

S Smart Control software for use with Brooks® Digital Mass Flow Meter/Controller Series



Essential Instructions

Read this page before proceeding!

Brooks Instrument designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining Brooks Products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Brooks Instrument representative for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by Brooks Instrument. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

ESD (Electrostatic Discharge)

CAUTION

This instrument contains electronic components that are susceptible to damage by static electricity. Proper handling procedure must be observed during the removal, installation or other handling of circuit boards or devices.

Handling Procedure:

1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

Comments

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, SMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

Installation and Operation Manual

X-SW-Smart-Control-eng

PN 541-C-054-AAG

October, 2008

Dear Customer,

We appreciate this opportunity to service your flow measurement and control requirements with a Brooks Instrument device. Every day, flow customers all over the world turn to Brooks Instrument for solutions to their gas and liquid low-flow applications. Brooks provides an array of flow measurement and control products for various industries from biopharmaceuticals, oil and gas, fuel cell research and chemicals, to medical devices, analytical instrumentation, semiconductor manufacturing, and more.

The Brooks product you have just received is of the highest quality available, offering superior performance, reliability and value to the user. It is designed with the ever changing process conditions, accuracy requirements and hostile process environments in mind to provide you with a lifetime of dependable service.

We recommend that you read this manual in its entirety. Should you require any additional information concerning Brooks products and services, please contact your local Brooks Sales and Service Office listed on the back cover of this manual or visit www.BrooksInstrument.com

Yours sincerely,

Brooks Instrument

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Section 1.

Introduction to Smart Control

1.1 GENERAL INFORMATION

Brooks Smart Control™ software for Microsoft® Windows™ provides a means of communication between an IBM® compatible personal computer and the Brooks Digital Mass Flow Meter models 5860S, 5861S, 5863S and 5864S and the Brooks Digital Mass Flow Controller models 5850S, 5851S and 5853S. Smart Control is designed to allow you to access configuration data in the models, take measurement data from the models and, in case of the Mass Flow Controllers send setpoint values. The protocol used by the Smart Control software is based on the Rosemount HART™ protocol and can take place over either RS-232C or RS-485 (The Bell-202 as normally used with the true HART is NOT supported within the S-series).

This manual explains how to use the Smart Control software under the Microsoft Windows graphical environment for IBM compatible personal computers in conjunction with the Brooks Digital Mass Flow products. This introductory part will first give a short overview of the Brooks Digital Mass Flow product range and it will describe the software package and system requirements. The following chapters will go in detail into all the aspects of the Smart Control software package.

The manual does not cover the functionality of the Brooks Mass Flow Meters and Controllers itself. Only if necessary for clarity some information is given. For this description please refer to document 541-C-051-AAA. Also it will not go into details of the HART protocol message structure, which is described in document 541-C-053-AAA.

NOTE: The reader is assumed to have knowledge on how to use the Microsoft Window graphical environment for IBM compatible personal computers.

1.2 THE BROOKS DIGITAL MASS FLOW PRODUCTS

The Brooks Digital Mass Flow Meter and Controller models can be used to measure and/or control the flow of gases. Both meter and controller models are therefore equipped with a sensor consisting of a small capillary by-pass element with a heater element in the middle and two heat dependent resistor (sensor) elements, symmetrically located with respect to the heater element. The absence of a gas flow will cause a symmetrical heat distribution, resulting in the same resistor value for each sensor element. A gas flow however through the capillary, which is a small portion of the main gas stream causes a asymmetrical heat distribution along the sensor capillary, causing the temperature (and thus the resistance) of the downstream sensor to increase and the temperature (and the resistance) of the upstream sensor to decrease. This difference in resistivity will cause an output voltage when the resistors are used in a wheatstone bridge configuration, proportional to the gas flow. In addition the mass flow controller models are equipped with a electromechanical valve in order to control the flow of gas.

The Brooks Digital Mass Flow Meter and Controller models come in a variety of models, each for a different range. Table 1.1 summarizes the models.

Table 1.1: Brooks Digital Mass Flow Meters and Controllers

Brooks Digital Mass Flow Products				
Mass Flow Controller	Mass Flow Meter	Flow Ranges		
Model:	Model:	Min. full scale	Max. full scale	Unit
5850S/MF50	5860S/MF60	0.003	30	ln/min
5851S/MF51	5861S/MF61	20	100	ln/min
5853S/MF53	5863/MF63	100	1000/2500	ln/min
	MF64	18	2160	m3n/hr

1.3 USES OF SMART CONTROL

The Brooks Digital Mass Flow products are equipped with two analogue outputs, representing mass flow. The information can be provided as a voltage signal ranging from either 0 to 5 Volt or from 1 to 5 Volt, i.e. no-flow (0%) to full scale flow (100%). Simultaneously a current signal ranging from 0 to 20 mA or from 4 to 20 mA is available at the current output.

In addition, all models can be equipped with communication software, which provides you access to the flow information, either in a range from 0% to 100%, or in selectable engineering units. You also have access to a number of configuration parameters of the device.

Smart Control can be used to perform the following tasks:

- Transferring configuration data between connected devices and Smart Control.
- Gathering data from one device or multiple devices, which are hooked up to a host computer through a multidrop network or through a point-to-point connection.
- Configuring operational settings and measurement units.
- Configuring control parameters in order to optimize the device for your process.
- Logging of measurement data.
- Reading process variables and output variables.
- Monitoring the process for alarm conditions.
- Printing of configuration data and logfiles.

The following list enumerates all new features and changes:

Operation under Windows 95/98/NT2000:

This version of Smart Control also operates under the Windows 95/98/NT 2000 operating system.

New DMFM/C features supported:

With the introduction of the Digital Mass Flow Meter and Controller 831-A-001 Revision H firmware (the firmware resides in the EPROM located on the piggyback board inside the DMFC), several new features were added to the Digital Mass Flow models. These new features are accessible using Smart Control version 1.4. The previous version of Smart Control (version 1.1) is not able to recognize the additional features. Refer to section 2 for more detailed information on new DMFC features.

Support of different RS-485 buffer switch lines:

To support a wide range of RS-485 converters and interface boards, the switch line can be selected to be either RTS, !RTS, DTR or !DTR. Section 3 describes these changes in detail.

Section 2. Installation

2.1 General

This section contains the procedures for the receipt and installation of the instrument. Do not attempt to start the system until the instrument has been permanently installed. It is extremely important that the start-up procedures be followed in the exact sequence presented.

NOTE: Operating procedure: do not operate this instrument outside the specification range listed in section 5.

Before bringing the unit into operation, make sure that all gas connections have been correctly tightened and that all the necessary electrical connections have been made.

2.2 Receipt of Equipment

When the equipment is received, the outside packing case should be checked for damage incurred during shipment. If the packing case is damaged, the local carrier should be notified at once regarding his liability. A report should be submitted to your nearest Product Service Department.

Brooks Instrument

407 W. Vine Street
P.O. Box 903
Hatfield, PA 19440 USA
Toll Free (888) 554-FLOW (3569)
Tel (215) 362-3700
Fax (215) 362-3745
Email: BrooksAm@BrooksInstrument.com
<http://www.brooksinstrument.com>

Brooks Instrument

Neonstraat 3
6718 WX Ede, Netherlands
P.O. Box 428
6710 BK Ede, Netherlands
Tel 31-318-549-300
Fax 31-318-549-309
Email: BrooksEu@BrooksInstrument.com

Brooks Instrument

1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
Tel 011-81-3-5633-7100
Fax 011-81-3-5633-7101
Email: BrooksAs@BrooksInstrument.com

Remove the envelope containing the packing list. Carefully remove the instrument from the packing case. Make sure spare parts are not discarded with the packing materials. Inspect for damaged or missing parts.

2.3 Recommended Storage Practice

If equipment supplied by Brooks Instrument is to be placed in intermediate or long-term storage, it is recommended that it be:

- a. Stored within the original shipping container.
- b. Stored in a sheltered area, under the following conditions:
 - 1) Optimum ambient temperature 21°C (70 °F), maximum 32 °C (90 °F), minimum 7 °C (45 °F),.
 - 2) Optimum relative humidity 45% (maximum 60%/minimum 25%).
- c. Subjected to a visual inspection upon removal from storage, to verify that the condition of the equipment is 'as received'. If the equipment has been in storage for more than ten months or if it has not been stored under the recommended conditions, all pressure containing seals should be replaced. In addition, the device should be subjected to a pneumatic pressure test in accordance with the applicable vessel codes.

2.4 Return Shipment

Prior to returning any instrument to the factory, contact your nearest Brooks location for a Return Materials Authorization Number (RMA#). This can be obtained from one of the following locations:

Brooks Instrument

407 W. Vine Street
P.O. Box 903
Hatfield, PA 19440 USA
Toll Free (888) 554-FLOW (3569)
Tel (215) 362-3700
Fax (215) 362-3745
Email: BrooksAm@BrooksInstrument.com
<http://www.brooksinstrument.com>

Brooks Instrument

Neonstraat 3
6718 WX Ede, Netherlands
P.O. Box 428
6710 BK Ede, Netherlands
Tel 31-318-549-300
Fax 31-318-549-309
E-mail: BrooksEu@BrooksInstrument.com

Brooks Instrument

1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
Tel 011-81-3-5633-7100
Fax 011-81-3-5633-7101
Email: BrooksAs@BrooksInstrument.com

Any instrument returned to Brooks requires completion of Form RPR003-1, Brooks Instrument Decontamination Statement, as well as, a Material Safety Data Sheet (MSDS) for the fluid(s) used in the instrument. This is required before any Brooks Personnel can begin processing. Copies of the form can be obtained from any Brooks Instrument location listed above.

2.5 Gas Connections

All models are fitted with the following inlet and outlet connectors as standard: NPT(F), tube compression fittings, VCR, VCO, DIN or ANSI flanges. Prior to installation, make certain that all piping is clean and free of obstruction. Install the piping in a manner that permits easy access to the instrument, should it need to be removed for cleaning or test-bench troubleshooting.

2.6 SYSTEM REQUIREMENTS

In order to be able to run Smart Control the following hardware and software is required:

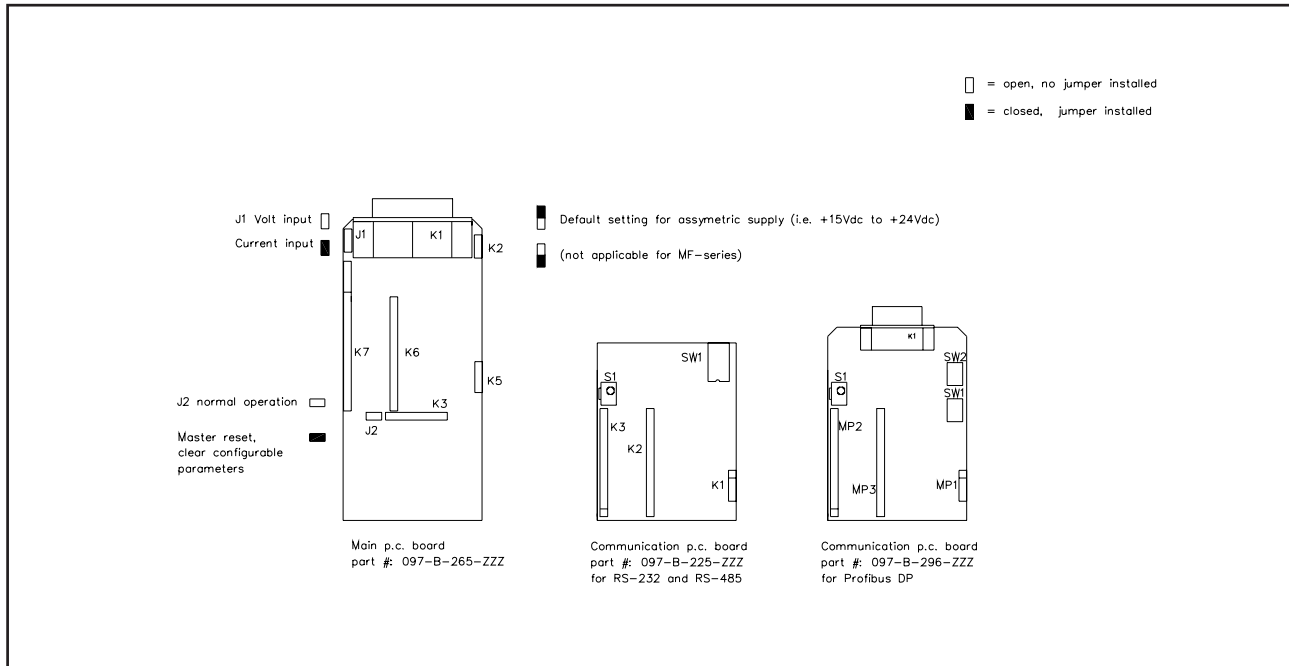
- IBM compatible personal computer with an Intel™ 80386, or higher microprocessor,
- MS-DOS 3.1 or higher revision software,
- Microsoft Windows graphical environment 95/98 or NT/ 2000 or higher revision software,
- Hard Disk Drive with at least 2 megabytes available for storage,
- CD-Rom drive
- VGA type monitor,
- 32 megabytes (or more) random access memory (RAM),
- An available 9-pin or 25-pin serial port for RS-232C communication.

NOTE: When using Smart Control with RS-485 a separate RS-232C to RS-485 converter is required, which must be purchased separately. Any commercially available converter, which uses the RS-232C RTS line for controlling the direction of the RS-485 buffers will satisfy. Contact Brooks Instrument for available converters.

2.7 HARDWARE SETTINGS AND CONNECTIONS

The Brooks Digital Mass Flow Meters and Controllers are all build up using two printed circuit boards: one motherboard containing the processor and analogue circuitry and one piggyback board. The motherboard is the same for all models and versions, but the type of piggyback depends on the requirements of your system. There are two types of piggyback boards: one version is the digital piggyback for communication purposes with a PC and one version for profibus DP communication. For Profibus please refer to the Profibus Manual (541-C-068-AAG). A piggyback board is installed by inserting it into the connectors K5, K6 and K7 on the motherboard (refer to figure 2.1). This document only covers the versions with the digital piggyback board installed.

Figure 2.1 Motherboard and communication piggyback board layout.



All communication related hardware is concentrated on this piggyback board. Consequently all communication related hardware settings must be made on this piggyback. For this purpose the piggyback board is equipped with 4 dipswitches allowing the customer to select the physical layer to be used, RS-232C or RS-485 and to select the baudrate to be used. Figure 2.1 shows the motherboard and the piggybacks and Table 2.1 summarizes the available settings. Note that the Bell-202 physical layer (OSI model), normally used in the HART protocol is NOT implemented. For RS-232C and RS-485 refer to the related documents EIA RS-232C and EIA RS-485.

Table 2.1 Dipswitch selections

	Physical Layer selection	Baudrate selection			
		Sw #1	Sw #2	Sw #3	Sw #4
RS-232C	Off				
RS-485	On				
1200		Off	Off	Off	Off
2400		On	Off	Off	Off
3600		Off	On	Off	Off
4800		On	On	Off	Off
7200		Off	Off	On	On
9600		On	Off	On	On
19200		Off	On	On	On
38400		On	On	On	On

The physical Layer selection is independent from the baudrate selection. The dipswitch numbers and the On/Off indication refer to the markings on the dipswitches on the piggyback board. Since communication is possible with the Brooks Digital Mass Flow Meters and Controllers right after startup, you should make the proper baudrate settings prior to power up.

However changes in the baudrate settings or the physical layer selection during operation will take effect immediately. I/O drivers are directly connected to two pins of the D-connector on top of the Digital Mass Flow Meter/Controller. Table 2.2 summarizes the necessary connections.

Table 2.2 D-connector communication pins

D-connector pin number	RS-232C	RS-485
Pin #9	Ground	Not Used
Pin #14	Receiver Input	A-
Pin #15	Transmitter Output	A+

2.8 INTERCONNECTION CONFIGURATIONS

The RS-232C is essentially a point-to-point connection, i.e. one host computer and one Digital Mass Flow Meter/Controller model with the possibility of simultaneously bidirectional data transfer. Most IBM compatible personal computers are standard equipped with one or more RS-232C ports (or COM-ports).

Figure 2.2. RS-232C interconnection of DMFM/C PC

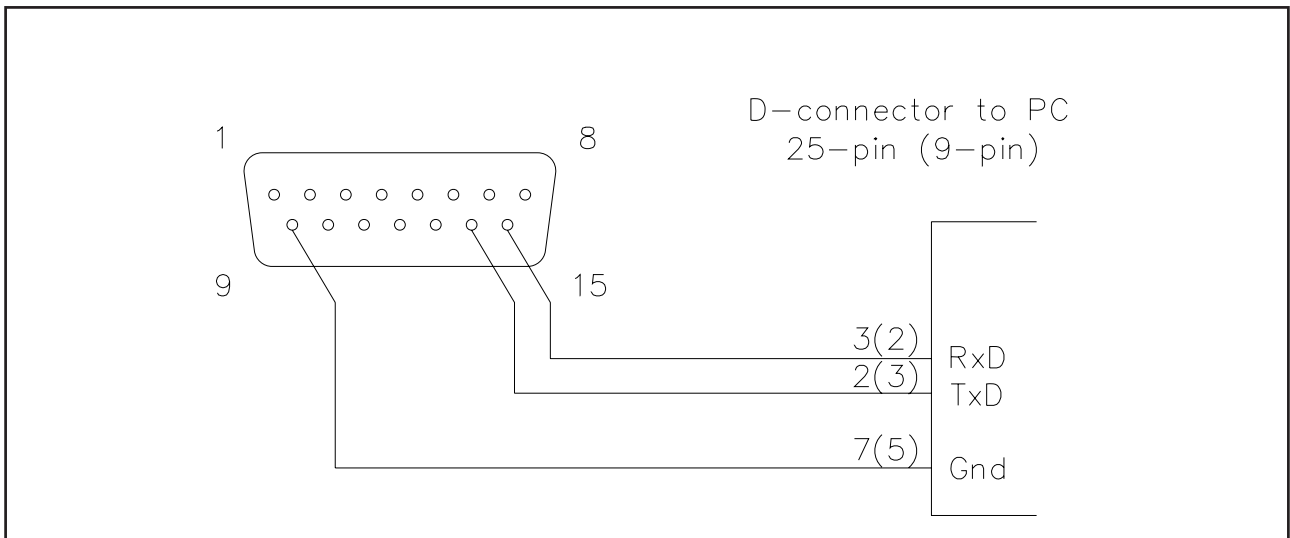
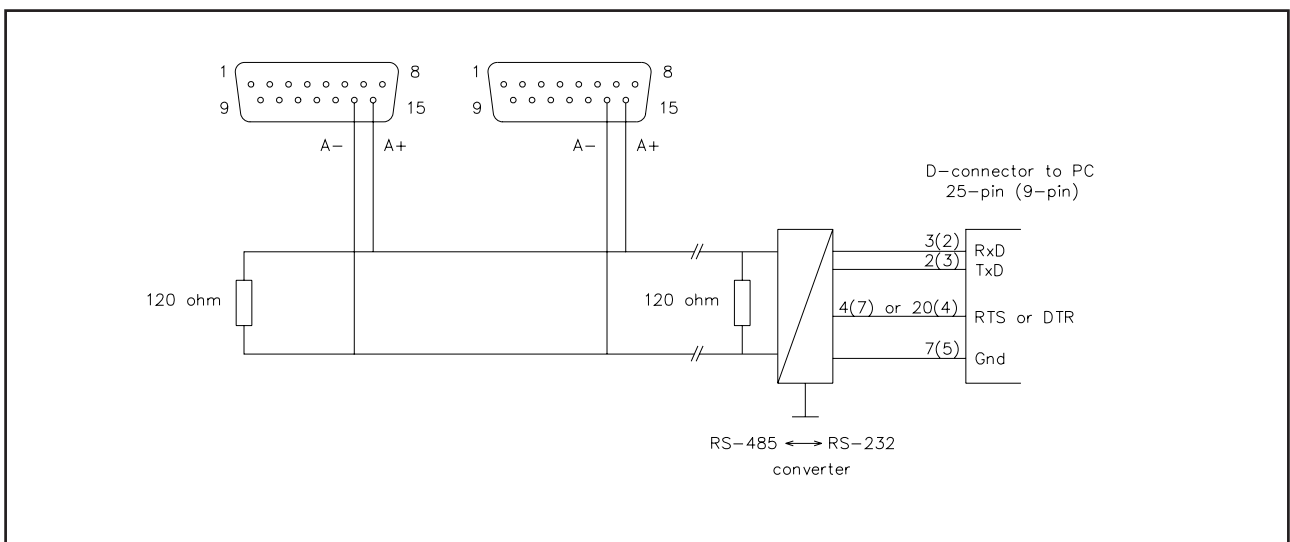


Figure 2.3. RS-485 multidrop interconnection DMFM/C's and PC



The standard cable supplied by Brooks (partnumber S-124-Z-614-ZZZ, S-124-Z-615-ZZZ or S-124-Z-614-ZZZ) is a split cable, suited for RS-232C communication: the communication part of the cable can directly be connected to the 9-pin serial COM-port of an IBM compatible PC. The other part of the cable can be connected to the Brooks model 0152/0154 Microprocessor based Read Out Control Electronics. This model provides power supply to the Digital Mass Flow Meter and Controller models and performs local read out and displaying of the analogue output signals. Figure 2.2 shows the interconnection diagram of the RS-232C configuration. The pin assignment on the DTE (Data Terminal Equipment), which represents the PC, is standard for RS-232C. The RS-485 is essentially a multidrop connection making it possible to connect a maximum of 32 devices to a computer system. IBM compatible PC's are NOT standard equipped with RS-485 ports, thus requiring an RS-485 to RS-232C converter in order to connect the RS-485 to the standard PC. The converter is NOT included as a part of the Smart Control product and should be acquired separately. Figure 2.3 shows the interconnection diagram of Digital Mass Flow Meters/ Controllers via an RS-485 bus and an RS-485 to RS-232C converter to an IBM compatible PC.

The RS-485 bus requires two matching resistors of 120 Ohm, one at the end of the bus and one at the beginning, near the converter.

NOTE: In figure 2.3 the RTS (Request To Send) line is shown between the PC and the converter. In an RS-485 connection at least one control line is required from the PC to the converter in order to control the data direction of the RS-485 buffers. Smart Control by default uses this RTS line, because it is commonly used for this task in a number of commercially available converters.

2.9 INSTALLING SMART CONTROL

The Smart Control software consists of:

The Smart Software CD Rom including the software and instruction / and operation manual.

2.10 STARTING UP SMART CONTROL

In order to start Smart Control:

Double clicking on the Smart Control icon will start the program.

After either double clicking the smart control icon the startup window for the Smart Control program will pop up.

Figure 2.4 shows this window and also enlightens the main controls of this window. The program is now ready for use.

Figure 2.4: Startup windows for Smart Control



2.11 CONNECTING A NEW DEVICE TO SMART CONTROL

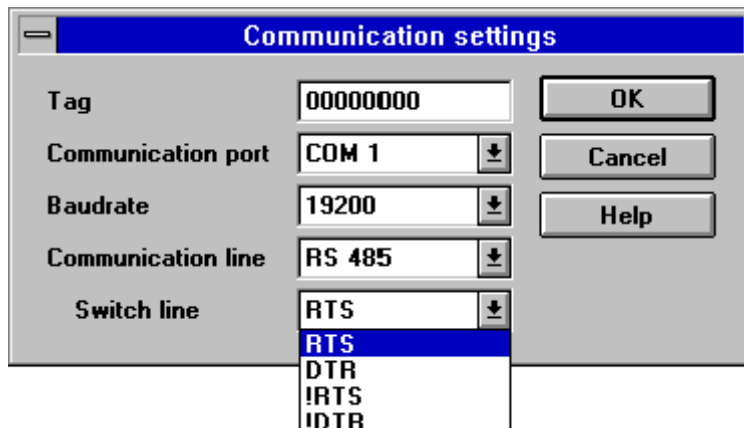
This section will provide you with startup information in order to get the Brooks Digital Mass Flow Meter or Controller active and to be able to give a short overview of the Smart Control program. More detailed information is given in the following chapters.

When showing the startup window the program is still inactive, i.e. Smart Control is not communicating with a device. Communication with a device can now commence by selecting a new device either through selection of the *File/New* option from the menu by using the mouse or the keyboard or through selection of the “new” speedkey from the speedbar (see figure 2.5). The Brooks Instrument logo will now disappear, making way for a standard main Digital Mass Flow device read-out window and a status window. Also a selection window pops up, prompting for:

1. The “tag number” (i.e. the identification number visible on the device’s tag), used to make a first identification of the device on the bus.
2. The communication port.
3. The baudrate or data transfer rate selection.
4. The type of physical layer used at the port: RS-232C or RS-485.

This window configuration is shown in figure 2.5.

Figure 2.5: baudrate options for a new device



Selections can be made by clicking with the mouse cursor on the down arrow buttons behind selection fields and clicking in the tag number input field after which you can enter the desired tag number. Figure 2.5 shows the Communication settings window with the list of available baudrates, which will pop up when clicking the down arrow button behind the baudrate selection field. The tagnumber has also been set.

After making the proper selections and selecting the “OK” button, the selection window will disappear and the Smart Control program will try to start communication with the device.

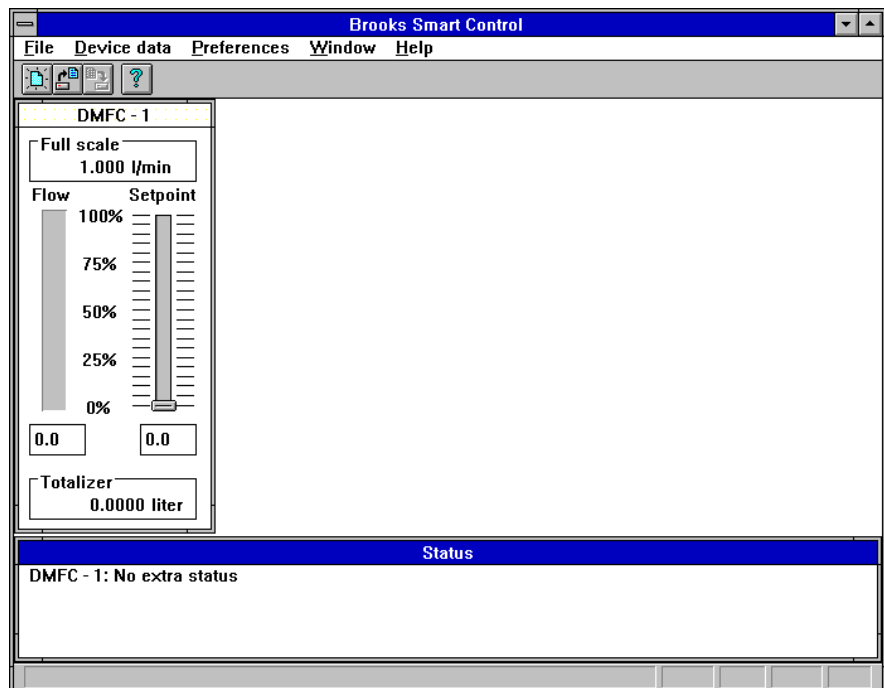
The communication settings are extended with a switch line selection. This selection is only available in case the communication line is set to RS-485. Valid switch line options are:

- RTS: The RTS line is **set** when writing and **reset** when waiting for response.
- DTR: The DTR line is **set** when writing and **reset** when waiting for response.
- !RTS: The RTS line is **reset** when writing and **set** when waiting for response.
- !DTR: The DTR line is **reset** when writing and **set** when waiting for response.

IMPORTANT NOTE: RS-232-to-RS-485 converters or RS-485 interface boards which use the RTS or DTR line for controlling the data direction buffers are recommended. When using the !RTS or !DTR switch line, communication errors (“Too many errors in data received from device”) can occur with certain RS-485 drivers.

If communication is established, data will show up at regular intervals in the datafields of the main Digital Mass Flow device read-out window. Also the status of the addressed device will now be shown on the first line of the status window (refer to figure 2.6).

Figure 2.6: Connecting a new device to Smart Control



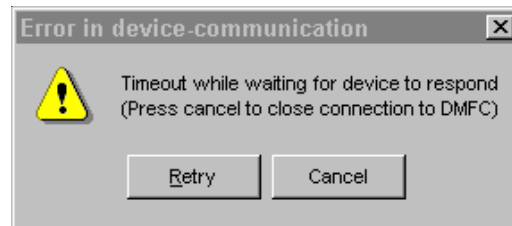
In case the addressed device is a Digital Mass Flow Meter (model 5860S, 5861S, 5863S or 5864S) the setpoint data field, as well as the slide bar will remain disabled. This is indicated by the fact that the field markers and the slide bar markers are shown in grey instead of black. Nothing will happen if you click with the mouse on these items.

Communication might fail when:

1. There is no proper hardware connection between the computer and the device.
2. The device is not powered up.
3. The baudrate selected in Smart Control does not match the baudrate settings of dipswitches on the device (see Table 2.1).
4. The tagnumber does not match the one of the device.

In either case a warning window will pop up after a certain time indicating a time out on the selected device, which in fact means that there is no communication between the computer and the device. This warning window is shown in figure 2.7.

Figure 2.7: Timeout warning window



In order to solve such a problem, you should

1. Check the connections between the computer and the device and make sure that the device is powered up.
2. Check the baudrate dipswitch setting on the device or select the proper baudrate in the program.
3. Stop the program trying to establish communication by selecting *File/Close* from the menu and re-run the sequence for selection of a new device as stated on the previous page.
4. Make sure the proper tagnumber is used.

With the communication running you will now be able to access the information stored in the device and to adjust a number of device parameters.

2.12 THE STATUS WINDOW

The status window will at any time display the status of all devices connected on the communication link. In case of an RS-232C type connection this will be just one device, but on an RS-485 type connection this may be multiple devices. Status information of a device is shown as the device main window title and a semicolon, followed by the information itself (refer to figure 2.6). The status information is updated at regular second intervals.

This status information can contain messages concerning the integrity of the device, which is established through self diagnostics tests, carried out at regular intervals by the device itself. It can also contain messages concerning the integrity of the measurement and/or control of gas flow, influenced by environmental conditions, such as the unexpected absence of gas, out-of-range conditions of sensor, temperature, analogue input and/or output, the clogging of a valve or sensor, etc. Please refer to section 6, table 6.1 and 6.2 for an overview of the possible error messages.

During normal operations, without any error situation the status information will read "no extra status". Figure 2.6 shows an example of a normal session involving one Brooks Digital Mass Flow Controller.

2.13 LOGGING OF DATA

During regular intervals the non-static, actual information (flow, setpoint, analogue output, etc.) can be collected through the communication with the device can be logged to a file on hard disk. By default no actual data items are logged, the items however can also be selected to include only a limited, user defined number of items, which are of interest to the user (see Section 5.2).

Updating the logfile takes place at the same rate with which the actual data is updated in the main window. The acquired data can be printed or used for further analysis in separate spreadsheet programs. Refer to chapter 5 for more information and examples.

2.14 MENU OVERVIEW

A short overview of the available menu options can now be given. In case there is no communication going on (i.e. there is no main display window associated with a Digital Mass Flow Meter or Controller) a number of available options will be disabled or non-accessible. The menu can be activated by clicking on the menu options with the. These options will be discussed below.

2.14.1 FILE MENU OPTIONS

The *File* selection contains all options related to the handling of files and the handling of device information in relation to the main program window. This means that although the *File/New* option is not really involved in file handling, but merely in connecting a new device (i.e. a device unknown to the program) and adding it to the main window.

The available options in the *File* menu are:

- New* - Connect a new, unknown device to the program and add it to the main window.
- Open* - Connect an already known device to the program by selecting it from a list of available devices and add it to the main window.
- Close* - Disconnect and close down a device in the main window. The device can be selected by clicking on the main read-out window of the device. If the data has not been saved to hard disk, before closing, a dialogue window will pop up, prompting for a save action.
- Save* - Save the device data to hard disk. The file name used will be equal to the device's tagnumber with the file extension *.APP.
- Save As...* - Save the device data to hard disk. The file name can be determined by you.
- Clear logfile* - Clear the logfile of the selected device. The device can be selected by clicking on the main read-out window of the device.
- Print* - Print either the logfile or the parameters of a selected device or both.
- Print setup* - This command invokes the printer setup window provided by the Windows environment.
- Exit* - Exit the Smart Control program.

More information on the File menu is available in Chapter 3.

2.14.2 DEVICE DATA MENU OPTIONS

The Device data menu offers access to the parameters of the selected device. Again selecting a device in order to access its data can be done by merely clicking on the main read-out window of the device.

The available options in the *Device data* menu are:

- | | |
|--------------------------|---|
| <i>Password</i> | - Set the selected device to the write protect mode or remove the write protect from the device. All static parameters are write protected to prevent unauthorized access. |
| <i>Database Backup</i> | - Perform a backup, i.e. the device is given the command to backup all the changes, previously made to accessible parameters to its non-volatile memory. |
| <i>Database Restore</i> | - Perform a restore, i.e. the device is given the command to discard all the changes, previously made, by overwriting them with the data available from its non-volatile memory. |
| <i>Database Download</i> | - Perform a download, i.e. all parameters available in the device are copied to the database in the computer. |
| <i>Actual data</i> | - Display actual data of the selected device. The window popping up shows additional information to the actual data displayed in the main read-out window. |
| <i>General data</i> | - Display general information such as traceability information, addresses, tagnumber, id number etc., related to the selected device. |
| <i>Mechanical data</i> | - Display mechanical information as well as the absolute maximum ratings at which the selected device may be used. |
| <i>Gas data</i> | - Display the calibration information of the device of one gas at a time. Calibration information on the other nine gases (if available) can be accessed from the window that pops up. |
| <i>Sensor data</i> | - Display information on the gas sensor and the temperature sensor of the selected device. The window that pops up from this menu option also allows you to perform a zero action on the gas flow sensor, provided the device is not write protected. |
| <i>General Settings</i> | - Display the general settings and make operations related selections. From the window related to this menu option you can select the gas calibration to be used, the units in which the actual data are to be shown and change the name of the main read-out window. |
| <i>I/O Settings</i> | - Display information on the setpoint input (controller models only) and analogue outputs and allow you to adjust the parameters to make them fit your needs. |

- Controller Settings* - (Controller models only:) Display the parameters used in the control of the gas flow and adjust the parameters to make them fit to your system.
- Alarm Settings* - Displays the alarm enable/disable setting. These settings allow you to enable or disable specific alarms inside the device in order to set the alarm handling appropriate for your application.

More information on the *Device data* menu is available in Chapter 4.

2.14.3 PREFERENCES MENU OPTIONS

The *Preferences* menu options allows you to select a number of preferences for the program. These settings include the specification of the logfile and the actual parameters to be logged. Also the communication for a specified already existing device can be adjusted.

The available options in the *Preferences* menu are:

- Logfile* - Select the parameters to be logged into a logfile during operation.
- Communication settings* - Select new communication setting for an existing device. The new settings take effect after closing and re-opening the selected device.

More information on the *Preferences* menu and data logging is available in Chapter 5.

2.14.4 WINDOW MENU OPTIONS

The *Window* menu options allows you to Tile or to Cascade all main read-out windows that are currently opened or to Close all windows that are currently opened. It also provides fast access to one of the opened windows by showing a list of all windows that are currently opened.

The available options in the *Window* menu are:

- Cascade* - Cascade the windows which are currently opened.
- Tile* - Tile the windows currently opened.
- Close All* - Close All windows currently opened.
- 1 Status* - Number and name of the window currently opened. The 4sign indicates the currently selected window. The length of the list depends on the number of windows opened.

Since the *Windows* menu option is fairly standard in at most every Windows application there is no chapter providing extra information on the available options.

2.14.5 HELP MENU OPTIONS

The *Help* menu option provides help information on several issues. Although you can access context sensitive help information from most of the pop up windows through a separate "HELP" button, the information is also available from the main window.

The available options in the *Help* menu are:

- Contents* - Provide access to the contents of the help file. From here you can select the topic on which help is required or you can browse through the available information.

- Using Help* - Display information on how to get help information and how to use it.
- About* - Display revision information on the Smart Control program.

Since the *Help* menu option is standard in every Windows application there is no chapter providing extra information on the available options.

2.15 SAVING DEVICE INFORMATION

The device information can be saved to hard disk by selecting either *File|Save* or *File|Save As...* both from the file menu. In the first case the information will be saved in either the file it was opened from, or a newly created file **which uses the tagnumber** as a filename and appends the (default) extensions .APP to the tagnumber. In the second case **you are prompted to specify the file name in which the information should be saved.**

2.16 EXITING SMART CONTROL

Exiting the Smart Control program is done through simultaneously pressing the Alt-F4 keys on the keyboard or by selecting *File|Exit* from the menu options. In case the data of one of the selected devices is not saved to disk, you will be prompted if a save before close should be performed.

The following list enumerates the new features:

1. Totalizer:

The totalizer function makes it possible to measure the amount of gas which flows through the device during a certain period. The main Digital Mass Flow device read-out window shows the totalizer counter, displaying the measured amount in the selected unit. The totalizer functions are accessible using the Device data|Actual data option from the menu.

2. Adaptive control:

The adaptive (valve) control algorithm is implemented in the Digital Mass Flow Controller in order to improve flow control under varying process conditions. The adaptive control mode can be selected using the Device data|Controller settings option from the menu.

3. Alarm enable/disable settings:

The Digital Mass Flow device is equipped with an alarm mask function, allowing the user to disable or enable device alarms. The device can be configured for application specific alarm handling (e.g. low and high flow limit alarms). Using the Device data|Alarm settings option from the menu, the alarm mask can be changed.

Section 3.

FILE menu

3.1 INTRODUCTION

This chapter is intended to provide you detailed information on the File menu options. It covers the selection of a device either from a list of known devices or a new device, adding it to the desktop and establishing communication. In addition all file related features are treated in this chapter, such as data logging and printing of logfiles and parameter files.

3.2 SELECTING A NEW DEVICE ON THE BUS

When a new device is added to a system and you want to establish communication with it, it has to make the new device known to the Smart Control program. In order to address the device during communication with the protocol used, a host computer assembles the device address using the manufacturer code, the device type code and the device identification number.

For all Brooks Instrument products the manufacturer code is 10 (decimal). The device type code depends on the specific device, but this is simply constructed by taking the last two digits from the model code (5850S: device type code = 50, 5864S: device type code = 64, etc.). The device identification number is a three byte integer, ranging from 0 to 16777215 (Theoretically you can hook up 16777216 devices with the same device type code and manufacturer code to the host computer).

All devices connected to the bus will listen to a so called broadcast command, but only the one which has the same tag number as the one transmitted with the command will respond. In response to the command the addressed device will, among other data, return the address. From there on, communication will commence, using the manufacturer code, the device type code and the device identification number.

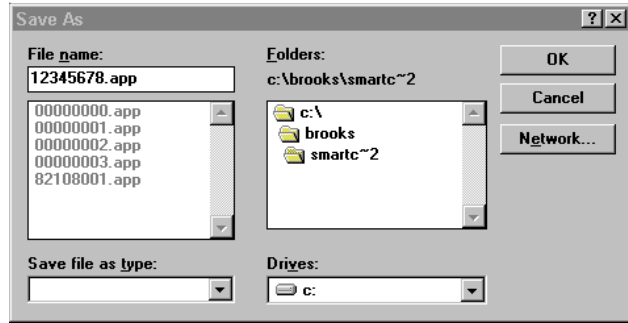
After establishing communication it is recommended that you perform a database download by selecting *Device data|Database|Download* in order to copy the database of the newly connected device to the host computer, after which this copy can be saved to disk. Refer to section 4.3.1 **Downloading data** for more information.

If communication fails, a warning window will pop up indicating that a timeout has occurred, i.e. to Smart Control it seems that the device is not responding within a certain time. Refer to Section 2.7 and figure 2.8 for the possible causes and how to solve this problem.

3.3 SAVING DEVICE INFORMATION

You can save the database of a device, currently communicating with the host computer by selecting either *File|Save or File|Save As...* Either one of these commands may be preceded by a *Device data|Database|Download* command, without prompting you for confirmation, in order to copy the database, stored in the newly attached device, to the host computer. This command is not performed in case the device is a known device, where the database is already stored in a diskfile. See Section 4.3.1 for more information on the download command.

Figure 3.1 Device selection window



In case you selected the *File|Save* command and the data has not been saved before, i.e. the data filename is unknown, the *File|Save As...* command will instead be created, prompting you for the file name. The default file name will be the tagnumber as a name, with the extension .APP. If for example the device has a tagnumber T5012301, the database will be saved in the file T5012301.APP.

If the *File|Save As...* option has been selected, the standard Windows fileaccess selection window, shown in figure 3.1 will pop up.

This window enables you to save the device data file under another name or to another (sub)directory. You can enter the name of the file on the first line and you can select the subdirectory. The file name may be any eight character name, the extension will by default always be .APP.s

When saving the device, by using the *File|Save* or the *File|Save As...* command the device access and configuration information will also be saved in the SMARTCON.INI file on disk. This file contains all necessary information to make future access of a device possible. This includes tagnumber, device type and id number, window title, data file name and log file name, type of communication link and baudrate and the data to be logged.

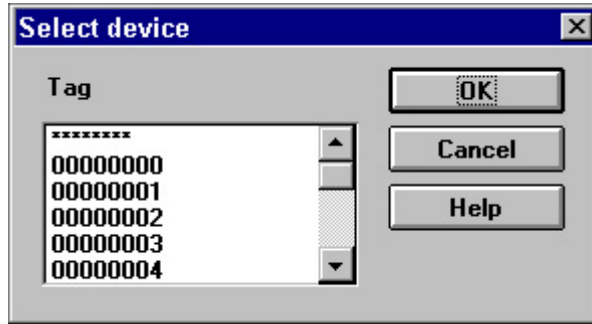
After saving the data, the device linked to Smart Control is “known” to Smart Control, so when reconnecting the device in the future, you can use the *File|Open* command, which uses the information in the SMARTCON.INI file to enable device selection from the list of “known” ones. This is described in the next section.

3.4 SELECTING AN EXISTING DEVICE ON THE BUS

If you want to establish communication with a “known” device, a device that has been linked to Smart Control in the past, and which was saved at that time, you should use the *File|Open* option from the menu. This will result in the device selection box popping up. This box, shown in figure 3.2, lists all devices known to Smart Control, identified by their tagnumber. After selection of the tagnumber and selecting the “OK” button, the Smart Control program will try to establish communication with the selected device, based on the information found in the SMARTCON.INI file.

The type of hardware link and the baudrate associated with the device are taken from the SMARTCON.INI file. If you selected another communication setting during the previous session (see Section 5.3), this new setting will now become active, instead of the settings used in the previous setting.

Figure 3.2 Device selection window

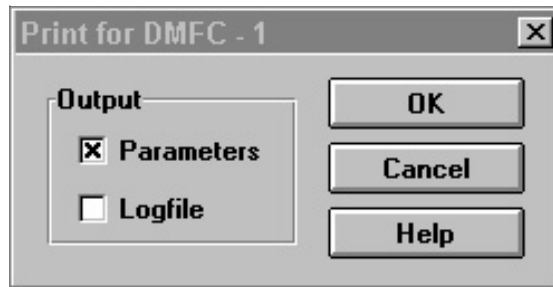


Also in this case, communication might fail and a timeout warning window will pop up. Refer to Section 2.7 and figure 2.7 in order to determine the possible cause and to solve the problem.

3.5 PRINTING

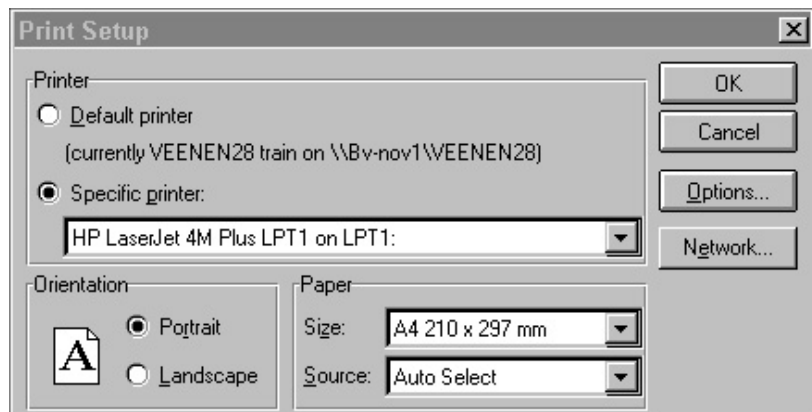
When selecting the File|Print option a selection window as shown in figure 3.3 will turn up offering the possibility to select between either the printout of the logfile and/or the parameter file.

Figure 3.3 Print item selection box



After marking the appropriate checkboxes and selecting the “OK” button, the standard Windows print selection box, associated with the standard Windows Print Manager application will show up (see figure 3.4) allowing you to select whether to print the data to the printer or to a file and with which print resolution this should be done (depending on the type of printer you have).

Figure 3.4 print control window



From this window you can also select the “ Setup” button, in order to select the printer settings. Refer to the Windows 3.1 User’s Guide for more information on the Print Manager and the selections available to you.

3.5.1 PRINTING DEVICE INFORMATION

By marking the checkbox before “Parameters” in the print select dialogue window shown in figure 3.3 and selecting the “OK” button in this window and the “OK” button in the standard Windows print control window, shown in figure 3.4, the printout will commence. An example of a device printout of parameters is given in Appendix C.

3.5.2 PRINTING LOGFILE

If the print logfile option has been marked in the print selection box (see previous sections) the complete logfile as of that moment will be printed. Every time the data is written to the logfile it is preceded by the date and the time, as shown in the first two columns.

The parameters who can be logged are:

- actual flow in percent of full scale
- actual setpoint in percent of full scale
- actual temperature in selected units
- actual analog output in percent of full scale
- actual valve control value
- actual valve (override) status

The units of the data are not explicitly given.

In case the device is a meter model, the actual setpoint, the actual valve control value and the actual valve status are omitted.

For using the log file option please refer to section 5.2.

3.6 CLEARING THE LOGFILE

Clearing the logfile means that the logfile of the selected device will be emptied. The file itself will remain to exist, only it is empty until the next data to be logged will be written into the file.

To clear the logfile refer to section 2.10.1 “File menu options”.

Section 4

DEVICE DATA MENU

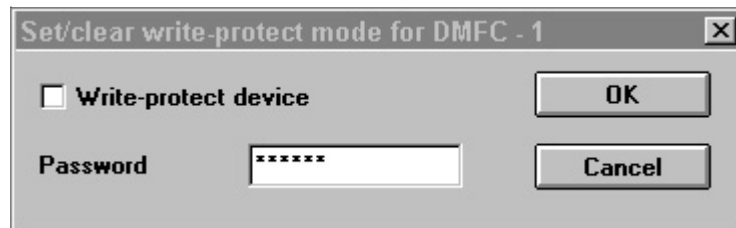
4.1 INTRODUCTION

This section is intended to explain the *device data* menu options, giving you access to the device dependent parameters. It enables you to inspect the parameters and, if applicable, change them. All static parameters, i.e. settings are write protected by the device itself, and in order to change them, you must first clear the write protection by entering the password and unmarking the write protect option. If this is not done, you will notice that the selection options and input lines are disabled. Therefore this section starts with entering the password, after which the parameters themselves shall be discussed.

4.2 PASSWORD PROTECTION

When selecting the *Device data / Password* menu option the window shown in figure 4.1 will be put on the screen. This window enables you to disable the write protection of the device or to set the device back to the write protect mode. Entering a password will, by convention, be shown on the screen as a row of '*' characters in order to avoid unauthorized people to read the password. The default password is "BROOKS".

Figure 4.1: Password entry window



By entering the password (as is done in figure 4.1) and selecting the "OK" button you can set the device either to the write protected mode or to the non-write protected mode. In the write protected mode all static parameters such as settings are protected against unauthorized access. The actual parameters, e.g. the setpoint, are not write protected.

A device being write protected or not can be determined by the fact that in case of a write protect, the statusbar on the lower border of the screen displays the string "Device is write-protected". Also the input lines in various windows are not accessible and selection buttons are displayed in a grey color indicating the protected mode.

Since the write protect mode is indicated in the device by the parameter "Write protect", which is like all the other parameters stored in the database, you must issue a *Device data|Database|Backup* command in order to store the new settings into the non-volatile database of the device. If you have changed the device to the write protect mode and the backup command is not issued, the device will be non-protected after the next power up.

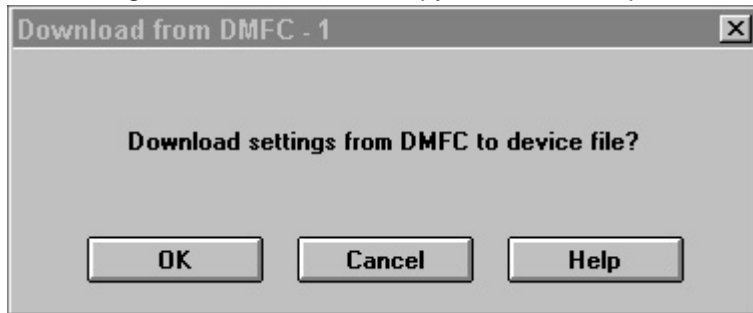
4.3 DATABASE

The *Device data|Database* option enables the handling of device databases. You can perform a complete download of data, i.e. the copying of data from the device to the host computer, or a restore or backup operation to restore the database after changes have been made or to store the changes made to a non-volatile memory in the device.

4.3.1 DOWNLOADING DATA

When selecting the *Device data|Database|Download* option a confirm window will be shown on the desktop (see figure 4.2), prompting you for a confirm of the download command. Downloading data results in overwriting the current database copy in the host computer.

Figure 4.2: Down confirm window



After confirming the download command, the Smart Control program will perform a sequence of read commands in order to get all the data out of the device to the host computer. Depending on the baudrate, this action will take at least 5 to 10 seconds (for 19200 baud), or longer for lower baudrates. An information window indicating the action will therefore replace the confirm window on the screen, if the confirm was positive. The download action will automatically be performed in case you want to save the data of a new device on the communication link to disk and the database has not been initialized, see Section 3.3.

4.3.2 PERFORMING A RESTORE/BACKUP

When changing device parameters and sending them to the specified device, the new parameter values will be stored in the SRAM database on board the device, i.e. the volatile working copy of the database. This means that, although the changes take effect immediately, they will be lost in the event of a power down, because at startup the working copy of the database is made by copying all parameters from the non-volatile database to the SRAM.

Therefore if you have made changes to the device parameters and you are satisfied with the changes you should perform the *Device data|Database|Backup* command in order to preserve the changes made. Selecting this command invokes a copy action within the device itself, where every parameter that has been changed and which has not been backed up will be copied from the volatile database to the corresponding location in the non-volatile database.

On the other hand if you made changes to the device and you are not satisfied with the results, a *Device data|Database|Restore* command can be issued. This will invoke a copy action within the device itself, but now every parameter that has been changed in the volatile working copy in SRAM and which has not been backed up will be replaced with the original value from the nonvolatile database. These changes to the device will take effect immediately.

As with the *Device data|Database|Download* command, selecting either the *Device data|Database|Restore* or the *Device data|Database|Backup* command will bring up a confirm window, prompting you for a confirmation of the selection.

4.4 ACTUAL DATA

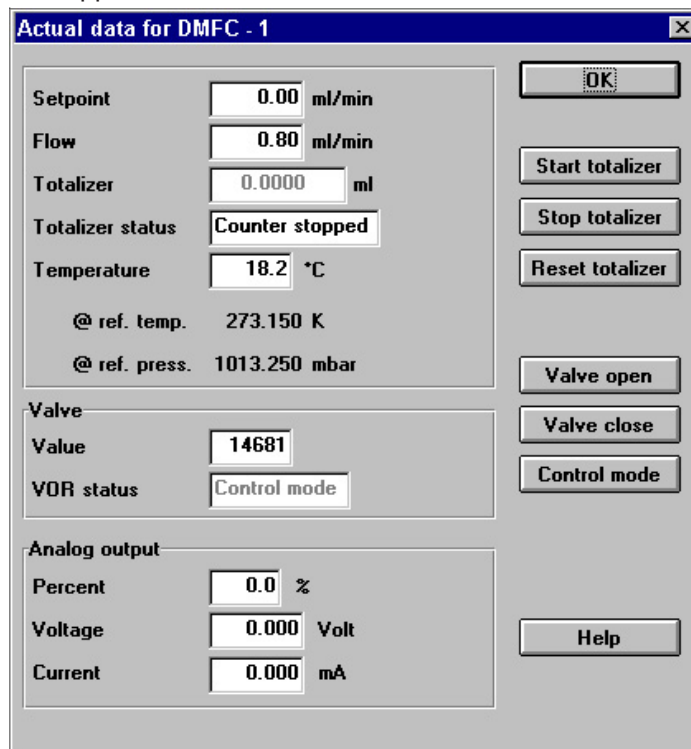
The *Device data/Actual data* selection allows you access to the actual data of the specified device and in the case of Digital Mass Flow Controller models it also allows you to select valve override commands. The window brought on the screen is shown in figure 4.3. The window is being updated approximately every second, and it will be closed by selecting the “OK” button.

4.4.1.1 VIEWING ACTUAL DATA

The window shows the actual flow and the setpoint (controller model only) in the units selected. The selection of units is discussed in the Sections 4.9.3 and 4.9.4. Apart from the flow and setpoint in units the reference conditions, i.e. the reference temperature and the reference pressure are also given. The otherwise generally used “normal” and “standard”, referring to the reference conditions 273.15 Kelvin/1013.33 mbar and 20°C/1013.33 mbar respectively are not used. This is done for reasons of clarity, e.g. the definition of what conditions are meant with “standard” sometimes differ from company to company. Displaying the reference conditions this way avoids this problem.

The flow and setpoint values as they are displayed in this window are send to the host computer (upon request) by the specified device, together with the indicator for the unit and the reference condition they are supplied in.

Figure 4.3: Actual data window



That means that each device performs his own conversion of units from the internally used unit to the unit selected by you (refer to section 4.9 for selection of the read out unit). The conversion formulas and factors used in the device are summed up in Appendix A.

Next in this window is the temperature value as send from the specified device to the host computer in the unit you selected. The temperature shown is a measure for the ambient temperature around the sensor. This temperature value, internally in the device expressed in Kelvin, is used to perform temperature compensation of the measured gas flow value. Refer to Section 4.9.4 for the selection of the temperature unit.

In case the device is a Mass Flow Controller model, the valve data block gives you information on the current control value of the valve and the status of the valve override (VOR status).

The valve value is a dimensionless number in the range from 0 to a maximum of 62500. It displays the number, which the D/A-converter uses for the valve control, and is a measure for the actual valve current. The higher the value, the more current goes through the valve.

In normal control mode (VOR status: Control mode) at a setpoint input of 0%, the value displayed will be the valve offset value, which can be set through the *Device data/Controller settings* menu option (refer to Section 4.11.2). When entering a setpoint the value will become higher as the controller tries to establish the requested flow. For “Normally-Opened” valve types the valve control value will run down from the valve offset value. In either case the value displayed in this field can be used to (re)adjust the valve settings in order to improve control characteristics. This is discussed in Section 4.11.2.

In case a no-flow condition arises (e.g. in the absence of gas) with a setpoint input of more than 1%, the valve value will not run to the maximum value of 62500 (or 0 in case of a Normally-Opened valve), but it is limited to a certain maximum. This is to prevent the “controller windup” problem, where the controller might go on for ever trying to open the valve. It also ensures fast recovery of control in case the supply of gas resumes. In case such a situation arises the valve-out-of-range alarm message will be displayed, as well as the no-flow indication alarm message.

At the bottom end of the window the analogue output data are given. They show the percentage of full scale of the analogue output D/A-converter and the values of the voltage output and the current output of the Brooks Digital Mass Flow Meter or Controller.

These output values can be used to calibrate the two analogue outputs for the conditions of your system (e.g. corrections for long connection lines can be made). Refer to Section 4.10.6 for calibration of the analogue outputs.

4.4.1.2 TOTALIZER FUNCTION

The totalizer field displays the actual totalizer value with its unit. The totalizer unit is derived from the selected flow unit, e.g. when the actual selected flow unit is ‘liter/min’ (refer to IOM section 4.9.3 how to select the flow unit), the totalizer value will be expressed in ‘liter’.

The totalizer status informs you about the actual totalizer mode of the device, which can be ‘Counting’, ‘Counter stopped’ or ‘Reset counter’. Use the totalizer buttons in order to change the totalizer mode (when a totalizer button is pressed, a confirmation window pops up before the command is send to the device):

Start totalizer	Push the start button in order to set the device into the ‘Counting mode’. As soon as the device is in this mode, the totalizer value will increase depending on the measure flow through the device.
Stop totalizer	Push the stop button in order to set the device into the ‘Stop counter’ mode. When the device is in this mode, the totalizer value remains unchanged.
Reset totalizer	Push the reset button in order to set the totalizer value to zero. When this button is pressed and confirmed, the totalizer status will indicate the ‘Reset counter’ mode for several seconds.

4.4.2 PERFORMING VALVE OVERRIDE

The actual data window also offers you the possibility to perform a valve override function, i.e. to fully open or close the valve independent of the setpoint input. Performing a valve override open, e.g. to purge the gassystem, is done by selecting the “Valve open” button in the window. A window will then pop up, requesting you to confirm the valve override open. After confirmation the VOR status will read “Valve Opened” and the valve value will be the maximum of 62500 (or 0 for a Normally-Opened valve). In this case the controller is overruled, in that it stays at the value of the last setpoint input, for fast recovery after the valve override has been turned back to Control mode.

Performing a valve override close, e.g. to stop a gasflow in order to perform a sensor zero, is done by selecting the “Valve close” button in the window. Again the confirmation window will pop up, requesting confirmation of the selected action. After confirmation the VOR status will read “Valve Closed” and the valve value will be the minimum of 0 (or 62500 for a Normally-Opened valve).

In both cases the valve override will be set back to normal control by selecting the “Control mode” button. The valve override entered through the computer may be overruled by the valve override entered through the analogue valve override input (pin #12 on the main connector), which takes precedence over the input through communication. The VOR status displayed will reflect the actual valve override on the device.

4.5 GENERAL DATA

The *General data* menu option brings up information window containing all general device information, such as device type, id number and tagnumber, but also information for the purpose of traceability. The General data window is shown in figure 4.4.

The window contains general device information related to the type and the manufacturer, the revision numbers on the software and hardware used internally and information related to the tagnumber on the outside of the device. The device information box contains the device manufacturer name, being “Brooks Instr.” for all Brooks Digital Mass Flow Meters and Controllers and the device type string, depending on the device, which is addressed. The type can be 5860S, 5861S, 5863S or 5864S for the meter models and 5850S, 5851S or 5853S for the controller models.

Figure 4.4: General data window

The screenshot shows a dialog box titled "General data for DMFC - 1". It is divided into three main sections:

- Device information:** Contains five text input fields:
 - Manufacturer: Brooks Instr.
 - Device type: 5850S
 - Brooks order number: T98019/005
 - Final Assembly number: 0
 - Device id number: 9801905
- Revisions:** Contains four spinners:
 - Hardware rev.: 1
 - Universal cmd. rev.: 5
 - Software rev.: 3
 - Transmitter cmd. rev.: 1
- Tag information:** Contains four text input fields:
 - Tag number: 98019005
 - Descriptor: (empty)
 - Date: 11/04/1994
 - Message: (empty)

On the right side of the dialog box, there are three buttons: OK, Cancel, and Help.

for
next

The Brooks order number and the final assembly number are strings indicating the reference numbers of the unit, used during the original order handling at Brooks. Brooks maintains a database of the device data, established during calibration time, which is stored under the Brooks order number. When contacting Brooks on service issues, you should use this number as a reference. The final assembly number is internal use with Brooks only. The device id number is treated in the section.

The hardware and software revisions indicate the hardware revision of the printed circuit boards used and the control software. The other two revision numbers, Universal Command Rev. and Transmitter Command Rev. refer to the revisions used in the communication protocol, i.e. the message structure used in the protocol complies with the Rosemount HART protocol revision 5.0.

All the mentioned database parameters can not be changed by you for the obvious reason that traceability of each device must be maintained.

4.5.1 CHANGING THE DEVICE ID NUMBER

The device id number indicates a unique number for the selected device. The number is used for identification in the addressing of the protocol used, but it can also be used for visual identification. The number is normally set by Brooks Instrument, during calibration to a unique number derived from the order number associated with the device. This ensures direct operation, when a new device is connected to a communication link.

If however you desire to change this number, e.g. because for some reason the number is also assigned to an already existing device of the same type and manufacturer, you should proceed as follows.

1. Make sure the write-protect mode has been disabled using the password entry window.
2. Make sure that the device to be changed is unique on the communication link, i.e. that another device of the same type and manufacturer and with the same id number is temporarily disconnected from the link.
3. Select from the menu the *Device data|General data* menu option.
4. Select the device id number entry field and enter the new device id number, which should be a non-negative number between 0 and 16777215.
5. After entering the number select the "OK" button and confirm again the "Change data" request.
6. If no warning window turns up, the action is successful and the Smart Control program as well as the device will now use the new id code.
7. Make the change permanent: select the *Device data|Database|Backup* menu option to store the new id number, and confirm the selection.
8. Next, if necessary, reconnect the devices with the old id number.

4.5.2 CHANGING THE DESCRIPTOR, DATE AND MESSAGE

The descriptor, date and message are three parameters related to the tag number of the device. They can contain extra information concerning the device (e.g. the gas that is measured or controlled or the location of the device in the system, if applicable).

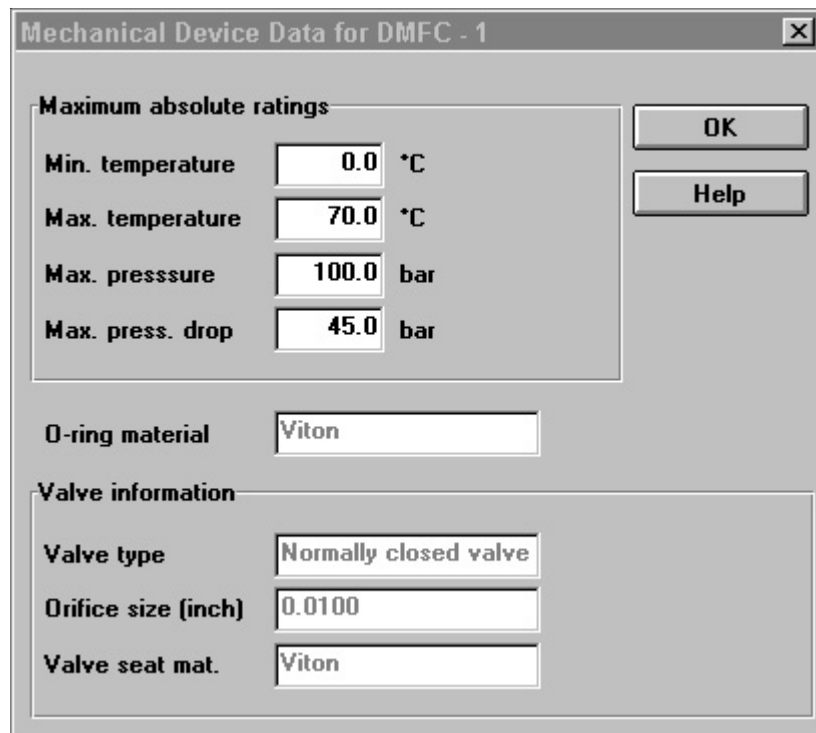
In order to change one or more of these parameters you first have to make sure that the device is not write protected. If this is not the case you can get access to the input field by moving the cursor to the selected input field and clicking the left mouse button. For the device descriptor a 16 character alpha-numerical string can be entered. The same applies to the message input field, where a 32 character alpha-numerical string can be entered. The format of the date associated with the tagnumber equals the one you have selected in the Windows environment. The date can be entered e.g. as dd/mm/yy separated by either a “/” character or a “-” character. After changes have been made, select the “OK” button in order to send the new parameters to the device.

If the date entered does not match the format used, the actual date send to the device will not comply with the date format used internally in the device and an error message will be returned. In this case a communication error window will pop up indicating that an invalid item has been send to the device. You can then either correct the date and try sending it again or cancel the action and discard the changes made.

4.6 MECHANICAL DATA

When selecting the *Device data*/*Mechanical data* menu option, the relevant mechanical data of the selected device can be examined. The Mechanical device data window popping up is shown in figure 4.5. The window contains the absolute maximum ratings for the process and environment conditions under which the device is able to operate properly. These parameters are set by Brooks Instrument during order handling and calibration and they can not be changed by a user.

Figure 4.5: Mechanical device data window



In most cases the minimum and maximum temperature will be 0.0°C and 70.0°C, but for the devices with remote electronics, the maximum temperature may be up to 100.0°C. The absolute maximum pressure is the maximum pressure allowed for the device. For the meter models this will be 300 bar absolute, whereas the controller models can withstand 100 bar absolute. The maximum pressure drop indicates the maximum difference allowed between the gas inlet pressure and the gas outlet

pressure. For controller models this pressure drop is determined by the selected orifice. Refer to the Instruction and Operations Manual for the Brooks Digital Mass Flow products (document 541-C-051-AAA) for the maximum pressure drop values associated with the possible orifice values.

The material used for the O-rings of the device is given in the next box. In case this reads "Special" it refers to the EPDM molded valve seats.

The valve information is displayed in case the device is a controller model. Otherwise this information box will be disabled. The valve type gives the installed type of valve, being either "Normally-Closed" or "Normally-Opened". The orifice size (in inches) and the valve seat material give the size of the orifice and the material used in the valve. Refer to Appendix B for the possible parameter values.

The mechanical device data window will be closed when selecting the "OK" button.

4.7 GAS DATA

The gas data window allows you to browse through and inspect the calibration data stored in the device. The device can be calibrated for ten different gasses, limited by the mechanical configuration, where for each gas the data shown in the gas data window is contained in the device. An example of the gas data window is shown in figure 4.6.

The data in this window can be viewed only, i.e. nothing can be changed. All parameters have been entered during calibration.

Information displayed in the gas data window is divided in four separate boxes: the Gas information box, giving general gas information, the Conditions box, specifying the process and calibration conditions, the Range box, specifying the flow range values and the Calibration box, displaying the actual calibration information.

The Gas information box provides general information on the types of gas(es) the device is calibrated for, the process gas, and type of gas used to calibrate the device, the calibration gas. The gas types are indicated by their names or their associated chemical formula in the fields behind the associated captions. The Density value displayed is the density of the process gas, mostly indicated in units of kg/m³ at 273.15 Kelvin and 1013.33 mbar. If available at Brooks Instrument, the device can be calibrated with the process gas itself. If the process gas is not available at Brooks Instrument, which is e.g. the case with highly toxic or highly flammable gasses, a substitute calibration gas will be used.

In order to ensure proper calibration, a scaling factor must be applied during calibration to scale the sensor output for the case of the calibration gas to the sensor output as it will be in the case of the real process gas. This scaling factor, also known as the gas factor, is a dimensionless number indicating the ratio between the calibration gas sensor output and the process gas sensor output. The factor is applied when calculating the linearization polynomial, and it is not used in the device itself. It is stored in the device for information purposes only. In case the calibration gas is the process gas the ratio will be 1.0 exactly. The factor is displayed below the process gas density value.

The Conditions box contains the gas temperature and pressure conditions for the process as specified by the customer and the conditions as they were, when the device was calibrated. The conditions specified here are displayed in the unit, specified by the customer at ordering. The calibration temperature will be used internally in the device for temperature correction of the sensor span, i.e. any deviation due to temperature shifts from the curve measured during calibration and under calibration conditions will be corrected using the calibration

temperature and the actual measured temperature. The pressure reference can be either absolute or gauge, i.e. measured with respect to zero pressure or with respect to the ambient pressure (approx. 1 atmosphere).

The Range box displays the information concerning the flow range of the device, specified in the unit given by the customer at ordering. Also the reference conditions are given used when calibrating the device, i.e. all flow calculations have been reduced to these conditions. Refer to Appendix A for the conversion formulas used.

The range factor is a dimensionless factor used to re-range the flow range within certain limits, i.e. if a device is calibrated for 1 ltr/min, it can be used for 0.8 ltr/min range full scale, when applying a range factor of 0.8. The factor is limited between 0.8 and 1.2. In most cases the factor will be set to 1.0.

The Calibration box in the lower part of the Gas Data window displays the linearization polynomial coefficients and the calibration tool identification number is given, serving the purpose of traceability. The linearization polynomial coefficients are the coefficients a0 through a3 used in the correction formula:

$$\text{flow} = a_0 + a_1 * (\text{sensor}) + a_2 * (\text{sensor})^2 + a_3 * (\text{sensor})^3$$

Figure 4.6: Gas data window

The screenshot shows a software window titled "Gas Data for DMFC - 1". It contains several sections for configuring gas measurement parameters:

- Gas information:** Process gas (Air), Calibration gas (N2), Density (1.2930 kg/m³), Gas factor (0.99800).
- Conditions:** Process and Calibration columns for Temperature (20.00 °C), Inlet pressure (0.20 bar), Outlet pressure (0.00 bar), and Pressure ref. (Gauge). Buttons for OK, Help, Next Gas, and Prev Gas are on the right.
- Range:** Flow range (100.00 ml/min), Range factor (1.00000), Ref. temperature (273.15 K), and Ref. pressure (1013.25 mbar).
- Calibration:** Linearization polynomial coefficients (a0: 0.000000, a1: 1.263450, a2: -0.038076, a3: 0.146294) and Calibration tool (05025/02).

This formula is the correction formula, using the sensor signal (in terms of 0% to 100% = full scale) as an input, resulting in the corrected flow value (in terms of 0% to 100%). It does NOT represent the actual uncalibrated sensor curve. When calibrating the device, these coefficients are calculated based on the actual flow measurements of an uncalibrated sensor (in this case the a0 through a3 are set to 0.0, 1.0, 0.0 and 0.0 respectively) and the gasfactor in case a calibration gas is used.

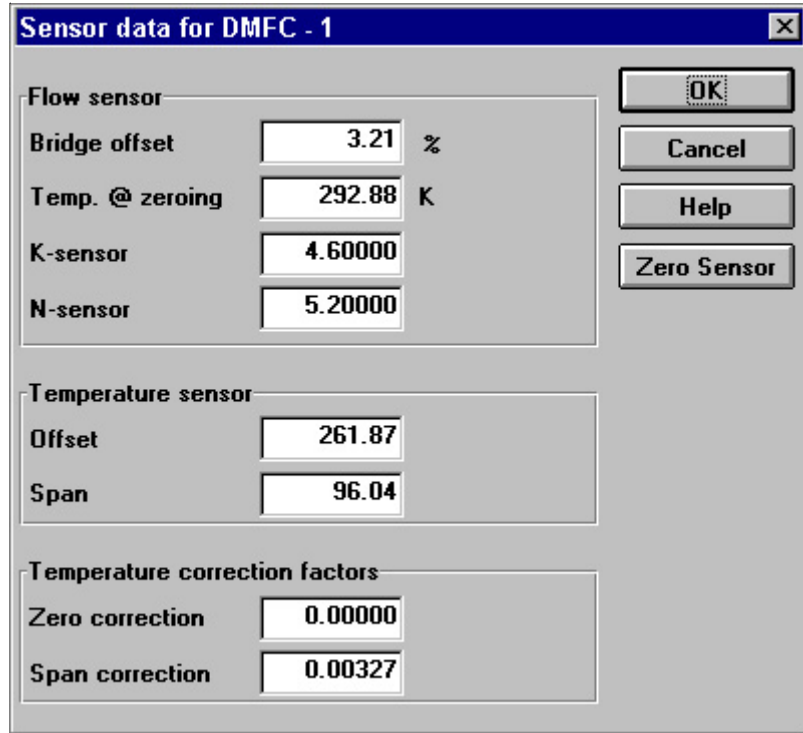
The Gas Data window shows the calibration data of one out of ten possible calibration data blocks. The other data blocks are accessible, by selecting the "Next Gas" and/or "Prev Gas" buttons, although the device may not be calibrated for all ten gases.

In this case you will be presented with a Gas Data window containing the default settings for a gas data block, i.e. empty Gas type fields, default temperature and pressure values and default polynomial coefficients for an uncalibrated sensor.

4.8 SENSOR DATA

The sensor data window shows information on the two sensors, the flow sensor and the temperature sensor on board the Brooks Digital Mass Flow Meter and Controller models. It also allows you to perform a flow sensor zero action, i.e. a re-balancing of the flow sensor measurement bridge, provided the device is not write protected. The sensor data window is shown in figure 4.7.

Figure 4.7: Sensor data window



4.8.1 VIEWING THE DATA

The flow sensor bridge offset is the full scale residual offset measured by the A/D-converter at a no-flow condition. This value, determined during a zero action, is eliminated from every flow measurement. During such an action (see the following section), the on board microprocessor balances the flow sensor bridge as good as possible and determines the remaining offset, which can not be eliminated through balancing. This value is stored in memory, and it is shown in the “Bridge offset” field in the sensor data window in figure 4.7.

The residual bridge offset is expressed in % of full scale.

During a zero action the local temperature at the sensor is also determined. This value, the “Temp. @ zeroing” shown below the bridge offset and expressed in Kelvin, is used in the temperature correction of the offset.

Next in the flow sensor data box two parameters are given, the “K-sensor” and the “N-sensor”, which are related to the frequency characteristic of the sensor (i.e. the response behaviour). The two constants, which are set at calibration time and which can not be modified by a user, are used in the sensor signal processing after A/D-conversion. Generally the lower the N-sensor value is, the faster the output signal response to sudden flow changes.

The second sensor on board is the temperature sensor, located under the sensor can of the Brooks Digital Mass Flow Meter and Controller models. This sensor sends a voltage signal to the A/D-converter, which is proportional to the sensor temperature. With help of two scaling constants, the temperature sensor span and offset, this voltage value is

scaled to the temperature in kelvin, the internally used engineering unit for temperature. The two parameters shown in the temperature sensor box in figure 4.7, are set during calibration time and can not be modified by a user.

The temperature correction factors are two factors used in the correction of the flow value measured for the temperature difference with respect to the calibration temperature. The sensor offset value slightly changes with temperature, a change which is flow sensor dependent, but it is corrected for by the software. The amount of correction is determined by applying the correction factor to the difference between the measured temperature and the temperature determined during a sensor zero action. The span correction factor is applied to the difference between the measured temperature and the gas calibration temperature, determined during the calibration for the specified gas (i.e. the calibration temperature found in the gas data window for the specified gas, see Section 4.7). The two temperature correction factors are set at calibration time and they should be considered as the rate of change per kelvin.

4.8.2 ZEROING THE SENSOR

The flow sensor bridge offset may change due to changes in the process pressure or the gas used. In order to get by this effect, you can give each device a zero command, by selecting the “Zero sensor” button in the sensor data window figure 4.7. When doing so, a confirmation window will pop up asking you to confirm your command.

The action should be given under strict no-flow conditions. This means that applied gas should be removed from the device, preferably by an external shutoff valve upstream from the device, and all gas flowing through the device prior to shutoff should be removed. Also the sensor should be allowed to reach a thermal equilibrium after shutoff, i.e. the sensor should be left in the no-flow conditions for at least 5 minutes. After these conditions have been taken in consideration, you may give the zero command.

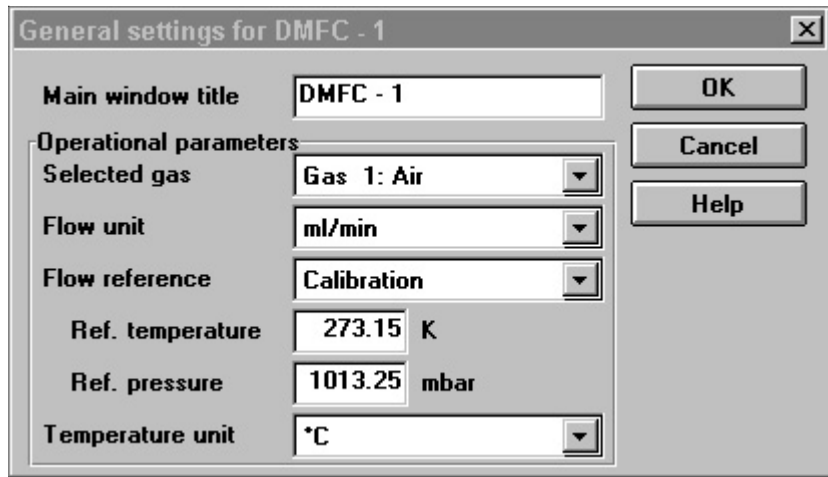
In response to this command the on board processor will start a zero sequence, trying to balance the flow sensor bridge as good as possible by controlling a digital balancing potentiometer. The residual offset which can not be eliminated, due to the resolution of the potentiometer, will be measured by the processor and stored in internal memory. A separate backup command is not required, since the measured value will automatically be stored permanently. The zero action will take the microprocessor five to ten seconds.

The new bridge offset value and the associated temperature value, which is determined during the zero action will become visible in the sensor data window the next time this window is opened.

4.9 GENERAL SETTINGS

The *Device data/General settings* menu option allows you to select the type of gas that will be measured or controlled (i.e. which calibration curve to use) and to select the preferred units for gas flow and temperature. It also allows you to customize the title of the main window in which the flow and/or setpoint are made visible. The general setting window is shown in figure 4.8

Figure 4.8: General settings window



The following sections will deal with the possible selections which are available. You have to be aware of that the write protect mode of the device must be disabled before any changes can be made to the settings. (refer to Section 4.2).

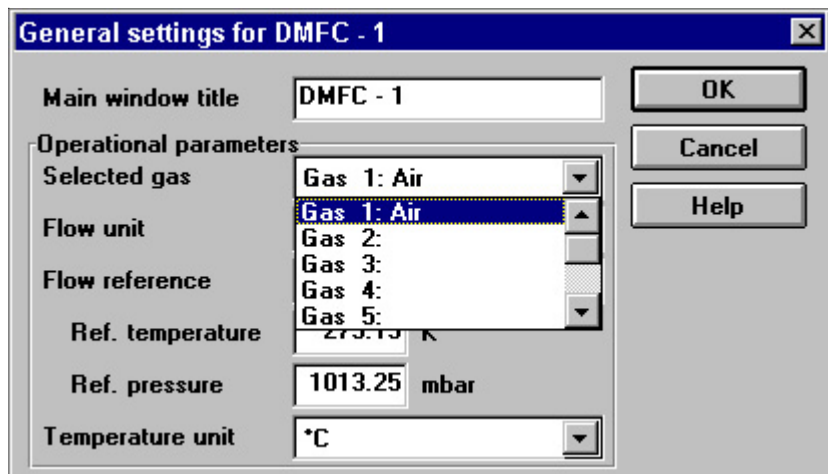
4.9.1 SELECTING A WINDOWS TITLE

You can determine the title of the main flow window associated with a Brooks Digital Mass Flow Meter or Controller model yourself, allowing you to set your own system dependent references, in order to provide clarity in the overview of multiple gas displays. You can move the mouse to the window title input field and click on it after which a name can be entered. Selecting the “OK” button and confirming the data change will then result in the direct implementation of the new name in the main window title. The window name is NOT send to the device.

4.9.2 SELECTING THE OPERATIONAL GAS

The Selected gas option in the operational parameters box lists the names of all the gasses for which the device is calibrated. On opening the General settings window the currently selected gas is shown in the selection field, but when clicking with the mouse cursor on the down arrow to the right of the selection field, the names of the other gasses in the device become available. Figure 4.9 shows an example of the general settings window after selecting the down arrow associated with the “selected gas” box.

Figure 4.9: Selecting the operational gas



Each gas is displayed by a leader, giving the gas number in the list and the associated gas name, which was entered during calibration. If the leader is there, but a name is missing, i.e. there is an empty gas name string, the specified gas number does not contain a calibration curve, although that curve can be selected. You will have to be aware that an uncalibrated gas is used, i.e. the linearization polynomial coefficient a 0 to a3 (refer to Section 4.7) are set to 0.0, 1.0, 0.0 and 0.0 respectively.

4.9.3 SELECTING THE FLOW UNIT AND REFERENCE

The flow unit and the flow reference condition selections allows you to select the flow unit in which the flow is displayed in the Actual data window (refer to Section 4.4). The flow can be expressed in either volumetric flow units or in real mass flow units. Figure 4.10 shows an example of the General settings window after selecting the down arrow associated with the “Flow unit” box.

Since volumetric values are strongly dependent on gas temperature and pressure, you need to specify the conditions to which the volumetric flow is referenced. Generally this is done by giving the volumetric flow in terms of “normal liters/min”, where the addition “normal” indicates the condition 273.15 Kelvin (= 0°C) and 1013.33 mbar. The indication “standard” is also used.

Figure 4.10: Selecting the flow unit

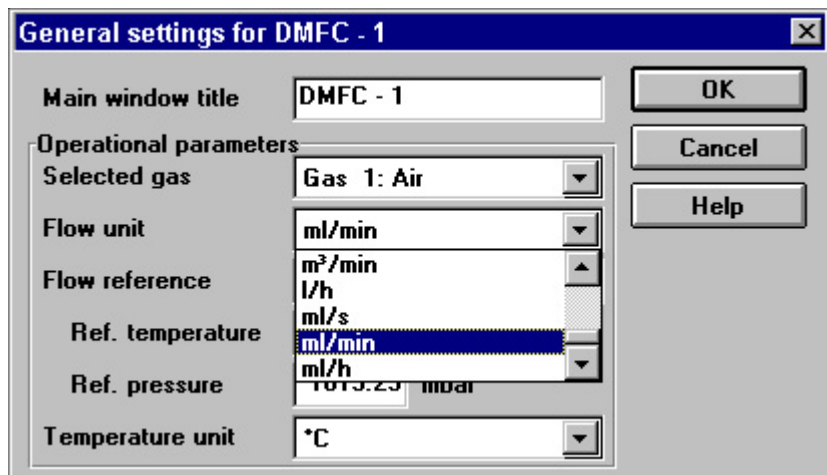
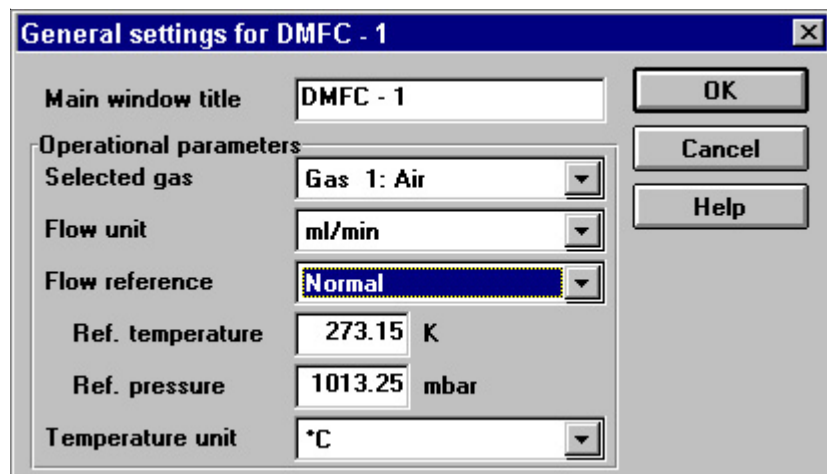


Figure 4.11: Selecting the flow reference



The “standard” indication however is not consistent, because its meaning is found to vary among different companies. Therefore in the case of the Smart Control program all reference conditions are ex

pressed in their respective value, when displaying a flow value in volumetric flow units, i.e. the condition is expressed as e.g. “273.15 Kelvin and 1013.33 mbar” instead of “normal”. You can select the reference condition to be used in the visualisation of the flow. This can be either the “normal” condition (i.e. 273.15 Kelvin and 1013.33 mbar), or the condition specified at calibration, which can be virtually any, user specified condition. Figure 4.11 shows the general settings window after selecting the down arrow behind the flow reference selection field.

In case true mass per time unit is selected as the flow unit, the reference condition is not available, i.e. it will not be used, since mass units are not dependent on gas temperature and pressure.

4.9.4 SELECTING THE TEMPERATURE UNIT

The last item in the Operational parameters selection box is the temperature unit. The selection made here specifies in which unit the temperature value in the Actual data window will be displayed. You can select between Kelvin, degrees Celsius and degrees Fahrenheit. These selections are made available by selecting the down arrow next to the temperature unit field. They are also accessible using the up and down arrow keys and the “Tab” key, when the temperature unit selection field has been selected.

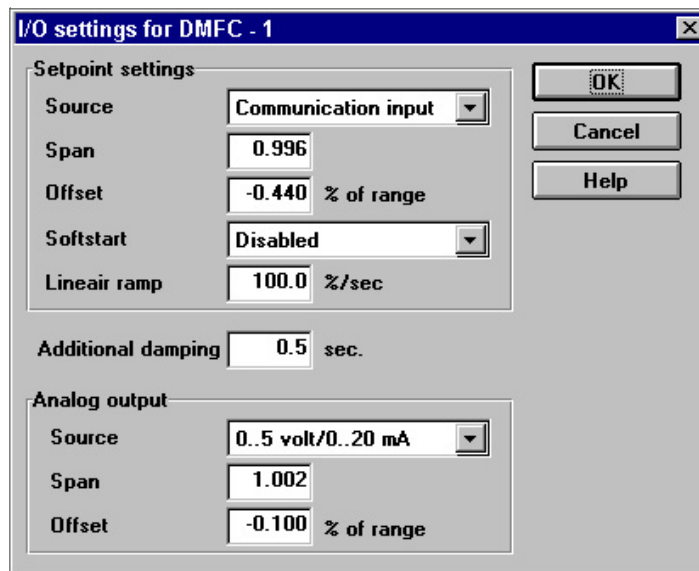
After the selection has been made, select the “OK” button and after confirming the parameter change, the temperature unit selected will be send to the specified device.

4.10 I/O SETTINGS

Selecting the Device data| I/O settings menu option brings up the I/O settings window, containing all necessary settings for the setpoint and the analogue outputs. All settings in this window can be adjusted, provided the device is a controller, i.e. in case it concerns a meter, the setpoint settings block will be disabled. The window is shown in figure 4.12.

In order to be able to make changes to the data displayed in the I/O settings window you will have to clear the write protection by entering the password with the write protect not selected. After changes made to the parameters, have been send to the device you should select the Devic data|Database|Backup menu option in order to make the changes permanent. The available selections are discussed in the following sections.

Figure 4.12: I/O settings window

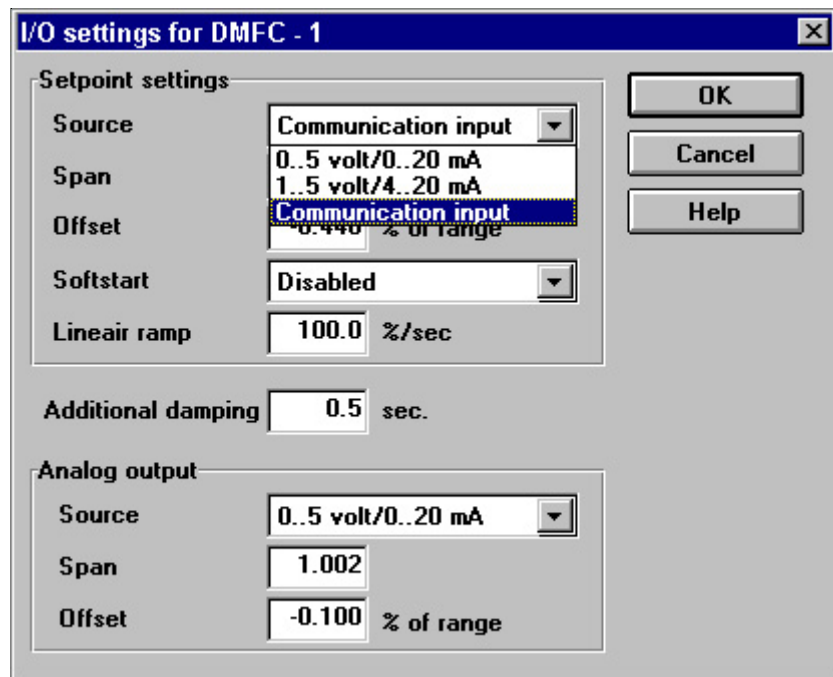


4.10.1 SELECTING A SETPOINT SOURCE

The setpoint for a Brooks Digital Mass Flow Controller model can originate from one of three possible sources, being:

1. The communication line, i.e. through the Smart Control program,
2. The analogue voltage or current input at a 0-5 Volt/0-20 mA range,
3. The analogue voltage or current input at a 1-5 Volt/4-20 mA range.

Figure 4.13: Setpoint source selection options



The selection between analogue voltage input and analogue current input is achieved with a jumper on the mainboard. Refer to the Brooks Digital Mass Meter and Controller Instruction and Operation Manual, document 541-C-051-AAA for the setting of the jumper. Normally the jumper is set as specified at ordering.

The setpoint input source can be selected from the Smart Control program, by selecting the down arrow icon next to the setpoint source input field, using the mouse or moving to the input field using the tab key and the down arrow key. After this selection a list with available option will pop up. The window with this list is shown in figure 4.13. By double clicking the left mouse button on the desired option or pressing the "Enter" button when moved to the desired option using the up and downarrow keys, the selection will be made, and the list with available options will disappear. The selected option will be displayed in the selection field.

4.10.2 CALIBRATING THE ANALOGUE SETPOINT INPUT

In case one of the analogue setpoint input options has been selected, you can calibrate the analogue input, if necessary, to make it comply with your system (i.e. the system may be used with long interconnection lines between the power supply or read out unit and the device, thus resulting in loss of signal due to cable resistance). The span and the offset of the analogue input can be adjusted in order to achieve the correct setpoint signal at the Brooks Digital Mass

Flow Controller. This means that if a 5 Volt setpoint is given in order to get a 100% flow, the adjustments can be made such that the signal received at the device is interpreted as a 100% setpoint.

In order to calibrate the analogue setpoint input, perform the following actions:

1. Select the desired analogue setpoint input and initialize the span and offset value to 1.000 and 0.000 respectively (i.e. uncalibrated analogue input).
2. Make sure both the I/O settings window and the main flow display of the specified device are clearly visible (the I/O settings window can be moved with the mouse)
3. Apply either from your system or a separate accurate source a known low analogue signal to the setpoint input, e.g. for a 0 to 5 Volt setpoint input (0% to 100%) apply 0.25 Volt (= 5%), for 4 to 20 mA range apply 4.8 mA (= 5%).
 - a. Recalculate the analogue input to a percentage of full scale, e.g. for a 0 to 5 Volt range, recalculate the 0.25 Volt to 5%.
 - b. Note the value of the setpoint in percentage as measured through the main window of the associated device.
4. Apply a known high analogue signal to the setpoint input, e.g. for a 0 to 5 Volt setpoint input (0% to 100%) apply 4.75 Volt (= 95%), for 4 to 20 mA range apply 19.2 mA (= 95%).
 - a. Recalculate the analogue input to a percentage of full scale, e.g. for a 0 to 5 Volt range, recalculate 4.75 Volt to 95%.
 - b. Note the value of the setpoint in percentage as measured through the main window of the associated device.
5. Use the two setpoint readings to calculate the correction values for span and offset using:

$$\text{span correction} = \frac{(\text{Input}_{\text{high}} - \text{Input}_{\text{low}})}{(\text{Setpoint}_{\text{high}} - \text{Setpoint}_{\text{low}})}$$

$$\text{offset correction} = - \frac{(\text{Setpoint}_{\text{low}} * \text{Input}_{\text{high}} - \text{Setpoint}_{\text{high}} * \text{Input}_{\text{low}})}{(\text{Input}_{\text{high}} - \text{Input}_{\text{low}})}$$

The span correction is a dimensionless factor (mostly around 1.0), whereas the offset correction is expressed in % of full scale.

6. Enter the two correction values found with the above formulas in the input fields in the I/O settings window and click on the *OK* button in order to send them to the device.
Inside the Brooks Mass Flow Controller, the offset correction value is in added to the measured setpoint value, after which the resulting value is multiplied with the span correction value. The values which can be entered are limited to a range of 0.8 to 1.2 for the span correction factor and -10% to 10% for the offset correction.

EXAMPLE: Suppose for a device with a 4 to 20 mA setpoint input selected, the lower analogue value entered by the user is 5.6 mA, which equals 10% and the higher analogue value entered by the user is 19.2 mA, which equals 95%. The measured values for the setpoint might be 10.25% and 97.5% respectively. Using the above formulas the span and offset correction values will be:

$$\text{span correction} = \frac{(95.0 - 10.0)}{(97.5 - 10.25)} = 0.97421$$

$$\text{offset correction} = - \frac{(10.25 * 95.0 - 97.5 * 10.0)}{(95.0 - 10.0)} = 0.01471$$

For this specific example this means that the correction for the offset for the 10.25% value would result in $10.25 + 0.01471 = 10.26471$, and after that the correction for the span would result in $10.26471 * 0.97421 = 9.999983$, which rounds to 10.0%.

4.10.3 SELECTING THE SOFTSTART

The Brooks Digital Mass Flow Controllers are equipped with the softstart feature, i.e. the possibility to use slow responses of the device to setpoint changes. This feature can be a necessity when rapid injections of gas in a system will lead to dangerous (e.g. explosive) situations. It can also be used in applications involving the careful mixing of different gasses through different controllers, keeping the ratio of concentrations at a constant level. A softstart is executed in the device, not in the Smart Control program, i.e. the setpoint changes entered via the Smart Control program can still be fast changes. Each device will handle the softstart itself when set for this feature.

The softstart feature includes several possibilities:

1. Traditional softstart ("traditional" with respect to the former 5850E/i series Mass Flow Controllers), where the response of gas flow from level a to level b to a setpoint change from level a to level b goes according to the algorithm:

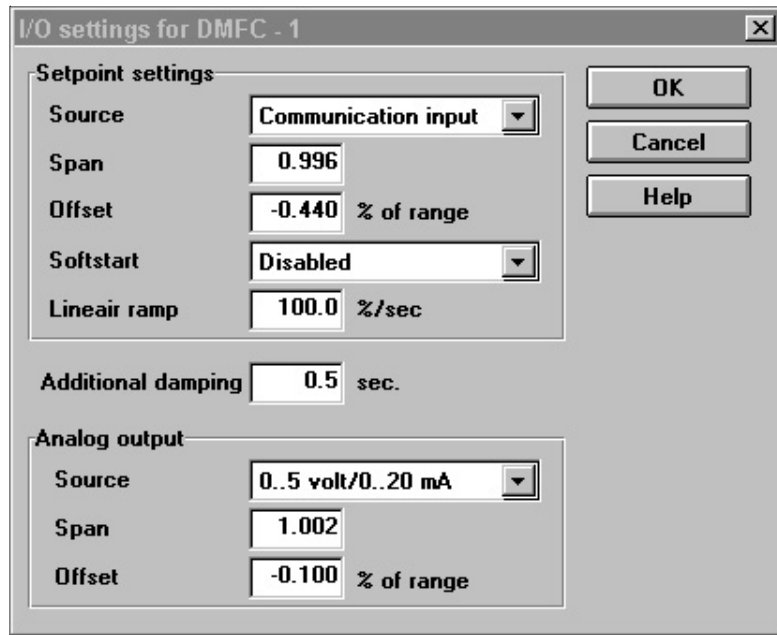
$$\text{flowrate} = b - (b - a) * e^{-\frac{t}{\tau}}$$

In which t represents time and τ a time constant.

2. Linear ramp up, where a setpoint change from the lower level a to the higher level b will result in a gas flow adapting to the new setpoint in a linear way with respect to time. Going from a higher level to a lower level will still result in a fast response.
3. Linear ramp down, the opposite of 2, in that changes from a higher level to a lower level will follow the linear ramp, whereas changes from low to high will be fast.
4. Linear ramp, the combination of 2 and 3, in that any change in setpoint will result in a gas flow changing linear with time.

The above options become available when you select the down arrow right next to the softstart selection field. The selection list, displaying the available options, is shown in figure 4.14.

Figure 4.14: Softstart selection options



By double clicking on the desired option the list will disappear and the selected option will be shown in the input field. Selecting the "OK" button will send the selected option to the device.

The parameters of option 1, the traditional softstart can not be set by a user. The constants used will result in a flow response to a setpoint change (0 to 100%) in approximately 15 seconds.

In the case of the other options you can determine the rate of change in % per second. This number can be entered in the "Linear ramp" input field, and although it will be send to the device even if the traditional softstart is selected, it will only be used by the device if one of the linear ramp softstarts has been selected. In case the fourth option, linear ramp for both positive and negative setpoint changes, has been selected, the number will be applied to both slopes.

The linear ramp value is limited between 0.5%/sec and 200%/sec. In the first case the change from 0% to 100% flow will take 3 minutes and 20 seconds. In the second case the flow change will take 0.5 seconds. The value can be entered by first clicking on the input field, or moving to it by using the "Tab" key, after which the number can be entered. By selecting the "OK" button the parameter will be send to the device.

4.10.4 SETTING ADDITIONAL DAMPING

All Brooks Digital Mass Flow Meter and Controller models are equipped with adaptive signal processing in order to get an accurate stable flow control and (analogue) output signal. The adaptive signal processing for the control of flow will be discussed in Section 4.11. The (analogue) output adaptive signal processing will be discussed here.

The Brooks Digital Mass Flow Meters and Controllers provide the flow information in three simultaneous ways:

1. via an analogue voltage output (0 to 5 Volt or 1 to 5 Volt),
2. via an analogue current output (0 to 20 mA or 4 to 20 mA),
3. via the communication.

In order to provide stable flow data, the source signal for these outputs is processed in an adaptive way, i.e. a signal filter is applied to the signal if the signal is supposed to be stable. When fast changes in the flow requiring a fast signal output adaption are detected, e.g. due to setpoint changes, the filter is temporarily switched off, to enable you to follow the

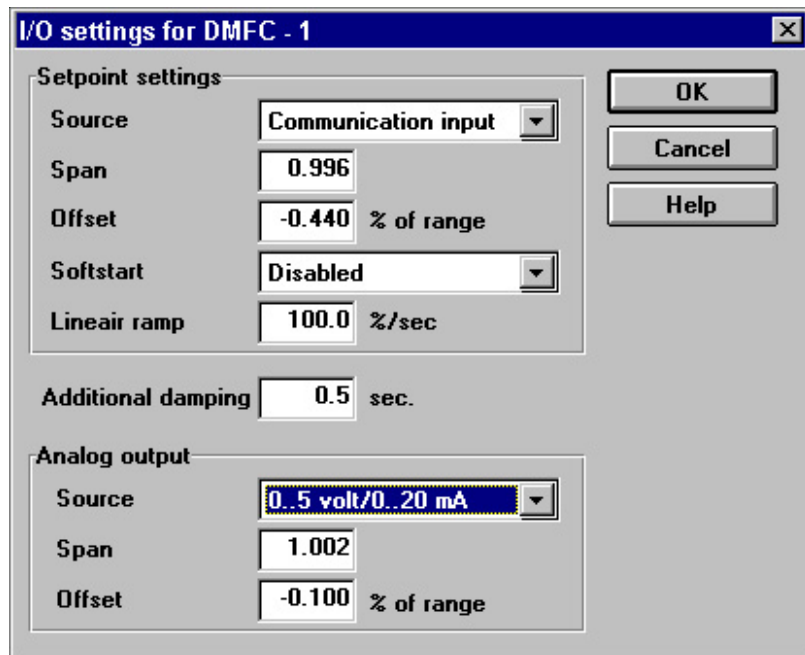
true flow signal. Fast disturbances in the signal, not originating from flow changes are filtered out. This technique results in a better signal performance in an environment where radiation is present. The filtering is applied to the flow signal source used in all the three output signals. It is NOT applied to the signal used in the control of flow, where other adaptive techniques are used to stabilize the flow control as well.

You can determine the amount of damping by entering a value for the filter (time) constant in the "Additional damping" inputfield. The value is expressed in units of seconds and is limited between 0.0 sec. (no damping at all) and 10.0 sec. (maximum damping). The input field can be reached by moving the mouse cursor to the field and clicking the left mouse button. After entering a number and selecting the "OK" button the value will be send to the device and will be active immediately.

4.10.5 SELECTING THE ANALOGUE OUTPUT RANGE

As stated in the previous section a number of signal output option are available to acquire flow information. In order to select the right output, the analogue output ranges can be selected and the analogue output can be calibrated for your system (similar to the analogue setpoint input). The two analogue outputs, the voltage output and the current output are coupled, i.e. selecting a certain voltage output range will also result in a change of the current output. Selecting the analogue output range does NOT affect the communication output signal.

Figure 4.15: Analogue output source selection



You can select between three options:

1. Voltage output 0 to 5 Volt and current output 0 to 20mA.
2. Voltage output 1 to 5 Volt and current output 4 to 20mA.
3. Both outputs switched off.

The selections can be made by moving the mouse to the down arrow next right to the "Analog output Source" input field and clicking the button. After that a selection list will pop up, offering you the three options as mentioned above. This is shown in figure 4.15.

By moving the mouse cursor to the desired option and double clicking on it with the left mouse button the selection list will close and the selected option will be moved to the input field above. Next you can select the "OK" button, which will again result in the changed parameter being sent to the device, taking effect immediately.

4.10.6 CALIBRATING THE ANALOGUE OUTPUTS

In order to use the analogue outputs correctly, they can be calibrated in order to provide the correct output signal at the point of detection. Again, as with the analogue setpoint signal, this feature facilitates the use of e.g. long supply lines in the user system. The analogue output uses the flow percentage value to set the physical output value through a D/A-converter. In most cases, e.g. with long lines present, this conversion will seem to be a non-one-to-one conversion, i.e. span and offset values in the conversion will not be equal to 1.000 and 0.000 respectively. Calibration can be performed by changing the analogue output span and offset parameters. The values for these parameters can be determined by measurement of the analogue output signal at the spot where actual signal detection takes place (e.g. at the end of a long line at the terminals of a readout unit).

If calibration is required, perform the following steps:

1. Select the desired analogue output range and initialize the span and offset values for the analogue output to 1.000 and 0.000 respectively (i.e. uncalibrated analogue output). Click on the OK button.
2. Apply a low gas flow by either setting the setpoint of the controller to a low value (e.g. 10%) or by applying a low gas flow from the system (in cases of a meter model).
 - a. Note the value of the flow in percentage as measured through the main window of the associated device.
 - b. Recalculate, if necessary, the analogue output value, measured at the detection point, to a percentage of full scale, e.g. for a 0 to 5 Volt range, recalculate 0.25 Volt to 5%. When using a Brooks model 0152/0154 readout unit the flow value in percentage of full scale can be read from the display.
3. Apply a high gas flow by either setting the setpoint of the controller to a high value (e.g. 95%) or by applying a high gas flow from the system (in cases of a meter model).
 - a. Note the value of the flow in percentage as measured through the main window of the associated device.
 - b. Recalculate, if necessary, the analogue output value, measured at the detection point, to a percentage of full scale, e.g. for a 0 to 5 Volt range, recalculate 4.75 Volt to 95%.
4. Use the two flow readings to calculate the values for span and offset correction using:

$$\text{span correction} = \frac{(\text{flow}_{\text{high}} - \text{flow}_{\text{low}})}{(\text{output}_{\text{high}} - \text{output}_{\text{low}})}$$

$$\text{offset correction} = - \frac{(\text{output}_{\text{low}} * \text{flow}_{\text{high}} - \text{output}_{\text{high}} * \text{flow}_{\text{low}})}{(\text{flow}_{\text{high}} - \text{flow}_{\text{low}})}$$

The span correction is a dimensionless factor (mostly around 1.0), whereas the offset correction is expressed in % of full scale.

5. Enter the two correction values found with the above formulas in the analogue output span and offset input fields in the I/O settings window and click on the *OK* button in order to send them to the device.

Inside the Brooks Mass Flow Controller/Meter, the offset correction value is added to the flow percentage value to be used in setting the output D/A-converter. The resulting value is multiplied with the span correction value. The values which can be entered are limited to a range of 0.8 to 1.2 for the span correction factor and -10% to 10% for the offset correction.

EXAMPLE: Suppose a device is configured with a 0 to 5 Volt output. In case the output is set to a fixed value of 0.5 Volt (i.e. 10%), the output value measured is 0.51 Volt, which equals 10.2%. For the high flow fixed mode, the output is set to a fixed value of 4.75 Volt (i.e. 95%), the output value measured is 4.77 Volt, which equals 95.4%. Using the above formulas the span and offset correction values for the analogue output will be:

$$\text{span correction} = \frac{(95 - 10)}{(95.4 - 10.2)} = 0.99765$$

$$\text{offset correction} = - \frac{(10.2 * 95 - 95.4 * 10)}{(95 - 10)} = -0.17647$$

For this specific example this means that applying these correction values to the flow values would result in a corrected flow value of:

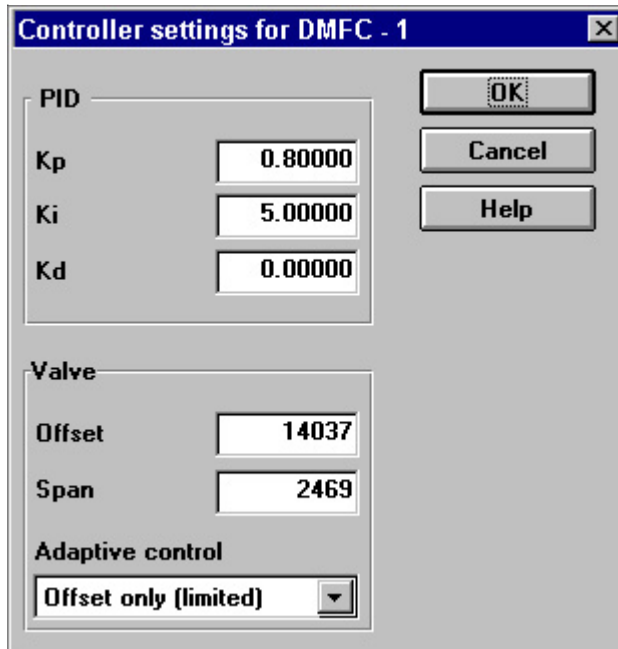
- $(95 + (-0.17647)) * 0.99765 = 94.60069$ for the high flow value
- $(10 + (-0.17647)) * 0.99765 = 9.80044$ for the low flow value.

These values are only used within the analogue output system. Applying these flow values to the analogue output system (with its deviation from the ideal span and offset) will result in the proper output values of 95.0% and 10.0% at the terminals of the signal detection point.

4.11 CONTROLLER SETTINGS

When selecting the Device data|Controller settings option from the menu, the controller settings box will pop up. This window gives access to all controller related parameters, provided the instrument is a controller type. If the instrument is a meter type, i.e. it has no valve, the window will still pop up, but all inputs will have been disabled. Figure 4.16 shows the Controller settings window.

Figure 4.16: Controller settings window



The following sections will deal with setting the controller values in order to optimize the device performance.

4.11.1 SETTING THE PID VALUES

The control system of a Brooks Digital Mass Flow Controller model consists of a number of controllers, operating simultaneously on their inputs. However the output of only one of these controllers is used at a time, e.g. depending on whether fast control for fast response is required or stable control for stable flow situations (i.e. non-changing setpoint values). If the type of control situation is changing, e.g. during a stable flow situation the setpoint is suddenly changed, the control is switched from the stable controller to the fast controller using "bump-less" transfer techniques.

The behaviour of all controllers on board can be set by determining the three PID parameters, the proportional, the integral and the differential parameter. The settings of the separate control blocks are derived from these three parameters. Since the settings, which can be changed are the settings of the fast controller, you will see a direct result from changes made to the PID parameters. If these parameters have been set to incorrect values, oscillations might occur when changing the setpoint. The oscillation however will disappear after some time due to the fact that one of the other controllers takes over. The default values of the PID parameters are 0.8, 5 and 0.0 respectively.

NOTE: It is advised to keep the differential controller (Kd in figure 4.16) to 0.0 at all times, since all Brooks Digital Mass Flow products use separate digital signal processing to extend the bandwidth of the sensor. This way a fast responding system is already created at the sensor, prior to the control system. Setting the differential controller to a non-zero

value would indeed make the system faster, but also more susceptible to fast disturbances, thus creating a "nervous", overreacting control system. Therefore only the settings of the proportional and integral parameters are discussed here.

In most cases you will find tuning the device for the desired control merely a matter of selecting the right valve settings (refer to the next section), then tuning the PID parameters. The PID parameters however can very well be used for fine tuning in the end.

The response to changed parameters should be monitored if possible on a fast flow or pressure measuring device down stream of the Mass Flow Controller to be set. This method is preferred over just examining the output signal, either through Smart Control or the analogue outputs, because the true control is found to be faster than the output signal. The control response time, i.e. the real flow response time, can be around 0.5 sec at a 0% to 100% setpoint step, whereas the output signal might take some 600 to 700 msec. for the step. During calibration at Brooks Instrument a fast pressure transducer (typical response time 100 msec) is used.

Changing the proportional setting, or the K_p in the window in figure 4.16, influences the control response the most. Care should be taken when increasing or decreasing this number. Increasing the K_p will speed up the response, but it will also increase the short term overshoot, e.g. increasing the K_p from 0.65 to 0.8 will cause overshoots of 40% and more. Increasing K_p too much will cause fast oscillations, which will disappear after a while due to one of the slower controllers taking over. Decreasing the K_p will slow down the response, i.e. the response will take longer to reach the end value. The ideal K_p value is determined for each model are presented in table 4.1 and are depending on the environmental parameters (inlet pressure, outlet pressure etc.), and as such depending on your system.

Changing the integral setting, the K_i in the window of figure 4.16, will have a lesser influence on the response, e.g. increasing the K_i from 3.8 to 4.5 will cause a long term overshoot, which slowly fades away, of approximately 10%, depending on your system. It will not change the response time significantly, and a K_i which is set too large will cause (slow) oscillations. Setting the K_i to a value which is too low (e.g. 2.0) will cause a slow responding system, which however will be less prone to fast disturbances in the system and the environment. In general you can tune the K_i value between 3.0 and 5.0 in order to get the right response. Again this should be verified using a fast metering device down stream of the device under test.

In the next section the setting of the control valve parameters will be discussed, which also offers a tool of tuning the system response.

4.11.2 SETTING THE VALVE OFFSET AND SPAN

The offset and span values of the valve as shown in figure 4.16 are used to preset the startpoint and the span of the control range of the valve. The numbers shown are related to the D/A-converter used to set the current through the valve. Both numbers are dimensionless and can be set in the range of 0 to 62500 (approximately 16 bits), but the sum of the offset and the span must also be in the range of 0 to 62500. The current through the valve drive coil is directly proportional to the number entered in the D/A-converter.

During normal control the output signal of the PID control is mapped on to the control range of the valve. A PID controlling 0.0% flow, results in a valve setting equal to the valve offset. Controlling 100% flow results in a

valve setting around the sum of the valve offset and the span. It will be clear that determining these two values greatly influences the control behaviour of the total device. Therefore care should be taken when selecting these values. A valve offset, which is too high will cause a leaking valve (remember that the valve used is a control valve, not a shutoff valve). A valve offset, which is too low will cause a dead time and slow down the response.

The following heuristic rule-of-thumb will assist in setting the offset and span for the valve.

1. Apply gas to the device and make sure that you are able to create flow with the current offset and span settings. If stable control is not achieved with these settings (the valve out of range message will turn up in the status window), increase the valve offset value to at least the current offset plus two times the span value, and send the new values to the device by selecting the "OK" button.
2. Enter a setpoint of 1%, through the main window and wait for the flow to settle at this value (this may take some time). Open the Actual data window (through the *Device data|Actual data* menu option) and read the valve value. This value, at 1% flow is a measure for the valve offset. Note the value and subtract the number of 1000 from it. The result is the valve offset value.
Example: suppose the valve value at 1% flow is 20300, the valve offset must then be set to $20300 - 1000 = 19300$
Select the *Device data|Controller settings* menu option and set the valve offset according to the value calculated from the 1% flow reading. Select the "OK" button and send the value to the controller.
3. Now enter a setpoint of 100% flow and wait for the flow to settle at this value. Open the actual data window and read the valve value. This value can now be used to determine the valve span. Note the value and subtract the just acquired offset value from it. In order to add some margin, add 300 to the result. The resulting value is the valve span.
Example: suppose the valve value at 100% flow is 22700, the span value will then be $22700 - 19300 + 300 = 3700$.
Select the *Device data|Controller settings* menu option and set the valve span according to the value calculated from the 100% flow reading. Select the "OK" button and send the value to the controller.

After having set the valve settings and the device behaves as desired, make sure that the parameters send to the device are stored in the device's non-volatile backup memory, by selecting the *Device data|Database|Backup* menu option.

The next chapter will deal with the *Preferences* menu option.

4.11.3 ADAPTIVE CONTROL

The offset and span values as shown in Figure 4.16 are used to preset the start point and the span of the control range of the valve. The numbers shown are related to the D/A-converter used to set the current through the valve. Both numbers are dimensionless and can be set into the range of 0 to 62500 (approximately 16 bits), but the sum of the offset and the span must also be in the range of 0 to 62500.

The adaptive control mode can be set to one of the following:

Off

No adaptive control; The valve can only be controlled within the adjusted valve control range.

Offset only (limited) (recommended)

Adaptive control for the valve offset only, within a limited range; The start point of the valve control range (offset) is automatically adjusted by the device itself when an offset shift is detected. The offset is limited to shift between fixed values.

Offset/span (limited)

Adaptive control for both the valve offset and span, within a limited range; The start point (offset) and the span of the valve control range are automatically adjusted by the device itself when an offset shift or span change is detected. The offset and span can increase or decrease within fixed limits.

Offset only (unlimited)

Adaptive control for the valve offset only; The start point of the valve control range (offset) is automatically adjusted by the device itself when an offset shift is detected. The offset can shift within the full range of the D/A-converter (0 - 62500).

Offset/span (unlimited)

Adaptive control for both the valve offset and span; The start point (offset) and the span of the valve control range is automatically adjusted by the device itself when an offset shift or span change is detected. The offset and span can increase/decrease within the full range of the D/A-converter (0 - 62500).

The adaptive control offset only (limited) mode is the recommended setting for most applications. In case readjusting of the valve offset and span is necessary due to changes in the ambient conditions, the following procedure should be executed:

1. Make sure gas is applied to the device.
2. Set the adaptive control mode to 'Offset and span (unlimited)' using the **Device data|Controller** settings option from the menu.
3. Enter a setpoint of 5% and wait until the flow has stabilized for several seconds at this value.
4. Enter a setpoint of 90% and wait until the flow has stabilized for several seconds at this value.
5. Repeat step 3 and 4 at least 3 times.
6. The DMFC has determined the offset and span. Use the **Device data|Controller settings** option from the menu to change the adaptive control setting into the recommended 'Offset only (limited)' mode.
7. Use the **Device data|Database...|Backup** option from the menu in order to store the determined settings into the non-volatile memory of the device.

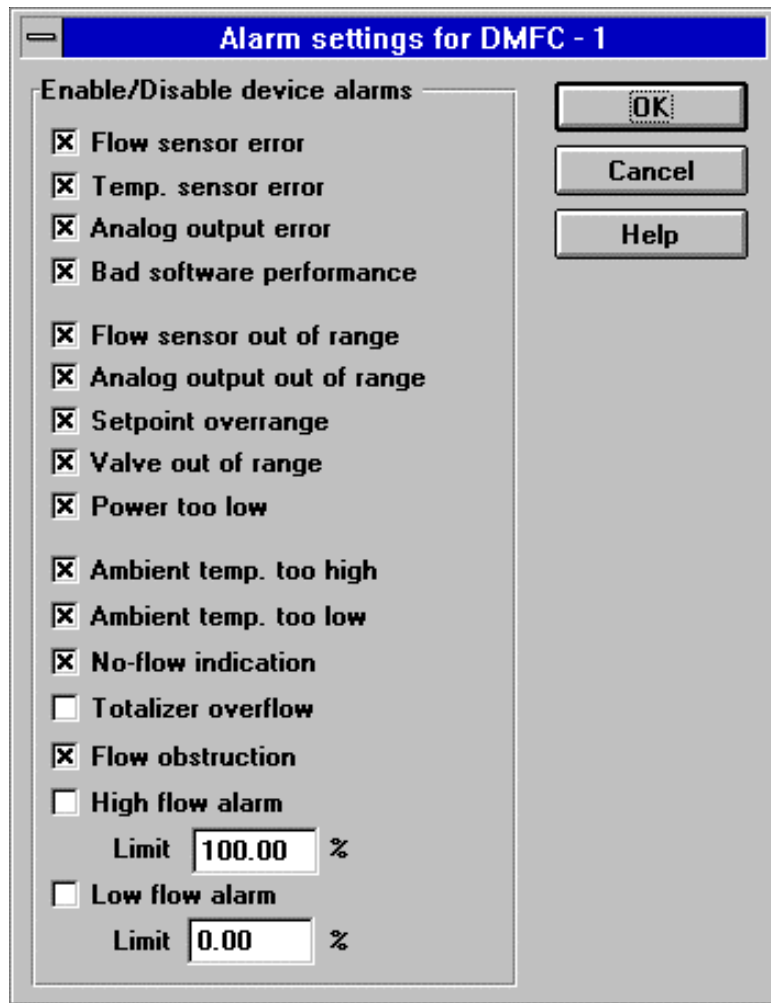
4.12 ALARM SETTINGS

The Digital Mass Flow device is equipped with an alarm handler, which generates alarm messages in case the device detects a fatal or non-fatal problem situation. The device indicates an alarm message via communication (Smart Control shows the message in the status window), via the LED (which is located under the electronics cover of the device) and via the alarm output (available at the D-connector of the device).

With the introduction of the DMFM/C revision E firmware, it is possible to mask non-fatal alarms, i.e. non-fatal alarms messages can be disabled or enabled.

Using the **Device data|Alarm settings** option from the menu, the Alarm settings window pops up the screen, see Figure 3.7.

Figure 3.7: Alarm settings window



The alarm settings window contains several checkboxes which allows you to enable or disable specific non-fatal alarms. When using the high and/or low flow limit alarms, you also need to specify the limits in percentage of full scale flow.

For a detailed description of all device alarms, refer to IOM section 6, System diagnostics and troubleshooting.

NOTE: The 'Totalizer overflow', 'Flow obstruction', 'High flow alarm' and 'Low flow alarm' are not implemented in the DMFM/C 831-A-001 Revision D or lower revision firmware. Refer to Table 3.1, Troubleshooting non-fatal alarms, for a detailed description of these alarms.

Table 4.1: Troubleshooting non-fatal alarms

Indication/Message	Possible cause	Corrective action
<p>“Low flow alarm” or “High flow alarm”</p> <p>(Measured flow outside specified limits).</p>	<p>The DMFC is indicating that the measured flow exceeds the specified limits. These limits can be set, using the Device data Alarm settings option from the menu.</p>	<p>In case high or low flow limit alarms are not desired, turn off these alarms using the Device data Alarm Settings option from the menu.</p>
<p>“Totalizer overflow”</p> <p>(Totalizer counter exceeds maximum value)</p>	<p>The flow totalizer counter exceeds the maximum value and starts again beginning from zero (0).</p>	<p>Use the Device data Actual data window in order to stop the totalizer, reset the flow totalizer counter and start the totalizer at a particular time.</p> <p>In case the totalizer function is not desired, disable the totalizer overflow alarm using the Device data Alarm settings option from the menu.</p>
<p>“Flow obstruction”</p> <p>(unable to create flow)</p>	<p>Occurs only together with “Valve out of range” message.</p> <ol style="list-style-type: none"> 1. Possible obstruction at the gas inlet or -outlet of the device. 2. No gas is applied to the device (“No-flow indication” is also shown). 	<ol style="list-style-type: none"> 1. Check the gas inlet and -outlet for obstructions. 2. Make sure gas is applied to the device with the correct pressure.

Section 5.

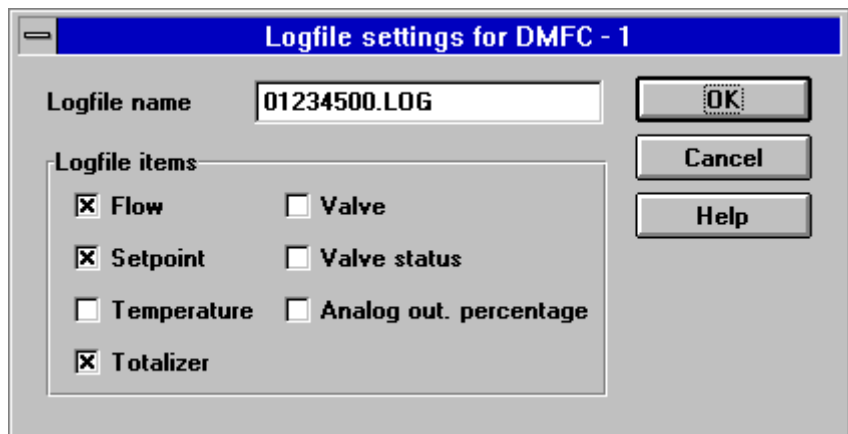
PREFERENCES MENU

5.1 INTRODUCTION

This section describes the selections, which can be made at the *Preferences menu*. These include the selection of the actual parameters to be send to the logfile at every update as well as the selection of the logfile name to use. Also the communication settings, which can be selected are dealt with.

5.2 LOGFILE SETTINGS

When selecting the *Preferences/Logfile menu*, the logfile selection window as shown in figure 5.1 will pop up.



This window allows you to select the logfile name to store the data in. The extension of the logfile will always be set to .LOG, no matter what you type in as an extension. By default the name of the logfile associated with a certain Digital Mass Flow Meter or Controller will be the tagnumber of the device with the extension .LOG. So if the device has, for example, a tagnumber 50123001, the logfile name will be 50123001.LOG. The logfile will be stored in the same directory as the Smart Control program.

The data to be stored can be selected in the same window, by marking the checkboxes before each actual parameter. In figure 5.1 all checkboxes have been marked, which is the default setting, so all parameters shown will be logged to the logfile. In case the addressed device is a meter model, the control related items setpoint, valve override status and valve value will be disabled in the selection box and will therefore not be logged. Figure 5.2 shows an example of a (part of a) logfile contents.

The logfile can be printed, as explained in Section 3.5.2, it also can be imported in other (Windows and non-Windows) applications, e.g. in spreadsheet applications, allowing you to perform data analysis over a long period of time. As an example the next section will show how to import the logfile of figure 5.2 in to Microsoft Excel and how to prepare the data for further analysis.

5.3 IMPORTING LOGFILES INTO MICROSOFT EXCEL

Start Excel and find the path where Smart Control is installed on your computer.

Select the recorded log file (tag number followed by log) to be able to select. the logfile use "select all files" when opening a file. In Excel. Exel will open a "wizard" to guide you by importing the loggeddata. (the textfile will be converted in to seperate colms.)

The data can be now used and Examined via Excel.

Figure 5.2: Parsing data in Microsoft Exel

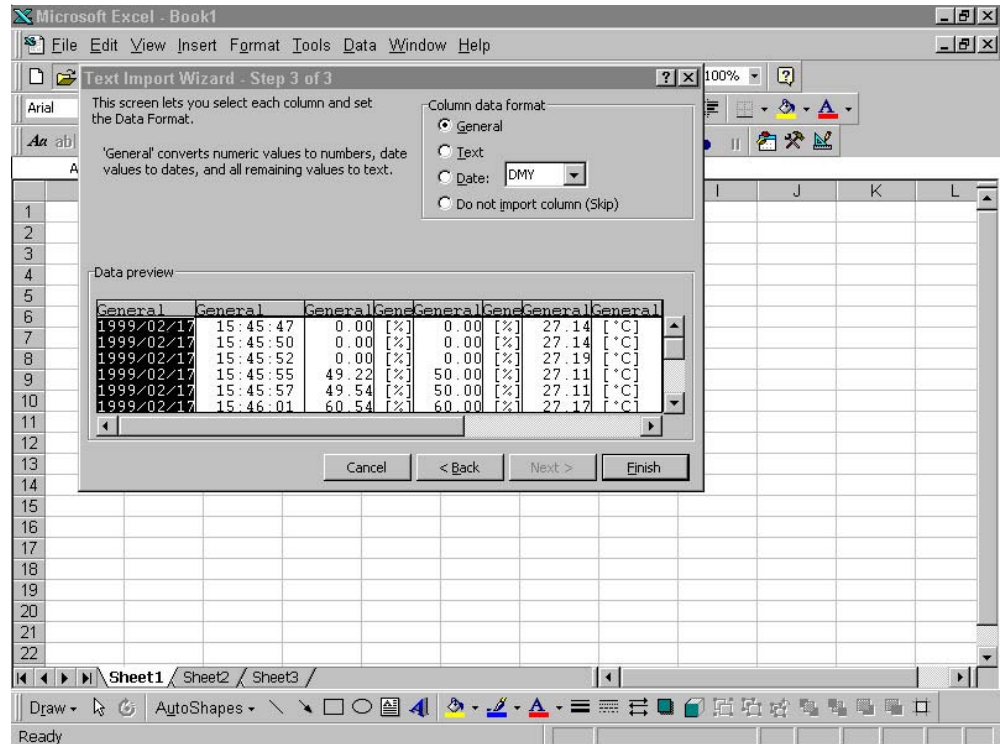


Figure 5.3: Smart Control logfile data prepared for analysis

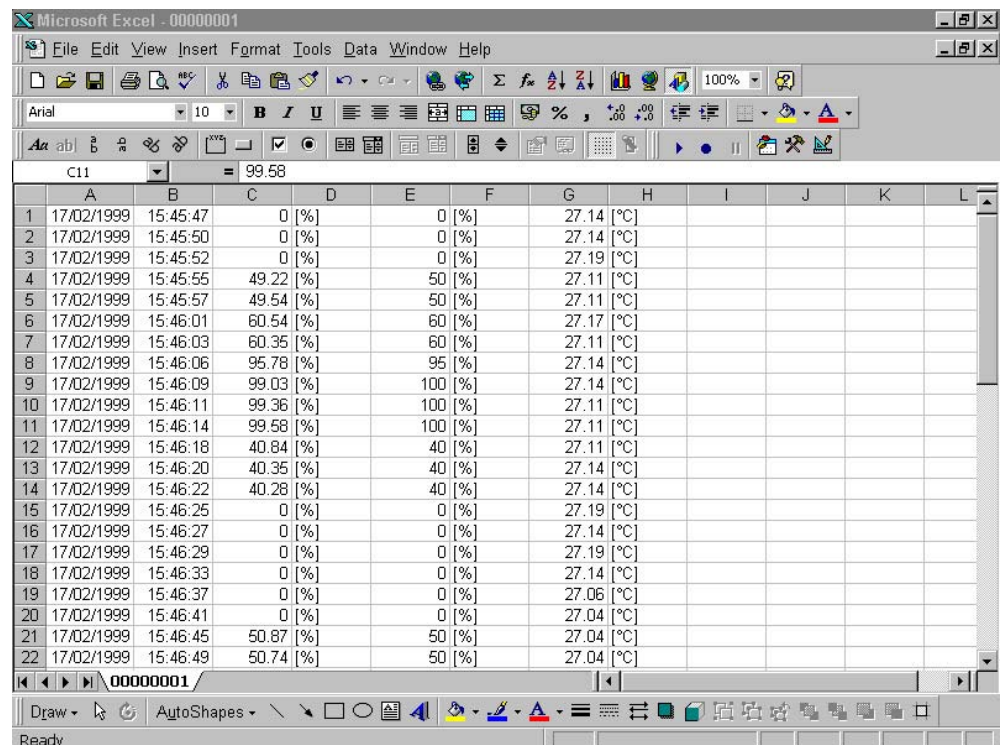
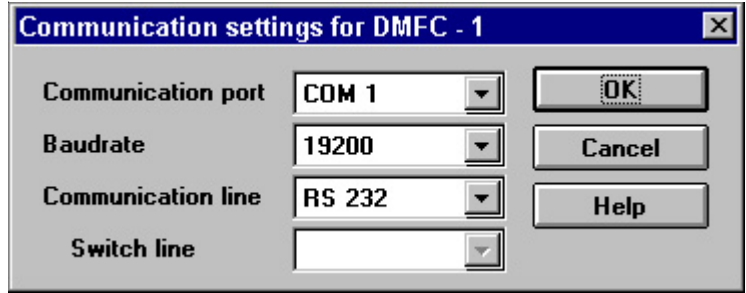


Figure 5.4: Communication settings selection box



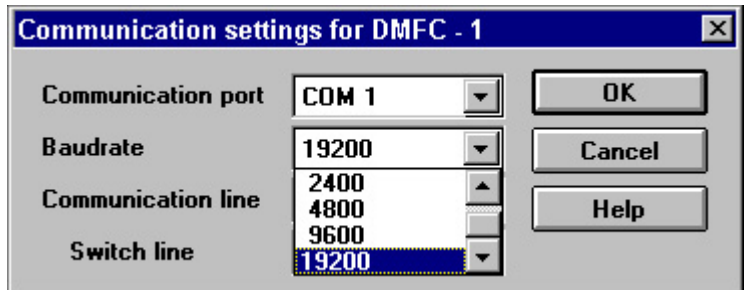
5.4 COMMUNICATION SETTINGS

Selecting the *Preferences/Communications* settings menu brings the communications settings window on the main screen. This window is shown in figure 5.6.

It offers you the possibility to change the communications settings of a selected device. Normally these settings were already determined, when the (new) device was added to the main window, thus establishing communication. There can however be a reason to change this setting, hence this selection window. Changes made to the communications settings however take effect after the selected device has been closed and reopened again.

As an example figure 5.7 shows the selection of another baudrate. The list of available baudrates will pop up when you select the down arrow button behind the baudrate input field. Selecting another baudrate is accomplished by doubleclicking on the desired selection and selecting the "OK" button.

Figure 5.5: Changing the baudrate



Section 6.

System diagnostics and troubleshooting

6.1 INTRODUCTION

The Smart Control software offers the possibility of performing trouble shooting on the devices connected to the computer or, to a certain extent on the gas system itself. Each device connected to the computer continuously performs diagnostics tests on his own electronics and databases in order to certify the device integrity. Also the measurement and/or control of gas and environmental parameters are continuously monitored by each device. An unusual situation leads to the generation of a status code being send to the host computer indicating the availability of further status data. The Smart Control software automatically performs a request for this extra information and displays the message containing status information in the status window.

By suitably interpreting the status messages, generated by the connected devices, you can draw conclusions about the functionality of specific devices or the gas system. In the following sections the possible error situations, which can arise and the status messages, which can appear are explained, together with possible causes and possible solutions.

6.2 ALARM TYPES

In general to each device fatal and non-fatal alarm situations can occur. A fatal alarm is generated when a situation occurs, which makes proper operation of the device either impossible or at least undefined. In the case of a fatal alarm the system will be shutdown to prevent the undefined control or measurement. Almost all actions will be halted, including in some cases communication. Because the occurrence of such a situation would leave you in a state of not knowing what is happening, a small red LED on the main printed circuit board will be flashing at a rate in accordance with the situation that occurred, enabling you to determine the error. The LED is not visible on the outside, so removal of the can is necessary. Also the alarm pin on the connector of a device (pin #3, open-collector output) will be activated, however not at a certain rate.

Non-fatal errors are generated when a situation occurs, which makes operation possible, but the outcome of the measurement may be questionable. Usually these situations are invoked by the environment (absence of gas pressure, temperature too high, etc.) or by non-fatal errors in the hardware (analogue output malfunction), and it may very well be possible the situation disappears by itself, thus removing the alarm. In these cases all measurement and control normally proceeds, the LED as mentioned before will be flashing at a rate of 2 Hz, and the alarm output will be activated.

6.3 STARTUP DIAGNOSTICS

Right after power up, before the databases are activated, a device first performs one complete memory test on both the program memory and the working memory. First the program memory (EPROM) is tested by determining the checksum (the sum of all the bytes in the program memory section) of this memory part, which should be 0000 hexadecimal. In case one location (or more) in the program memory is faulty, it is likely that the sum will not end up to be 0000 exactly. In this case almost all action is halted, including communication, because the

error might be located in the (fairly large) communication program part.

The failure of the test is regarded as fatal and the only action the device will be performing is running a small routine, which makes the LED on the main printed circuit board flash at a rate of approximately 20 Hz and which activates the alarm output pin. This enables you to determine the type of alarm.

If the EPROM test does not result in an error, the volatile working memory (SRAM) is tested by writing and reading two different binary patterns to and from each memory location. The patterns read from a location should always match the written pattern. If a mismatch is detected, the addressed location is a faulty one, an error which is considered to be fatal. All action is halted, including communication. The LED will be flashing at a rate of 10 Hz and the alarm pin is activated.

In case of either an EPROM error or an SRAM error, you should contact Brooks Instrument B.V. in order to service the device.

6.4 RUN TIME DIAGNOSTICS

During normal operation both the non-volatile database and its working copy are tested. An error occurring in these tests will also be considered fatal and will lead to a proper system shutdown. A database error is in fact an undefined situation: the contents has been changed in an irregular way or the electronics are malfunctioning.

The working copy of the database is tested by comparing the checksum of each parameter contents in the database to the checksumbyte stored with the parameter in the same database. Every second one parameter is tested. After successful completion of the test of the working copy of the database, the non-volatile or backup database is tested. This is done by comparing each parameter in the non-volatile database to its working copy. Again every second one parameter is tested, parameters, which have been changed by you and not yet been backed up are excluded from the test. Both errors may occur with malfunctioning electronics.

A third diagnostic test is done after a zero command of the sensor. If the device is not able to establish a zeroing of the sensor bridge (i.e. a residual zero of more then 5% remains), a fatal error will be generated, again leading to a system shutdown. A faulty zero or an undefined zero is a situation that will not disappear by itself and it will influence the dynamic range of the flow sensor negatively so that proper operation is no longer possible. The possible cause may be a malfunctioning of the electronics, this error can also occur when the flat cable from the sensor has become disconnected from its connector. In order to check this one has to remove the can.

If one of these fatal errors occurs, a system shutdown will be performed, i.e. measurement of flow and temperature will continue, control of flow is no longer possible. Communication will commence and the status code indicating the error, will be send to the host, resulting in a status message popping up in the status window. Changing parameters or performing the execution of commands (i.e. zeroing) is no longer possible. If the error is caused by malfunctioning electronics, you should contact Brooks Instrument B.V. in order to service the device.

6.5 RUN TIME MONITORING OF DATA

During run time a number of actual parameters are being monitored. If one or more of these parameters goes beyond its limits a non-fatal alarm is generated, resulting in the LED to flash with 2 Hz, the alarm output being activated and a status code being send to the host

computer. A status message will pop up in the status window on the screen.

An error in the flow sensor, the temperature sensor or the analogue output will result in such an alarm. Sensor errors occur, when the sensor signal to the processor goes below a certain offset value which should be present (i.e. the residual offset of the flow sensor). In case of the analogue output, the alarm situation occurs when the true analogue output value deviates more than 10% (full scale) from its expected value. This way a short circuited or heavily loaded output can be detected. A flow sensor error or a temperature sensor error may also occur when the sensor flat cable has become disconnected from its connector on the printed circuit board. In this case you should remove the can and reconnect the flat cable.

Overrange alarms can originate from the flow sensor or the analogue output, and in case of a controller model also from the analogue setpoint input or the valve. An overrange alarm from the flow sensor is generated when the flow signal goes beyond 110%. It disappears if the flow returns to values below 105%.

An overrange alarm from the analogue output is generated when the analogue output module is not able to generate the output signal, due to the D/A converter range limits. When in case of a controller model the analogue setpoint input is selected as setpoint source and an input signal is supplied to the analogue setpoint input, causing the setpoint to become more than 105%, a setpoint over range alarm is generated. It will disappear if the setpoint returns below 102%.

In order to prevent the so called "controller windup", the pid controller software has been limited to the maximum value of five times the output value at normal full scale flow control. This value is reached when the controller tries to establish a requested flow and does not succeed, for instance because there is no gas applied to the controller. At this point a valve overrange alarm is generated indicating that the maximum control value is reached (although it is in fact a controller overrange). If in this case the measurement of flow indicates a flow of less than 2%, the "no-flow indication" alarm is also set.

If the ambient temperature as measured by the on board temperature sensor indicates a temperature which goes more than 5 degrees Celsius out of the limits set by the maximum absolute temperature ratings (see *Device data|Mechanical Data*) the "Ambient temperature too high" or "Ambient temperature too low" alarm will be generated. Such an alarm will for instance be generated by a device which has a temperature range from 00 to 700C if the ambient temperature is 800C. The temperature limits are taken as the test criterium, so for a device with remote electronics, e.g. for high temperatures the alarm may for instance be generated if the ambient temperature goes beyond 1000C. The alarm situation will disappear if the temperature becomes within the absolute maximum temperature ratings.

Finally the analogue power as used by the on board electronics is monitored. The analogue electronics use 12 Volt for power, whereas the digital electronics use 5 Volt to operate. If the power goes below 12 Volt the analogue electronics may not operate properly and an alarm is generated. It will disappear if the power becomes 12 Volt or more again. This alarm situation can have an external cause (i.e. the power supply is too low) or an internal cause (i.e. a short circuit on the printed circuit board).

In the following section the alarm messages are summarized as well as the possible causes and the action you should take. It also shows how to put the alarm detection capability to use for system troubleshooting.

6.6 SYSTEM TROUBLESHOOTING

This section summarizes the status messages generated by a device, shows the possible causes and the actions to be taken to remove the message. The summarized information on troubleshooting fatal alarms is shown in table 6.1

In order to speed up the repair of the device it is important that you take good notice of the situation in which the alarm occurred and of the actions you have taken to remove the error.

TABLE 6.1: TROUBLESHOOTING FATAL ALARMS

INDICATION / MESSAGE	POSSIBLE CAUSE	ACTION
LED flashing at 20 Hz/Alarm output activated. No communication.	Checksum mismatch detected in program memory at power up, caused by: 1. Possible faulty electronics	Contact factory! Device needs servicing!
LED flashing at 10 Hz/Alarm output activated. No communication.	Write/Read error in SRAM location detected at power up, caused by: 1. Possible faulty electronics.	Contact factory! Device needs servicing!
LED flashing at 5 Hz/Alarm output activated. Status: "Database corrupt". No flow control.	Checksum mismatch at a parameter in the volatile database, caused by: 1. Possible irregular change of database parameter(s). 2. Possible faulty electronics.	1. Retry a power up (changes made to the data are lost). 2. If the error turns up again within approx. 5 min. after power up: Contact factory! Device needs servicing!
LED flashing at 5 Hz/Alarm output activated. Status: "EEPROM corrupt". No flow control.	Compare mismatch between volatile and non-volatile database, caused by: 1. Possible irregular change of database parameter(s). 2. Possible faulty electronics.	1. Retry a power up (changes made to the data are lost). 2. If the error turns up again within approx. 10 min. after power up: Contact factory! Device needs servicing!
LED flashing at 5 Hz/Alarm output activated. Status: "Sensor zero failed". No flow control.	A proper balancing (zeroing) of the flow sensor could not be established, caused by: 1. Possible faulty electronics. 2. Possible faulty sensor.	1. Remove the can. Make sure the flow sensor is connected to the printed circuit board (see note). 2. Re-apply power and retry a zero command. 3. If the alarm turns up again: Contact factory! Device needs servicing!

NOTE: When checking the sensor flow cable, please note that there are 7 pins on the cable, but 8 pins on the mating connector on the main board. The sensor cable should be connected to pin 1 to 7 (left to right) and leave exactly one pin open on the right of the cable connection.

The summarized information on troubleshooting non-fatal alarms is shown in Table 6.2. With these alarms the LED will be flashing at 2 Hz whereas the alarm output will be activated.

TABLE 6-2: TROUBLESHOOTING NON-FATAL ALARMS

INDICATION / MESSAGE	POSSIBLE CAUSE	ACTION
"Flow sensor error" (Flow sensor signal less than half the residual offset)	1. Possible disconnected or faulty sensor. 2. Possible faulty electronics.	1. Remove the can and make sure the flow sensor is connected to the printed circuit board.
"Temperature sensor error" (Temperature sensor signal below certain offset value)	1. Possible disconnected or faulty sensor. 2. Possible faulty electronics.	2. If the alarm turns up again: Contact factory! Device needs servicing!
"Analogue output error" (True analogue output voltage deviates more than 10% from expected value)	1. Power too low ("Power too low" message also shown). 2. Incorrect output load (short circuit?) 3. Possible faulty electronics.	1. Remove the can and make sure the flow sensor is connected to the printed circuit board. 2. If the alarm turns up again: Contact factory! Device needs servicing! 1. Make sure the applied power is at least 15 Volts. 2. Make sure the output is correctly connected. 3. If the error still remains: Contact factory! Device needs servicing!

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TABLE 6-2: TROUBLESHOOTING NON-FATAL ALARMS (CONTINUED)

INDICATION / MESSAGE	POSSIBLE CAUSE	ACTION
"Setpoint overrange" (Analogue Setpoint > 100%)	<ol style="list-style-type: none"> 1. Selected setpoint source is either 0-5 Volt or 1-5 Volt, but analogue signal is more than 5 Volt. 2. Selected setpoint source is either 0-20mA or 4-20mA, but current jumper J1 is disconnected or missing. 	<ol style="list-style-type: none"> 1. Make sure that the (voltage) signal stays below 5 Volt, or 2. If setpoint source is 0-20mA or 4-20mA, make sure the current jumper is present (J1 on the mainboard, refer to fig 2.1, section 2).
"Flow sensor out of range" (Flow sensor signal > 110%)	<ol style="list-style-type: none"> 1. Flow is too high. 2. Possible clogging restrictor. 3. Possible wrongly connected sensor flat cable ("Ambient temperature too high" message also shown). 4. Possible faulty sensor or electronics. 	<ol style="list-style-type: none"> 1. Make sure the flow is within range. 2. Remove the can and check the sensor flat cable. 3. Remove the restrictor. Make sure it is not clogged. 4. If the error still remains: Contact factory! Device needs servicing!
"Analogue output out of range" (Analogue output set value too high for D/A converter)	<ol style="list-style-type: none"> 1. Flow is too high or flow sensor is too high (see "Flow sensor out of range"), the output can not follow. 	<ol style="list-style-type: none"> 1. Make sure the flow is within range.
"Valve out of range" (Valve maximal opened, unable to create flow).	<ol style="list-style-type: none"> 1. No gas is applied to the device ("No-flow indication" is also shown). 2. Not enough gas pressure on the inlet, or the pressure for which the valve was calibrated is not applied. 3. The valve has suffered from mechanical distress. 4. The power applied to the system (and the valve) is not sufficient to control the valve (applies to 5851S model). 5. The orifice may be clogged 	<ol style="list-style-type: none"> 1. Make sure gas is applied to the device with the correct pressure. 2. Make sure the power supplied is sufficient for the valve. Try a "valve override open" command to check if the valve is capable of achieving flow at all. 3. Re-adjust the valve offset and the valve span to enable correct control. 4. Clean the orifice if necessary. 5. If the error still remains: Contact factory! Device needs servicing!
"Ambient temperature too high" "Ambient temperature too low" (Ambient temperature outside its operating limits).	<ol style="list-style-type: none"> 1. Ambient temperature is too high or too low for the specified device. 2. Possible wrongly connected sensor flat cable ("Flow sensor error" or "Flow sensor out of range" message also shown). 3. Possible faulty sensor or electronics. 	<ol style="list-style-type: none"> 1. Make sure the operating temperature is within the operating limits. 2. Remove the can and check the sensor flat cable. 3. If the error still remains: Contact factory! Device needs servicing!
"Power too low" (Analogue power < 12 Volt)	<ol style="list-style-type: none"> 1. The applied power is less than 15 Volt. 2. Possible short circuit on the printed circuit. 	<ol style="list-style-type: none"> 1. Make sure the applied power is sufficient for the device. 2. If the error still remains: Contact factory! Device needs servicing!
"No-flow indication" (Flow sensor output less than 2%, with valve opened)	<ol style="list-style-type: none"> 1. Occurs only together with "Valve out of range" message (see there). Possible absence of gas. 2. The gas sensor may be clogged. 3. No flow can be achieved, due to the valve not opening. 	<ol style="list-style-type: none"> 1. Make sure that gas is applied to the system. 2. Make sure that the applied gas pressure and the valve settings are correct. 3. Clean the sensor if necessary.

Section 7

Appendix A: Unit Conversions

7.1 INTRODUCTION

In this appendix the conversions are shown, which are used by the Brooks Digital Mass Flow Meters and Controllers to convert (mass) flow, density, temperature and pressure. The conversions are performed by the Brooks Digital Mass Flow Meter and Controllers themselves and not by the Smart Control program. The devices store their data internally in engineering units (ltr/min at 273.15 K/1013.33 mbar, kg/ltr at 273.15 K/1013.33 mbar, Kelvin and Bar), together with a code for the unit in which it was presented by the host computer. When sending data in a certain unit to the device, this device first converts it from the value in the presented unit to the value in the internal engineering unit. When reading data from the device, it is converted first from the internally used engineering unit to the user selected unit or the unit it was originally presented in.

7.2 FLOW RATE CONVERSIONS

All flow values, involved in the exchange of data during communication, whether it be volume flow per unit of time at a certain reference condition or mass flow per unit of time, are converted to or from the internal used flow unit of liters per minute at 273.15 Kelvin and 1013.33 mbar. For mass flow units this conversion involves the use of the density value for conversion. The density value must be expressed in kilograms per liter at 273.15 Kelvin and 1013.33 mbar (i.e."normal" conditions). This implies that, depending on the command, a density conversion will have to be done prior to the flow rate conversion. For volume flow units the type of unit and the reference conditions needs to be taken into account, because of the compressible nature of gas. The conversion of the reference condition is performed first. This is however only done if the reference conditions of the unit to be converted and the unit converted to, are not the same. Conversion is done using the Boyle-Gay-Lussac law

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} = \text{constant}$$

where P is pressure, T is temperature and V is volume (per unit of time). The indexes 1 and 2 represent the two different reference conditions. This results in the conversion formula

$$V_2 = \frac{(P_1 T_2)}{(P_2 T_1)} * V_1$$

The reference conditions used in the conversion can be either the conditions of the selected gas as stored in the memory of the device, or the conditions as supplied with the command. In the latter case it may also be possible that the conditions are stored in a unit which differs from the internally used units for temperature and pressure, so that these values have to be converted first.

Where applicable the conversion factors for Tables 7.1 to 7.4 are taken from *The handbook of Chemistry and Physics*, 60th edition, R.C. Weast (Ed.), CRC Press Inc., Cleveland, Ohio.

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TABLE 7-1 FLOW CONVERSION FORMULAS

User flow unit	Conversion to Ltr/min (at 273.15 K/1013.33 mbar)	Conversion from Ltr/min (at 273.15 K/1013.33 mbar)
Milliliter per second	$Y = X*(60/1000)$	$Y = X*(1000/60)$
Milliliter per minute	$Y = X*(1/1000)$	$Y = X*1000$
Milliliter per hour	$Y = X*(1/60000)$	$Y = X*60000$
Liter per second	$Y = X*60$	$Y = X*(1/60)$
Liter per minute	No conversion	No conversion
Liter per hour	$Y = X*(1/60)$	$Y = X*60$
Cubic meter per second	$Y = X*60000$	$Y = X*(1/60000)$
Cubic meter per minute	$Y = X*1000$	$Y = X*(1/1000)$
Cubic meter per hour	$Y = X*(1000/60)$	$Y = X*(60/1000)$
Grams per second	$Y = X*(60/1000)*(1/D)$	$Y = X*D*(1000/60)$
Grams per minute	$Y = X*(1/1000)*(1/D)$	$Y = X*D*1000$
Grams per hour	$Y = X*(1/60000)*(1/D)$	$Y = X*D*60000$
Kilograms per second	$Y = X*60*(1/D)$	$Y = X*D*(1/60)$
Kilograms per minute	$Y = X*(1/D)$	$Y = X*D$
Kilograms per hour	$Y = X*(1/60)*(1/D)$	$Y = X*D*60$
Pounds per second	$Y = X*27.2155422*(1/D)$	$Y = X*D(1/27.2155422)$
Pounds per minute	$Y = X*(1/2.20462262)*(1/D)$	$Y = X*D*2.20462262$
Pounds per hour	$Y = X*(1/132.277357)*(1/D)$	$Y = X*D*132.277357$

X represents the value to be converted, and Y the converted value. D represents the density value of the gas involved, expressed in kilograms per liter at 273.15 K and 1013.33 mbar.

7.3 DENSITY CONVERSIONS

Gas density values stored in the device, are used to calculate the flow rate in mass units per time unit from the internal flow rate expressed in liters per minute at 273.15 Kelvin and 1013.33 mbar. The density values used in the communication to and from the Brooks Digital Mass Flow Meter/Controller models should therefore be given at 273.15 Kelvin and 1013.33 mbar. Internally the densities are expressed as kilograms per liter at 273.15 Kelvin and 1013.33 mbar. As with flow rate the conversion of density values in the request message to the internal unit used, takes place just after receiving the message, whereas conversion to the user defined density unit takes place just prior to transmission of the response message. The conversion formulas for densities are given in Table 7.2.

TABLE 7-2 DENSITY CONVERSION FORMULAS

User densit unit:	Conversion to kg/Ltr:	Conversion from kg/Ltr:
Grams per cubic cm	No conversion	No conversion
Kilograms per cubic meter	$Y = X/1000$	$Y = X*1000$
Pounds per cubic foot	$= X/62.42796203$	$= X*62.42796203$
Kilograms per liter	No conversion	No conversion
Grams per liter	$Y = X/1000$	$Y = X*1000$

X represents the value to be converted, and Y the converted value.

7.4 TEMPERATURE CONVERSIONS

All temperature values are internally expressed in Kelvin. Conversion of temperature values to Kelvin is performed just after receiving the request message, whereas conversion to the user selected temperature unit is performed just prior to transmission of the response message. The conversion formulas are given in Table 7.3 below.

TABLE 7-3 TEMPERATURE CONVERSION FORMULAS

User temperature unit:	Conversion to Kelvin:	Conversion from kelvin:
Degrees Celsius	$Y = X + 273.15$	$Y = X - 273.15$
Degrees Fahrenheit	$Y = (5/9)*(X+459.67)$	$Y = (9/5)*X - 459.67$
kelvin	No conversion	No conversion

X represents the value to be converted, and Y the converted value.

7.5 PRESSURE CONVERSIONS

All pressure values are internally expressed in Bar. Conversion of pressure values to Bar is performed just after receiving the request message, whereas conversion to the user selected pressure unit is performed just prior to transmission of the response message. The conversion formulas as used in the Brooks Digital Mass Flow Meter/ Controller models are given in Table 7.4.

TABLE 7-4 PRESSURE CONVERSION FORMULAS

User pressure unit:	Conversion to Bar:	Conversion from Bar:
Psi	$Y = X*0.068974$	$Y = X/0.068974$
Bar	No conversion	No conversion
Millibar	$Y = X*0.001$	$Y = X/0.001$
Kilograms per square cm	$Y = X*0.9806652$	$Y = X/0.9806652$
Pascal	$Y = X*0.00001$	$Y = X/0.00001$
Kilopascal	$Y = X*100$	$Y = X/100$
Torr	$Y = X*1.33322e3$	$Y = X/1.33322e3$
Atm	$Y = X*1.01325$	$Y = X/1.01325$

X represents the temperature value to be converted, and Y the converted value.

Section 8

Appendix B: List of parameters

This section lists all the parameters of the Brooks digital Mass Flow and Controller models, accessible to the user through Smart Control. Per parameter the name and its options are given (if applicable), as well as its accessibility in terms of Read/Write Password-protected. In case of values, which can be expressed in different units (i.e. flow rate, temperature, pressure), only one value expressed in one of the units is given.

TABLE 8-1 GENERAL PARAMETERS

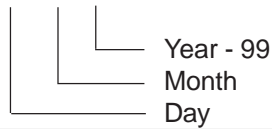
Parameter	Options	Access
Device manufacturer identification code	Brooks Instrument (code 10)	R
Manufacturer device type code	5850S 5851S 5853S 5860S 5861S 5863S 5864S	R
Device identification number	0-16777215	R/W/P
Universal command revision number	0-255	R
Transmitter specific command revision number	0-255	R
Control software revision number	0-255	R
hardware revision number	xxxxx.yyy (binary) xxxxx = 0- 32 hardware rev # yyy = 0 - 7 physical signalling code	R
Brooks order number	12 character string	R
Final assembly number	0 - 16777215	R
Write protect code	write protected not write protected	R/W/P
Tag number	9 character string	R/W/P
Descriptor associated with tag number	16 character string	R/W/P
Date associated with tag number message associated with tag number	dd-mm-yy 	R/W/P
	32 character string	R/W/P

TABLE 8.2: CONFIGURATION PARAMETERS

Parameter	Options	Access																																																															
Temperature unit for maximum temperature range	degrees celsius degrees fahrenheit kelvin	R																																																															
Absolute maximum temperature	max.: 343.15 K or 373.15 K (with remote electronics)	R																																																															
Absolute minimum temperature	min.:273.15 K	R																																																															
Pressure unit for maximum absolute pressure	psi bar millibar pascal kilopascal torr atm kg/cm ²	R																																																															
Absolute maximum pressure	max.:100 bar (a) for controller models 300 bar (a) for meter models	R																																																															
Valve type (controller models only)	Normally-closed Normally-opened Meter only (valve disabled)	R																																																															
Orifice size (controller models only)	<table border="1"> <thead> <tr> <th>5850S:</th> <th>5851S:</th> <th>5853S:</th> </tr> </thead> <tbody> <tr><td>0.0013 inch</td><td>0.0040 inch</td><td>0.0200 inch</td></tr> <tr><td>0.0020 inch</td><td>0.0067 inch</td><td>0.0280 inch</td></tr> <tr><td>0.0030 inch</td><td>0.0091 inch</td><td>0.0320 inch</td></tr> <tr><td>0.0040 inch</td><td>0.0120 inch</td><td>0.0480 inch</td></tr> <tr><td>0.0050 inch</td><td>0.0160 inch</td><td></td></tr> <tr><td>0.0070 inch</td><td>0.0210 inch</td><td></td></tr> <tr><td>0.0100 inch</td><td>0.0260 inch</td><td></td></tr> <tr><td>0.0140 inch</td><td>0.0310 inch</td><td></td></tr> <tr><td>0.0200 inch</td><td>0.0360 inch</td><td></td></tr> <tr><td>0.0280 inch</td><td>0.0410 inch</td><td></td></tr> <tr><td>0.0320 inch</td><td>0.0465 inch</td><td></td></tr> <tr><td>0.0480 inch</td><td>0.0550 inch</td><td></td></tr> <tr><td>0.0520 inch</td><td>0.0635 inch</td><td></td></tr> <tr><td>0.0620 inch</td><td>0.0700 inch</td><td></td></tr> <tr><td>0.0670 inch</td><td>0.0760 inch</td><td></td></tr> <tr><td>0.0780 inch</td><td>0.0820 inch</td><td></td></tr> <tr><td>0.0930 inch</td><td>0.0935 inch</td><td></td></tr> <tr><td>0.1160 inch</td><td>0.1065 inch</td><td></td></tr> <tr><td>0.1200 inch</td><td>0.1200 inch</td><td></td></tr> <tr><td></td><td>0.1405 inch</td><td></td></tr> </tbody> </table>	5850S:	5851S:	5853S:	0.0013 inch	0.0040 inch	0.0200 inch	0.0020 inch	0.0067 inch	0.0280 inch	0.0030 inch	0.0091 inch	0.0320 inch	0.0040 inch	0.0120 inch	0.0480 inch	0.0050 inch	0.0160 inch		0.0070 inch	0.0210 inch		0.0100 inch	0.0260 inch		0.0140 inch	0.0310 inch		0.0200 inch	0.0360 inch		0.0280 inch	0.0410 inch		0.0320 inch	0.0465 inch		0.0480 inch	0.0550 inch		0.0520 inch	0.0635 inch		0.0620 inch	0.0700 inch		0.0670 inch	0.0760 inch		0.0780 inch	0.0820 inch		0.0930 inch	0.0935 inch		0.1160 inch	0.1065 inch		0.1200 inch	0.1200 inch			0.1405 inch		R
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Valve seat material (controller models only)	316 Stainless Steel PTFE (Teflon®) Viton Buna-N Kalrez® EPDM	R																																																															
O-ring material	316 Stainless Steel PTFE (Teflon®) Viton Buna-N Kalrez® EPDM																																																																

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TABLE 8-2 CONFIGURATION PARAMETERS (CONTINUED)

Parameter	Options			Access
Absolute maximum pressure drop (controller models only), expressed in same unit as absolute maximum pressure rating	5850S: 100 bar 45 bar 38 bar 22 bar 16 bar 12 bar 6 bar 5 bar 4 bar 3 bar 2 bar 1.5 bar	5851S: 100 bar 45 bar 35 bar 26 bar 22 bar 18 bar 13 bar 11 bar 10 bar 6 bar 5 bar 4 bar 3 bar 2 bar 1.5 bar	5853S: 20 bar	R

TABLE 8-3 CALIBRATION PARAMETERS

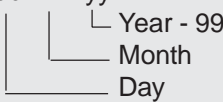
Parameter	Options	Access
Calibrators name	12 character string	R
Last calibration date	dd-mm-yy 	R
Process gas name (for each gas)	12 character string	R
Density unit (for each gas)	gram/cm ³ kilogram/m ³ lb/ft ³ kilogram/ltr gram/ltr	R
Density value (for each gas)	gas dependent value (> 0.0)	R
Flow rate unit (for each gas)	mltr/sec mltr/min mltr/hr ltr/sec ltr/min ltr/hr m ³ /sec m ³ /min m ³ /hr	R
Reference temperature unit (for each gas)	degrees celsius degrees fahrenheit kelvin	R
Reference temperature value (for each gas)	temperature value typically 0°C to 20°C	R
Reference pressure unit (for each gas)	psi bar millibar pascal kilopascal torr atm kg/cm ²	R
Reference pressure value (for each gas)	pressure value typically 1013.33 mbar or 1 atm	R

TABLE 8-3 CONFIGURATION PARAMETERS (CONTINUED)

Parameter	Options	Access
Flow range (for each gas)	5850S/5860S: min. 0.003 ltr/min, max. 30 ltr/min 5851S/5861S: min. 20 ltr/min, max. 100 ltr/min 5853S/5863S: min. 100 ltr/min, max. 1000 ltr/min 5864S: min. 18 m ³ /hr, max. 2160 m ³ /hr	R
Re-range factor for flow range (for each gas)	0.8..1.2	R
Linearization coefficients a ₀ to a ₃ (for each gas)	a ₀ : typically -0.00xxx £ value £ 0.00xxx a ₁ : typically 0.8 £ value £ 5.0 a ₂ and a ₃ : typically -0.5 £ value £ 0.5	R
Process temperature unit (for each gas)	degrees celsius degrees fahrenheit kelvin	R
Process pressure unit (for each gas)	psi bar millibar pascal kilopascal torr atm kg/cm ²	R
Process pressure reference (for each gas)	absolute gauge	R
Process temperature (for each gas)	max.: 343.15 K or 373.15 K (with remote electronics) min.: 273.15 K	R
Process inlet pressure (for each gas)	max.: 100 bar (a) (controller models) 300 bar (a) (meter models) min.: 0.8 bar (a) (meters controllers)	R
Process outlet pressure (for each gas)	depending on max. pressure drop determined by orifice selection for controller models 0 bar (a) for meter models	R
Calibration gas name (for each gas)	12 character string	R
Calibration tool number (for each gas)	12 character string	R
Calibration temperature (for each gas)	max.: 343.15 K or 373.15 K (with remote electronics) min.: 273.15 K	R
Calibration inlet pressure (for each gas)	max.: 100 bar (a) for controller models 300 bar (a) for meter models min.: 0.8 bar (a) for both meters and controllers	R
Calibration outlet pressure (for each gas)	depending on max. pressure drop determined by orifice selection for controller models 0 bar (a) for meter models	R
Calibration gas factor (for each gas)	ratio between molar heat capacity of calibration gas used and molar heat capacity of process gas value depends on the calibration gas used	R

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TABLE 8-3 CONFIGURATION PARAMETERS (CONTINUED)

Parameter	Options	Access
Temperature sensor correction (span and offset values used to calculate temperature in kelvin from temperature sensor signal)	span: 96.0 offset: 250.0 < value < 270.0	R
Sensor bridge residual offset (user changeable through a zero command)	1% < value < 5%	R/W
Sensor bridge calibration temperature (temperature at which zero command was executed, expressed in kelvin)	max.: 343.15 K or 373.15 K (with remote electronics) min.: 273.15 K	R/W
Sensor bridge zero correction factor for	0.0 ≤ value ≤ 0.05 [%/kelvin] temperature	R
Sensor bridge span correction factor for temperature	0.0 ≤ value ≤ 0.04	R

TABLE 8-4 OPERATIONAL PARAMETERS

Parameter	Options	Access
Selected gas (calibration curve to be used)	selection code 1 to 10	R/W/P
Selected flow unit	mltr/sec mltr/min mltr/hr ltr/sec ltr/min ltr/hr m ³ /sec m ³ /min m ³ /hr gram/sec gram/min gram/hr kilogram/sec kilogram/min kilogram/hr lb/sec lb/min lb/hr	R/W/P
Selected flow reference	normal (≡ 273.15 kelvin/1013.33 mbar) calibration (as defined at calibration)	R/W/P
Selected temperature unit	degrees celsius degrees fahrenheit kelvin	R/W/P
Additional damping (of output signals)	0 to 10.0 seconds	R/W/P
Analogue output selection	off 0 to 5 Volt/0 to 20 mA 1 to 5 Volt/4 to 20 mA	R/W/P
Analogue output span	0.8 ≤ value ≤ 1.2	R/W/P
Analogue output offset	-10.0% ≤ value ≤ 10.0%	R/W/P
K sensor (intrinsic sensor pole, value expressed in seconds)	4.0 ≤ value ≤ 6.0	R
N sensor (artificial sensor pole, value expressed in seconds)	0.7 ≤ value ≤ 4.0	R

TABLE 8-4 OPERATIONAL PARAMETERS (CONTINUED)

Parameter	Options	Access
Setpoint source (controller models only)	0 to 5 Volt/0 to 20 mA 1 to 5 Volt/4 to 20 mA communication	R/W/P
Setpoint span (Rangefactor, controller models only, analogue setpoint only)	$0.8 \leq \text{value} \leq 1.2$	R/W/P
Setpoint offset (controller models only, analogue setpoint only)	$-10.0\% \leq \text{value} \leq 10.0\%$	R/W/P
Softstart selection (controller models only)	off traditional (non-adjustable) linear ramp (up only) linear ramp (down only) linear ramp (up and down)	R/W/P
Softstart linear ramp (only valid if linear softstart selected) (controller models only)	$0.5 \leq \text{value} \leq 200$ [%/second]	R/W/P
Proportional control (P) (controller models only)	typically 0.3 to 1.0	R/W/P
Integral control (I) (controller models only)	typically 3.0 to 7.0	R/W/P
Differential control (D) (controller models only)	0.0 in most cases	R/W/P
Valve range (controller models only)	typically: 1000 to 6000 (max. 62500)	R/W/P
Valve offset (controller models only)	typically: 15000 to 25000 (max. 62500)	R/W/P

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TABLE 8-5 ADDITIONAL PARAMETERS

Parameter	Options	Access
Flow totalizer mode	Start totalizer Stop totalizer Reset totalizer	R/W/P
Flow totalizer counter	Depends on the selected flow unit 0 .. 26214300 [%·min] (i.e. the totalizer value exceeds the maximum value after ± 182 days at 100 % continuous flow)	R
Adaptive control mode (Controller models only)	Off Offset only (limited) Offset and span (limited) Offset only (unlimited) Offset and span (unlimited)	R/W/P
Alarm masking	Enable/disable settings for Flow sensor error Temp sensor error Analog output error Bad software performance Flow sensor out of range Analog output out of range Setpoint overrange Valve out of range Power too low Ambient temp. too high Ambient temp. too low No-flow indication Totalizer overflow Flow obstruction High flow alarm Low flow alarm	R/W/P
Low flow alarm limit	0 .. 100 %	R/W/P
High flow alarm limit	0 .. 100 %	R/W/P

IMPORTANT NOTE: The items described in above table are implemented in the DMFC 831-A-001 Rev. E firmware and are not present in previous firmware revisions.

TABLE 8-6 ACTUAL PARAMETERS

Parameter	Options	Access
Additional status (refer to Section 6, System diagnostics and troubleshooting)	5850S,5851S,5853S: EPROM corrupt, RAM corrupt, database corrupt, EEPROM corrupt, sensor zero failed, flow sensor error, temp. sensor error, analogue output error, setpoint overrange, flow out of range, analogue output out of range, valve out of range, temp. too high, temp. too low, power too low, no-flow indication 5860S,5861S,5863S, 5864S: EPROM corrupt, RAM corrupt, database corrupt, EEPROM corrupt, sensor zero failed, flow sensor error, temp. sensor error, analogue output error, flow out of range, analogue output out of range, temp. too high, temp. too low, power too low	R
Valve override (controller models only)	off (normal control) valve override open (purge) valve override close (shut off)	R/W/P
Setpoint in selected units (controller models only)	depends on selected flow rate at calibration	R
Setpoint in % of full scale (controller models only) writable from MassView only if setpoint source is set to communication	$0 \leq \text{value} \leq 100\%$	R/W/P
Actual flow in % of full scale	$0 \leq \text{value} \leq 110\%$	R
Actual flow in selected units	depends on selected flow rate at calibration	R
Actual temperature in selected units	max.: 343.15 K or 373.15 K (with remote electronics) min.: 273.15 K	R
Valve control value (controller models only)	$0 \leq \text{value} \leq 62500$	R
Analogue output in % of full scale	$0 \leq \text{value} \leq 105\%$ (0 to 5 Volt range) $20 \leq \text{value} \leq 105\%$ (1 to 5 Volt range)	R
Analogue output in Volt	$0 \leq \text{value} \leq 5.25$ Volt (0 to 5 Volt range) $1 \leq \text{value} \leq 5.25$ Volt (1 to 5 Volt range)	
Analogue output in mA	$0 \leq \text{value} \leq 21$ mA (0 to 20 mA range) $4 \leq \text{value} \leq 21$ mA (1 to 20 mA range)	R

Section 9

Appendix C: Parameter pintout example

Parameter report DMFC: DMFC - 1

Manufacturer	= Brooks Instr.	Final assembly	= 0
Device type	= 5850 S	Descriptor	= GAS TYPE
Tag num	= 01234500	Date	= 16/2/95
Brooks order num	=	Message	= MESSAGE CONTAINING MORE INFO
Device id num	= 0	Hardware rev.	= 1
Universal rev.	= 5	Software rev.	= 1
Transmitter rev.	= 1	Valve type	= Normally closed valve
Max. temp. range	= 0.000 0C	Orifice size	= 0.00130 inch
Max. temp. range	= 70.000 0C	Valve seat mat.	= Kalrez
Max. pressure	= 100.000 bar	O ring material	= Kalrez
Max. press. drop	= 100.000 bar	Kp	= 0.500
K. Sensor	= 4.000	Ki	= 3.700
N. Sensor	= 0.900	Kd	= 0.000
Bridge zero	= 2.226%	Valve offset	= 20000
Temp. zero corr.	= 0.000	Valve range	= 3000
Temp. span corr.	= 0.003	Temp. sensor span	= 96.036
Temp. sensor offset	= 255.000	Analog output offset	= 0.004%
Analog output enable	= 0.5 volt/0..20 mA	Analog output span	= 1.001
Add. damping	= 0.500 sec	Setpoint source	= Communication input
Selected gas	= 1	Setpoint offset	= -0.330%
Sel. flow unit	= ml/min	Setpoint span	= 1.000
Sel. flow ref.	= Normal	Calibration date	= 11/4/94
Sel. temp. unit	= 0C	Calibration gas	= N2
Softstart	= Disabled	Gas factor	= 1.000
Softstart ramp	= 100.000 %/sec	Ref. temperature	= 0.000 0C
Calibrator	=	Ref. pressure	= 1013.330 mbar
Process gas	= N2	Calibration temp	= 20.000 0C
Density	= 1.251 kg/cubic m.	Cal. inlet press	= 3.000 bar
Flow range	= 1.000 liter/min	Cal. outlet press	= 1.000 bar
Range factor	= 1.000	Calibration tool	= 40001/02
Process temp.	= 20.000 0C	Linerization 2	= 1.32457
Proc. inlet press	= 3.000 bar	Linerization 4	= 0.06764
Pr. outlet press	= 1.000 bar		
Pressure ref.	= Absolute		
Linerization 1	= 0.00035		
Linerization 3	= -0.04357		

Parameter report DMFC: DMFC - 1

Process gas	= He	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.0000C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	= C2H4	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	= CO2	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000

Parameter report DMFC: DMFC - 1

Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000

Parameter report DMFC: DMFC - 1

Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000
Process gas	=	Calibration gas	=
Density	= 1.000 kg/cubic m.	Gas factor	= 1.000
Flow range	= 1.000 liter/min	Ref. temperature	= 273.150 K
Range factor	= 1.000	Ref. pressure	= 1013.330 mbar
Process temp.	= 20.000 0C	Calibration temp	= 20.000 0C
Proc. inlet press	= 100.000 bar	Cal. inlet press	= 100.000 bar
Pr. outlet press	= 0.000 bar	Cal. outlet press	= 0.000 bar
Pressure ref.	= Absolute	Calibration Tool	=
Linearization 1	= 0.00000	Linerization 2	= 1.00000
Linearization 3	= 0.00000	Linerization 4	= 0.00000

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LIMITED WARRANTY

Seller warrants that the Goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service and that the Software will execute the programming instructions provided by Seller until the expiration of the earlier of twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller. Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer.

All replacements or repairs necessitated by inadequate preventive maintenance, or by normal wear and usage, or by fault of Buyer, or by unsuitable power sources or by attack or deterioration under unsuitable environmental conditions, or by abuse, accident, alteration, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense.

Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller.

BROOKS LOCAL AND WORLDWIDE SUPPORT

Brooks Instrument provides sales and service facilities around the world, ensuring quick delivery from local stock, timely repairs and local based sales and service facilities.

Our dedicated flow experts provide consultation and support, assuring successful applications of the Brooks flow measurement and control products.

Calibration facilities are available in local sales and service offices. The primary standard calibration equipment to calibrate our flow products is certified by our local Weights and Measures Authorities and traceable to the relevant international standards.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required.

For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

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Brooks Instrument can provide customer seminars and dedicated training to engineers, end users and maintenance persons. Please contact your nearest sales representative for more details.

HELP DESK

In case you need technical assistance:

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Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.

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Brooks Instrument
 407 West Vine Street
 P.O. Box 903
 Hatfield, PA 19440-0903 USA
 T (215) 362-3700
 F (215) 362-3745
 E-Mail BrooksAm@EmersonProcess.com
www.BrooksInstrument.com

Brooks Instrument
 Neonstraat 3
 6718 WX Ede, Netherlands
 T 31-318-549-300
 F 31-318-549-309
 E-Mail BrooksEu@EmersonProcess.com

Brooks Instrument
 1-4-4 Kitasuna Koto-Ku
 Tokyo, 136-0073 Japan
 T 011-81-3-5633-7100
 F 011-81-3-5633-7101
 E-Mail BrooksAs@EmersonProcess.com

