OPERATION MANUAL DUST MONITOR

POWER

ALARM
CONTACTS

4 ... 20 mA

Modbus

USB

MRU®
since 1984
AIR *fair*
EMISSION MONITORING SYSTEMS

DM 401

62799GB

1 CONTENT

Inspect Shipment for Damage

Carefully inspect the entire shipment for damage in the presence of the shipper's agent, removing packaging material if necessary. Note any damage to packaging and/or goods on Packing List and have it signed by the shipper's agent prior to accepting the shipment. Submit damage claim to MRU immediately.

NOTE: Damage claims not received by MRU within 3 days of receipt of shipment will not be accepted.

Save the original box and the packing material for use if the analyzer must be shipped in the future.

The products described in this manual are subject to continuous development and improvement and it is therefore acknowledged that this manual may contain errors or omissions. MRU encourages customer feedback and welcomes any comments or suggestions relating to the product or documentation.

Please forward all comments or suggestions to the Customer Feedback Department at the following address:

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This manual is intended solely as a guide to the use of the product.

MRU shall not be liable for any loss or damage whatsoever arising from content errors or misinterpretation of information's from this manual or any mis-use resulting from the use of this manual.

About this Manual

This manual assumes that the DM 401 has been properly installed in accordance with the separate installation manual.

This manual contains instructions for setup, calibration, commissioning, maintenance, and general operation of the DM 401 particulate monitor, using either the DM 401 Utility Software.

This manual also contains instructions for installation of the Utility Software on a PC.

2 INTRODUCTION

2.1 The company MRU GmbH

Your analyzer is produced by the MRU GmbH in Neckarsulm Germany (founded in 1984), a medium sized company that specializes in developing, producing and marketing high quality emission monitoring analyzers. MRU GmbH produces a wide range of instruments, from standard analyzers up to tailor made industrial analyzers. MRU GmbH contact details are listed on the previous page.

Factory 1 (service department, development division, administration)

Factory 2 (Product division)

3 RETURNED GOODS

Packing regulation of 12.07.1991

If your local waste facility does not except MRU packing materials for disposal, you may return it to MRU or our local sales representative. Packing materials returned to MRU must be returned prepaid.

3.1 Return of analyzer according to ElektroG

MRU GmbH is required to accept the return, for proper disposal, of all analyzers delivered after 13th of August 2005. Analyzers must be returned to MRU prepaid.

4 Installing the Utility Software and Configuring USB

4.1 Warnings

Warning: The Utility Software and the USB Driver MUST BE INSTALLED ON THE PC FIRST i.e. before connecting the DM 401 to your PC. Connecting your PC to the DM 401 before installing the Utility Software and the USB Driver, will cause problems with installation and may even cause the installation to fail.

4.2 Minimum hardware/software specification for host PC

The DM 401 Utility Software is not a large or particularly complex program, and therefore has no requirement for a high performance host PC. Any reasonably modern PC/laptop will be suitable. The only "must have" requirements are:

- Windows XP or Windows 7 operating system
- All recent operating system Service Packs and upgrades (visit the Microsoft website) must have been installed
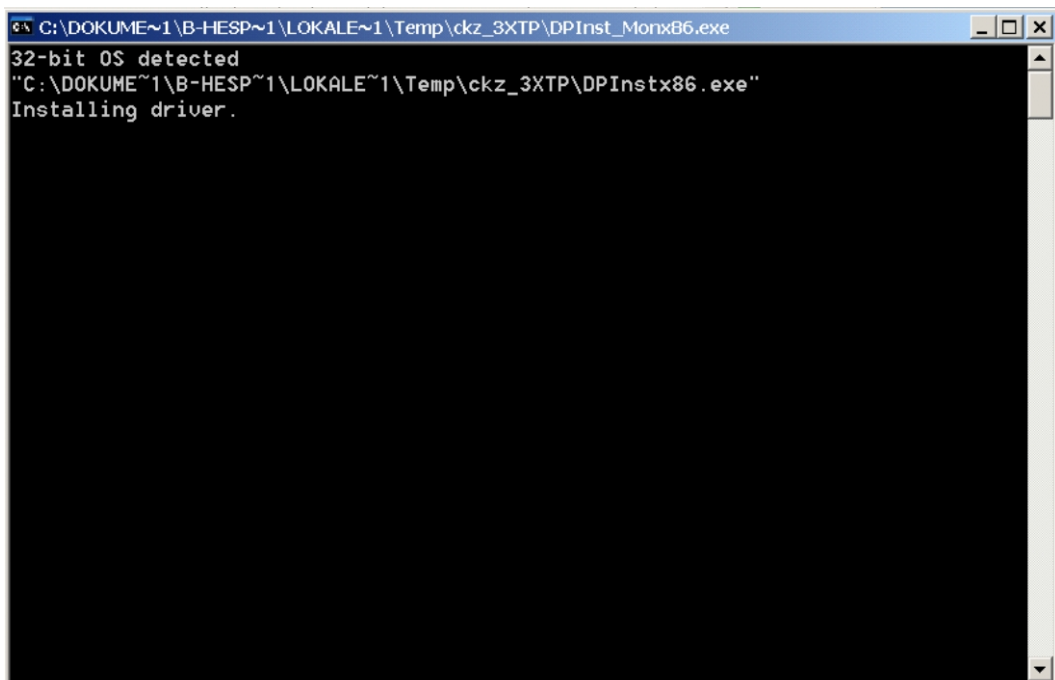
At least one free USB slot (assigned to a COM Port between COM1 and COM6 – see later section on Assigning a Valid COM Port).

4.3 Installing the USB Driver

The DM 401 USB Driver software is supplied on a CD that is shipped with your instrument.

1. Ensure that you are logged onto your PC with Administrative rights, so that you have the necessary permission to install software.
2. Copy the "DM 401 USB DRIVER (CDM 2.04.06).zip" file from the CD to any suitable location on the host PC ("My Documents" is a good location).
3. Extract the contents of the zip file (right click on the zip file and click "Extract All") to a local directory ("My Documents" is a good location again).

Navigate to the extracted files and double click "CDM 2.04.06.exe". This will start a DOS Prompt window that will automatically install the USB driver. See the following screenshot. It may take up to 1 minute to install the driver, so please be patient and wait for the DOS Prompt window to disappear before performing any other actions on your PC.

4.4 Installing the Utility Software

The DM 401Utility Software is supplied on a CD that is shipped with your instrument. There are two separate versions of the software: one for Windows XP and one for Windows 7.

1. Ensure that you are logged onto your PC with Administrative rights, so that you have the necessary permission to install software.
2. Copy the "DM 401 Utility Install "DM 401 Utility Install WINXP V*.*.*.zip" file (choose the version for your operating system) from the CD to any suitable location on the host PC ("My Documents" is a good location).
3. Extract the contents of the zip file (right click on the zip file and click "Extract All") to a local directory ("My Documents" is a good location again).
4. Navigate to the extracted files and double click "setup.exe".
5. Follow the onscreen installation prompts.

If you encounter any warning messages about replacing existing .dll files, always choose NOT to replace the existing files.

The software should now be installed and should appear in the "All Programs" list as "DM 401 UTILITY".

4.5 Updating the Utility Software

From time to time MRU GmbH may release updated versions of the DM 401 Utility Software. If you receive an updated version, it is essential that you remove any existing version from your PC before installing the new one.

To remove your existing Utility Software use the Windows "Add or Remove Hardware" option from the Windows "Control Panel".

4.6 Assigning a valid COM Port

When you first connect your PC to the DM 401, it is very likely that your PC will assign the USB connection to a COM Port number outside the acceptable range of COM1 to COM6, in which case the DM 401 Utility Software will be unable to communicate with the instrument.

You can check which COM Port your PC has assigned to the DM 401 by opening Windows "Device Manager" before connecting your DM 401. To open "Device Manager":

1. Right click on "My Computer"
2. Click on "Manage"
3. Click on "Device Manager"
4. Scroll down to "Ports (COM & LPT)", then click the "+" symbol to look at the list of COM Ports

Once you can see the list of current COM Ports, connect your PC to a DM 401 by plugging the USB cable from your PC into the USB connection on top of the TRX head (unscrew the weatherproof cap to gain access).

As you connect, your PC should indicate that it has "Found New Hardware" and a new COM Port number should pop up in the "Ports (COM & LPT)" list.

If the new COM Port is between COM1 and COM6 then your PC has allocated a valid COM Port and no further action is required.

However, if the COM Port number that was assigned to the connection is outside the acceptable range then you must change the assigned COM Port to a number between COM1 and COM6. Follow the procedure below to assign a valid COM Port:

1. Right click on the COM Port (in the "Ports (COM & LPT)" list) that appeared when you connected to the DM 401
2. Click "Properties"
3. Select the "Port Settings" tab
4. Click on the "Advanced" button
5. Click the "COM Port" and select a new "COM Port Number" between COM1 and COM6 (avoiding any COM Ports which are marked as in use) from the drop down list

Once you have assigned a valid COM Port number to the DM 401 USB connection your PC will remember this COM Port assignment and you should not need to repeat the process again when connecting your PC to the instrument, provided that you always use the same PC and you always connect via the same USB slot in your computer.

Note: If you connect to the DM 401 from a different computer, you will need to repeat the process above and assign a valid COM Port.

Note: You should always connect to the DM 401 using the same USB slot on your PC. If you use a different USB slot you will need to repeat the process above and assign a valid COM Port again, because the PC sees each USB slot as a separate entity.

5   Using the Utility Software

5.1   Warnings

Warning: The Utility Software and the USB Driver MUST BE INSTALLED ON THE PC FIRST i.e. before connecting your PC to the DM 401. Connecting your PC to the DM 401 before installing the Utility Software and the USB Driver, will cause problems with installation and may even cause the installation to fail.

5.2   Connecting a PC to the DM 401

Before connecting your PC to the DM 401 you MUST have installed the USB Driver, and assigned a valid COM Port – see the previous section on installing software.

With the driver installed and com port assigned, connect your PC to the DM 401 using a standard USB cable (type A to Type B).

On the TRX, the USB connection can be found inside the TRX enclosure itself (on the circuit board inside).

5.2.1   The Comms tab

On first running the Utility Software you will always arrive at the Comms tab. See the following screenshot.
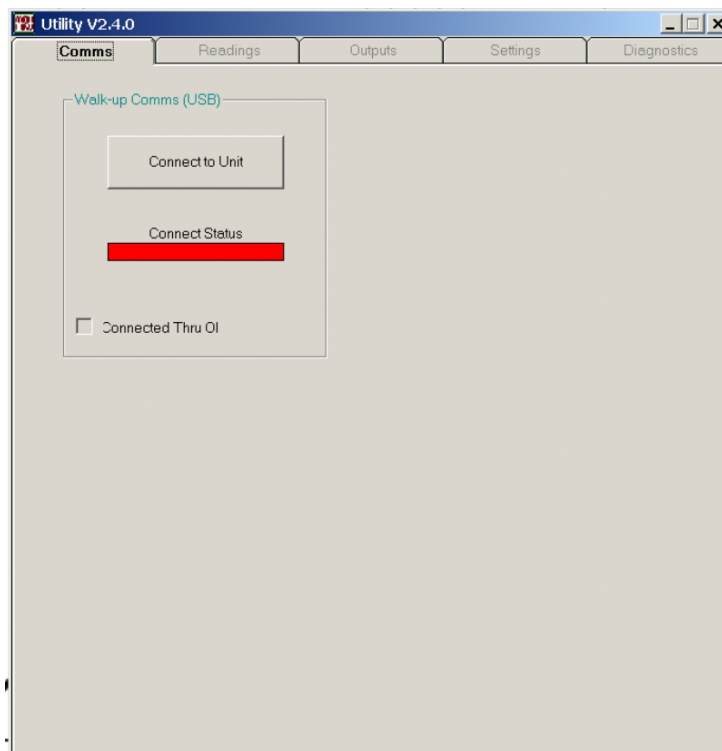
The Comms tab allows you to establish a connection with the DM 401. When you first run the program there will be no connection, so the status bar will always be red (indicating no connection). You will not be able to select any other tab until a comms connection has been established.

5.2.2 Connect to DM 401

To establish a connection with the DM 401 click the "Connect to Unit" button. The software will scan Com Ports 1 to 6 looking for any DM 401 monitors that may be connected. More than one Com Port may exist, so more than one DM 401 may be connected.

When the scan is complete the software will report the status of any Com Ports found and any DM 401s connected on a separate pop-up window. See the following screenshot.
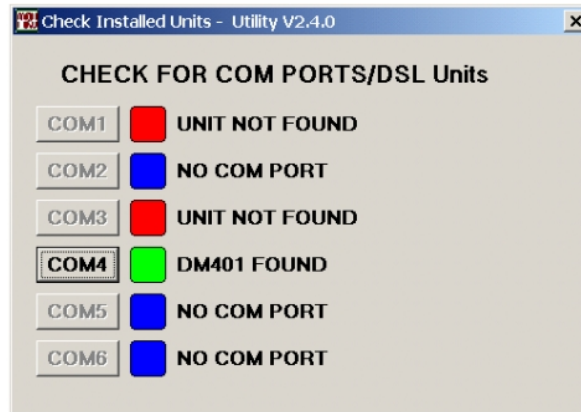
Select a Com Port with "DM 401 FOUND" alongside it (it will have a green status indicator). You will then be returned to the Comms tab where the status indicator bar will now be green (indicating a positive connection). See the following screen shot. Once a comms connection is established you will able to select any of the five tabs.
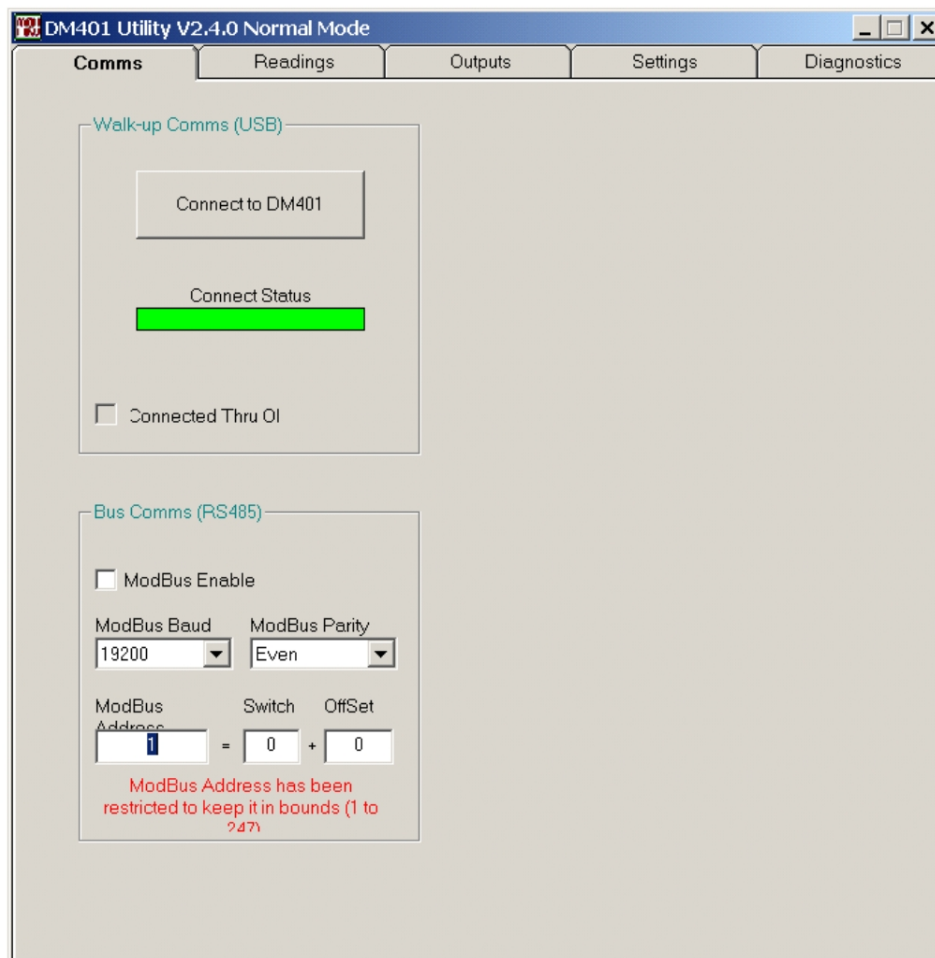
5.2.3 ModBus Enable

The settings and controls in this box allow for the main RS485 Bus Comms (on the terminal marked J6 inside the TRX) to be configured for ModBus RTU protocol.

When the ModBus Enable box is CHECKED the RS485 communications from the TRX will use ModBus protocol.

When the ModBus Enable box is UN-CHECKED the RS485 communications from the TRX will use the proprietary MRU protocol.

5.2.4 ModBus Baud

This drop down list allows the desired baud rate to be chosen for ModBus communications.

5.2.5 ModBus Parity

This drop down list allows the desired parity setting to be chosen for ModBus communications.

5.2.6 ModBus Address

This box displays the current ModBus address of the TRX to which the USB is connected. The ModBus address is the sum of the Offset value, and the Switch value. However the ModBus address is restricted to the range 1 to 247, so in a situation where the sum of the Offset and Switch values is outside this range (e.g. 0+0), the ModBus address will be forced to the nearest suitable valid address (e.g. 1 in this example).

Warning: it is essential that all instruments in a multi-drop ModBus system have a unique ModBus Address. If two or more instruments share the same ModBus Address the ModBus master device will not be able to communicate with the correct slaves.

5.2.7 ModBus Switch

This box displays the current switch position setting inside the TRX. Each DM 401 has a rotary binary switch on the main circuit board inside the TRX head. This switch can be set to any number in the range 0 to 9.

5.2.8 ModBus Offset

This box allows the operator to apply an offset to the ModBus Address. The value entered in this box will be added to the ModBus Switch value to calculate the ModBus address.

5.3 The Readings tab

The Readings tab shows the current particulate reading, the status of both warning alarms and the last activated error message. It also shows the damping applied to the particulate reading, and allows for this value to be altered. This tab also has a logging checkbox which will activate automatic data logging on one minute intervals – saving readings, settings, and other diagnostic data directly to the PC hard drive. See the following screen shot.
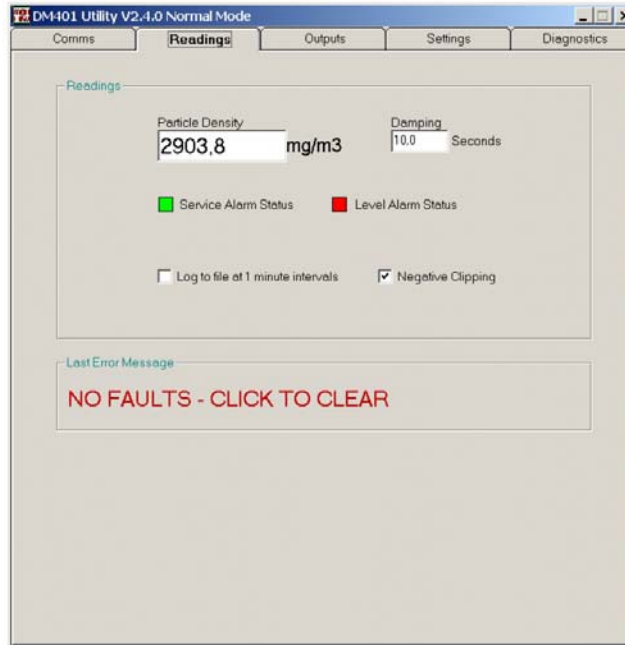
5.3.1 Particle Density

This box shows the current particulate reading, after damping. This is the value on which all outputs and alarms act.

5.3.2 Alarm status

The alarm status is displayed graphically in two coloured boxes: green indicates the alarm is inactive, red indicates the alarm is active.

5.3.3 Damping

This value (in seconds) determines the level of damping applied to the particulate reading. The default damping for this instrument is 10 seconds. The response time of the instrument to a step change in the reading is approximately three times the damping.

5.3.4 Log to file at 1 minute intervals

When checked, a log file will be created in the location C:\DM 401 MINUTE LOGS on the PC. A new log file will be generated automatically every minute whilst this checkbox is checked.

The log file can be opened in a text editor and data can be extracted into spreadsheets etc. Log files can be used for data logging or for diagnostics.

5.3.5 Negative Clipping

If this box is CHECKED the instrument will clip all the reading and the output at zero (0.0mg/m³), so positive readings will show as normal, but when the instrument calculates a negative reading it will hold the display and the outputs at zero.

If this box is UN-CHECKED the instrument will display and output the true reading, even if that reading is negative. Negative readings are possible when the instrument is not set-up and calibrated properly.

5.3.6 Last error message

The last known error message is displayed in a boxed area below. Clicking on the message will make it disappear, unless the error is still present in which case the error message will re-appear instantly. If there are more than one error messages active at one time then they will flash up here alternately.

See the section on Error Messages and Troubleshooting later in this manual.

5.4 The Outputs tab

The Outputs tab allows for configuration of electrical interface outputs, such as the 4-20 mA current loop, and alarm relay contacts, and it also displays the likely effect of those settings. See the following screen shot.
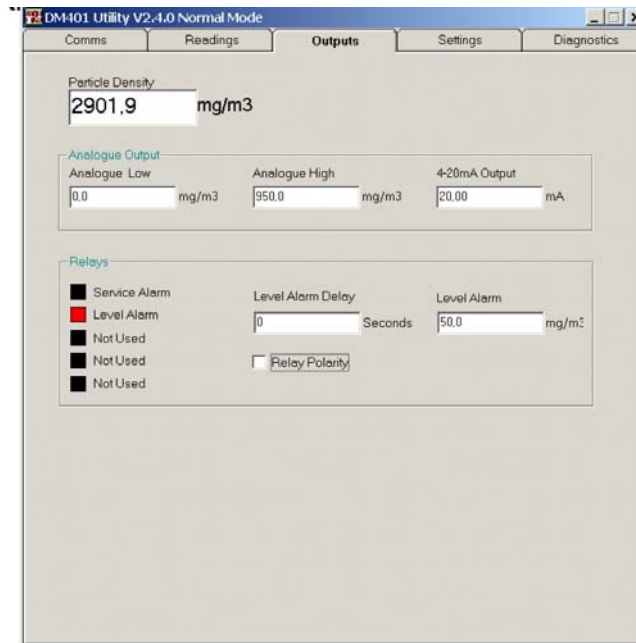
5.4.1 Analogue Low and Analogue High

These two parameters set the upper and lower scaling points of the 4-20 mA output.

Set the analogue low value to the reading at which the analogue output should generate 4 mA.

Set the analogue high value to the reading at which the analogue output should generate 20 mA.

5.4.2 4-20 mA Output

The 4-20 mA output value is a calculated indication of the expected 4-20 mA output - taking into account the analogue low/high settings.

The value shown here is a calculated value, it is not a measured value from the actual 4-20 mA outputs. There is no direct connection between the calculated value and the actual output. However, unless there is a fault with the instrument, the correlation between the calculated value and the real output should be very good.

The default state of the alarm relay (i.e. energised or de-energised) can be determined with the Relay Polarity checkbox).

5.4.3 Level Alarm Delay

This value determines the length of time (in seconds) for which the particulate reading must have exceeded the Level alarm value, before the level alarm will activate.

Delaying the activation of the level alarm can prevent borderline alarm readings from "dithering" in and out of active alarm status. Only genuine, sustained alarm readings will actually trigger the Level alarm.

5.4.4 Alarm Relays status indicators

The five square relay status indicators can each be coloured either red or black to indicate the state of the associated relay.

Red indicates the associated relay is in an energised state. Black indicates the associated relay is in a de-energised state.

Each relay indicator has the name of the associated alarm alongside:

- The service alarm activates in the event of a self diagnosed fault or service requirement.
- The level alarm activates when the reading (after damping) exceeds the level alarm value for a continuous length of time greater than that set in the alarm delay parameter.

The standard DM 401 uses only two of the possible 5 alarms, so only the first two status boxes will be active.

Its worth noting that the relays on the circuit board each have an LED alongside them to indicate their status, and that the status indicators here in the DM 401 Utility Software mimic that of the LEDs on the circuit board.

The default state of the relays (i.e. the state in which they remain when their associated alarm is inactive) can be determined with the relay polarity checkbox.

5.4.5 Relay Polarity checkbox

Checking this box changes the default state of the relays in their non-alarm condition.

With the checkbox UNCHECKED, the relays will all be de-energised in a non-alarm condition, and the relay status indicators will all be black in the same non-alarm condition. In this polarity relays will energise when an alarm is activated.

With the checkbox CHECKED, the relays will all be energised in a non-alarm condition, and the relay status indicators will all be red in the same non-alarm condition. In this polarity relays will de-energise when an alarm is activated.

We strongly recommend that users have this checkbox CHECKED so that the relays are used in a "failsafe" configuration.

5.5 The Settings tab

Warning: The Settings tab should only be used by a trained instrument engineer who has read and understood the later section on "Setup, Commissioning and Calibration" and "Calibration Checking", as the settings and controls on this tab determine the calibration of the instrument and the particulate reading it generates.

The Settings tab has a range of settings and controls for initial setup and calibration of the instrument.

See the following screenshot for appearances of the Settings tab.
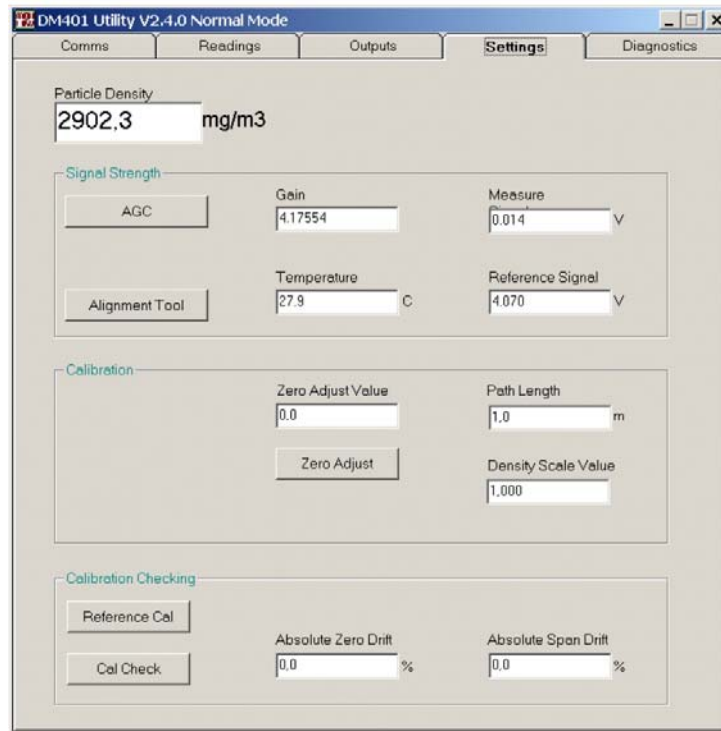
5.5.1 AGC button

Clicking this button will perform an Automatic Gain Correction (AGC), which will adjust the instruments gain value to achieve optimum signal strength.

5.5.2 Alignment Tool button

Clicking this button will open the Alignment Tool window which will assist in aligning the Reflector and TRX heads.

5.5.3 Gain

This box displays the gain value as determined by the AGC routine (above).

This value can be manually overridden, but such action should only be undertaken in certain unusual circumstances, and should only be performed by a MRU trained engineer, who fully understands the consequences of such action.

5.5.4 Measure signal

This box displays the signal strength on the measurement detector in volts, and is used as a diagnostic tool to confirm gain settings, or diagnose application problems.

5.5.5 Temperature

This box displays the current circuit board temperature inside the TRX head and is a diagnostic tool to determine operating conditions.

5.5.6 Reference signal

This box displays the signal strength on the reference detector in volts. The reference detector is used to determine changes to the intensity of the LED source, so that any changes can be compensated for in the particulate measurement. This value is presented as a diagnostic tool.

5.5.7 Zero Adjust Value

The zero adjust value defines the value to which the particulate reading will be adjusted when using the zero adjust button.

As the name implies, this value should normally be zero (0.0) as the purpose of the zero adjust button is to adjust the instrument to a particulate reading of 0.0 mg/m³ under clear path conditions.

Whilst the Utility Software does allow the zero adjust value to be overwritten with another value, this is not a recommended action, and is something that should only be done in certain specific situations by a MRU trained engineer who fully understands the consequences.

5.5.8 Zero Adjust button

The zero adjust button will cause the instrument to adjust its internal zero and span values to achieve a particulate reading equal to the value defined in the zero adjust value box (normally 0.0).

5.5.9 Path Length

Use this box to enter the installed path length, i.e. the flange to flange distance between the TRX and Reflector heads in metres (m). The path length is an essential element of the expression that relates the measured opacity and particle density. It is therefore necessary to enter this value to accuracy of ±0.05 m (5cm).

5.5.10 Density Scale Factor

The density scale factor is a multiplying factor which will be applied to the reading, and is used to perform an up-scale calibration against independent reference measurements.

5.5.11 Reference Cal button

Clicking this button will start a reference calibration routine which will define the reference against which all future calibration checks will be compared. This routine is only possible with the optional calibration head and filters (available separately) and with manual user intervention at the TRX head.

5.5.12 Cal Check button

Clicking this button will start a calibration check routine which will determine both relative and absolute drift in the measurement performance. This routine is only possible with the optional calibration head and inserts (available separately) and with manual user intervention at the TRX head.

5.5.13 Absolute Zero Drift

This box reports the absolute zero drift as calculated by use of the reference calibration and calibration check routines. These routines require the optional calibration head and inserts (available separately) and manual user intervention at the TRX head.

Absolute zero drift is defined as the difference between the 0.0 % opacity reading measured during the last reference calibration routine, and the 0.0% opacity reading measured during the last calibration check routine.

5.5.14 Absolute Span Drift

This box reports the absolute span drift as calculated by use of the reference calibration and calibration check routines. These routines require the optional calibration head and inserts (available separately) and manual user intervention at the TRX head.

Absolute span drift is defined as the difference between the upscale opacity reading measured during the last reference calibration routine, and the upscale opacity reading measured during the last calibration check routine.
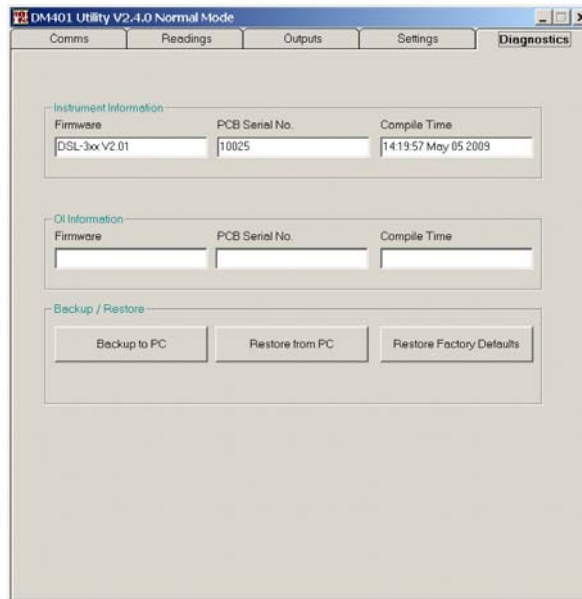
5.6 The Diagnostics tab

The Diagnostics tab has a number of read only boxes, and buttons for backup and restore. See the following screen shot.

5.6.1 Firmware

There are two boxes indicating firmware, the first relates to the DM 401 instrument itself (the firmware in the TRX circuit board).

5.6.2 PCB Serial No.

There are two boxes indicating PCB Serial No., the first relates to the DM 401 instrument itself (the serial no. of the TRX circuit board).

5.6.3 Compile Time

There are two boxes indicating compile time, the first relates to the DM 401 instrument itself (the date/time on which firmware in the TRX circuit board was compiled).

5.6.4 Backup to PC

Clicking this button will cause a simple log file to be created in the location: C:\DM 401 BACKUPS on the PC.

This log file will be identical in format to the log file that can be generated automatically at 1 minute intervals from the Readings tab.

It is highly recommended that you use this button to take a backup of your instrument settings after successfully completing installation, calibration and commissioning.

5.6.5 Restore from PC

Clicking this button will allow the selection of a log file from which to restore your instrument settings.

Alarm points and scaling factors will all be overwritten, so it is essential that you have confidence in the log file from which you restore.

WARNING! It is highly recommended that you take a backup prior to restoring, so that in the event that you restore from a bad file or unusable settings, you can always restore back to a known good point.

WARNING! Restoring from a log file will overwrite ALL settings, parameters and variables, including those that define the zero point and calibration. Restoring from a log file could change the calibration of your instrument.

5.6.6 Restore Factory Defaults

Clicking this button will restore all settings and parameters to default values as determined at the factory.

WARNING! This action will overwrite all existing settings and parameters with default values, so your setup and calibration will be lost, as will any alarm points, and output scaling factors.

6 Setup, Calibration and Commissioning

6.1 Warnings

Warning: It is essential that all components of the instrument have been properly installed, both physically and electrically, before proceeding with setup, calibration and commissioning. See the separate DM 401 Installation Manual for full details of installation requirements.

This manual assumes a basic knowledge of industrial instrumentation and its associated terminology. It is therefore highly recommended that only engineers with instrumentation experiences perform any of the setup, calibration, and commissioning routines.

6.2 Overview

The DM 401 Particulate Monitor is an in-situ analyser that relies on the local plant structure to determine both the length and angular alignment of its light path (the path along which the light beam travels, and along which measurements are made).

The natural variation that can be found between installations, in both length and alignment of the light path, requires the DM 401 to be capable of working with a wide range of signal strengths.

This necessity to work with a range of signal strengths means that it is impossible for the DM 401 to be supplied pre-calibrated or in any way readied for a specific installation.

It is therefore necessary to perform a number of basic setup, commissioning and calibration routines (after the instrument has been properly installed) to make allowance for the actual signal strengths achieved in the specific installation. These routines must be performed properly before the instrument can be considered operational or accurate.

Please note: subtle differences between apparently identical installations can produce very different signal strengths, so it is essential that the setup, calibration and commissioning process is performed independently for each installed instrument.

Setup, calibration and commissioning involves the following procedures, which must be completed **in order**. The list below is only an overview of the steps required and their order. See later on in this section for a detailed description of how to perform each step:

IMPORTANT STEPS

1. **Perform a Head Alignment** – This optimises the mounting angle of the Reflector and TRX heads to achieve the largest possible measured signal with the least gain.
2. **Perform an Automatic Gain Correction** – This adjusts the gain applied to the measurement signal to achieve an amplified signal that is within the required voltage range.
3. **Perform a Zero Adjust to 0.0 mg/m³ Particulate under clear path conditions** – This adjusts the instruments span setting to define 0.0 mg/m³ particulate (bottom of scale).
4. **Perform an upscale calibration** – This involves using the density scale factor to force the particulate reading to match independent reference measurements taken coincidentally.
5. **Configure the outputs** – Once the instrument is calibrated, the 4-20 mA and level alarm outputs can be configured as required for integration with the wider plant systems

It is absolutely essential that steps 1 to 4 are performed in order before considering the instrument operational.

Please note: if at any stage during the operational life of the instrument there is a significant change to the DM 401 or its installation, it is essential that you repeat the steps above i.e. you must perform the setup, calibration and commissioning procedures all over again.

Significant changes include: moving the position or alignment of the heads, reducing the path length between Reflector and TRX, replacing any functional component of the instrument (especially the circuit boards), changing the gain value, or performing a zero adjust.

6.3 Head Alignment

The mounting flanges should have been installed on the stack with a maximum angular deviation of ±2°, as per the DM 401 Installation Manual.

Before performing the head alignment it is important to confirm that the narrow green light beam produced by the TRX fully overlaps the aperture of the Reflector head on the other side of the stack. A local viewing port may allow sight of the Reflector aperture on the inside of the stack, in which case visual inspection can confirm that the light beam fully overlaps the Reflector aperture.

Alternatively the Reflector head can be unclipped from the air-purge head and an observer can look through the back of the air-purge head (effectively placing their eye where the Reflector would have been) to assess the brightness of the beam coming into the Reflector aperture. The observer should be able to move their head up, down, left and right to locate the bright central spot of the light beam.

If the observer cannot locate the bright central spot of the light beam it is likely that the beam does not properly overlap the Reflector aperture.

Where the light beam does not fully overlap the Reflector aperture it is likely that the basic alignment of the mounting flanges is not within the ±2° tolerance, and this error must be addressed before performing the head alignment.

The same visual techniques described above can be used to make a crude initial alignment of the heads to centralise the light beam over the Reflector aperture. This can result in a near perfect alignment which only requires minor adjustment in the head alignment procedure.

To adjust the angular alignment of the heads it is essential that the 12 mm thick red silicone gaskets have been properly installed as per the DM 401 Installation Manual.

Changes in the angle of the head are achieved by individually tightening the M14 mounting bolts/nuts that secure the air-purge head to the mounting flange, to achieve uneven pressures. The differential pressures on the bolts compress the gasket unevenly, applying an angular change between the head and the mounting flange.

The objective of head alignment is to maximise the measured signal strength, and to achieve the smallest possible gain value. The better the alignment is, the larger the signal strength will be, and the lower the gain will be.

In order to monitor both the signal strength and the gain value simultaneously it is recommended that operators use the Alignment Tool function available on the Settings tab in the Utility Software. See below.
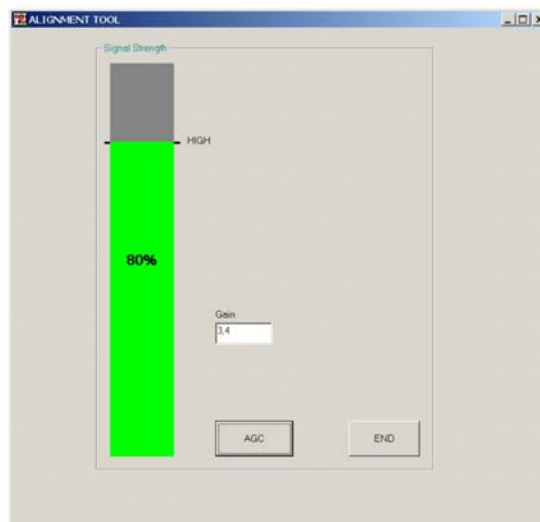
The Alignment Tool has a signal strength bar which increases in height with increases in the measured signal. If the measured signal goes too high or too low for the gain range currently set, the colour of the bar turns from green to red. The bar also has a HIGH marker to indicate the best signal strength achieved in this session.

If the bar is red (i.e. too high or too low) the AGC button should be used to adjust the gain value and bring the signal strength back within the acceptable range (i.e. green bar).

With the instrument powered up, monitor the signal strength bar shown in the Alignment Tool window, and adjust the angle of the TRX head to achieve the maximum possible signal strength with the lowest possible gain value.

The TRX should always be adjusted first (i.e. before the Reflector)!

Please note: the measured signal is slightly damped so it takes a few seconds for the signal strength bar to respond to an adjustment in the head alignment.

When the TRX is properly aligned, make sure that all four mounting nuts are tight and secure.

Then perform the same procedure on the Reflector - again ensure that all four mounting bolts are left tight and secure on completion.

On completion of the alignment process the Alignment Tool window should be closed by clicking the End button.

6.4 Automatic Gain Correction (AGC)

An AGC alters the instruments gain value to achieve the optimum signal strength of 4 V. It is essential that the ~4.0 V is achieved under clear path conditions. Clear path conditions are defined as follows:

1. The instrument must be properly and permanently installed as per the separate Installation Manual and the heads must be properly aligned as described above.
2. The instrument must have been powered up and left to settle for a minimum of 1 hour.
3. The optical surfaces of the instrument must be perfectly clean and free from dirt, dust, moisture, or oil.
4. The optical path between the TRX and the Reflector must be clear and free from any obstruction.
5. The duct or stack must be free from any dust, smoke, soot, steam, or particulate (i.e. the process behind the stack must be shut down).

Once clear path conditions have been achieved the gain correction should be performed, either by clicking the AGC button on the Settings tab in the Utility Software.

This will cause the instrument to automatically calculate and store a new gain value to achieve the optimum signal strength ~4.0 V.

Please note: the DM 401 should not be operated with a gain of more than 2000. The instrument is capable of setting higher gains, but these are for use in alignment and setup only. If the AGC produces a gain higher than 2000 then either the path length between the Reflector and TRX is too long, or the heads have not been aligned correctly.

The level of gain can also be determined manually (by overwriting the value in the gain box) but this is NOT recommended. Manual gain values should only be determined by MRU trained engineers who fully understand the implications of such actions.

Warning! Setting a measure signal of ~4.0 V (using either automatic or manual gain correction) without clear path conditions can cause the measure signal to become saturated when the plant stops and a clear path is established. This is because as the light path clears, the measure signal will increase. The maximum possible measure signal is 5.0 V, but any voltage above 4.5 V is considered unsuitable for normal operation and will generate a service fault message in the instrument.

6.5 Performing a Zero Adjust

A zero adjust should be performed to achieve a particulate reading of 0.0 mg/m³ under the same clear path conditions achieved for the AGC.

To perform the zero adjustment using the Utility Software: click the zero adjust button.

6.6 Performing an upscale calibration

Having zeroed the instrument it is necessary to perform an upscale calibration by altering the density scaling factor to force the instruments reading to match independent reference measurements taken coincidentally.

A new density scaling factor will be calculated by comparing average reference measurements with average instrument readings.

In order to achieve the most accurate calibration it is necessary to take the calibration measurements at the highest possible particulate concentration levels, i.e. the plant should be operational and the particulate level in the stack gas should be at the high end of anticipated levels. Calibrations performed with reference measurements close to 0.0 mg/m³ are not valid.

In order to perform an upscale calibration the following conditions must be met:

- The instrument must have been properly and permanently installed as per the separate Installation Manual and the heads aligned for optimum signal.
- A head alignment and AGC must have been performed, and the instrument must have been zeroed, as described earlier in this section.
- The instrument should have been powered up and left to settle for at least one hour.
- The plant should be operational and the particulate concentration in the stack at the highest possible level.

To perform the calibration the sampling probe for the reference measurement should be inserted into the duct slightly downstream of the instrument head position. Care must be taken to ensure that the sampling probe does not interfere with the light beam or the air flow around the head position. However, the probe should be inserted relatively close so that the reference measurements and the instrument measurements are taken from the same gas sample and under the same conditions.

During the time period over which the reference sample is taken (typically 30 mins) the average particulate reading displayed by the DM 401 instrument should be recorded (PD).

The particle density measured by the standard reference method (PD_{REF}) is then compared to that displayed by the DM 401 (PD) and a new density scale factor is calculated to force the two measurements to agree, using the expression below. This new density scale factor should then be entered into the Utility Software.

$$DSF = DSF_0 \left(\frac{PD_{REF}}{PD_I} \right)$$

Where:

DSF = the new density scale factor

DSF_0 = the original density scale factor

PD_{REF} = the particle density (mg/m³) from the standard reference method

PD_I = the particle density (mg/m³) from the DM 401 instrument

For improved accuracy this process should be repeated a number of times (at least 5) using the original density scale factor (DSF_0) for all measurements. The average of all the calculated density scale factors should then be used as the final density scale factor to be entered into the instrument.

6.7 Configuring the Outputs

The DM 401 has a 4-20 mA current loop output and two alarm relay contacts, one for reading level and the other to indicate a service requirement or error.

The service alarm operates under predefined conditions and requires no configuration; however the level alarm and the 4-20 mA Output can be configured as required.

6.7.1 4-20 mA Output

The DM 401 has an isolated 4-20 mA current loop output (see the separate Installation Manual for wiring details). This output can be scaled as required using the analogue high and analogue low boxes on the Outputs tab of the Utility Software.

The value set in the analogue low parameter determines the particulate reading at which the analogue output will produce 4 mA.

The value set in the analogue high parameter determines the particulate reading at which the analogue output will produce 20 mA.

A calculated indication of the real time 4-20 mA output level (based on the analogue high/low values) can be viewed on the Readings tab of the Utility Software.

6.7.2 Level Alarm

The level alarm activates when the particulate reading exceeds the alarm level for a continuous period in excess of the alarm delay time.

To determine the alarm level using the Utility Software, use the level alarm value on the Outputs tab.

To determine the alarm delay time using the Utility Software, use the level alarm delay value on the Outputs tab.

When the level alarm is activated it changes the state of the associated alarm relay (see the separate Installation Manual for wiring details) and it also changes the associated alarm status indicator on the Readings tab and the relay status indicator on the Outputs tab of the Utility Software.

The default state of the alarm relay (i.e. energised or de-energised) can be determined with the relay polarity checkbox on the Outputs tab of the Utility Software.

With the Utility Software checkbox UNCHECKED the relays will all be de-energised in a non-alarm condition, and the relay status indicators will all be black in the same non-alarm condition. In this polarity relays will energise when an alarm is activated.

With the Utility Software checkbox CHECKED the relays will all be energised in a non-alarm condition, and the relay status indicators will all be red in the same non-alarm condition. In this polarity relays will de-energise when an alarm is activated.

We strongly recommend that users have this checkbox CHECKED so that the relays are used in a "failsafe" configuration.

Please note: the relay polarity checkbox effects both the level alarm relay and the service alarm relay equally.

6.7.3 Service Alarm

The service alarm operates under predefined conditions and requires no configuration. However, it is necessary to understand that the service alarm polarity is determined by the relay polarity checkbox on the Outputs tab of the Utility Software, and that this checkbox affects both the service alarm and the level alarm equally.
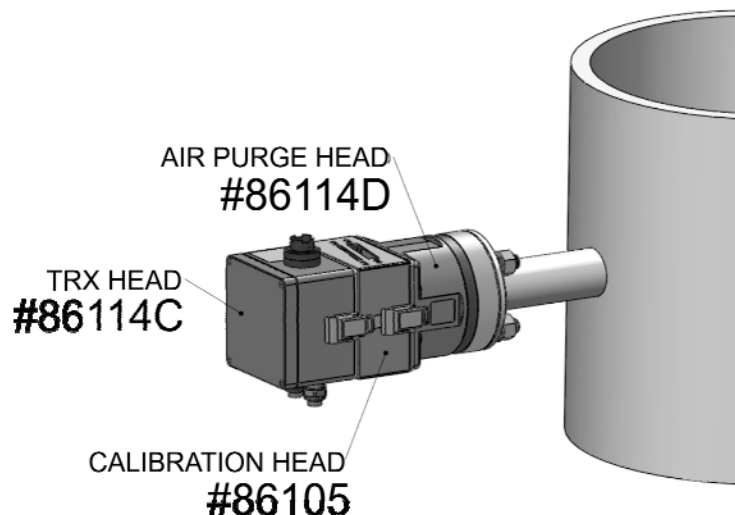
7 Calibration Checking

The zero and span calibration of the DM 401 can be checked manually using the optional Calibration Head (Cal Head) and calibration inserts: a Zero Mirror used to simulate a clear path condition; and a Span Filter with a single pass opacity of ~21% (dual pass opacity ~38%).
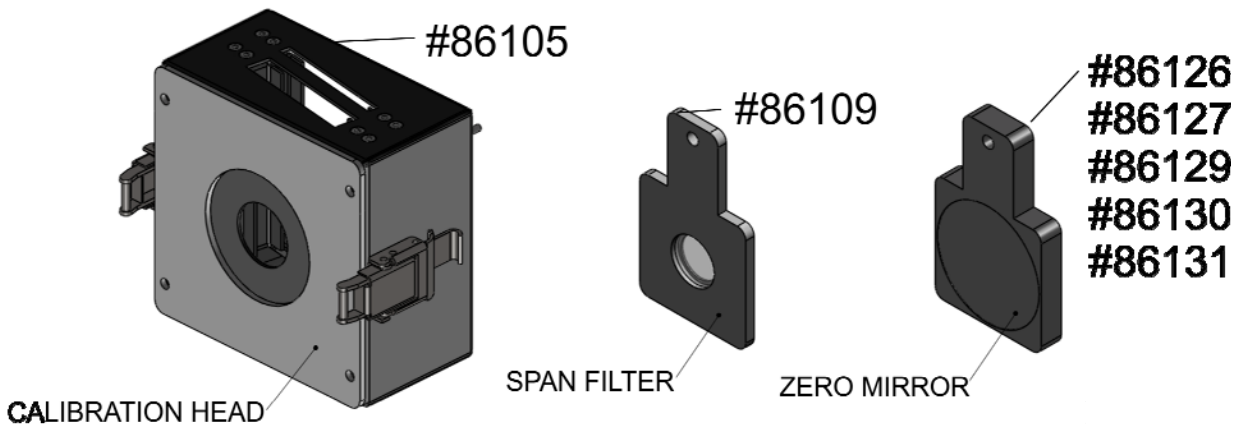
The two calibration inserts have a different thickness and are designed to fit into two separate slots in the Cal Head. To improve the repeatability of the calibration measurements the inserts are a tight fit in the Cal Head slot. For this reason each insert has a hole in its handle which can be used to assist in extracting the insert from the Cal Head.

When performing a calibration the Cal Head is designed to be inserted between the TRX Head and the Air-Purge Head.

After the calibration checking routine has been completed the Cal Head must be removed for normal operation of the instrument.

The two inserts are to be used to periodically check the calibration of the instrument. It is therefore essential that they are kept clean and undamaged.   When not in use they should always be stored in the bags provided. The optical surfaces of the inserts should not be touched. Before use the optical surfaces should be inspected for scratches, dust and contamination.

Any dust should be removed with a blast of clean dry air from a clean air canister. Remove any stubborn particles or grit with a camera lens brush. Once all the particles and grit have been removed the optical surface can be wiped over with a spectacle cleaning solution and dried with a lint free cloth.

The calibration checking routine can only be performed via the Utility Software on a PC or Laptop connected to the TRX head via its external USB port.

Please note: all calibration checking measurements are performed in opacity (%) and are not scaled to particulate density (mg/m³), and all displayed values, including relative and absolute drift, are shown as opacity (%).
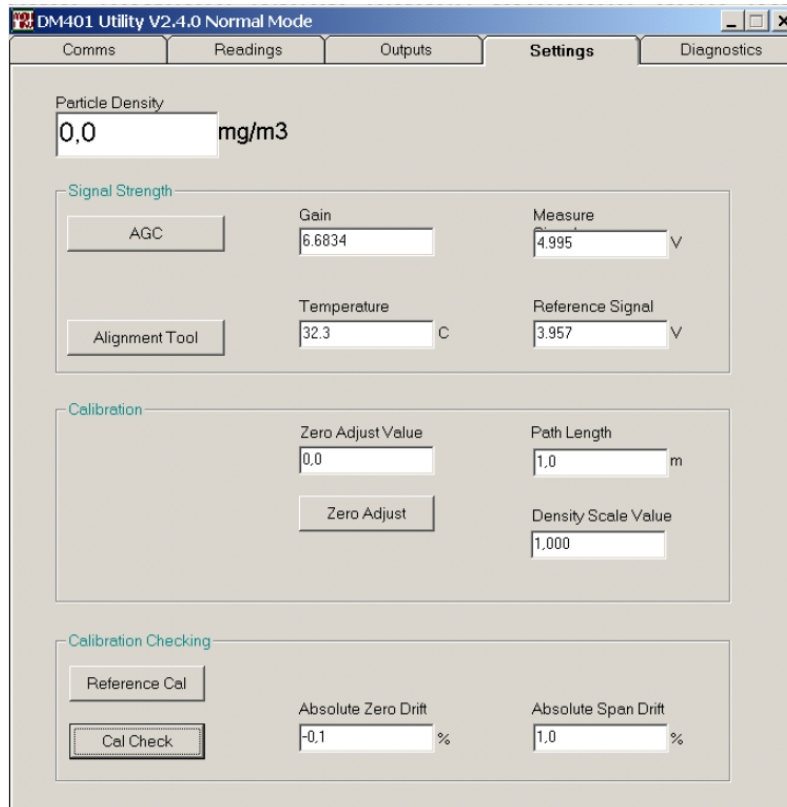
7.1 Reference Calibration

If regular manual calibration checks are to be made on the DM 401 then a reference calibration must be performed first. This reference calibration provides the initial zero and span settings, which will be used to determine the zero and span drifts.

The reference calibration must be performed after the DM 401 has been correctly set-up, calibrated, and commissioned, as described earlier in this manual. A reference calibration will need to be repeated if major changes are made to the instrument that require the gain or zero adjust to be changed, or if new Zero and Span filters are to be used.

Before starting the reference calibration ensure that the instrument has been powered up for at least 1 hour.

To start the reference calibration, go to the Settings tab of the DM 401 Utility software and select the Reference Cal button in the Calibration Checking box.

A new window will appear which guides you through the reference calibration procedure in a step-by-step format. Note that when in the calibration mode the normal mode window is locked and all outputs are frozen.

At any stage during the reference calibration process the procedure can be stopped by selecting the Abort button. This will take the user to the Exiting window which guides the user to safely return the instrument to the normal window with no changes having been made to the settings stored in the instrument. The Exiting window is described in more detail later.

7.1.1 Step1
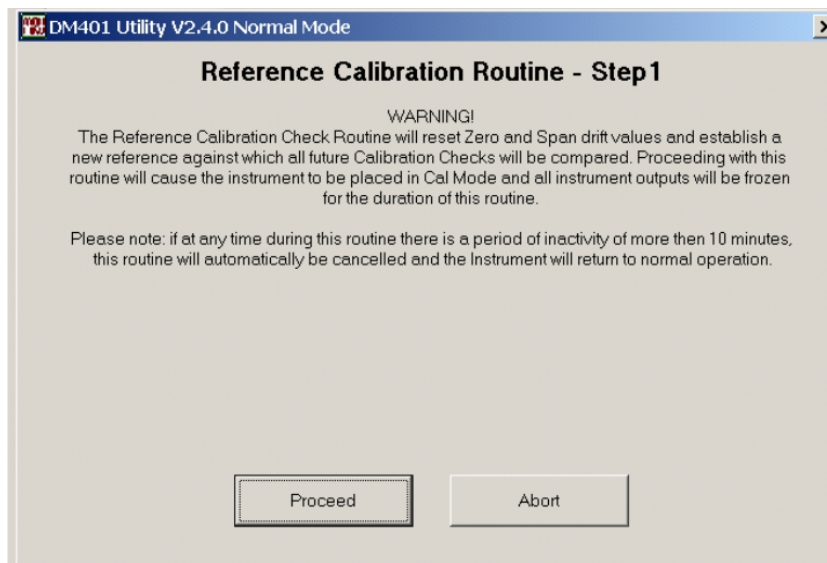
The first window to appear, after selecting reference calibration, is a warning window. This explains what will happen if you proceed, and allows the user to abort if they do not want to perform a reference calibration. Selecting the Abort button will take the user to the Exiting window. To continue to Step 2 select the Proceed button.

7.1.2 Step 2
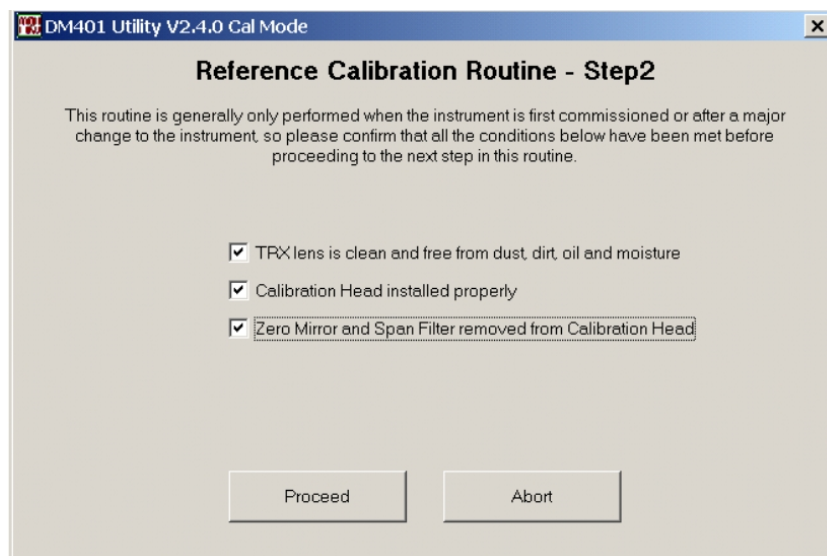
This window has three check boxes that must be completed before the user can proceed.

1. Check the first box to confirm that the TRX lens is clean. This should be the case since the reference calibration should only take place under clean, set-up conditions.

2. Check the second box to confirm that the Calibration Head has been installed correctly, as illustrated below.

AIR PURGE HEAD

TRX HEAD
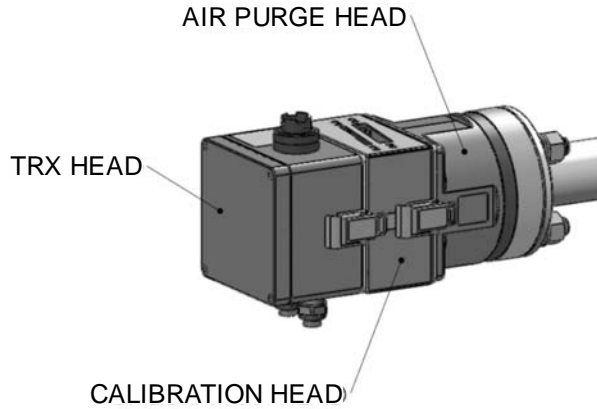
CALIBRATION HEAD

3. Check the third box to confirm that there is no Zero Mirror or Span Filter inserted in the Calibration Head at this stage.

When all three check boxes have been checked the Proceed button becomes available, click on this to proceed to step 3.

7.1.3 Step 3
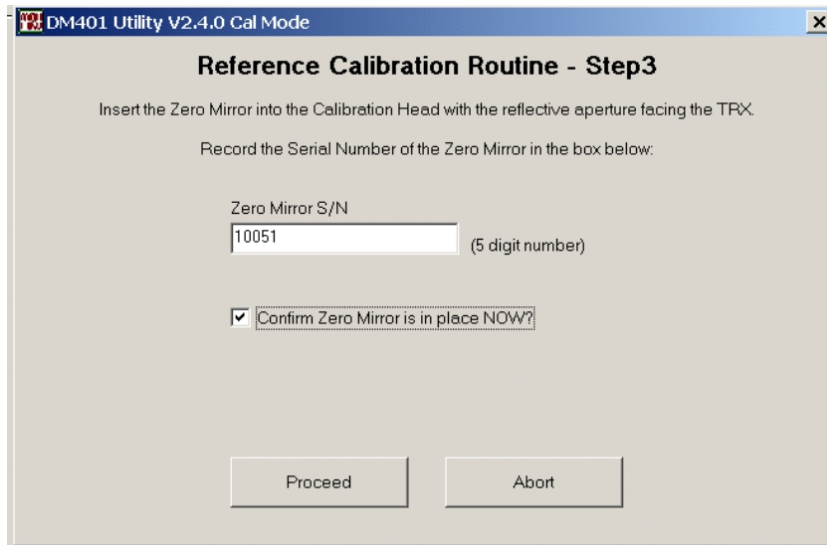
This step performs the reference Zero Mirror calibration. Each Zero Mirror has its own serial number and the same Zero Mirror must be used for all calibration checking. The 5 digit serial number is marked on the Zero Mirror and should be typed into the Zero Mirror S/N box.

The Zero Mirror should now be placed in the large slot in the top of the Cal Head with the mirror side facing the TRX head see illustration below.

INSERT ZERO MIRROR
INTO WIDE SLOT, WITH
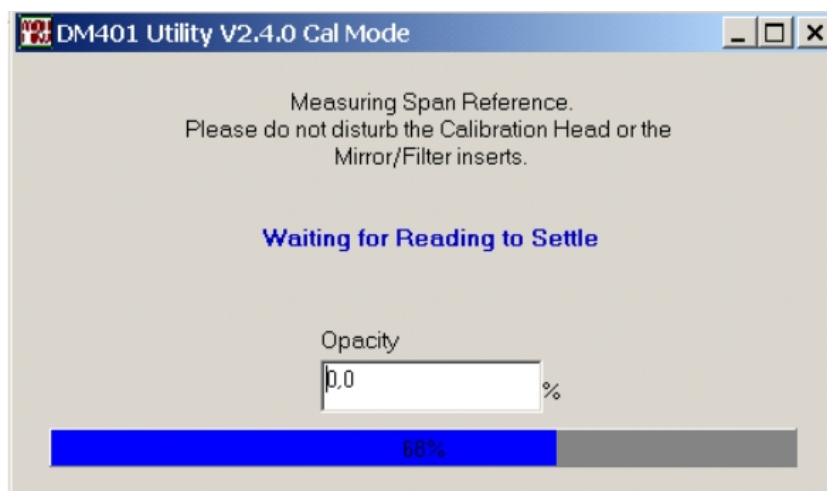APERATURE TOWARDS
TRX HEAD, AS SHOWN
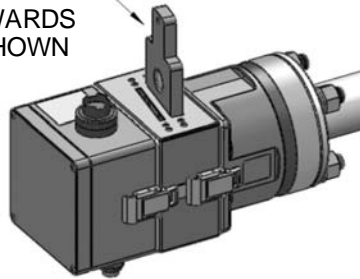
It should be pushed down firmly into the Cal Head slot until the hole in its handle is just above the top surface of the Cal Head.
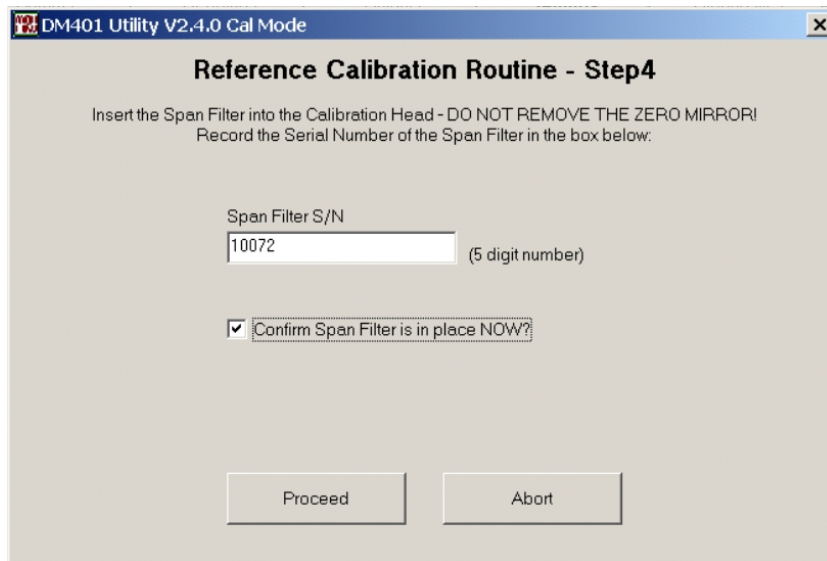
ENSURE ZERO MIRROR
IS FULLY INSERTED
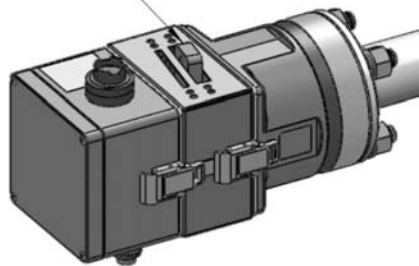
When this is complete select the check box. This makes the Proceed button available, click to proceed. When proceed has been selected the instrument goes through an automatic measurement routine which takes about 20 seconds. A window is displayed showing the progress and also the measured opacity. Do not close this window, if the user wants to abort wait for this measurement to finish and use the abort button in the step 4 window.
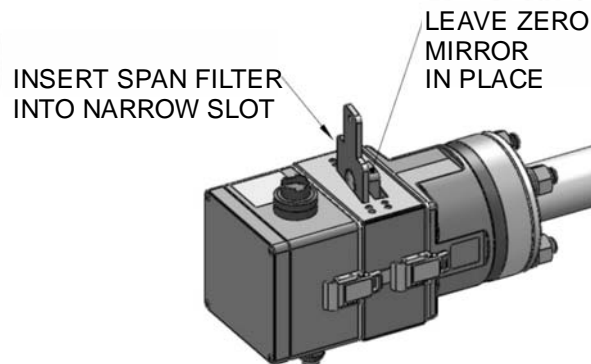

Do not disturb the head or the program until this measurement is complete. On completion the step 4 window automatically appears.

7.1.4 Step 4

This step performs the reference Span Filter calibration. Each Span Filter has its own serial number and the same Span Filter must be used for all calibration checking. The 5 digit serial number is marked on the Span Filter and should be typed into the Span Filter S/N box.

With the Zero Mirror still in place and undisturbed the Span Filter should be pushed into the smaller slot in the top of the Cal Head.


It should be pushed down firmly into the Cal Head slot until the hole in the handle is just above the top surface of the Cal Head.
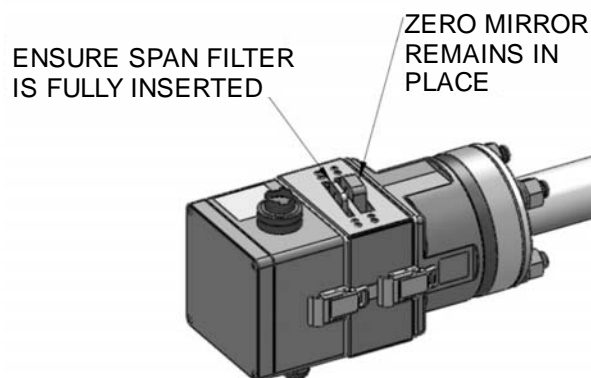

When this is complete select the check box. This makes the Proceed button available, click to proceed. When Proceed has been selected the instrument goes through an automatic measurement routine which takes about 20

seconds. A window is displayed showing the progress and also the measured opacity. Do not close this window, if the user wants to abort wait for this measurement to finish and use the abort button in the step 5 window.
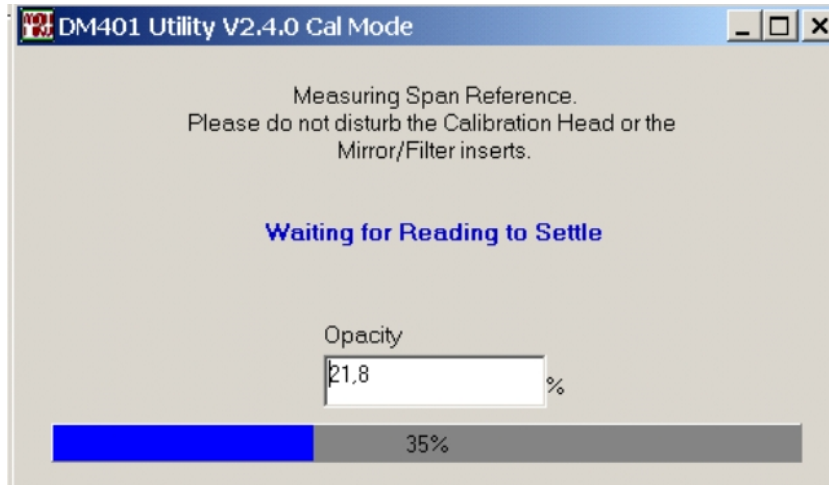

Do not disturb the head or the program until this measurement is complete. On completion the step 5 window automatically appears.

7.1.5 Step 5
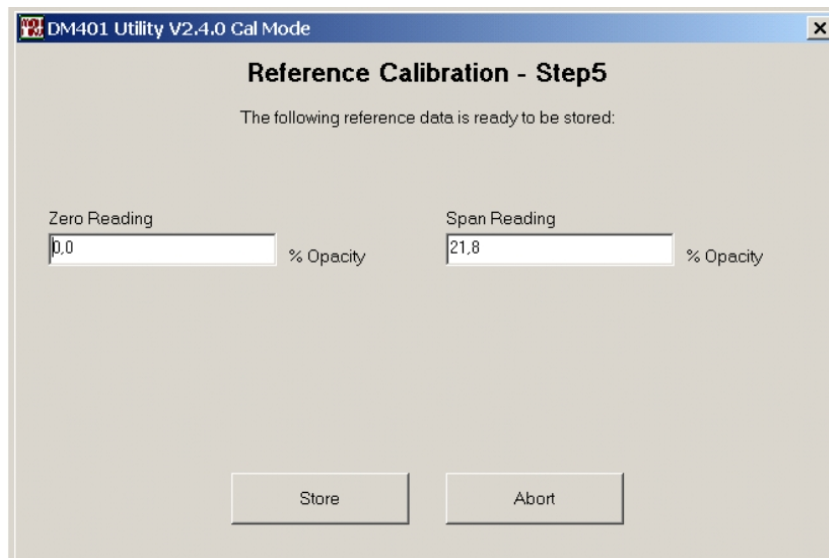
This window displays a summary of the measured reference calibration zero and span opacity values. Selecting the Store button will save these values in the instrument, along with the settings used to perform the reference calibration. All subsequent calibration checks will be performed using the stored settings and any drift will be measured relative to the stored values.

On selecting Store another window will appear when the data has been stored. Click OK to proceed to the final stage which is used to exit from the reference calibration routine.
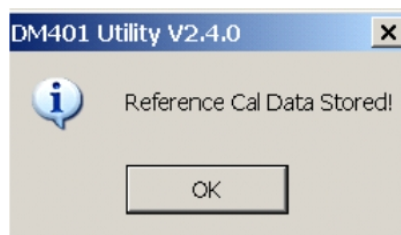
7.1.6 Exiting
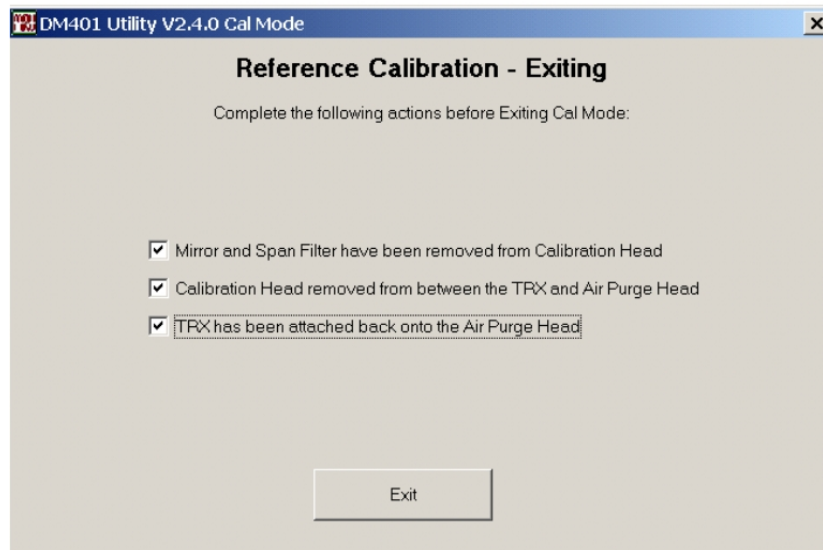
This window has three check boxes that must be completed before the user can proceed. These steps must have been completed before it is safe to return to the normal measurement mode. Note that this Exiting window is also accessed if the user aborts from the reference calibration at anytime.

1. Check the first box to confirm that the Span Filter and Zero Mirror have been removed from the Cal Head. These calibration check inserts must be stored safely and kept clean for future use.

   Note that the inserts may be a tight fit in the Calibration Head in which case the holes in their handles can be used, with a suitable tool, to assist in removing them.

2. Check the second box to confirm that the TRX head has been removed from the Calibration Head and that the Calibration Head has been removed from the purge head.

3. Check the third box when the TRX has been re-attached to the purge head and locked in place with the side latches.

When all three boxes have been ticked the Exit button becomes available, click on this to exit the calibration mode and return to normal operating mode. The reference calibration is now complete and after a few seconds the instrument will be back operating as normal.

7.2 Relative and Absolute Drift

The DM 401 monitors relative drift (i.e. the change is zero and span measurements since the last drift correction) and absolute drift (i.e. change in zero and span measurements since the last reference calibration).

The calibration check process described above measures and (if required) corrects for the *relative* drift in the zero or span calibration of the instrument.

It's important to remember that performing a drift correction will reset the reference values for relative drift, and that future calibration checks will determine relative drift from these new reference values.

Absolute drift calculations reference the values stored during the last known reference calibration routine, and therefore charts the underlying long term change in the instruments calibration. The absolute drift is re-calculated each time a calibration check routine is performed and is displayed on the Settings tab in the Utility Software.
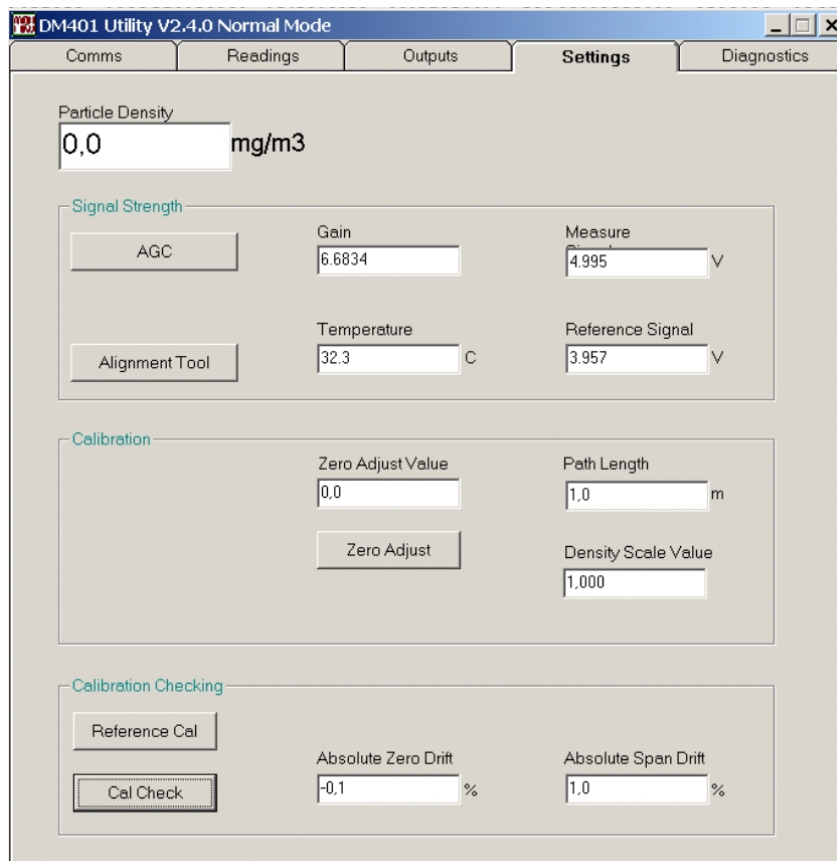
One use of the absolute drift is that it can indicate gradual build up of dirt on the lenses by giving an increasing positive absolute drift. The recommendation is that if the absolute drift becomes greater than 10.0% then the lenses should be cleaned.

8 Maintenance

The DM 401 requires very little maintenance because it has no moving parts and no perishable components.

8.1 Cleaning the lenses

The main maintenance consideration is the cleanliness of the optical surfaces in both the Reflector head and the TRX head. Dirty lenses will introduce an opacity which will be measured by the instrument in the same way that suspended particulate in the stack gas will, and it will therefore cause the instruments particulate reading to drift accordingly.

It is therefore recommended that the external surface of the Reflector and TRX lenses are cleaned at regular intervals to ensure that they remain completely clear and do not cause drift.

The required interval between cleaning will vary between installations, depending on the nature of the process, the stack, and the air purge system. A properly installed and effective air-purge system will significantly lengthen the time between maintenance.

Initially it is recommend that lenses are checked, and if necessary cleaned, once a week. If at weekly intervals the lenses are found to be clean and free from particle deposition, then the cleaning interval should be increased to two weeks, then 1 month, 2 months etc. until the ideal cleaning frequency is established.

In order to clean the lenses, first remove the Reflector/TRX head from the air-purge head by releasing the two latches. Inspect the lenses and remove any heavy deposition with a blast of clean dry air from a clean air canister. Remove any stubborn particles or grit with a camera lens brush.

Once the heavy particles and grit have been removed the lenses can be wiped over with a spectacle cleaning solution and dried with a clean lint free cloth. It is essential that all grit has been removed from the lens before wiping over with any cloth. If the lenses are wiped over whilst grit is still present the lenses will be scratched and a permanent particulate drift will be introduced.

8.2 Checking the Reference Signal

The LED light source in the TRX head is a long life component that should maintain normal operation for at least 5 years, however eventually its light output is likely to diminish to a level where it should be replaced.

The light output of the LED is continuously monitored by an independent photocell located alongside the LED in the TRX head. This photocell generates a signal that is displayed in volts in the reference signal parameter on the Settings tab of the Utility Software. As the light output falls, so does the reference signal.

The DM 401 monitors the reference signal itself and will activate the service alarm when this signal falls below a critical level, but ideally operators would also monitor the reference signal and consider replacing the TRX head if the signal consistently falls below 3V.

It is therefore recommended that the reference signal is checked on a 6 month interval.

9 Modbus Communication

The DM 401 has the attribute to communicate and store data with a RS 485- interface. However it is only possible to make a two-wire connection with the PC. Because, the most PCs have USB-ports, it is necessary to work with a RS-485 / RS-232 Converter and a RS-232 / USB-Converter. The follow sketch shows the wiring from both converters:
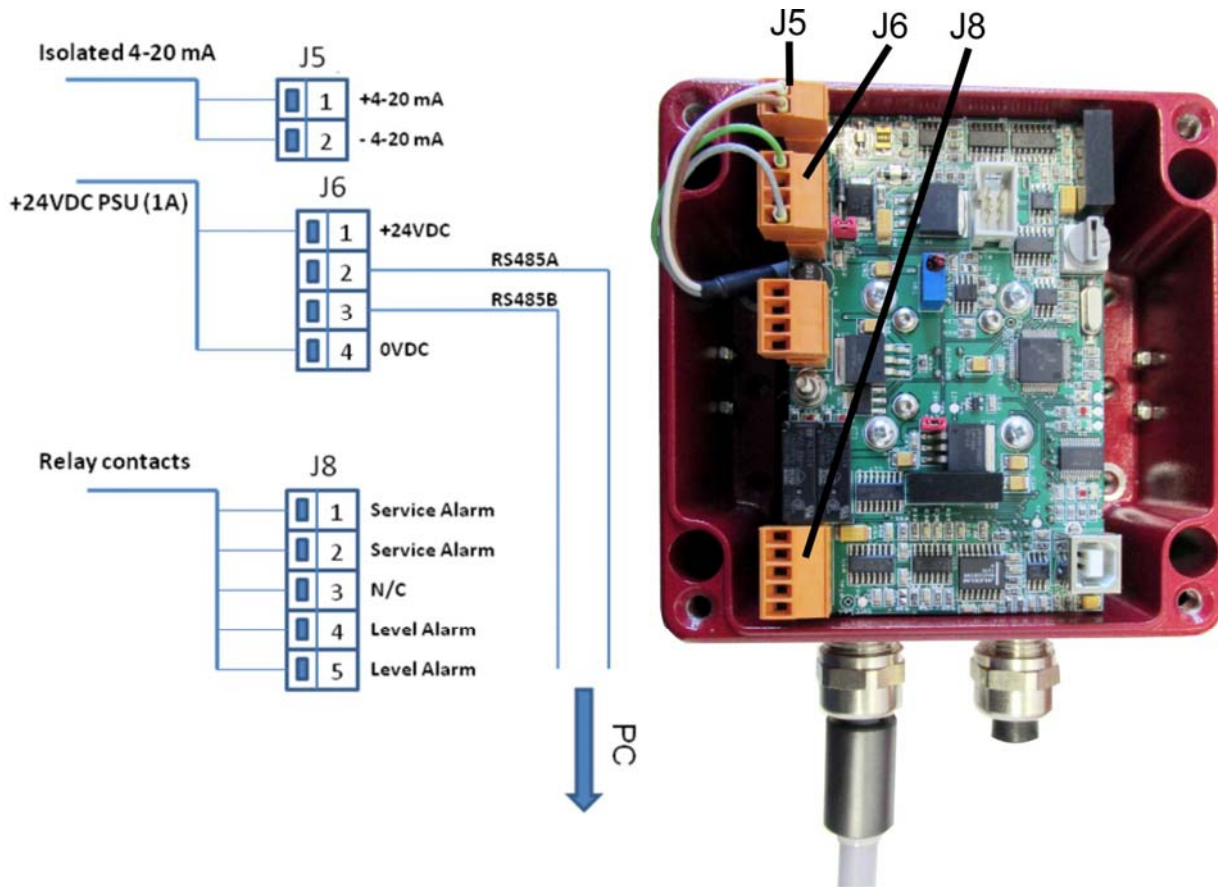
The ModBus function has to be activated with the utility software one time. For this the checkbox *"ModBus enable"* on the window *"comms"* must be checked (see screenshot below).
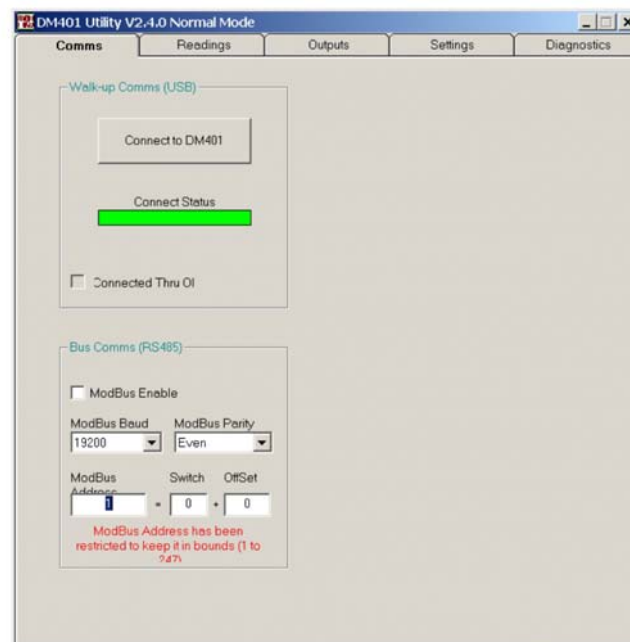
After the activation of the checkbox, you are able to set the Baud rate, the parity and the ModBus address. For more details go to the chapter "Using the Utility Software".

It is important, that the ModBus address on the Utility Software and the DM 401 have the same address. For this the potty on the circuit-board must screw on the same number, had been set on the "Switch" window of the Utility Software. For example, if in the window "Switch" the number 0, then you must screw the potty on the circuit-board to the number 0, too. On the window "Offset" you can write an address between 1 and 247.
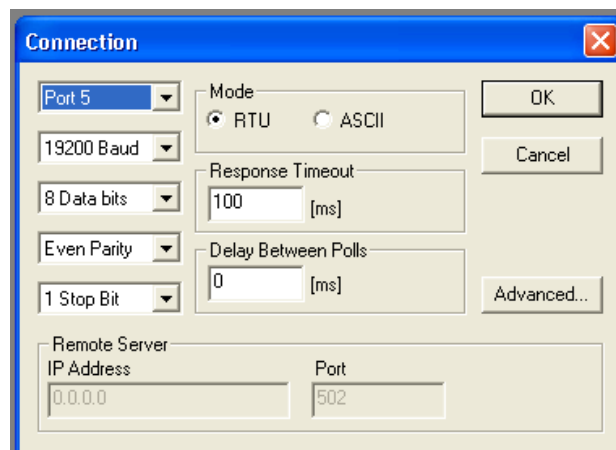
The next step is to start a ModBus program. This manual shows the setting of the connection with the program "*ModBusPoll V3.6.0*".

To start the communication, follow the steps below:

- Start *ModbusPoll V3.6.0*.
- Open a new file.
- Open the connection window and go of the connect button.
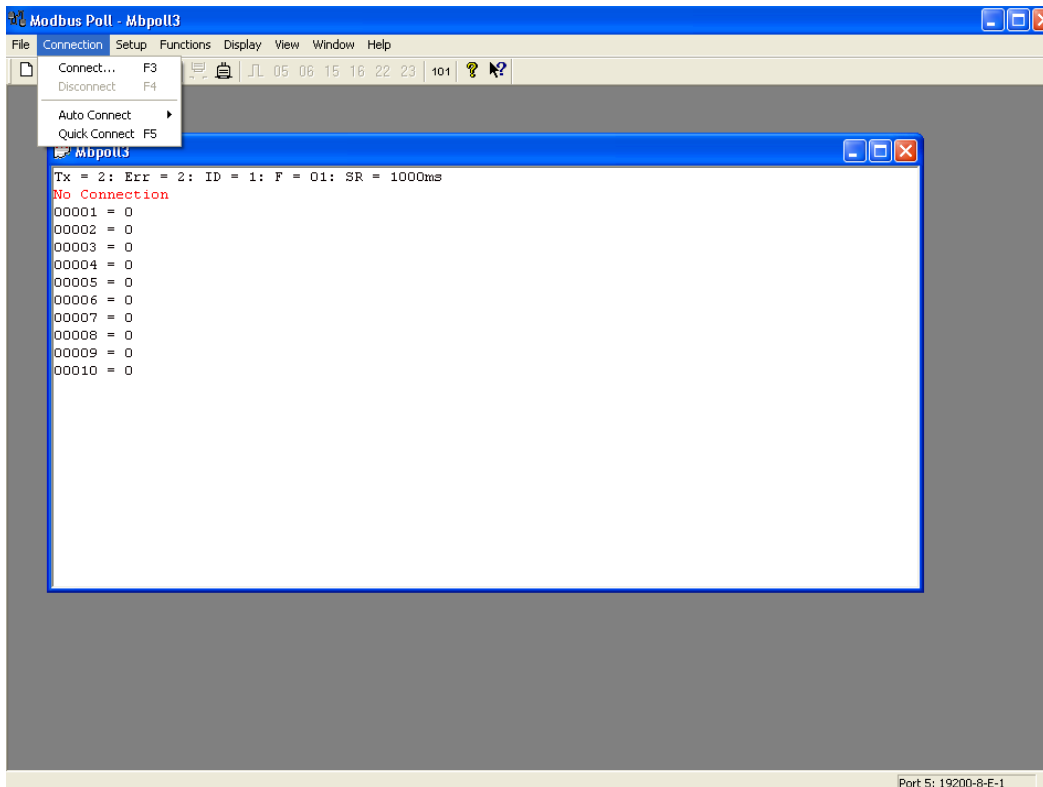
- After this follow window will be open:

Here you can set the baud rate, the data bits, the parity and the stop bits, which should be equal to the settings on the Utility Software. As well the RTU Mode must be activated.

- Activate the RTS -Toggle and remove the echo: To do this, go to the "Advance" button. The window below will be open.
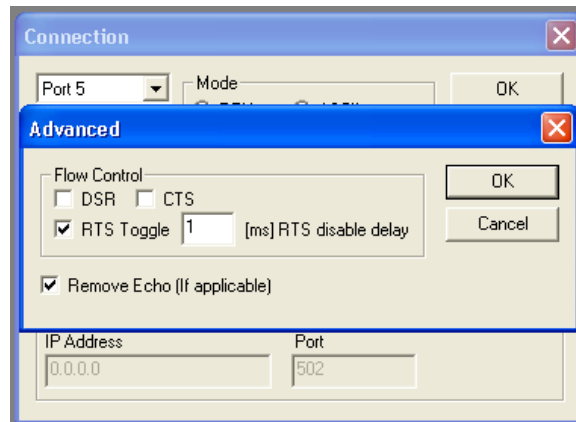
Then activate the checkboxes *"RTS Toggle"* and *"Remove Echo"*.

The next step is that the right protocol must be adjusted. For this open the "Display" window and make a heel on the *"Protocol Addresses (Base 0)"*.
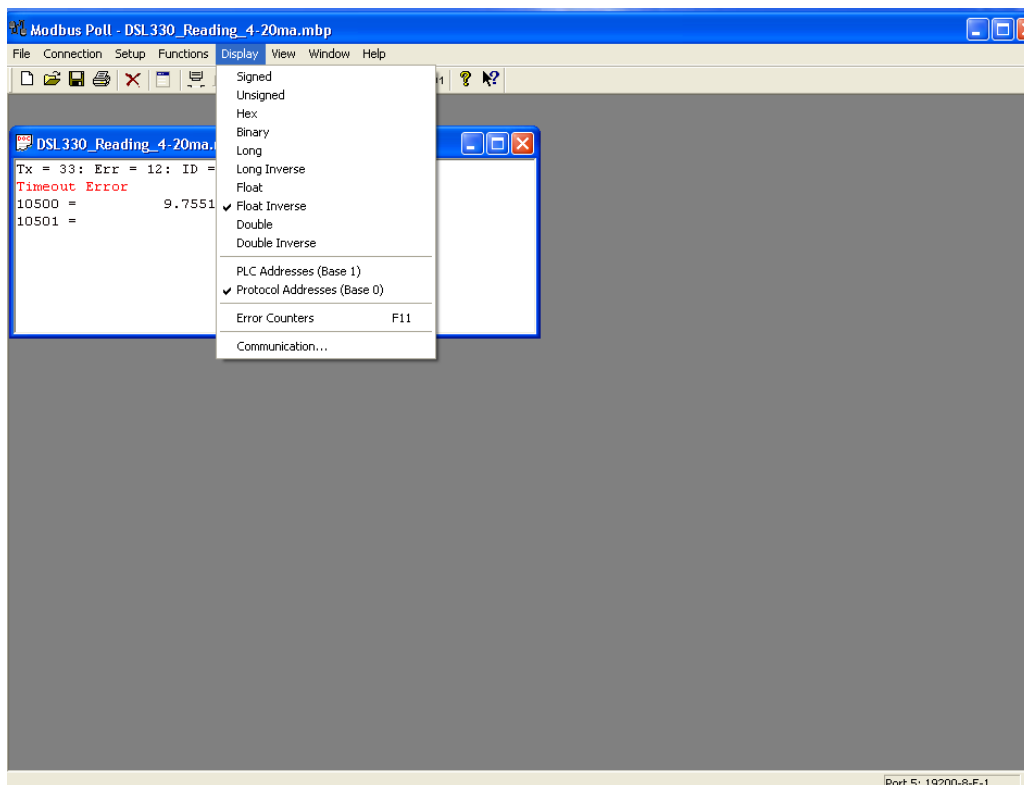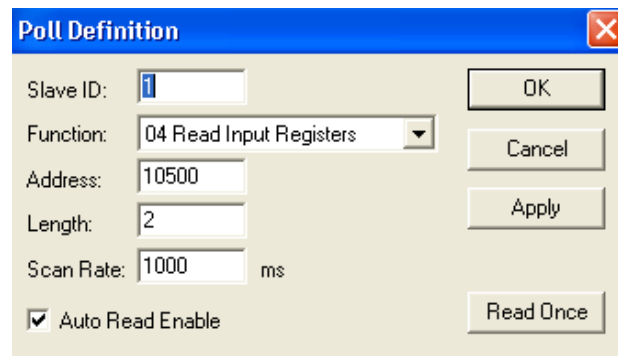

After this the basic settings are adjusted. In the further settings the DM 401 protocol setup must be adjusted.

- Adjusted the DM 401 protocol: For this setting you need the protocol, being in the attachment. In the follow instruction it will be show how to adjust the protocol *"Visibility Reading"* for example. For this open the window *"Setup"* and go to the button *"Poll Definition"*.

A new window will appear. On this window you are able to set the address, the Slave ID and the function. Here were entered the address "10500", standing for Visibility Reading for example. As function should be chose *"Read Input Registers"*. The Slave ID is the ID, had been chosen for the ModBus address in the Utility software.

If the Ok-button is press, the communication normally will be work (see window below).
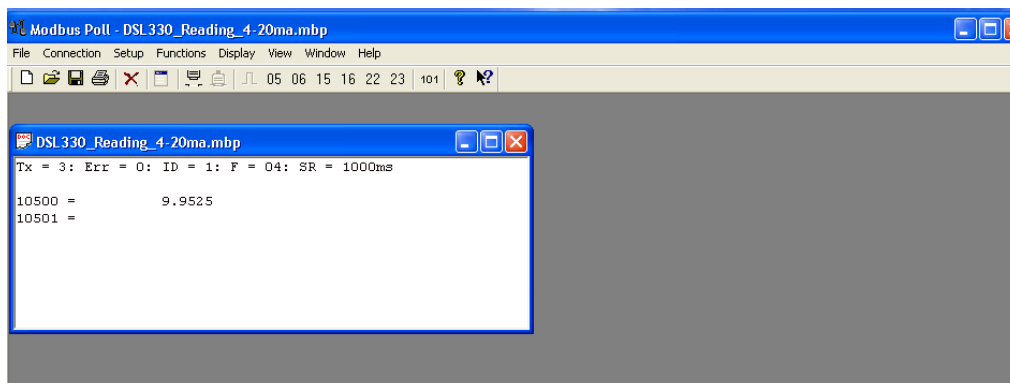
10 Error Messages and Trouble Shooting

Error messages can appear on the Readings tab of the Utility Software.

Where messages appear in the Utility Software they will remain permanently displayed on the Readings tab until the fault has been cleared and the operator has clicked on the text to acknowledge the fault. This means that even if a fault occurs only temporarily and has been resolved before the operator views the Utility Software, the fault message will remain visible until the operator has clicked on the text to acknowledge it. Fault message text can only be cleared if the fault has been resolved.

10.1 LOREF_FAULT

LOREF_FAULT status indicates that the reference signal has fallen below 2.4V. The reference signal is a measure of the LED brightness, made by a photocell sat alongside the LED source. This error is caused by a dim (or failed) LED in the Reflector head.

However, it can also be triggered by a failure of the LED drive circuit, or a low power supply voltage to the DM 401 (should be 24VDC), or failure of the reference signal measurement circuit.

Check the reference signal value on the Settings tab in the Utility Software- it should be ~4.0V. The voltage shown here is the voltage being returned from the photocell mounted directly alongside the LED in the TRX head.

If there is a low voltage (<2.4v) shown in the LED parameter then it is possible that the power supply to your DM 401 is low, so the first action should be to verify that the DM 401 has a 24 VDC power supply, by measuring the voltage across the terminals in the TRX head with a DVM.

If the supply voltage is ok, then it is likely that the LED power has been diminished with time and needs replacing. In this instance the TRX head should be swapped out and the original returned to MRU for a replacement LED to be fitted.

If the reference signal shows 0.0v then it is likely that the LED has failed completely, but it may also be that the reference signal circuit that has failed. In either case the TRX head should be swapped out and returned to MRU for repair.

In the event that the TRX is swapped out it will be necessary to complete the full setup, calibration and commissioning process as described in the earlier section in this manual.

10.2 HIREF_FAULT

HIREF_FAULT status indicates that the reference signal has risen above 4.7 V. The reference signal is a measure of the LED brightness, made by a photocell sat alongside the LED source. The DM 401 electronics can only measure a maximum signal of 5.0 V, so any voltages above this level will saturate the measurement circuit.

Although LEDs can increase in brightness slightly with decreasing temperature, it is unusual for LEDs to increase in brightness with time. So it is unlikely that ageing is the cause of the HIREF_FAULT message.

The reference signal is adjusted for a target voltage of ~4.0 V during test at our factory, allowing for up to 1.0V increase in brightness due to reductions in temperature. This "headroom" makes it unlikely that a change in temperature is the cause of the HIREF_FAULT condition. However, it is possible in some very cold climates for the LED brightness to rises above a reference signal of 4.7 V.

If cold temperatures are the cause of the problem then the only way to resolve this error is to warm up the LED. The LED will naturally warm up with operation, so you may find that leaving the instrument running for an hour solves the problem.

However, the most likely cause of this error message is manual interference with the potentiometer marked VR1 on the TRX circuit board. This pot is used to adjust the reference signal voltage, but should only be adjusted during test at our factory. After adjustment it is sealed with a red varnish. If the varnish is either missing, or looks broken, it is likely that the pot has been tampered with.

In this case you should contact MRU for further advice, which will vary depending on the age of the instrument.

10.3 HIMEAS_FAULT

HIMEAS_FAULT status indicates that the measure signal has risen above 4.7 V. The measure signal is the main signal used to generate the instruments measurement reading. The measure signal is a voltage generated by light falling on the main photocell in the TRX head. The DM 401 electronics can only measure a maximum measure signal of 5.0 V, so any voltages above this level will saturate the measurement circuit.

This is usually seen when the necessary clear path conditions were not met prior to an AGC being performed.

If an AGC is performed when the plant is running then the gain will be set to achieve a measure signal of ~4.0 V, but when the plant stops and the stack clears the measured signal will rise and may exceed the 4.7 V trigger point, causing a HIMEAS_FAULT STATUS.

The same is true if an AGC is performed with dirty windows, then they are cleaned; or if an AGC is performed with poor alignment, and then it is corrected.

In all these cases the solution is to perform an AGC under the proper clear path conditions. If you perform an AGC, then you must also complete the full setup, calibration and commissioning process as described in the earlier section in this manual.

11 Attachment

11.1 Protocol

Address	Length	Type	Description
10000	13	String (Read Only)	Unit Version (see attached VER.jpg)
10500	2	Float (Read Only)	Visiblity Reading (see attached VIS.jpg)
10502	2	Float (Read Only)	4-20 mA Output
11000	2	Float (Read)	Analogue Low Read (see attached ANLO-R.jpg)
1000	2	Float (Write)	Analogue Low Write (see attached ANLO-W.jpg)
11002	2	Float (Read)	Analogue High Read
11002	2	Float (Write)	Analogue High Write

11.2 Technical specification

Parameters	Value	remarks
Installation		
Wavelength at peak spectral response	520+/-10nm	
Wavelength at mean spectral response	525+/-10nm	
Angle of View	<3deg	
Angle of Projection	<3deg	
Range (opacity)	0 to 100%	
Performance		
Span value	~20%	Depends on source
Calibration error	<2%	
Attenuator calibration	<2%	
Response time (95% level)	<10s	
Schedule for zero-span check	Manual	End user defined
Procedure for zero-span check	All system components	
Zero calibration drift (24hrs)	<1%	
Span calibration drift (24hrs)	<1%	
Conditioning test period	>1week	
Operational test period	>1week	

12 Declaration of confirmity

EG-Konformitätserklärung
Declaration of confirmity

C E
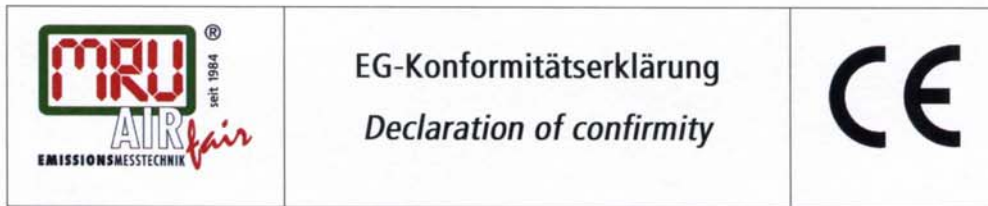
MRU Messgeräte für Rauchgase und Umweltschutz GmbH

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Bevollmächtigte Person, für die Zusammenstellung der technischen Unterlagen
Person authorized to compile the technical documents

Name / *name:*	Dierk Ahrends
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Firmenname / *company:*	Messgeräte für Rauchgase und Umweltschutz GmbH
Straße / *street:*	Fuchshalde 8 + 12
Ort / *city:*	74172 Neckarsulm
Land / *country:*	Deutschland / *Germany*

Produkt/Product

Bezeichnung /*designation:*	Staub- und Trübungsüberwachung
	Dust and opacity monitor
Produktname / *name:*	DM 401
Funktion / *function:*	Siehe / see Bezeichnung /*designation*

Hiermit erklären wir, dass das oben beschriebene Produkt allen einschlägigen Bestimmungen entspricht, es erfüllt die Anforderungen der nachfolgend genannten Richtlinien und Normen:

We declare the conformity of the product with the applicable regulations listed below:

- EMV-Richtlinie / *EMV-directive* 2004/108/EG

- Niederspannungsrichtlinie / *low voltage directive* 2006/95/EG

- RoHS-Richtlinie / *RoHS directive* 2011/65/EU (RoHS II)

Neckarsulm, 22.11.2013

Erwin Hintz, Geschäftsführer / *Managing Director*

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All technical details and specifications are subject to change without notice

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