SMT Seefelder Messtechnik

Hg-CEM®

Continuous Emissions Monitoring System (CEMS) for Mercury

User's Guide

www.seefelder-messtechnik.com

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1 CUSTOMER SERVICE

We at SMT want to provide you with the very best customer service possible. If you have any questions, problems or comments about the system, we would like to hear from you. In addition, it is recommended that all maintenance and repair work on the system should only be done by SMT customer service or appropriately trained personnel. You can reach us at:

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Fax: 0049 8152 / 9939-29
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2 SAFETY INSTRUCTIONS

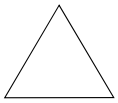
Throughout this User's Guide we will try to indicate explicitly hazardous situations that could potentially result in personal injury or damage to the system.

Please read this User's Guide carefully before installing and using the system. In particular, please pay attention to paragraphs that refer to possible hazardous situations.

Warnings and messages are presented as follows:

Indicates that non-compliance with the instructions can lead to potential personal injury.

Warning



Indicates that the instructions must be followed explicitly to avoid damage to the system.

Attention

Warning

Voltage

Danger of potential injury

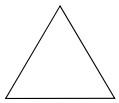
- Always run the system with a ground connection (grounding).
- Do not remove or open the internal ground connection under any circumstances.
- If the system is switched on, the electrical connections are charged. Therefore, do not attempt to touch internal components when the system is switched on. Internal components should only be touched or removed when the monitor has been switched off.

The following general guidance should be followed during operation of the system:

- Do not touch the interior components of the system when it is switched on.
- Never operate the system if the cover or any other parts are removed.
- Only SMT customer service or appropriately trained personnel should perform maintenance and repair work.
- If you observe that the system has insufficient grounding or that the grounding connection is damaged, please take the system out of operation and prevent unauthorized use of the system.

Some situations leading to insufficient system grounding include:

- System has visible physical damage.
- System was stored for a long time under unfavorable conditions (e.g. high humidity environments).
- System was handled improperly during transportation and shipping.



Attention

Explosive gases in the operating environment

The system should never be operated in an explosive environment.

Some other environments that can lead to operating problems and should be avoided include:

- Outdoor environments where the system is not appropriately protected from nature's elements (sun, rain and snow).
- Excessively humid environments.

3 INTRODUCTION

3.1 About this User's Guide

The Hg-CEM® represents a state-of-the-art comprehensive Continuous Emission Monitoring System (CEMS) for Mercury. It includes a sampling system and all components for making the actual measurement. In this User's Guide you will find a description of the common components used to assemble the Hg-CEM® Mercury CEMS. Description of special configurations such as special housing enclosures and customized modifications are provided to you in separate documents.

For a simple installation it is sufficient to read **Chapter 4 (System Description)**, **Chapter 5 (User Interface)** and **Chapter 6 (Installation and Startup)**. The manual does not contain service instructions to open and modify the housing enclosure. Trained personnel must carry out these operations. The Mercury photometer used in the Hg-CEM® is only briefly described in this User's Guide. The Mercury photometer used by the Hg-CEM® is a modified version of a standard ambient air mercury photometer with special control software. For a detailed description of the Mercury photometer a separate manual is available. The operation and service of the Amalgamation unit AMU 2000 along with the Thermocatalytic converter are provided in detail in this User's Guide.

All other system components, for example, the enclosure cabinet and the internal wiring can be customized or dependent on the installation type for each individual site. Each system is delivered however with complete system documentation. This documentation contains the complete wiring diagram of the enclosure cabinet and the operating instructions for all components used to assemble the system.

4 SYSTEM DESCRIPTION

The Hg-CEM® Mercury CEMS consists of a sampling probe, a thermocatalytic converter, a sample conditioning gas cooler, an amalgamation unit followed by a mercury photometer. The thermocatalytic converter converts all ionic mercury (e.g. Mercuric Chloride) into elemental Mercury.

4.1 Mercury Photometer

4.1.1 Description of the Mercury Photometer

The Mercury photometer is a compact fixed wavelength UV photometer for laboratory application, process monitoring and mobile applications. The instrument has been designed to operate for prolonged periods of time without supervision. We briefly describe the photometer in this section and a detailed description is available in a separate document. The User Interface for the photometer is described in the User Interface section of this manual.

Apart from being a simple measurement sensor for continuously measuring mercury, the photometer also performs the following auxiliary functions: ·

- Controlling all valves in the Amalgamation unit AMU 2000 with digital outputs ·
- Controls the heating cycle for the gold trap in the Amalgamation unit AMU 2000
- Regulation of the flow throughput of the pump in the AMU 2000 by pulse width modulation with the signal of the flow meter built in the photometer ·
- Reading and displaying digital signals of the system. Some of them include
  - Temperature alarms associated with the heated components of the sampling system
  - Temperature alarms associated with the gas coolers output of digital signals for the description of the supervisor state.
- The photometer also displays the following signals:
  - Ready for use
  - Maintenance mode
  - Maintenance required

- Failure
- Switching of measuring range

All signals specified above are obtained from the enclosure cabinet. The position of the clamps can be inferred from the terminal diagram of the cabinet.

4.1.2 Measurement Principle for the Mercury Photometer

The Hg Monitor 3000 operates on the principle of Atomic Absorption Spectroscopy (AAS). This technique is one of the most reliable and sensitive methods for measuring mercury. Besides noble gases (e.g. Argon, Krypton etc), Mercury is one of the few elements that is mono-atomic at ambient temperatures. This attribute allows mercury to be measured using AAS. Sample air passes continuously through the optical cell where absorption (attenuation) of the light produced by a UV lamp (253.7 nm Hg line) is measured.

The Hg Monitor 3000 consists of a radiation source (UV lamp at 253.7 nm), the absorption cell/optical cell, a photodetector with an amplifier and the computer. A diaphragm pump pulls air directly through the optical cell. The UV radiation is absorbed by mercury atoms in the sample gas stream resulting in a signal modification, which corresponds to the concentration of mercury within the sample stream.

An electrodeless low-pressure mercury lamp is used to obtain long-term stability. This UV source was developed exclusively for our mercury analyzers. The extremely long life span of the lamp is achieved because the lamp does not possess any inner electrodes (which are common in hollow cathode lamps.) To maintain constant output, a high-frequency field is maintained around the lamp. The main spectrometric line produced by the analyzer is 253.7 nm and it is extremely narrow. In order to eliminate lamp drift, the lamp temperature is controlled thermostatically.

A unique UV sensitized photodiode is used for measuring UV radiation. The photodiode together with the preamplifier form the UV detector. Using a narrow-band interference filter eliminates stray radiation.

The optical cell is constructed from SUPRASIL and has an optical path length of 230 mm. The pump is configured behind the optical cell and ensures an even flow rate within the optical cell. Within the optical cell, mercury atoms absorb the UV radiation resulting in an attenuated signal that is dependent upon the mercury concentration.

4.2 Sample Probe

The sample probe consists of a fine particle filter placed outside of the stack and an inlet pipe, which projects into the stack. The inlet pipe can be configured differently depending upon each application. The standard probe pipe is a high-grade steel pipe with 8 mm inside diameter within which a PFA tube with 6 mm inside diameter is inserted. Inside the fine particle filter you also find the MERCAT thermocatalytic converter. The catalytic filters removes all dust particles that interfere with the measurements. Additionally the catalyst reduces the temperature in at which Mercuric Chloride (HgCl2) is converted to elemental mercury Hg(0) and chlorine (Cl2). At this reduced temperature the back combination reaction (of Hg(0) and HCl is prevented. Basically the catalyst is in a high temperature furnace, whose temperature is so high such that particle-bound Hg is set free. After the particle filter, the flue gas is transported to the Mercury CEMS cabinet within a heated (approximately 200 °C) PFA sample line.

Note: In some cases, the thermocatalytic converter is not placed within the sample probe but is located downstream within the main CEM cabinet.

4.3 Sample Gas Preparation

The sample gas is passed over a two-step a 2-step compressor cooler. After the first step, a bypass stream is removed and vented out. Only a small fraction (about 0.35 l/min) of the entire sample flow rate is actually needed for the measurement. However the larger bypass flow is needed to reduce the response time and memory effects associated with mercury.

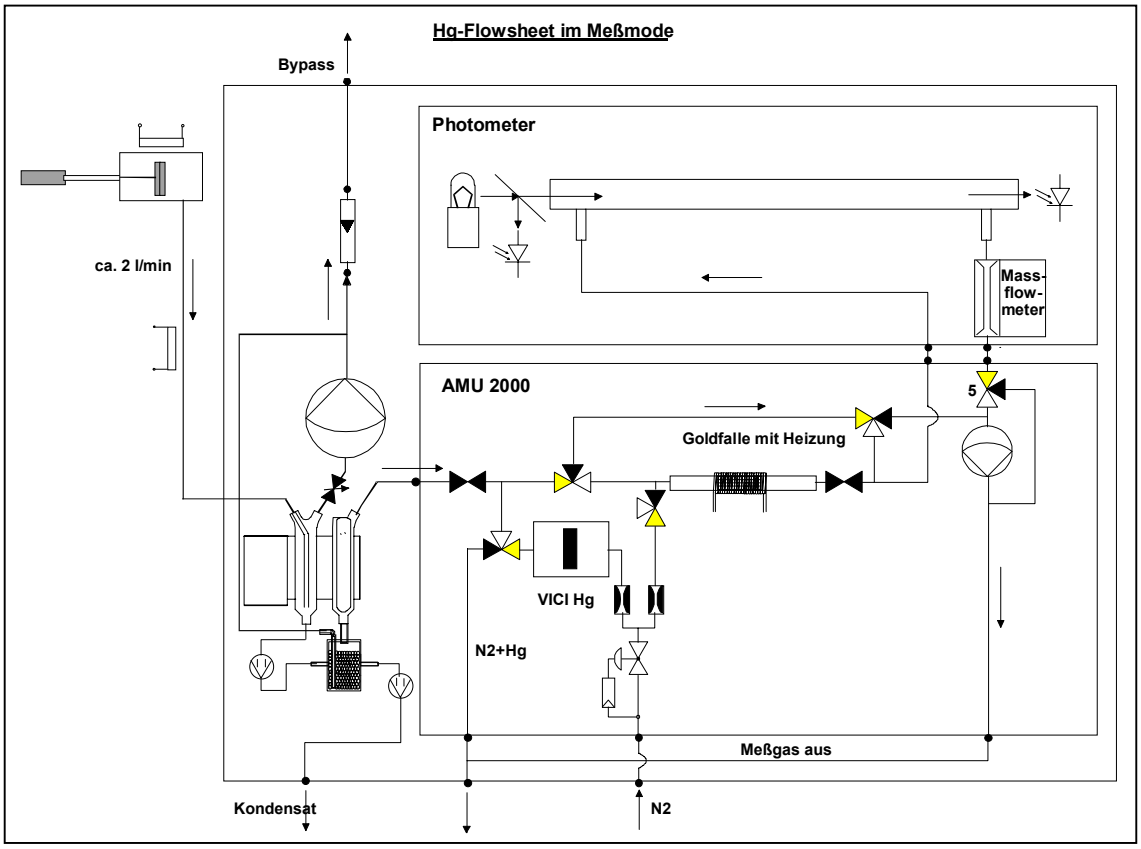


Fig. 1 Flow chart for the total system

4.4 Amalgamation Unit AMU 2000

Fig.1 also includes a flow sheet for the Amalgamation unit AMU 2000. In this module, elemental mercury forms an amalgam within the gold trap. The AMU 2000 has adjustable loading and heating time intervals. During the heating period, mercury is emitted and the peak concentration is measured. An integration of the area under this peak results in the Mercury concentration during the loading phase.

This measurement technique has two distinct advantages:

- The measurement is completely free of cross-sensitivities of the other components in the flue gas (like sulfur dioxide) since mercury forms a unique amalgam with gold
- By varying the loading time during the amalgamation phase, it is possible to measure various different ranges of mercury concentrations. Theoretically by increasing the loading time it is possible to go to extremely small mercury concentration levels.

In addition to the Amalgamation mode measurements, it is possible to make continuous mode measurements. In the continuous mode, the flow bypasses the gold trap and goes directly into the mercury photometer. The continuous mode is better suitable for measuring high concentration levels. With high concentrations the measuring peaks become so high with the Amalgamation mode and significant non-linear phenomena can occur. Therefore the system switches automatically to the continuous mode when concentrations exceed a specific user-specified limit. For both measuring modes it is possible to perform automatic or manual calibration utilizing the internal Mercury Calibration device. In the following sections we will describe the two measurement modes in detail.

4.4.1 Measurement Readings made using the Amalgamation mode

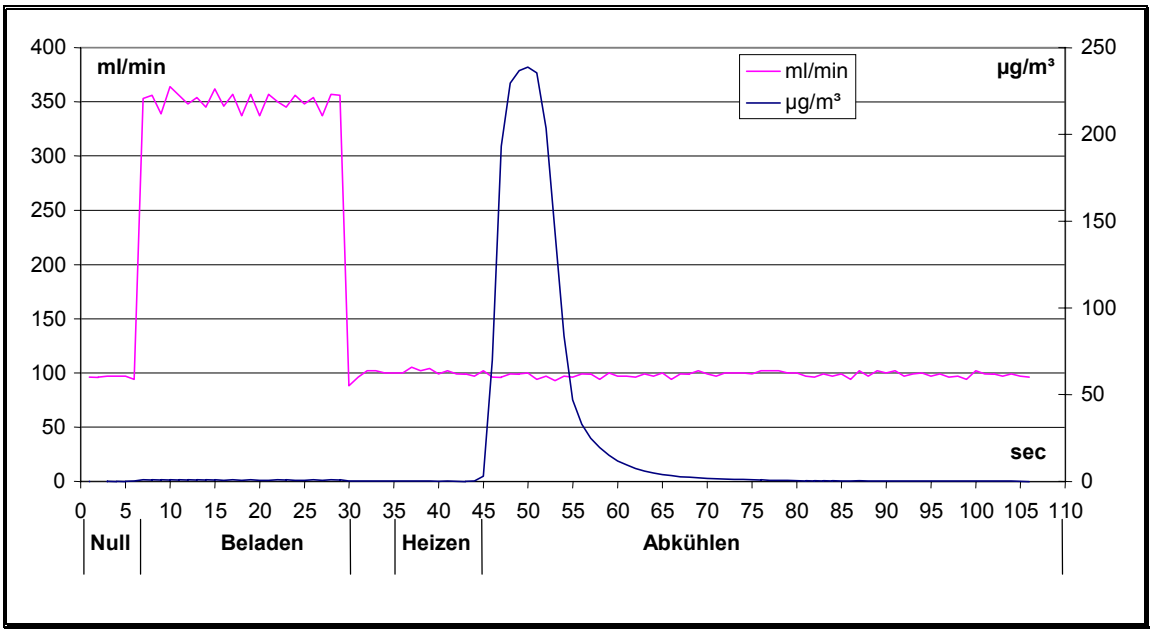


Fig. 2 Flow rate and concentration profiles associated with an Amalgamation Cycle

Figure 2 displays a typical cycle associated with a measurement taken with an Amalgamation mode. The x-axis (horizontal) indicates typical time values in seconds. Flow rate is shown the left y-axis (vertical) while mercury concentration is shown on the right y-axis (vertical).

- During the first phase, the zero point of the photometer is measured and stored in the memory. Valve positions correspond to those displayed in Figure 1. During this phase, Nitrogen flows through the critical orifice, over valve 4 and through the photometer.
- The next phase is associated with loading of mercury on the gold trap. The valve positions are shown in Fig. 3. The measuring gas allowed to pass over the gold trap. The pump is regulated with the help of the signal from the mass flow meters in the photometer in order to maintain a constant throughput value.
- After the loading phase a short transition phase follows. During this phase, nitrogen from the critical orifice is used to drive out the flue gas from the gold trap and the photometer.
- Subsequently the heating phase of the gold trap follows.
- The final phase is the cooling phase during which we observe the Hg peak. The duration of the cooling phase is selected such that optimal temperatures exist for the next loading phase in the cycle.

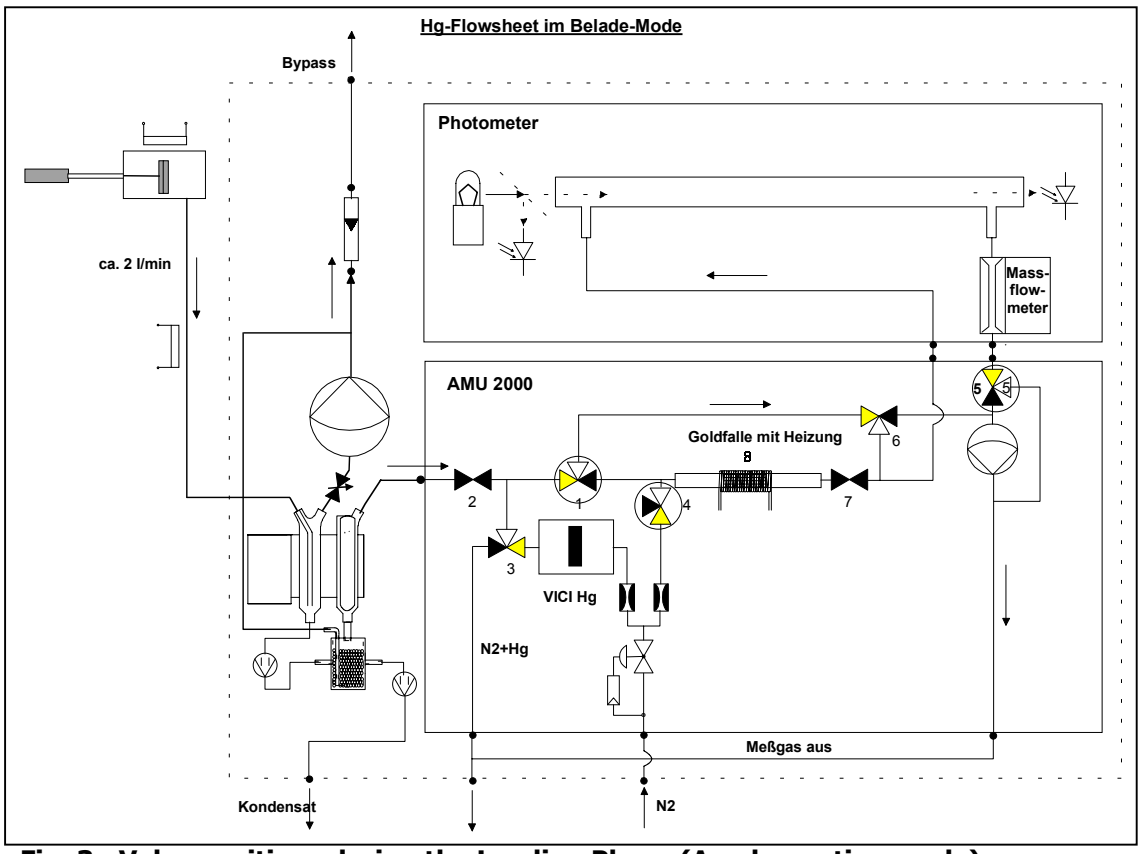


Fig. 3: Valve positions during the Loading Phase (Amalgamation mode)

4.4.2 Measurement Readings made using the Continuous mode

When the concentration levels exceed a user-specified threshold value, the system automatically switches into the continuous mode. It is also possible to choose the continuous mode manually. The next section regarding the User Interface describes how to select the threshold level and how to switch manually into the Continuous mode. Figure 4 illustrates the valve positions during the continuous mode. The measuring gas bypasses the amalgamation gold trap and goes directly into the photometer. The averaging time associated with the continuous mode is chosen to be identical to the time interval associated with one amalgamation mode cycle.

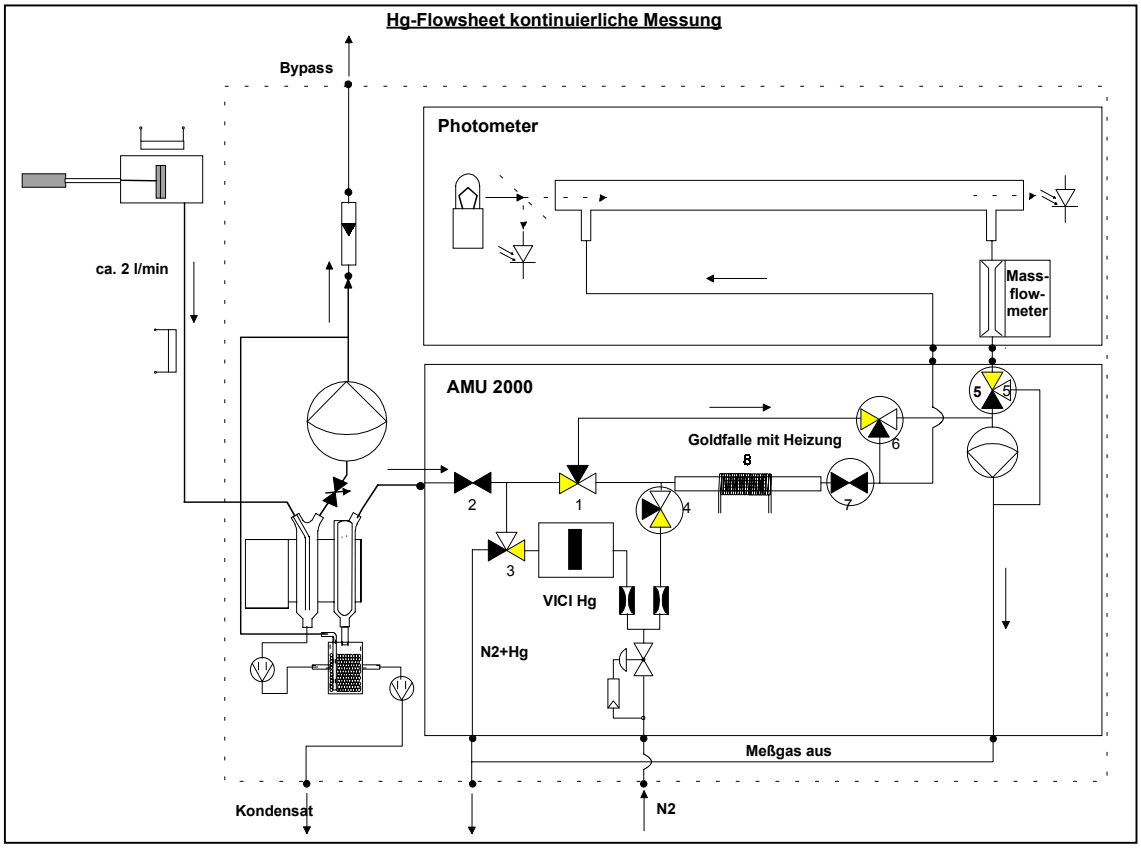


Fig. 4 Valve positions during the Continuous measurement mode

4.4.3 Calibration Phase

The system can be calibrated separately measurements made during the Amalgamation and continuous modes. Both calibrations can be taken place automatically with a given cycle time or can be activated manually. In the following chapter on the User Interface the appropriate inputs associated with the calibration mode are described. Within the calibration cell, mercury is

allowed to permeate from a constant temperature source. A constant stream of nitrogen (created using a

critical orifice) carries the mercury vapor from the source. This produces a highly reproducible constant concentration mercury source. Figure 5 shows the valve positions of the Calibration phase associated with the Amalgamation mode. Figure 6 shows the valve position associated with the calibration phase during the continuous mode.

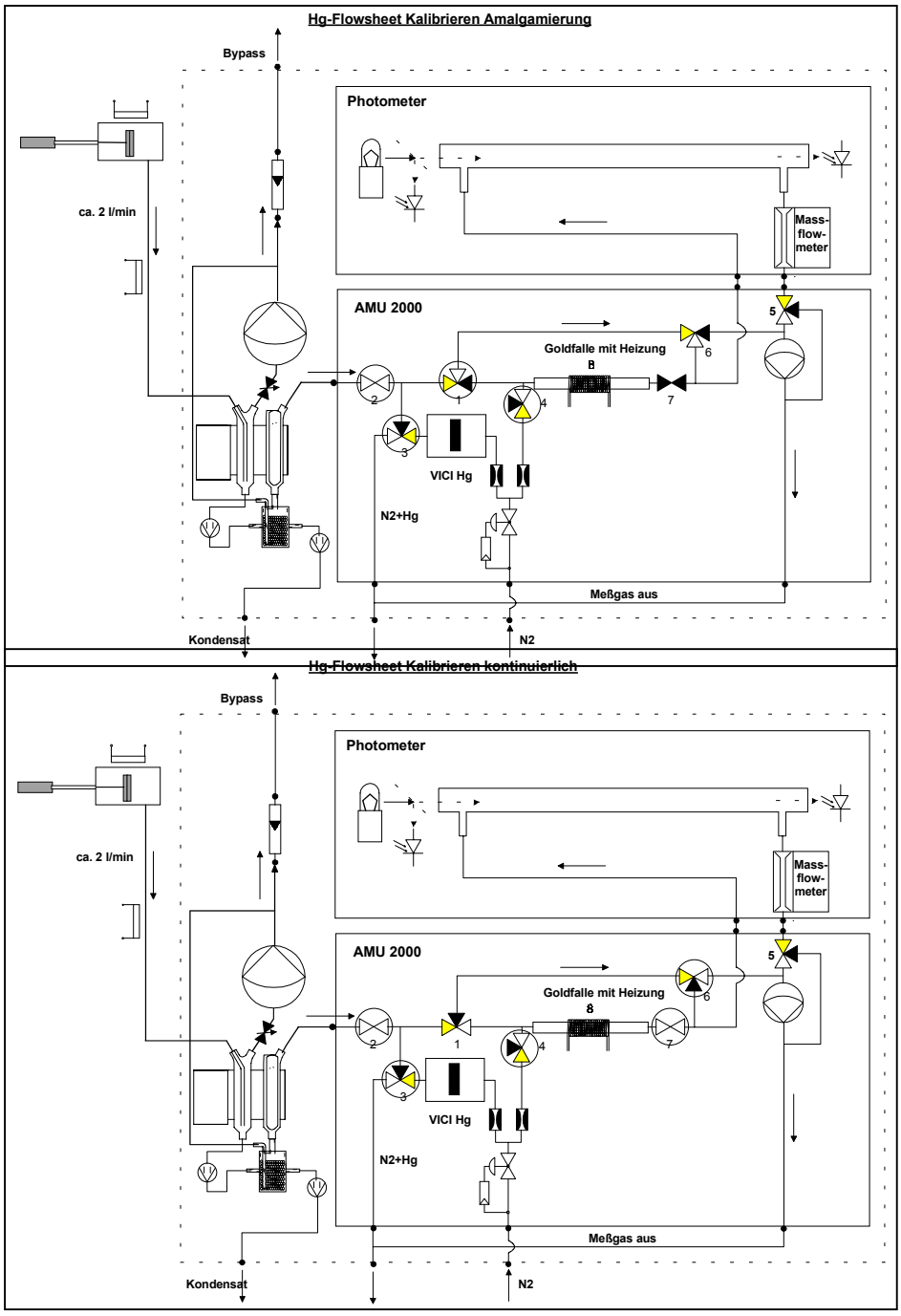


Fig. 5 Valve positions during the Calibration phase (Amalgamation mode)

Fig. 6 Valve positions during the Calibration phase (Continuous mode)

5 USER INTERFACE

All modifications and settings regarding the measuring system can be made by using the digital keypad located on the front panel of the. The inputs and outputs are shown on the front panel color display.

5.1 Front Panel Keyboard

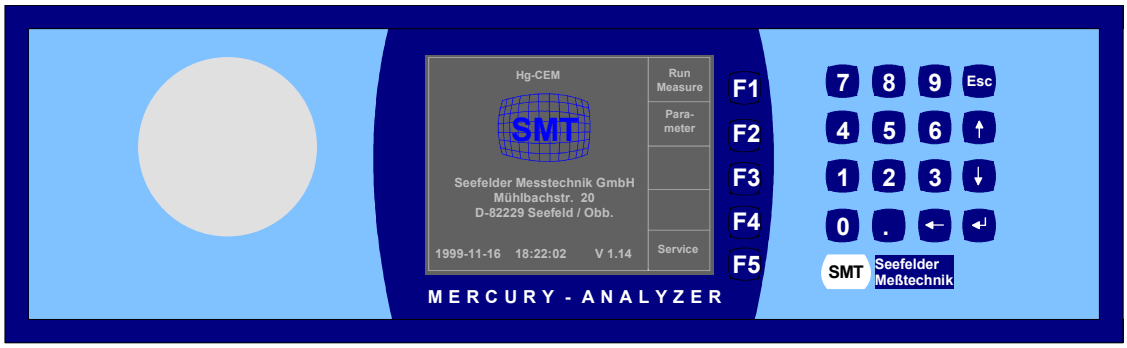


Fig.7 Front Panel of the Mercury Photometer used in the Hg-CEM® Mercury CEMS

The front plate has a color display, a block with five function keys beside the display and a numeric key block for the input of numbers. The ESC, ENTER and cursor keys of this block have the normal functionality. The five function keys are soft keys, i.e. each key has a particular function that is explained next to it (left hand side). Most keys have two types of behavior:

1. Navigation: Here you branch to a submenu or return to the previous menu
2. Input help associated with cases where numeric values can be inputted.

5.2 Main Menu

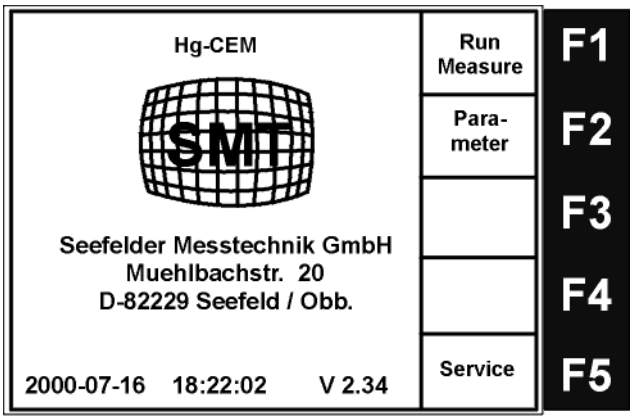


Fig.8 Main Menu

The Main Menu appears on the photometer when it is switched on. It is also accessible by selecting the Function key "Main" from several sub-menus. From the Main Menu you can branch to three other menus:

1. Run Measure: This initiates the measuring process.
2. Parameter: This will take you to a menu which displays important parameter values
3. Service: This menu is used for configuration of the photometer and entire system

5.3 Service Menus

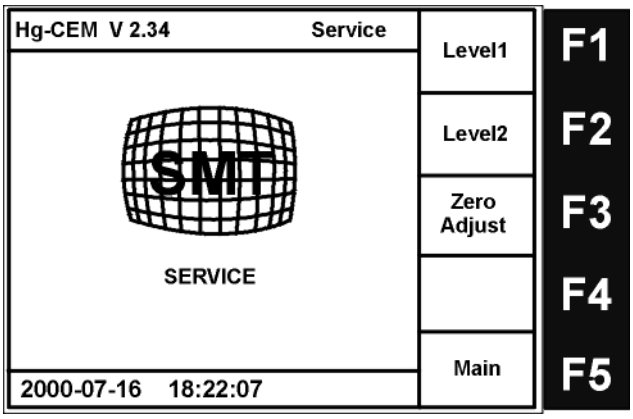


Fig.8 Service Menus

When you select the Service selection from the Main Menu you will arrive to the Service Menu. Here you can branch to two levels of Service:

- **Level 1:** Enables you to enter standard variables which are useful for maintenance purposes.
- **Level 2:** Contains access to variables that are critical to the performance of the system. This level is PASSWORD PROTECTED and should only be accessed by appropriate knowledgeable personnel.

5.3.1 Service Menu Level 1

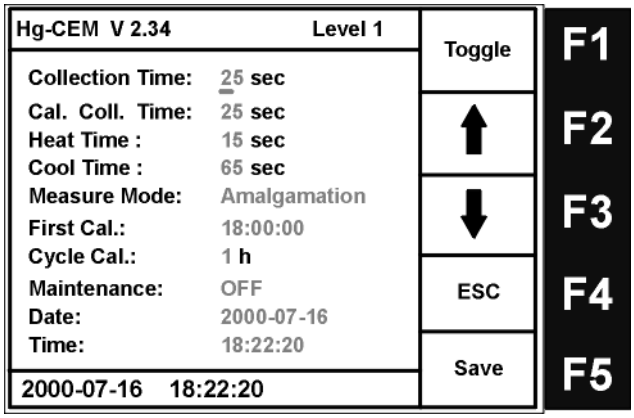


Fig.9 Service Menu Level1

You will reach this menu after selecting Level 1. Here you will be able to make selections using the Function keys (F1 through F5) and also numeric inputs.

- **F1 Toggle**

  With this selection you can choose the operation mode for the system:

  - **AMALGAMATION MODE**

    Measurements are made using the Amalgamation mode described in the earlier chapter.

  - **CONTINUOUS MODE**

    Measurements are made using the Continuous mode described in the earlier chapter.

  - **CALIBRATION DURING AMALGAMATION MODE**

    Continuous calibration cycles are performed in the Amalgamation mode. After each cycle you acknowledge whether the new calibration values are to be applied.

  - **CAILBRATION DURING CONTINUOUS MODE**

    Continuous calibration cycles are performed in the Continuous mode. After each cycle you acknowledge whether the new calibration values are to be applied.

  - **MAINTENANCE**

    ON – The maintenance relay switch is set and hence values transmitted to the data acquisition system must be appropriately flagged.

    OFF – The maintenance relay switch is opened.

- **F2 Up Navigation Key**

Use this key for moving the cursor up one line. It is identical to the UP Arrow key on the digital keypad.

- **F3 Down Navigation Key**

  Use this key for moving the cursor down one line. It is identical to the DOWN Arrow key on the digital keypad.

- **F4 ESC**

  Use this key when you want to exit the Service Level 1 menu screen without saving nor storing the inputs and changes you made.

- **F5 SAVE**

  Use this key to save all modifications. You will also exit the Service Level 1 screen.

The numeric fields on this screen include the following:

Collection time: The time interval during which mercury will be collected on the gold trap (loading phase duration).

Cal. Coll. Time: The time interval for a calibration cycle during which mercury will be collected on the gold trap (loading phase duration of an amalgamation calibration cycle).

Heat Time: The time interval during which mercury is driven out of the gold trap (heating phase duration).

Cool Time: The waiting time interval before the next measurement cycle is begun (cooling phase duration).

First Cal.: The time of the day when the first automatic calibration cycle is performed.

Cycle Cal.: The time interval in hours between two automatic calibration cycles. If you enter 0 hours, no automatic calibration is performed.

Date: Enter the current date.

Time: Enter the current time.

5.3.2 Service Menu Level 2

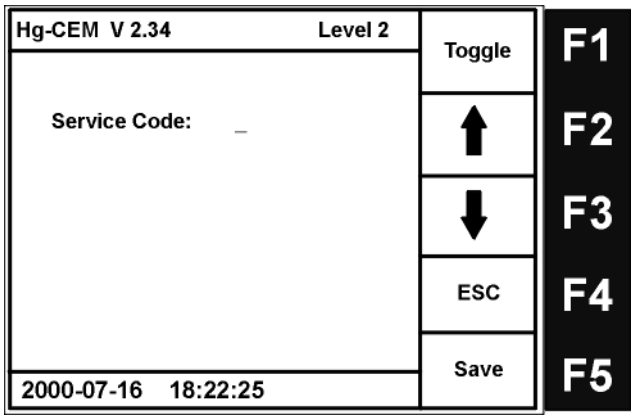


Fig.10 Service Menu Level 2 Password Access

After selecting Level 2 from the Service menu you will have to enter a password. This is required for accessing the Service Level 2 screen. The password is supplied with the system documentation.

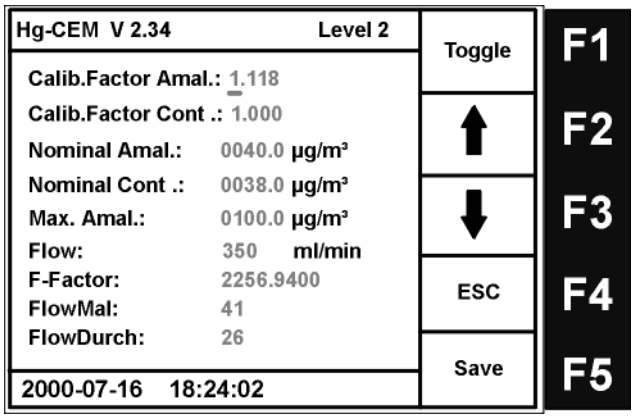


Fig.10 Service Menu Level 2 Password Access

The Function keys on the Level 2 menu are identical to those described on the Level 1 menu. The numerical inputs are the following:

Calib. Factor Amal.: This factor is multiplied to the measured value in the amalgamation mode so that the reading is consistent with the calibration of the system.

Calib. Factor Cont.: This factor is multiplied to the measured value in the continuous mode so that the reading is consistent with the calibration of the system.

Nominal Amal: This is the expected value which the instrument should show when it is in a Amalgamation mode calibration cycle.

Nominal Cont: This is the expected value which the instrument should show when it is in a Continuous mode calibration cycle.

Max Amal.: This is the threshold value at which the analyzer switches from the Amalgamation mode to the Continuous mode. Hysteresis of +/- 10% is allowed around this threshold value. The analog output (4 to 20 mA) is also coupled to this number. 20 mA corresponds to 75% of the threshold value.

Flow: The set value of the flow rate during the continuous mode measurement or the loading phase of an amalgamation mode.

F-Factor: This is an empirical factor associated with each instrument. It is used to convert raw absorption numbers to actual concentration values. **NEVER MODIFY THIS FACTOR!**

5.3.3 Service Menu Zero Adjust

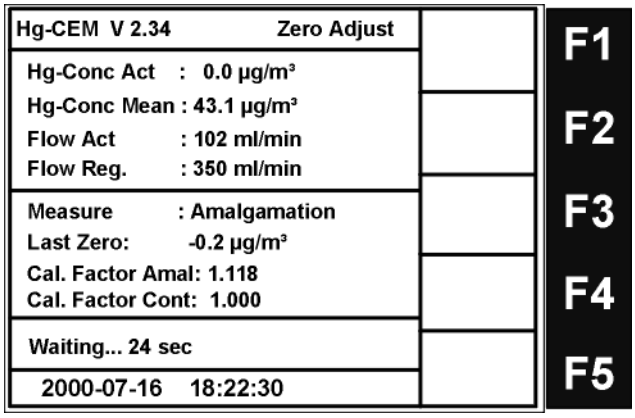


Fig.10 Service Menu Level Zero Adjust

After selection of zero Adjust on the Service menu the internal zero point of the photometer will be reset. This process takes 30 seconds. You should not intervene during this process. On the second last line the time countdown will be displayed. After completion, you will be returned to the main Service menu.

5.4 Parameter Display

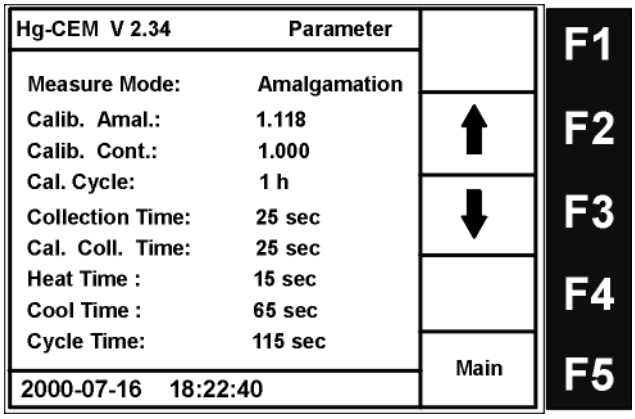


Fig.11 Parameter Display Menu

On this display screen you will see the values of important parameters. This is a purely display screen and does not allow inputting of parameters. All values have been explained previously in the Service Level 1 screen. The exception being the CYCLE TIME entry. The cycle time is associated with the amalgamation mode and is the sum total of the Collection Time + Heating Time + Cooling Time + 5 seconds (for zero-phase at entry) + 5 seconds (waiting period after loading). This cycle time is also used for averaging during continuous measurement mode.

5.5 Run Measure Display Menu

When you press the Run Measure selection you will enter the measurement mode which you selected in the Service Level 1 menu screen.

5.5.1 Display Menus in Amalgamation Mode

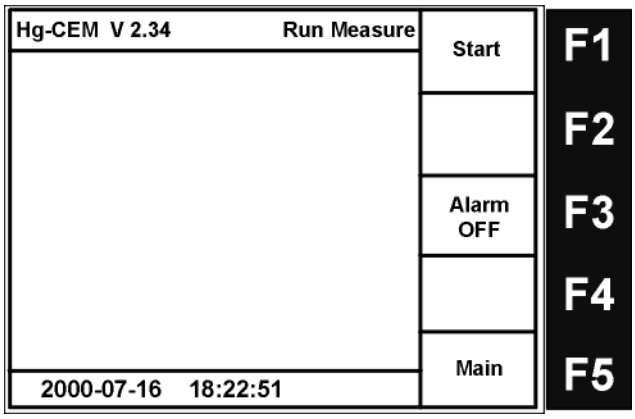


Fig.12 Start Menu associated with the Amalgamation mode

Before measurement values are displayed, there is an intermediate screen showing the adjusted parameters as well as results of measurement from the last measurement cycle. When you press the START F1 key measurements will begin and you will see a measurement display screen.

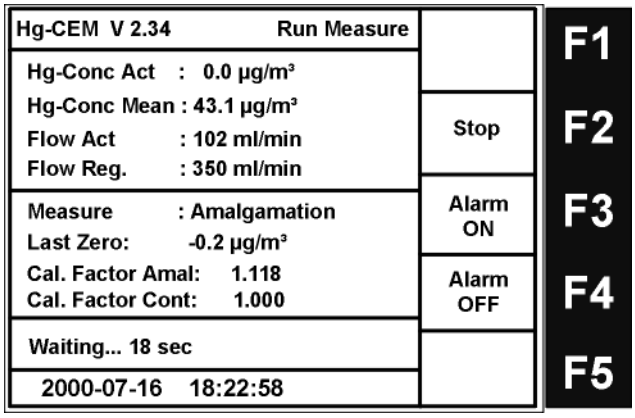


Fig 13 Measurement Display Menu during the Amalgamation mode

Before the actual measurements begin a time interval of 20 seconds elapses. This is used to stabilize the photometer and possibly an automatic switching of the measurement modes. This can occur when:

1. The concentration levels are high and so the mode is switched from Amalgamation to Continuous.
2. The concentration levels are low enough such that the mode is switched from Continuous to Amalgamation.
3. Calibration phase is occurring or has been completed.

On the second last line you will see a time countdown status line. The display entries will cycle in the following order:

1. **Zero: READ photo/flow… 2 seconds:** The zero level is set and the flow rate for nitrogen is checked. If the flow rate is greater than or less than by 20% then a YELLOW nitrogen flow alarm message is displayed. The alarm can be acknowledged by pressing the F2 alarm OFF key. The alarm will also be sent out in the digital output signal as a system failure.
2. **Collecting: READ flow… 17 seconds:** The gold trap is being exposed to the mercury stream (loading phase). The average value of the flow rate is being calculated for the measurement. In case the flow rate is +/- 20% off the set values an alarm identical to the Nitrogen stream alarm will be activated.
3. **Waiting after Collect… 2 seconds:** Waiting period after loading phase.
4. **Heating READ photo… 5 seconds:** Gold trap is being heated. The integration of process of the measurement peak begins.
5. **Cool time… 58 seconds:** Gold trap is cooled down and the integration of the measurement peak is continued.

The other display fields on the screen are:

Hg-Conc Act: The current measured value of the photometer during the measurement cycle.

Hg-Conc Mean: The result of the last measurement cycle.

Flow Act: The current measured value from the flow meters during the measurement cycle.

Flow Reg: The desired (or set) value during the loading phase.

Measure: Amalgamation Displays the selected measuring mode (Amalgamation or Continuous)

Last zero: The result of the last zero-measurement in the current or the last cycle.

Cal Factor Amal: The calibration factor for the Amalgamation mode.

Cal Factor Cont: The calibration factor for the continuous measurement mode.

5.5.2 Continuous Measurement Display Menus

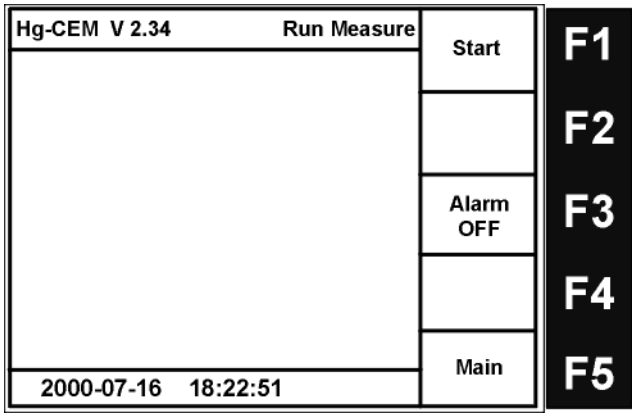


Fig.14 Start Menu associated with the Continuous mode

Similar to the Amalgamation mode, in the Continuous mode an intermediate screen is displayed. However no parameters and measurement results from the last measuring cycle are displayed. By pressing the START selection, you begin the process of actual measuring the data.

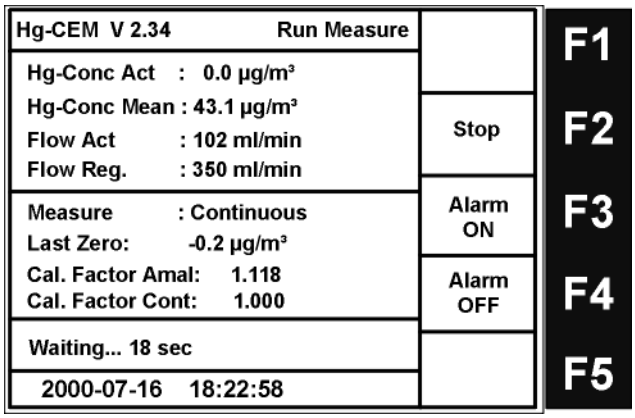


Fig 15 Measurement Display Menu during the Continuous mode

The display is to a large extent identical to the display when measurement is done with Amalgamation . However over the entire cycle there is only one status message. The zero value is also originating from the last amalgamation mode measurement. **Therefore the system should be never started in the continuous mode, in order to avoid offset errors.**

5.5.3 Calibration Display Menus

The display menus with calibrations are identical to those associated with measurements (amalgamation and continuous). For Measurements the values are flagged under "calibration mode" and the maintenance relay is set. During the automatic calibration successively 2 calibration cycles are carried out in the Continuous and Amalgamation modes.

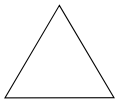
6 INSTALLATION AND STARTUP

Each system is custom-designed to meet your needs. Whenever there are deviations from our standard design, we will document the changes and supply you with appropriate drawings and diagrams. In particular, before a system startup, you should check the electrical drawing diagrams and internal flow connections and make sure that they are consistent with the documentation supplied with your system.

The installation consists of the following procedures:

1. HG-CEM® setup
2. Electrical connections
3. Attaching the sample line to the input port and the outlet gas to the exit vent
4. Attaching the Nitrogen dilution gas to the appropriate port
5. Switching on the HG-CEM®

6.1 Location Requirements



Attention

Avoid setting up the system in an area where there are strong vibrations. Additionally, protect the system against excessive moisture and ambient humidity.

The HG-CEM® is supplied in a cabinet, which varies depending upon your needs. For each system we will supply diagrams showing your configuration.

6.2 Electrical Connections

All electrical connections are located at the back of the cabinet. The connections are labeled and can be cross-referenced with the supplied electrical diagrams.

6.2.1 Mains Connection

Usually two separate electrical connections have to be made. These are divided as following:

1. Heated components in the system:
    a. Thermocatalytic converter
    b. Heated sample line
    c. Heated sample probe (optional)

    Depending upon loading requirements of these components, this electrical connection may be a 230 V for three-phase alternating current. All temperature regulators for the heaters are also connected to this electrical link.

2. Other components in the system:
    a. Mercury photometer
    b. Amalgamation unit AMU 2000
    c. Gas cooler
    d. 24 V electrical supply
    e. Bypass pump

6.2.2 Signal Outputs

The system has an analog output (4 to 20 mA) for the Hg measured value. The result is updated at the end of every measurement cycle (about 2 minutes). The location of the connectors for analog output can be found in the electrical diagrams supplied with the system.

Additionally the system has various digital outputs, which are laid out as relays:

- **Maintenance.** When this relay is open, the system is under maintenance.
- **Failure.** When this relay is open, a system failure has occurred. Usually this relates to a common alarm that can occur due to various causes. The individual reason for the failure can be seen on the front panel display of the photometer where a yellow flashing display occurs.
- **Maintenance Requirement.** When this relay is open, it indicates that as soon as possible a maintenance procedure must be carried out. The measured values are valid. However this status condition indicates that if an immediate maintenance is not carried out, the system performance will degrade leading to a failure. A typical

occurrence of this event relates to flow rate that is falling but has still not fallen beneath a critical value to trigger a entire failure.

The location of the connectors for digital outputs can be found in the electrical diagrams supplied with the system.

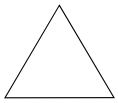
6.3 Sample Gas and Nitrogen Supply

6.3.1 Sample Gas Input

The sample gas line is typically a heated line with an exchangeable Teflon interior (6 mm outside, 4 mm inside). Different line configuration can be used and each installation tends to be different. The transition between the heated line and the gas cooler is usually a flexible tube which ends on a bulkhead union. The heated line is usually electrically connected to an appropriate contact fitting in the cabinet (exact location indicated in your electrical diagrams). The connector for the thermocatalytic converter to the heated line is indicated in a subsequent section.

6.3.2 Bypass Gas Flow

Typically the bypass gas flow is led out separately over a bulkhead union located on the top of the system enclosure.



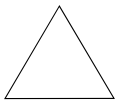
Attention

The bypass gas and the sample gas output should **never** be combined after the cabinet. The bypass pump may lead to back pressure and oscillations that may impact the sample gas flow leading to faulty measurements.

If possible the exit gas should be connected to an appropriate exhaust vent for the enclosure.

6.3.3 Exhaust Gas

Typically the exhaust gas flow is led out separately over a bulkhead union located on the top of the system enclosure.



Attention

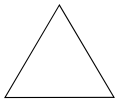
This exhaust gas always contains mercury, because within the system the sample gas stream and the gas stream from the internal calibration device are merged. Thus the exhaust gas should be vented away from the analysis location or through an appropriate activated charcoal filter.

6.3.4 Nitrogen Connection

The input for the nitrogen is on a bulkhead union located on the top of the enclosure cabinet. The inlet should be checked thoroughly for leaks, in order to avoid unnecessary nitrogen consumption. The input pressure must be reduced using a pressure-reducing valve to 7 bar. The total consumption is approximately 10 m³ per month (about 1 cylinder of 200 bar of 50 liters per month).

6.3.5 Condensate Output

The condensate output usually occurs through a bulkhead union located on the lower part of the enclosure cabinet.



Attention

The condensate of flue gases can be strongly corrosive. In order to dispose this condensate use appropriate corrosion resistant transfer line.

6.4 Switching On

The system has a main switch with two settings located on the front plate. The first setting switches on the heaters of the heated sampling components including the appropriate automatic controllers. With the second setting all other components in the enclosure cabinet are powered. It is recommended to switch and wait for setting 1, until all components achieved the temperature set points. The actual temperature and set points are displayed on the front panel of the cabinet. When all temperatures are correct, the second setting can be

switched. After about 5 minutes the set point for the gas cooler is reached. Subsequently the bypass pump starts and the system is ready for measurement if the photometer is also ready for use. Whether the photometer is ready for use is signaled on the display. Successively the following messages appear: -

- Waiting for lamp
- Stabilizing
- Zero Adjust

Subsequently the Main Menu is displayed and the measurement can be started.

7 SERVICING THE AMU 2000

7.1 Exchange of the Gold Trap

Warning

You access the gold trap from the front plate (folding open). High voltage electronic components exist within the AMU 2000. Also please take precaution for burn damage associated with heated components. Hence before accessing the AMU 2000, switch the front panel main switch to setting 1.

Open the folding front plate of the AMU 2000. The gold trap is easily accessible from this point. The gold trap is mounted in a quartz tube with metallic brass mounting blocks at both ends. A heating coil is wound around the quartz tube holding the gold trap. Also two quartz rings are used to hold the quartz tube between the brass mounting blocks.

First loosen the knurling screws holding the brass mounting blocks. These can usually be unscrewed with the hand. Then using a wrench and moving it in the opposite direction, unscrew the quart tube. Carefully remove the heating coil wound around the quartz tube. Also hold on to the two quartz rings located at either end of the tube.

Reinstallation proceeds in the reverse order described above. Make sure that the glass tube with the union screws is firmly sealed. Generally, a tight seal is obtained when things are seated firmly in their proper locations. The gold trap should be located in the central portion of the tube and within the heating coil region. Tighten the knurling screws to firmly position the brass blocks holding the quartz tube.

7.2 Leak Test

The AMU 2000 has an internal flow meter which can be used to perform a leak test. The actual flow through the AMU and photometer (after the T junction at the bypass pump) is quite low (approximately 350 ml/min). This low flow rate needs to be verified by the following three tests:

1. **CONTINUOUS MODE LEAK TEST:** Open the connection between the T-fitting and the bypass pump. Switch the analyzer to Continuous mode. Manually close (with a hand) the tube going to the washer vessel. The flow can be read on the display of the photometer and should be less than 20 ml/min.

2. **AMALGAMATION MODE LEAK TEST:** A similar procedure as the Continuous Mode Leak Test. Put the analyzer in the Amalgamation mode. Measure the flow rate during the Collection/Loading Phase. It should be less than 20 ml/min.
3. **NITROGEN PATH LEAK TEST 1:** Put a finger on the free open end of valve 4. Let the pressure build up. Remove the finger and hear/feel the pressure relief.
4. **NITROGEN PATH LEAK TEST 2:** Put a finger on the free open end of the nitrogen outlet. Let the pressure build up. Remove the finger and hear/feel the pressure relief.

8 SERVICING THE THERMOCATALYTIC CONVERTER

8.1 Heated Line Connection

First remove the outer protection cover for the thermocatalytic converter. Then remove the internal aluminum protective cover. The heated line is fastened to the Swagelok screw connection, which is bent downward.

Attention

The Swagelok screw connection becomes very hot during operation. A direct connection of the sample line PFA tube to the elbow is therefore not possible. Thus we place a transition stainless steel tube between the PFA tubing in the sample line and the thermocatalytic converter connection. The length of this transition tube depends on the type of the sampling line and other site-specific characteristics.

8.2 Exchange of the Thermocatalytic Converter

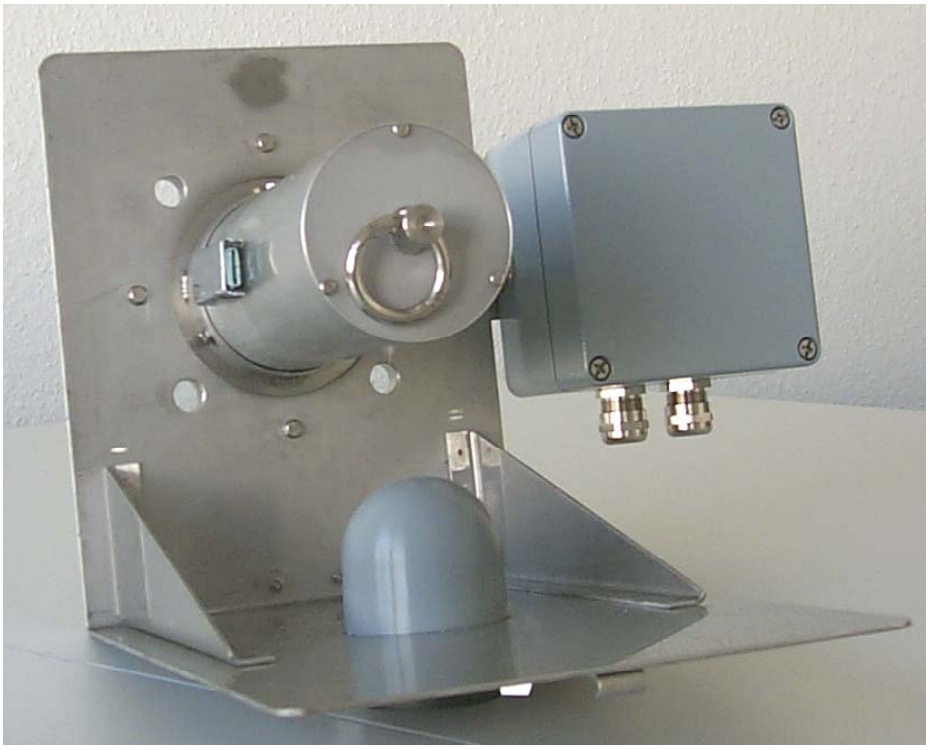


Fig 16 Thermocatalytic Converter without Protective Hood

Remove the cover over the connecter. Remove the nut and bolt screws holding the flange. The thermocatalytic converter can now be pulled out.

Attention

The Swagelok screw connection can become very hot during the operation. The screw threads will become difficult to remove or mount. Use a second wrench to carefully unscrew the fitting

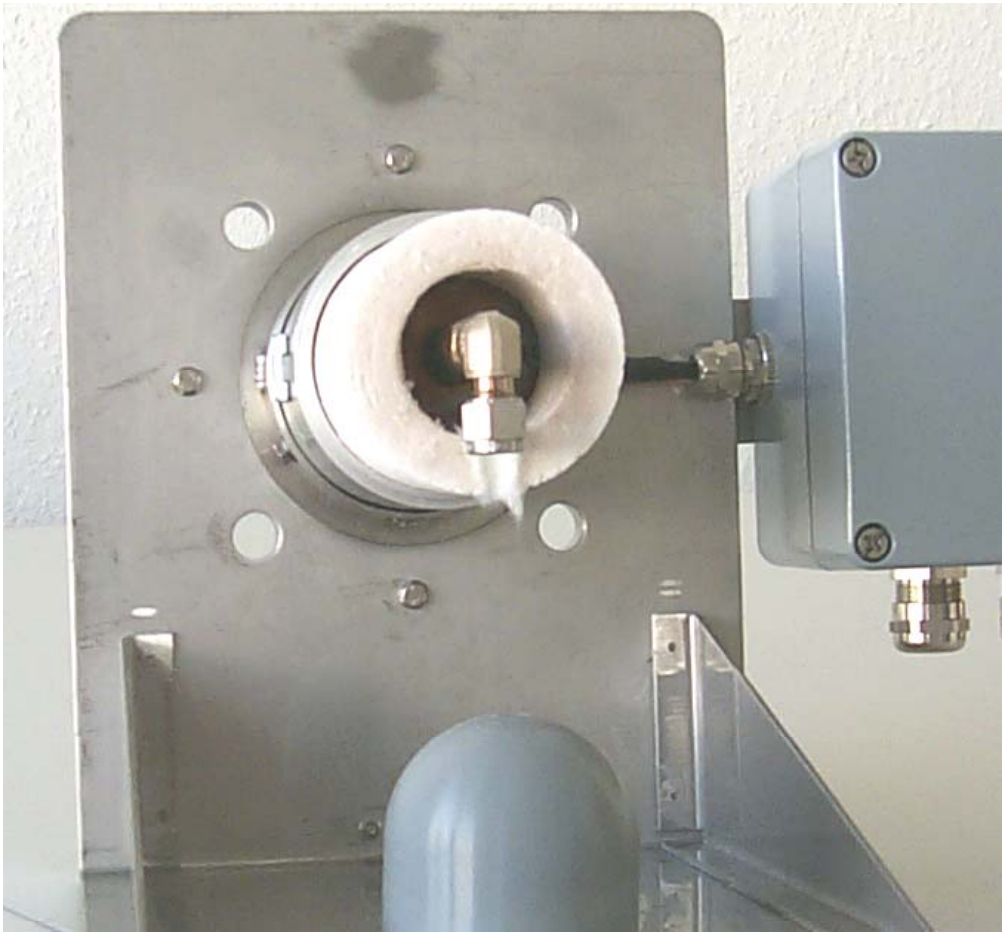


Fig 17 Measurement Gas Connection Fitting at the Thermocatalytic Converter

Attention

When exchanging the thermocatalytic converter, make sure that all components has cooled down. Otherwise there is the danger that the NPT thread screws on which the catalyst is mounted can become damaged.

When placing the new catalyst, no sealing material or Teflon tape should be used at the flange fitting. The copper seal should only be replaced if it is visibly damaged.

Fig 18 Flange with Thermocatalytic Converter

9 DIAGNOSTIC MESSAGES

Digital output is conveyed over relays when there is a Failure, Maintenance or a Maintenance Requirement status condition. Under normal conditions 24 V exists across the relays. This voltage drops when there is an error condition.

9.1 Failure

The Failure relay is triggered under the following conditions:

1. High water (humidity) content occurs after the gas cooler and is detected by the humidity sensor
2. Temperature too high or too low for the heated probe (optional feature)
3. Temperature too high or too low for the thermocatalytic converter
4. Temperature too high or too low for the heated sample line
5. Temperature too high for the gas cooler
6. 24 volt supply failure
7. Flow rate in the Amalgamation mode while loading of the Gold trap is greater than or less than 50% of the set value.
8. Flow rate through the critical orifice 1 (Calibrator) is greater than or less than 50% of the set value.
9. Flow rate through the critical orifice 2 (Measuring mode) is greater than or less than 50% of the set value.
10. The calibration value (Amalgamation mode) is greater than or less than 50% of the set value.
11. The calibration value (Continuous mode) is greater than or less than 50% of the set value.

If Failure 1 through 5 occurs, the Bypass pump is switched off for safety reasons.

9.2 Maintenance

The Maintenance relay is triggered under the following conditions:

1. Manual selection of the Maintenance ON switch
2. During the Zero Point Adjust phase
3. In case of a measurement that has been stopped
4. During each calibration cycle

9.3 Maintenance Required

The Maintenance Required relay is triggered under the following conditions:

1. Flow rate in the Amalgamation mode while loading of the Gold trap is greater than or less than 20% of the set value.
2. Flow rate through the critical orifice 1 (Calibrator) is greater than or less than 20% of the set value.
3. Flow rate through the critical orifice 2 (Measuring mode) is greater than or less than 20% of the set value.
4. The calibration value (Amalgamation mode) is greater than or less than 20% of the set value.
5. The calibration value (Continuous mode) is greater than or less than 20% of the set value.