing are documented with time and date in the Event-Log.

To enable an alarm, its parameter **Threshold** has to be set to a valid alarm threshold and **Enable/Disable** has to be set to Enabled. The Low-Alarm threshold always has to be below the High-Alarm threshold.

Both alarms are equipped with a hysteresis, which means that during a High Alarm ozone concentration has to fall 0.2 % of range below the threshold, before the alarm is cleared. Similarly a Low-Alarm will only be cleared, when concentration rises 0.2 % of range above the threshold.

If an alarm will be cleared also depends on the setting of **Latching**: if set the alarm will continue, also if the triggering condition (too high or too low concentration) does not exist anymore. The alarm can be cleared by pressing the button ENTER. To only stop the beeper without clearing the alarm, the BACK key may be used in case the menu on the front panel is on its basic level.

## 10 Error Handling and Early Warnings

The BMT 964 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, see chapter 4: Output and Control Terminals) 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 key 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. 10) and are documented in the Error-Log. 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 any more. 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.

### 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).

**Caution:** 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 MESSTECHNIK GMBH.

### Cuvette Dirty Warning

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

```
Warn: Cuv. Dirty
```

is displayed between measurement results, as soon as dirtyness 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 dirtyness 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, which is also shown on the front panel during warmup. 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 position.

## Overrange

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

Err: Overrange

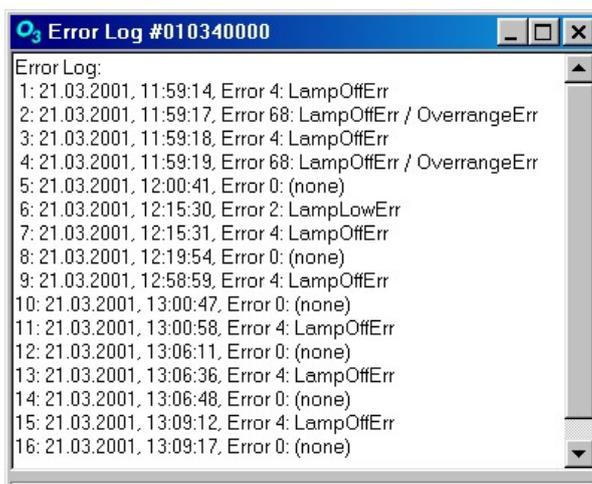
and ozone concentration range is shown. The Error Relay is set to error. The analog outputs are on their maximum values.

## EEPROMError

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.

## 11 Event- and Error-Log

These two logs are stored by the BMT 964 and document important events and errors. The last 48 events and the last 16 errors are stored, which means that the oldest entries are overwritten when new entries are stored. Both logs are read out via the serial interface. For this purpose the program BMT 964 Link or the Link-Mode command \*49# respectively \*50# can be used. Each entry in these logs has a time stamp, which means that date and time are recorded with a resolution of 1s. The user is responsible for setting the internal clock. Life expectancy of the battery is 10 years or more. An empty battery will only result in erroneous time stamps in the logs.



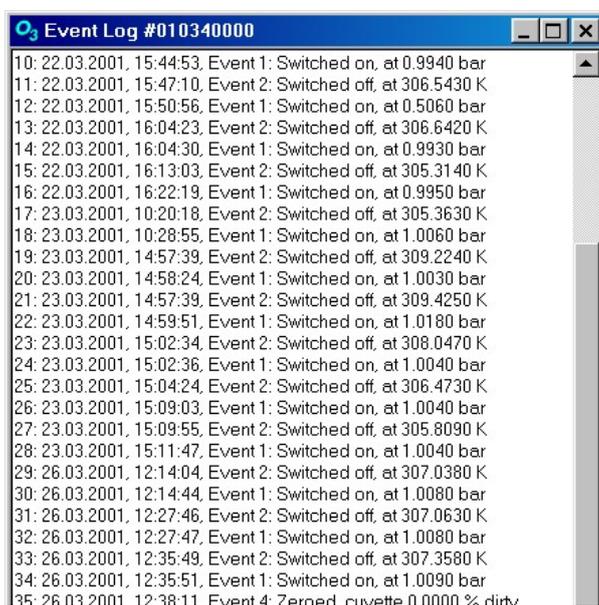
The Error-Log documents all errors described in chapter Error Handling with date and time. The above picture is a view of the Error-Log in the program BMT 964 Link.

In order to create errors for this example the UV-lamp was switched on and off several times.

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

- Switching on of the BMT 964, cuvette pressure at this time
- Switching off of the BMT 964, temperature at next switching on
- Zeroing, dirtyness of cuvette in % (if changed more than 1 % from last EventLog record)
- High Alarm, High Alarm Limit
- High Alarm cleared, High Alarm Limit
- Low Alarm, Low Alarm Limit
- Low Alarm cleared, Low Alarm Limit

The next picture shows an Event-Log example as displayed by the program BMT 964 Link:



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

## 12 The Program BMT 964 Link

On the CD which is delivered with the instrument you will find the Windows program BMT 964 Link. It has been designed for Windows 95/98/ME/NT/2000/XP/Vista/7 & 8. 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 CD for further information.

The instrument's serial interface has to be connected to one of the serial ports of a PC via a normal RS-232 cable (max. length 10 m) as delivered with the analyser. The configuration of the communication parameters (Link Baud rate etc.) is set automatically.

Among other features, the software allows:

- simple configuration of all parameters of the BMT 964. With a few mouse clicks you can view respectively change e.g. the units of ozone concentration and pressure, alarm parame-

ters, 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.
- recording (logging) of selectable measurement results or parameters (e.g. cuvette dirtyness) in a file on a PC.
- view and printout of all internal system data (e.g. raw data from the A/D-converter, hours running).

The main screen shows the basic measurement of the ozone content, the pressure measured internally for compensation and cuvette status. From the View menu, you may choose the Parameter window, which shows all 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 analyzer, and set the time according the local time in your area. This is the time used in the Error- and Event Log (built-in clock of the BMT 964).

Also in the main menu, you'll find a Monitor window, designed to be enlarged so that you may view the measurements from 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 program itself, e.g. the COM port parameters. It also lets you switch on or off the Logger function, which is used to log measurement data every few seconds into a file.

On some screens, you'll find a print function for two different printouts, one summarizing the settings and measurement for documentation, one for troubleshooting by BMT. Both should be faxed 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 964 onto your PC and load it again at a later time. This helps configuring all analyzers the same in different installations of one project.

For a more detailed description of the software, please refer to the helpfile (bmt964.chm, to be opened with F1 within the program or double click in the Windows Explorer).

## 13 Maintenance

Maintenance is limited to a regular check of the sample gas input filter. The pure white material easily displays any dirt (except it is white). An Allen wrench 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 26), the cuvette should be cleaned. We recommend to send in the analyzer to the manufacturer or representatives (see chapter Troubleshooting).

**Warning:** The cuvette may 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 25) 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.

## 14 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 964 Link** in order to locate possible sources of error. The logging capabilities of the software can also be used to detect randomly occurring errors.

In case the BMT 964 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:

<input type="checkbox"/> The products have not been exposed to any hazardous substance at any time
<input type="checkbox"/> The products have been completely decontaminated and contain no residual hazardous substances
<input type="checkbox"/> The remaining contamination is not unhealthy, toxic, carcinogenic, radioactive, microbiologic, explosive, corrosive or caustic, it is harmless <b>and contains</b> (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:

<input type="checkbox"/> Liquid Oxygen	<input type="checkbox"/> bottled Oxygen	<input type="checkbox"/> PSA, VPSA	<input type="checkbox"/> dry air	<input type="checkbox"/> don't know
<input type="checkbox"/> N2 or other gas added for performance	<input type="checkbox"/> analyser does not measure generator output			

### Service: Checklist

<input type="checkbox"/> fill out and sign above Hazardous Material Certification		
by all means include in all paperwork accompanying your shipment:		
<input type="checkbox"/> your contact details: delivery & invoicing address, phone number, EMail address		
<input type="checkbox"/> serial number of the instrument		
<input type="checkbox"/> reason for return:		
<input type="checkbox"/> ship to one of the following addresses:	BMT MESSTECHNIK GmbH Attn: Klaus Tiedemann 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
<u>For North America, Central America, Pacific Rim:</u>	OSTI Inc. 1110 Elkton Drive, Suite F, Colorado Springs, CO 80907, USA	www.osti-inc.com service@osti-inc.com Tel. +1-831-649-1141 Fax +1-831-649-1151

## 15 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 <sup>3</sup> , selectable units %wt/wt & ppm <sub>v</sub>
optional ranges	2, 5, 10, 20 g/Nm <sup>3</sup> , selectable units %wt/wt and ppm <sub>v</sub>
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	0.03 s (analog output), 0.3 s (display)
zero drift	typ. 0.2 % of range per day, after warm-up, non-cumulative
proof pressure	1 bar above pressure range
ambient temperature	0 - 50°C (non-condensing)
materials in contact with ozone	quartz (cuvette windows), Al <sub>2</sub> O <sub>3</sub> (cuvette), FPM (window seals), PTFE (tubing), stainless steel (fittings, cuvette spacer)
gas ports	for PTFE tubing 3 x 5 mm (1/8" x 3/16"), opt. 1/8" or 1/4" Swagelok, or 4 x 6 mm PTFE. Built-in sample gas filter is standard
recommended flow rate	0.1 to 1 l/min typical
pressure drop	approx. 3 mbar at 0.5 l/min (with sample gas filter)
temperature compens.	is standard
pressure compensation	for ozone measurement at an arbitrary systemic pressure, with built-in cuvette pressure transducer, abs. pressure ranges 1.15 (optional up to 4.0 bara in steps of 0.5) 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 V, 18 mA, isolated)
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, 1 A, summarizing instrument failures. Warnings and errors: Lamp Low Warning, Lamp Low Error, Lamp Off Error, Cuvette Dirty Warning, Cuvette Dirty Error, Overrange, Overpressure
serial interface	RS-232, bidirectional, 2400 - 38400 Baud, isolated (RS-232 GND connected to analog GND)
automatic zeroing	with opt. external or internal purge pump and solenoid valve (e.g. BMT Purge Unit)
software	BMT 964 Link, instrument configuration and readout of Event- and Error 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 43 700 (ranges 2 and 5g/Nm <sup>3</sup> : 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. Commands with question-marks retrieve information from the BMT 964.

**Caution:** This set of commands should only be used by programmers who have a good understanding of the BMT 964 and ozone measurement in general!

Cmd	Meaning	PC->964	964->PC
0	Start Link-Mode	*0#DL4EBY	*0#DL7ZN
2	Ozone Range and Unit? byte1: Range-ID (see table on page 16) byte2: Unit 0: g/Nm <sup>3</sup> 1: %wt/wt 2: ppm <sub>v</sub> 3: g/m <sup>3</sup> (without pressure and temperature compensation) 4: ppm	*2#	*2#byte1, byte2
3	Set ozone unit Meaning of byte: 0: g/Nm <sup>3</sup> 1: %wt/wt 2: ppm <sub>v</sub> 3: g/m <sup>3</sup> 4: ppm	*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#long
9	Concentration? float: Concentration byte: Unit: 0: g/Nm <sup>3</sup> 1: %wt/wt 2: ppm <sub>v</sub> 3: g/m <sup>3</sup> 4: ppm	*9#	*9#float,byte

Cmd	Meaning	PC->964	964->PC
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#long
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 (High Limit > Low Limit!) (first retrieve concentration unit)	*15#float	*15#
16	Set Low Alarm Limit (High Limit > Low Limit!) (first retrieve concentration unit)	*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
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
25	Molecular weight of carrier gas? byte: 0: Oxygen : 31.9988 g/mol 1: Air: 29.0 g/mol	*25#	*25#byte
29	Time? hh,mm,ss	*29#	*29#byte,byte, byte

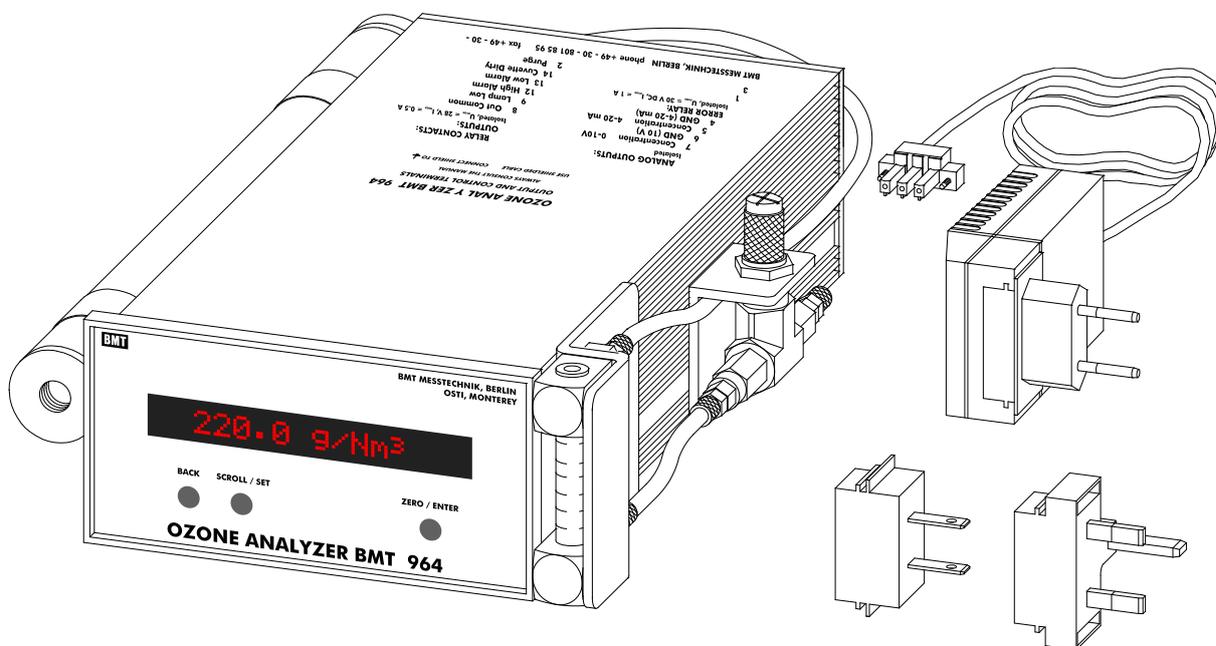
Cmd	Meaning	PC->964	964->PC
30	Set Hour	*30#byte	*30#
31	Set Minute	*31#byte	*31#
32	Set Second	*32#byte	*32#
33	Date Format? 0: DD.MM.YY 1: MM/DD/YY	*33#	*33#byte
34	Set Date Format 0: DD.MM.YY 1: MM/DD/YY	*34#byte	*34#
35	Date? DD,MM,YY	*35#	*35#byte,byte,byte
36	Set Day	*36#byte	*36#
37	Set Month	*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 (wenn 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 wenn 0: no Autozero	*44#	*44#byte
45	Set Autozero Interval byte: hours if 0: no Autozero	*45#byte	*45#
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
49	Send Error Log (max. 16 Entries) Format: YY,MM,DD,HH,MM,SS,Error Error has the same format as described in table on page 21	*49#	*49#byte1, byte2,byte3, byte4,byte5, byte6,word#...

Cmd	Meaning	PC->964	964->PC		
50	Send Event Log (max. 48 Entries) Format: YY,MM, DD,HH,MM,SS, byte 7 /additional float:	*50#	*50#byte1, byte2,byte3, byte4,byte5, byte6,byte7, float # byte1,...		
	<b>7-Bits</b>			<b>Meaning</b>	<b>float Parameter</b>
	0			Switched on	pressure [bar]
	1			switched off	Temperature when switched on [K]
	2			Zeroed	Dirty (0 – 100 %)
	3			High Alarm	High Alarm Limit
4	Low Alarm	Low Alarm Limit			
83	Trigger Zero (Parameter for security) float: Dirty If Autozero Interval > 0 ist, this command will take about 20 s	*83#3.14159	*83#float		
85	Firmware-Version?	*85#	*85#float		
86	Status (decimally coded, as decribed in table on page 21):	*86#	*86#word		
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#word (0..9999)	*99#		
160	Set Purge Time byte: Seconds (10..100s)	*160#byte	*160#		
161	Get Purge Time byte: Seconds	*161#	*161#byte		

## Appendix B: Bench Top Version BMT 964 BT

### General Description

The OZONE ANALYZER BMT 964 BT is the portable version of the standard BMT 964. The instrument is not much bigger than the standard BMT 964. 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 3 x 5 mm (1/8" x 3/16") PTFE tubing, and then via the flow meter enters the BMT 964 through a sample gas filter with a replaceable white filter insert. Upon exiting the analyzer, the sample gas passes through the Catalyzing Cartridge where the ozone is destroyed.

### Operation

The operation of the BMT 964 BT is the same as of the standard BMT 964. Care must be taken using the Catalyzing Cartridge, which may never see water or humidity. This might damage the catalyzing material. The sample gas filter can only keep dirt from entering the analyser, not humidity.

As an option the OZONE ANALYZER BMT 964 BT may be ordered equipped with the Internal Purge Unit, 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 23. 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.

**Attention:** If the analyser is equipped with the Internal Purge Unit, terminal 2 of the green signal connector must not be connected externally because it is already connected to the internal 5 VDC power supply!

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

**Note:** Setting the Autozero Interval to zero hours means, that the analyzer 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 964 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 PTFE connecting tubing.

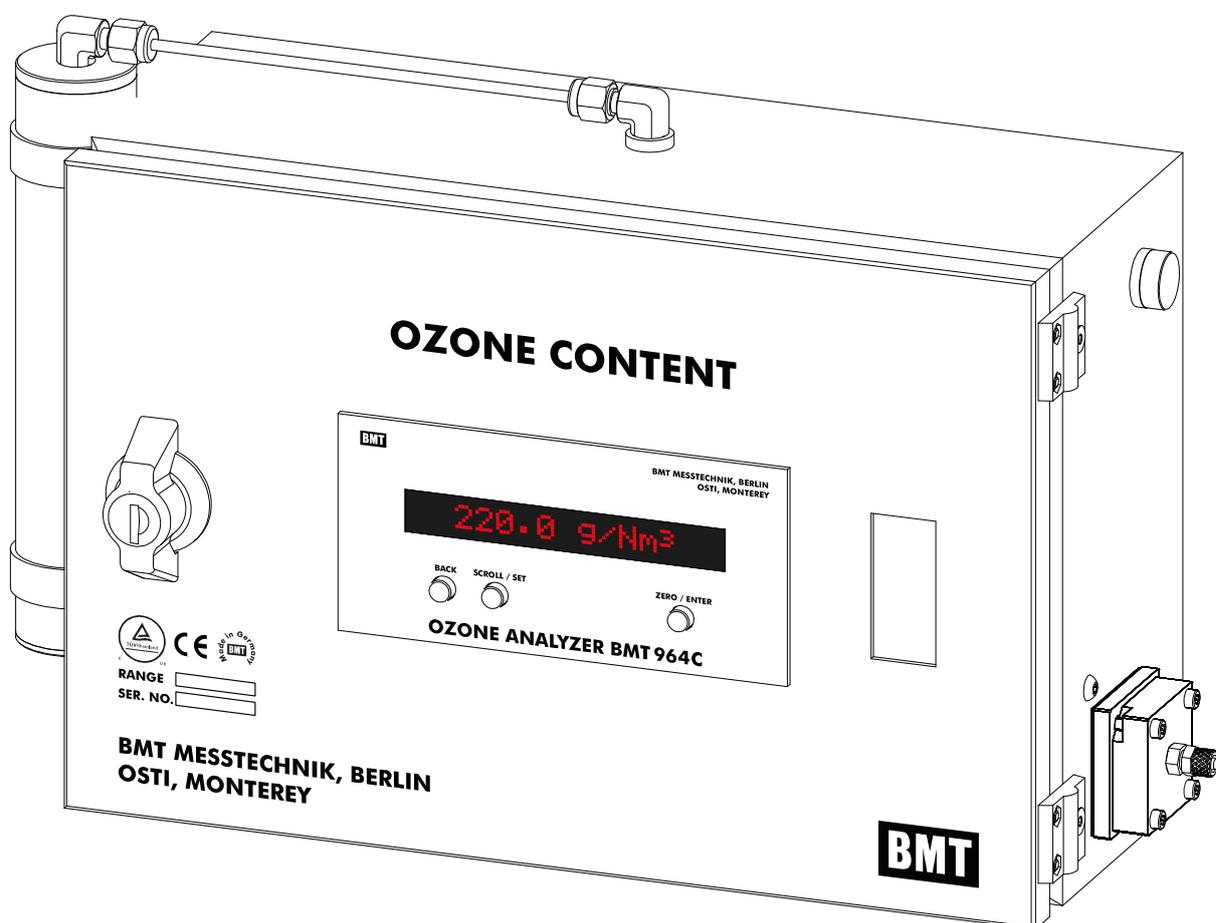
## Appendix C: Cabinet Version BMT 964C

### General description

The OZONE ANALYZER BMT 964C (cabinet version) is housed in a splash-proof IP 65 (NEMA 4X) aluminum cabinet, and 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 automatic purge 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 23).

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 analyzer, 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 240 x 225 mm).

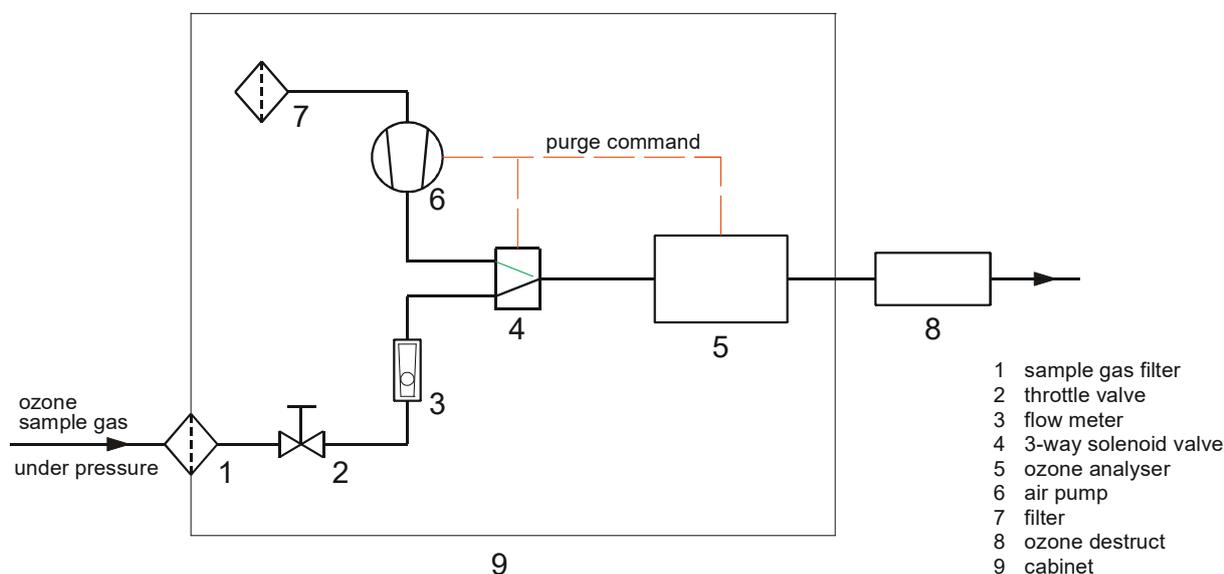
For sample gas connection 3 x 5 mm PTFE (or 1/8" x 3/16" FEP) tubing should be used, which will be supplied on request.

**Warning:** Do not apply more than 2.5 barg gas pressure to the instrument!

The Cabinet is also available with 1/8" or 1/4" compression fittings at the sample gas inlet. The catalyzing cartridge CAT-35 provides a G 1/8 thread (BSPP 1/8") at the outlet. The power and signal connectors are waterproof.

The built-in purge unit enables the processor to automatically zero the instrument. The purge contact is used internally to control the valve and the pump. This purge unit is only activated with Autozero Interval > 0h. The contact is not available externally.

Automatic zeroing may be initiated in different ways. For a detailed description, see chapter Zeroing. After approximately 15 minutes of warmup the first Auto Zero cycle is initiated. After



every purge interval, the processor starts a zeroing cycle. See page 23 on how to change the purge 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 12 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 26). Deactivating the valve and pump allows the ozone gas 12 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 tubing 1/4" x 5/32"(or 4 x 6 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 installation of a stop cock or a 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 with nitrogen doping). For replacement order "REFILL".

### Operation

The operation of the BMT 964 C is the same as of the standard BMT 964, see chapters 1 to 14!

**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 0.8 l/min, 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.

If the Autozero 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 23.

**Note:** Setting the Autozero Interval to zero hours also means, that the analyzer 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 a purge interval of 24 hours.

### Maintenance

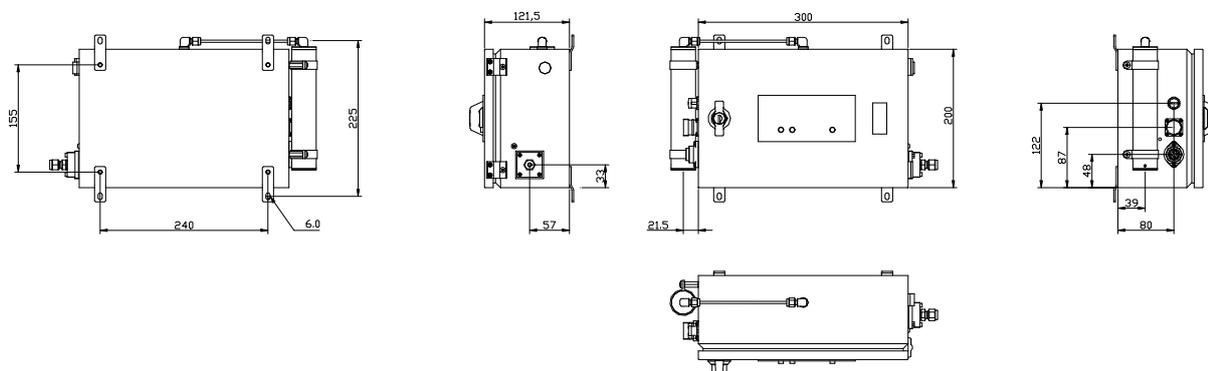
The only maintenance recommended is checkig the sample gas filter insert on a regular basis. The insert of pure white material easily shows most kind of dirt, except if the dirt is white.

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

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

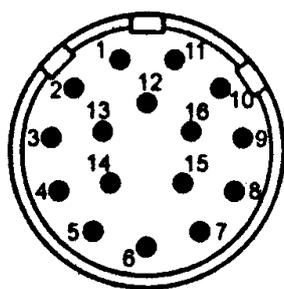
## Dimensions

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



## Electric connections:

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		not connected	
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	

RS-232 connector:

1	Cable Shield
2	TxD (from BMT 964 C)
3	RxD (to BMT 964 C)
4	Signal GND (= analog GND)



(screw terminal side)

Mains connector:

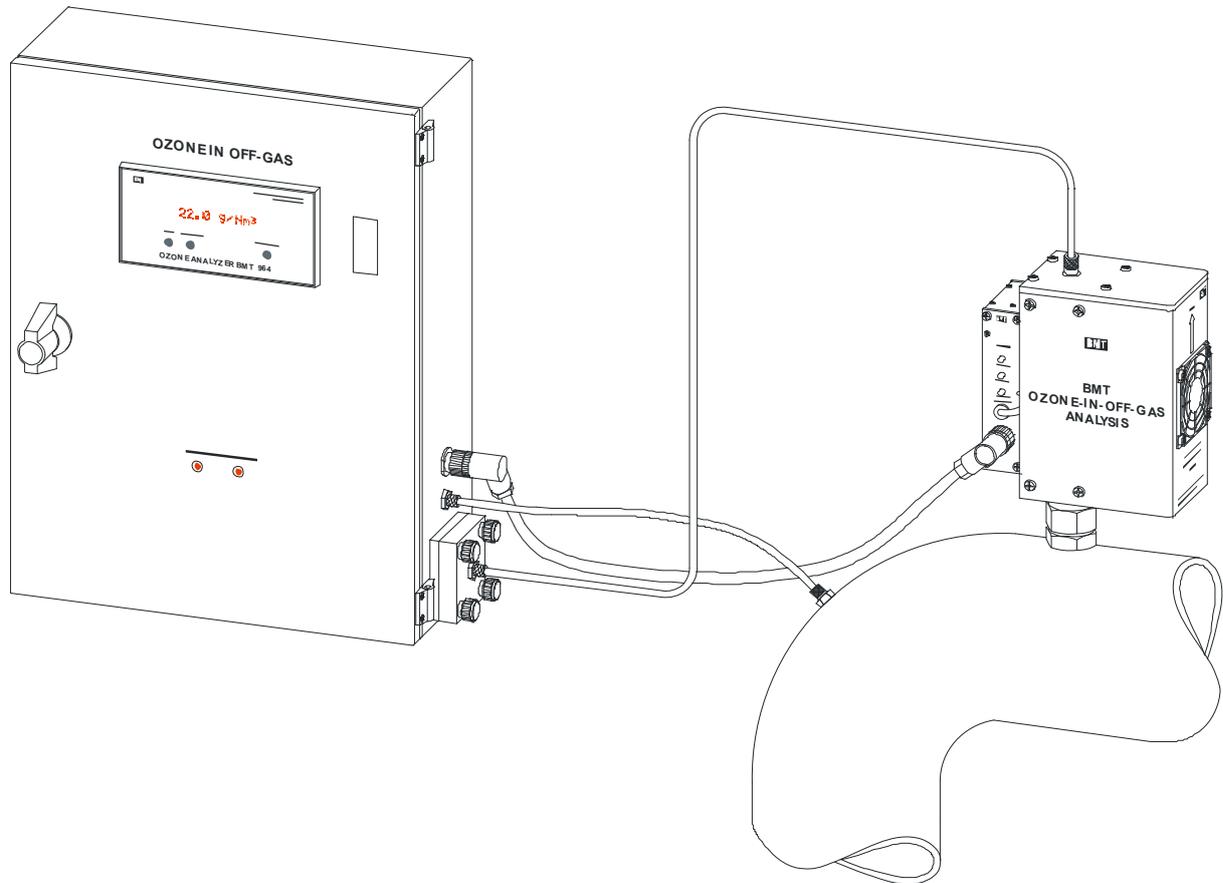
1	mains	} (100 bis 240 VAC, 50/60 Hz, 35 VA)
2	mains	
3	(free)	
⏚	Protective Ground	

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

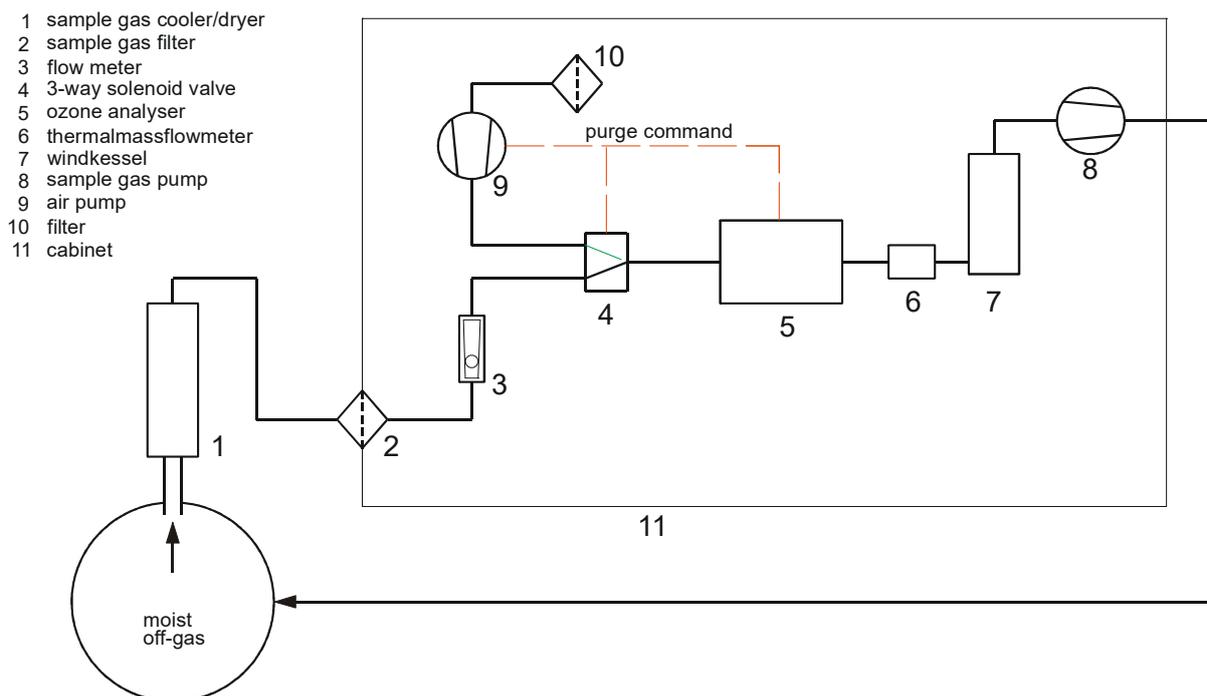
**Note:** The signal connector pinout of the BMT 964 C is different to the pinout of the standard instrument BMT 964! Also, the purge contact (Pin 9) is not connected, as it is used internally.

## Appendix D: OZONE-IN-OFF-GAS System

### General Overview



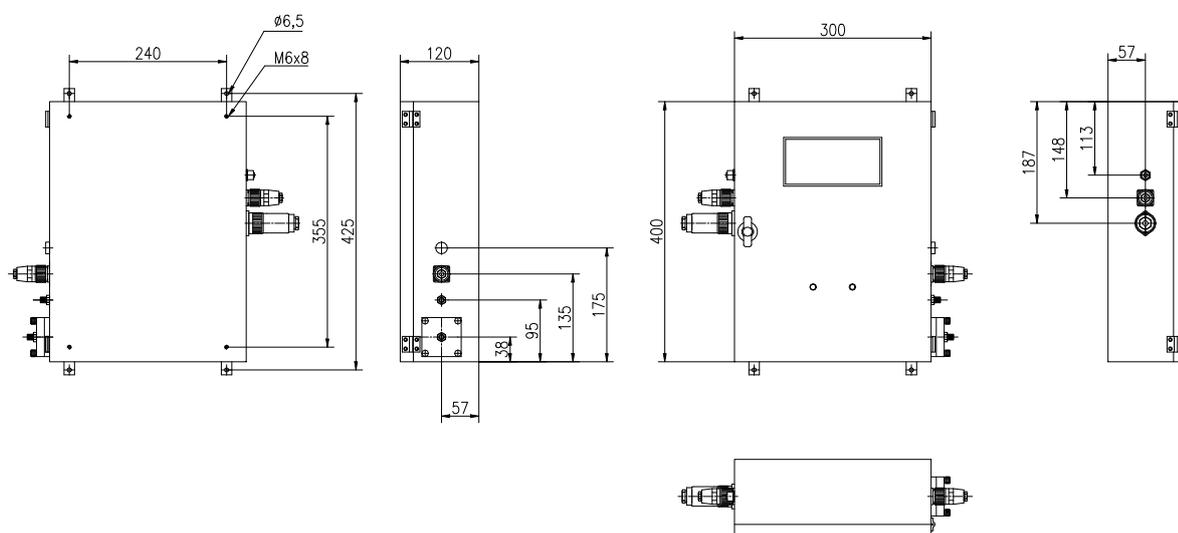
The BMT OZONE-IN-OFF-GAS System is an ozone analysing system for moist off-gases, housed in a splash-proof IP 65 (NEMA 4X) aluminum cabinet. It consists of the Off-Gas Cabinet BMT 964OG, and the separate Peltier-electric cooler/dryer DH5.



The Off-Gas Cabinet contains an OZONE ANALYZER BMT 964, the ozone resistant sample gas pump SGP 5, and the DH5 power supply, in a wall mounted aluminum cabinet, 300 x 400 x 120 cm (W x H x D, twice the height of the standard BMT 964C cabinet). The cooler/dryer DH5 is mounted upright on top of the reaction vessel, or in a large diameter off-gas tube.

### Off-Gas Cabinet BMT 964OG

As the standard configuration the cabinet contains the UV photometric ozone analyser, a long-life ozone resistant sample gas pump, the power supply for the external Peltier-electric cooler/dryer DH5, a purge unit (solenoid valve/air pump assembly) 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 (WARM).



Ozone off-gas leaving an ozone process is not always at atmospheric pressure. Sometimes it is at an elevated pressure, and transport of the sample gas to the ozone analyser does not need a pump. Sometimes the off-gas is not moist, and does not need drying. Consequently the configuration of the off-gas measuring system may be different from case to case.

### Sample Gas Pump SGP 5

The sample gas pump SGP 5 is a membrane pump driven by a brushless DC motor. Life expectancy of pump and motor is several years.

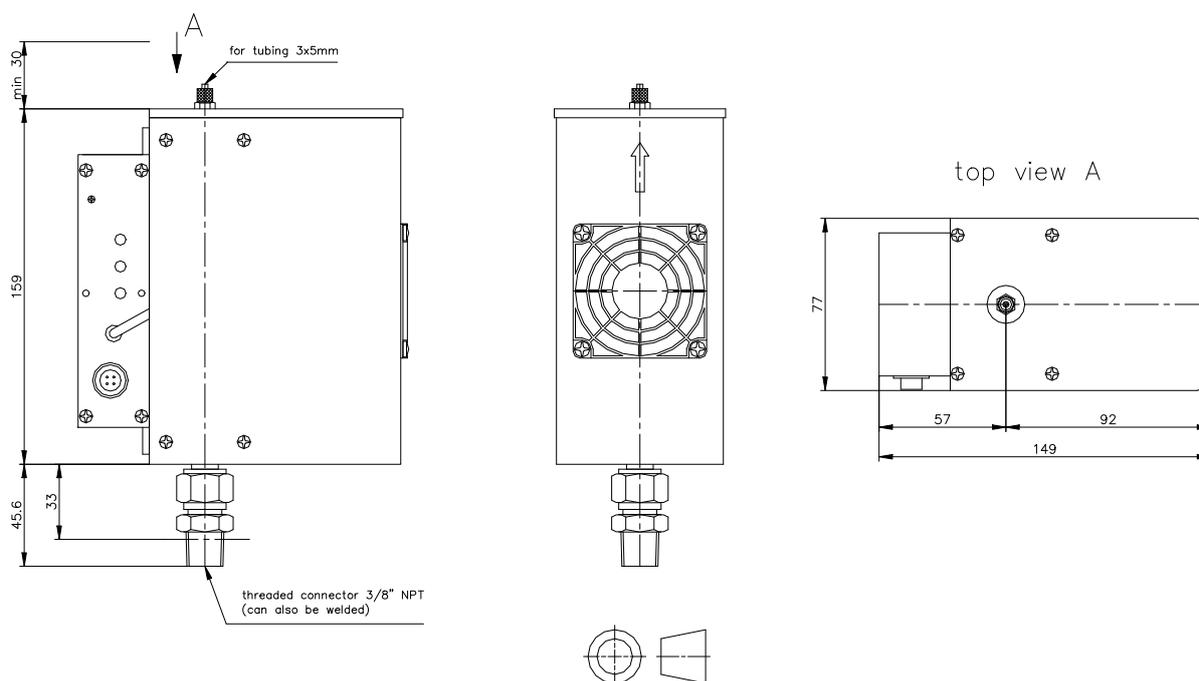
The SGP 5 may be operated at a maximal system pressure of  $\pm 100$  mbar. In other words: The internal pressure may not differ from the ambient pressure by more than 100 mbar. Against zero pressure head (differential pressure) the pump moves about 0.5 l/min. At a pressure head of 100 mbar it still 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 barg gas pressure to the instrument!

## Sample Gas Cooler/Dryer DH5

The DH5 electric cooler/dryer is a box about 80 x 160 x 150 mm (W x H x D). It has to be mounted standing **upright**\* on one "leg" on top of the reaction vessel, or on a 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 fitting 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.

If the off-gas is at an overpressure, or at a slight vacuum, the DH 5 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 DH5 electric cooler/dryer and the analyser cabinet BMT 964OG are connected with an electric cable, and with two PTFE tubings 3 x 5 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.

\* The DH5 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.

### Operation

The operation of the Off-Gas Cabinet is the same as of the standard BMT 964, see chapters 1 to 14!

Adjustment of Sample Flow: The sample gas flow is produced by the sample gas pump SGP 5, and is set in the factory. If no pump is provided, but instead a throttle valve, 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 0.8 l/min, and the red ruby ball inside the flow meter is not at its upper stop!

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

If the Autozero 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 23.

**Note:** Setting the Autozero Interval to zero hours also means, that the analyzer 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 a purge interval of 24 hours.

### Maintenance

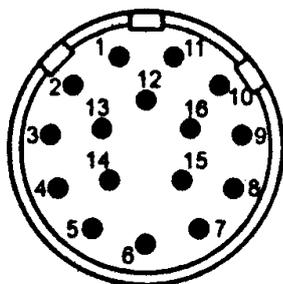
The only maintenance recommended is checking the sample gas filter insert on a regular basis. The filter insert is of pure white material which easily shows most kind of dirt, except if the dirt is white.

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

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

## Electric Connections

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, 18 mA)	
6	Auto Zero, input	low	
7	Error Contact, output	} open on error	
8	Error Contact, output	} open on error	
9	WARM (DH5)	open on error	
10	Output contacts, Common	for pins 9, 12, 13, 14, 15, 16	
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	LOW FLOW (SGP5)	open on error	

RS-232 connector:

1	Cable Shield
2	TxD (from BMT 964 C)
3	RxD (to BMT 964 C)
4	Signal GND (= analog GND)



(screw terminal side)

Mains connector:

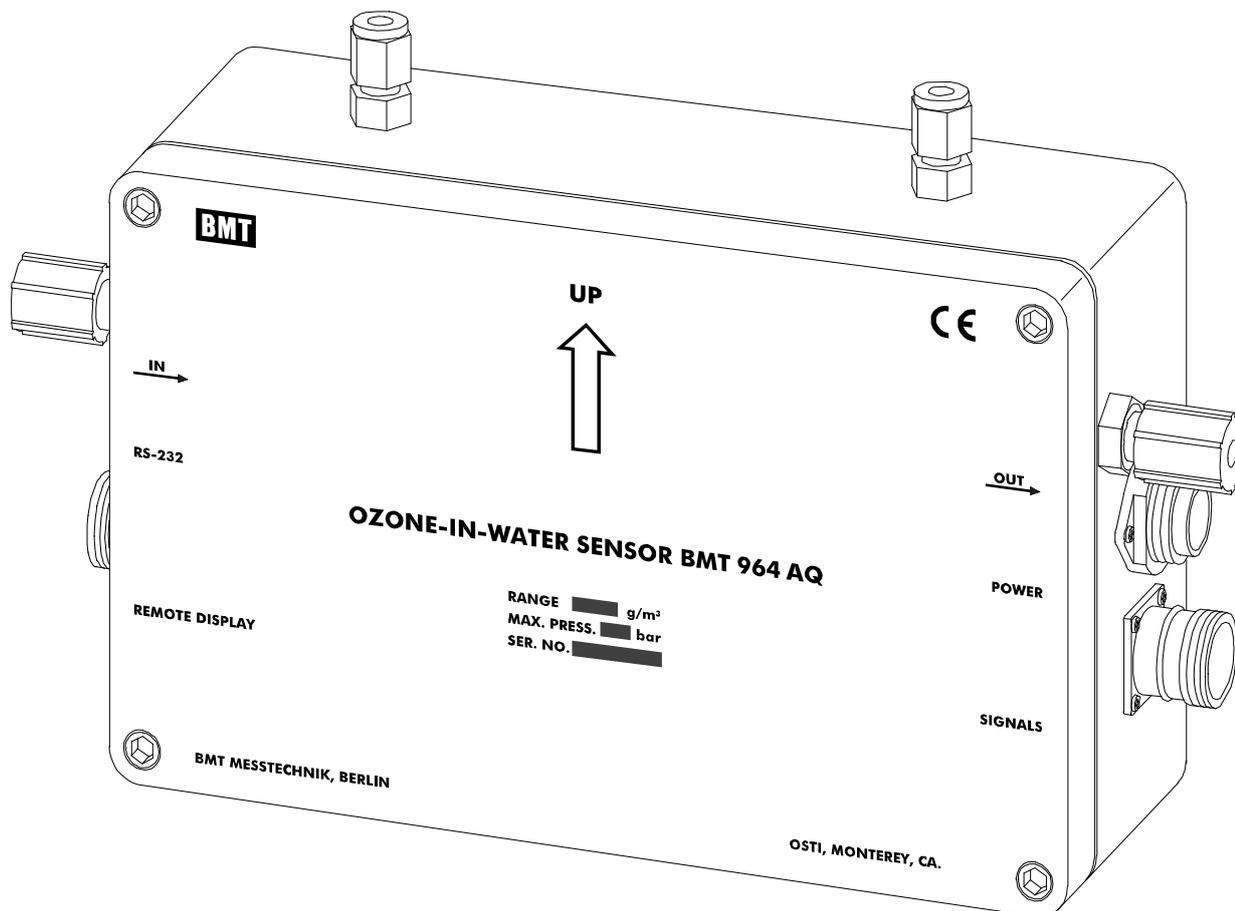
1	mains	} (100 to 240 VAC, 50/60 Hz, 200 VA)
2	mains	
3	(free)	
	Protective Ground	

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

## Appendix E: DI Water Version BMT 964 AQ

### General Description

The OZONE-IN-WATER SENSOR BMT 964 AQ is a UV photometer for the direct measurement of the ozone content of clean, de-ionised water (special version HF for up to 20% hydrofluoric acid, range 50 g/m<sup>3</sup>). The instrument is based upon our OZONE ANALYZER BMT 964 for the measurement of ozone in gas.



The BMT 964 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 964 RD is available for installations without a workstation (to be specified in the order, needs e.g. BMT 964 AQ/RD, BMT 964 AQ/HF/RD).

The BMT 964 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 RS-232 cable with the D-Sub 9 connector is supplied at a standard length of 2m, other lengths on request. The cable connecting the Remote Display is supplied with the Display.

The inlet and outlet fittings are 1/4" PFA Flaretek (for 1/4" OD PFA tubing). A Flarellok 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 ozonised water are only quartz glass, and PFA (sapphire, PFA and PTFE in the HF version). The connections between the PFA tubing and the quartz cuvette are secured with special, spring loaded, uniform peripheral pressure clamps.

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

Measurement ranges and associated maximum pressure:

BMT 964 AQ	BMT 964 AQ/HF
10 g/m <sup>3</sup> (10 ppm, max. 1 bar g)	10 g/m <sup>3</sup> (10 ppm, max. 2.5 bar g)
-	20 g/m <sup>3</sup> (20 ppm, max. 2.5 bar g)
50 g/m <sup>3</sup> (50 ppm, max. 4 bar g)	50 g/m <sup>3</sup> (50 ppm, max. 2.5 bar g)
100 g/m <sup>3</sup> (100 ppm, max. 4 bar g)	100 g/m <sup>3</sup> (100 ppm, max. 4.0 bar g)
150 g/m <sup>3</sup> (150 ppm, max. 6 bar g)	150 g/m <sup>3</sup> (150 ppm, max. 4.0 bar g)

Some ranges may be ordered compatible with up to 20% hydrofluoric acid (BMT 964 AQ/HF, see table). Pressure and temperature compensation (which is standard in our gas analyzers) is not provided because it is not necessary here. Proof pressure is listed above.

We recommend a water flow rate between 100 and 300 cm<sup>3</sup>/min. Pressure head (with 2 x 50 cm PFA tubing, 4 mm ID, connected to the inlet and outlet fittings) is about 7.5 cm H<sub>2</sub>O for a flow rate of 100 cm<sup>3</sup>/min, 18 cm H<sub>2</sub>O for 200 cm<sup>3</sup>/min, and 33 cm H<sub>2</sub>O for 300 cm<sup>3</sup>/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. When the cuvette is filled with water having zero ozone concentration, zeroing has to be initiated by pressing the push button **ZERO** at the optional REMOTE DISPLAY BMT 964 RD, or via the binary input at pins 5 and 6 of the signal connector, or RS-232 (for details see the main part of the manual).

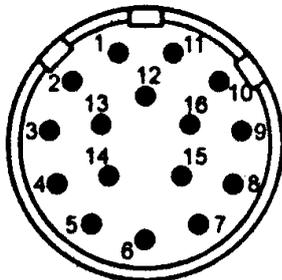
The REMOTE DISPLAY is connected to its own 12-pole connector. The 16-pole Signal Connector is free for access to all signal inputs and outputs. The analyzer must be ordered as BMT 964 AQ/RD in order to operate together with a REMOTE DISPLAY.

In the BMT 964 AQ series of sensors, the isolated signal outputs are tied to Protective Ground by 10 MΩ.

For further description of the functions and properties of the OZONE-IN-WATER SENSOR BMT 964 AQ refer to the main part of the manual.

### Electric connections

**Note:** The signal connector pinout of the standard instrument is different to the pinout of the BMT 964 AQ!

 <p>(conn. soldering side)</p>	<b>Signal connector:</b>	1 current signal, output 2 current signal, output 3 voltage signal, output 4 voltage signal, output 5 Auto Zero, input 6 Auto Zero, input 7 Error Contact, output 8 Error Contact, output 9 Purge Control, output 10 Output contacts, Common 11 Cable Shield 12 Lamp Low, output 13 Low Limit Alarm, output 14 High Limit Alarm, output 15 Cuvette Dirty, output 16	4 - 20 mA high 4 - 20 mA low 0 - 10 V high 0 - 10 V low high (+24 VDC, 18mA) low } open on error for external pump / solenoid valve for pins 9, 12, 13, 14, 15 open on error opening or closing opening or closing open on error not connected
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<b>Mains connector:</b>	1 mains	} (100 bis 240 VAC, 50/60 Hz, 15 VA)
	2 mains	
	3 (free)	
	⏚ Protective Ground	

Alternatively:

<b>DC power connector:</b>	1 positive	} (12-36 VDC)
	2 negative	
	3 (free)	
	⏚ Protective Ground	

<b>RS-232 connector:</b>	1 Cable Shield	
	2 TxD (from BMT 964 AQ)	
	3 RxD (to BMT 964 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 964 AQ is based on the same type of power connector, but with the female connector on the SENSOR side.

## Appendix F: Remote Display BMT 964 RD

### General Description

Several models of the OZONE ANALYZER BMT 964 are available with the display and control panel separated from the analyzer, 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.

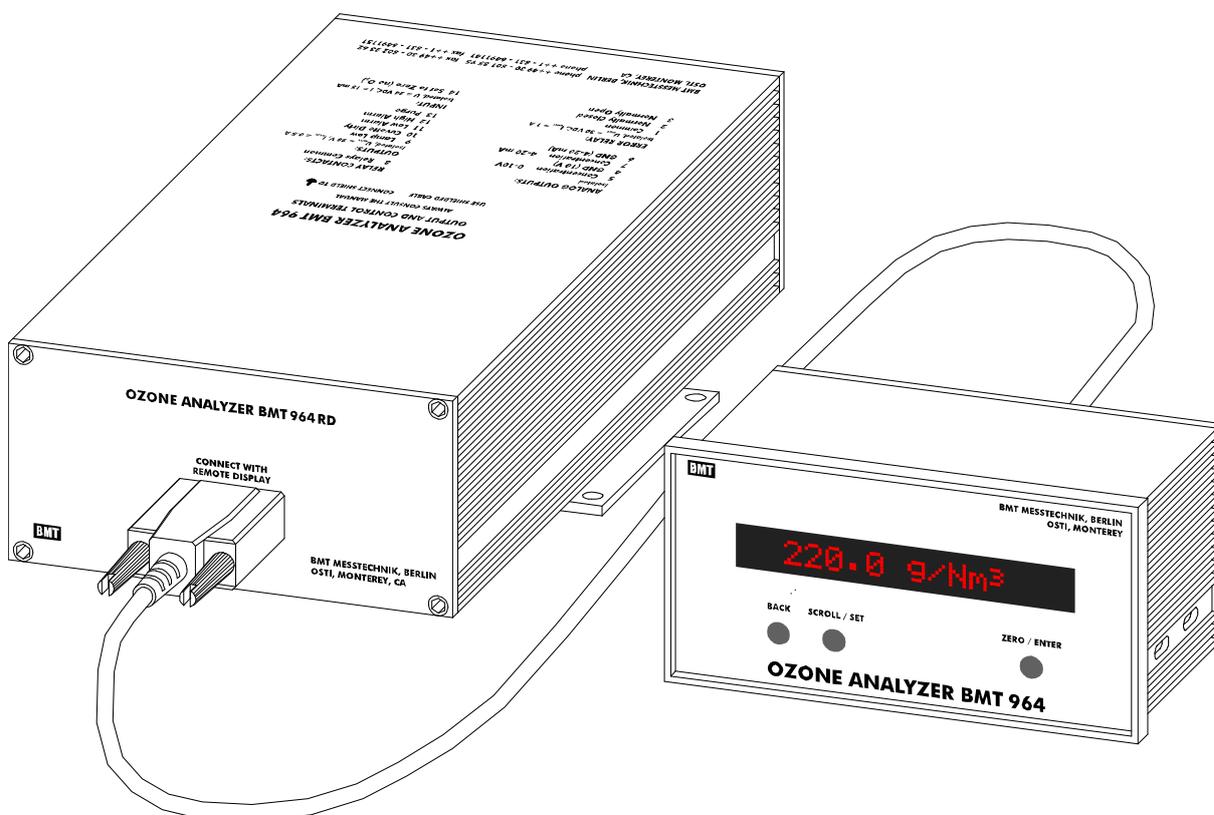
Dimensions of the REMOTE DISPLAY BMT 964 RD are 144 x 72 x 60 mm.

The connecting cable has a special pin-out on a 12-pole connector (depends on analyzer model), and must be ordered for the appropriate type of analyzer. Models available as a sensor with REMOTE DISPLAY are: BMT 964 S/RD and BMT 964 AQ/RD. Both must be ordered as /RD versions in order to operate together with the REMOTE DISPLAY.

**Note:** The BMT 963 RD is not compatible to the BMT 964 series of analyzers!

### Operation

The Sensor with REMOTE DISPLAY is operated the same way as the standard BMT 964 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: MODBUS RTU Communication

MODBUS RTU is a widely used serial communication protocol. The physical interface used in this implementation of the protocol is the common two-wire RS485 connection. MODBUS RTU supports up to 32 nodes on the bus, with one master and several slaves. It is available as an option for all IP65 variants of the BMT 964. This implementation conforms to the following MODBUS standards:

MODBUS Application Protocol Specification , V1.1b

MODBUS Over Serial Line Specification and Implementation Guide, V1.02

These documents can be found at <http://modbus-ida.org/specs.php>.

MODBUS enables a SCADA system to have direct access to all relevant parameters (concentration, pressure, cuvette status etc.) and all alarms of the BMT 964. 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.

Communication parameters can be set on the front panel, while the instrument is connected to the bus, or via the RS-232 serial port with the BMT 964 Link program.

### Physical Connection

The MODBUS interface is electrically isolated and has built in transient protection. A BMT 964 equipped with MODBUS comes with a male 5 pole IP67 M12 connector. The female counterpart for the bus cable is also supplied. The cable should be of a shielded three conductor twisted-pair type, OD 5-8 mm, e.g. Belden 3106A. With such a cable and proper bus termination (see MODBUS standard) it is possible to transmit data at a speed of 19200 Baud over a distance of 1,000 m. Connecting the cable shield can improve noise immunity, but can also create problems, if the cable connects distant locations. In this case large currents due to potential difference between different mains installations could flow, making it necessary to connect the cable shield only at one point of the bus.

Electrical Connection:

Pin	Function
1	Connect with 2
2	Connect with 1
3	0 V Common
4	Signal A (-)
5	Signal B (+)

It is important to connect pin 1 to pin 2, because this bridge will signal to the BMT 964, that a MODBUS cable is connected (MODBUS auto detect). MODBUS communication parameters will be automatically loaded, and communication can commence, as soon as this bridge is detected. Also, MODBUS parameters can now be set in the 'Set I/O' menu on the front panel.

Please note: It is not possible to use the RS-232 and the MODBUS interface at the same time. When Modbus is disconnected, RS-232 is available again. Shield should connect to connector housing, not pin 3.

### Set Communication Parameters

Communication parameters can be set with the program BMT 964 Link, or, if the bridge between pins 1 and 2 of the MODBUS connector is detected, also on the front panel menu (Set I/O -> MODBUS Parameters). The following can be set:

Link speed:

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

Parity:

- None (default)
- Odd
- Even

MODBUS address can be set between 1 and 247. Default address is 203. These parameters are stored in non-volatile memory.

### MODBUS Operation

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.

The instrument will then check query data, and, if invalid data is detected, will respond with a MODBUS Exception. An exception has two fields that differentiates it from a normal response: The high bit of the function code is set (function code + 80h), and the data field contains the exception code.

The following exception codes are used:

Exception Code	Definition	Description
1	Illegal Function	This function code is not supported
2	Illegal Data Address	Start register is not available
3	Illegal Data Value	Quantity of requested registers not supported
4	Slave Device Failure	An illegal parameter was sent in the query

Note: The MODBUS standard defines exception code 4 as: "An unrecoverable error occurred while the slave attempted to perform the requested action." In this implementation of the proto-

col exception 4 is used, because the standard does not define an exception, that will convey to the master the use of an out-of-range system parameter. There is no "unrecoverable error". Exception 4 merely means that the request was rejected and nothing was changed.

The BMT 964 supports a subset of the standard MODBUS RTU function codes:

Function Code	Name	Usage
1	Read Single Coil	Read binary data, e.g. alarms
3	Read Holding Registers	Read numeric data, e.g. concentration
5	Write Single Coil	Write binary data, e.g. zero command
8	Diagnostics	Check communication quality
16 (10h)	Write multiple registers	Write numeric data, e.g. alarm limits

The following section describes these function codes and their use in detail. The following tables contain register addresses referring to the MODBUS data model (starting with 1), not the actual content of the data stream (where address space starts with 0).

Caution: Care has to be taken that the MODBUS master does not reconfigure the BMT 964 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 1 – Read Single Coil

This code 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 first bit of the first byte of the response contains data from the start coil number. Data from the other coils fill up the bits of the first and subsequent bytes in low to high order. Bits not used in the last byte will be padded with zero. Status is indicated as 1 = ON, 0 = OFF.

Start Coil	Description
1	Low Alarm
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

### Function Code 3 – Read Holding Registers

This code is used to request numeric information. The query specifies a start register and the number of registers to be transmitted. Register size is 16 bits. Floating point and long values require two words to be transmitted. This means that a request for e.g. one single floating point value has to have the data length field in the query set to 2. Floating point numbers are sent in the standard 32-bit IEEE 754 format.

Start Register	Length	Format	Description
1	2	Float	Concentration (in set unit)
3	2	Float	Ozone range (in set unit)
5	2	Float	Pressure (in bar)
7	2	Float	Cuvette Status: Dirty value in %
9	2	Float	Pressure range (bar)
11	2	Float	Temperature (Kelvin)
13	2	Float	Low alarm limit (in set unit)
15	2	Float	High Alarm Limit (in set unit)
17	2	Float	Molecular weight of carrier gas
19	2	Float	Firmware Version
21	2	Long	Operating hours
23	2	Long	Serial Number
25	1	Word	Ozone unit: 0: g/Nm <sup>3</sup> 1: %wt/wt 2: ppm <sub>v</sub> 3: g/m <sup>3</sup> (without pressure and temperature compensation) 4: ppm
26	1	Word	Front panel is set to display pressure in: 0: bar (1.0) 1: psi (14.50778) 2: Torr (750.0617) 3: MPa (0.1) In parenthesis : Factor to calculate MODBUS pressure value given in bar to set unit.
27	1	Word	Autozero Interval in hours, if 0: no Autozero

### Function Code 5 – Write Single Coil

This code sets Low and High Alarms behaviour and allows execution of the zero command. Setting to 1 activates function, 0 deactivates.

Start Coil	Description
1	Low Alarm Enable
2	High Alarm Enable
3	Low Alarm Latched
4	High Alarm Latched
5	Execute Zero

Sending a 0 to coil 5 will result in an exception code 4.

## Function Code 8 – Diagnostics

This function code provides some diagnostic tools for MODBUS communications. The query contains a sub-function code defining the diagnostic action to be taken:

Sub-Function	Description
0	Return Query Data, (2 bytes only!)
10	Reset Error Counters
12	CRC Error Counter
13	Exception Counter

Return Query Data is a simple loop-back test. The BMT 964 will echo the message sent to it. Please note, that the data field of this query should be two bytes long. Both CRC Error Counter and Exception Counter will start at 0 when the instrument is switched on.

## Function Code 16 (10h) – Write multiple Registers

This function code provides means to configure the instrument. Float formatting is the same as for function code 3.

Start Register	Length	Format	Description
1	1	Word	Set Ozone unit: 0: g/Nm <sup>3</sup> 1: %wt/wt 2: ppmv 3: g/m <sup>3</sup> (without pressure and temperature compensation, for AQ only) 4: ppm (for AQ only)
2	2	Float	Low Alarm Limit (in set unit)
4	2	Float	High Alarm Limit (in set unit)
6	1	Word	Molecular weight of carrier gas? 0: Oxygen : 31.9988 g/mol 1: Air: 29.0 g/mol
7	1	Word	Autozero Interval in hours (max. 99, if 0: no Autozero)

If parameters outside of the range given in the table above are used, or Low Alarm Limit is set higher than High Alarm Limit, or High Alarm Limit is set lower than Low Alarm Limit, the instrument will reply with an exception 4.