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Operation instructions

Digitel High Volume Sampler

DH-77

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Applicable since the software release 5x.22

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2 Introduction

This user manual contains complete information on operation, assembly and putting Digitel High Volume Samplers DH-77 under operation.
Please, read carefully safety instructions before putting it under operation.

2.1 Safety instructions

Please, adhere to the following safety instructions, assembly instructions (Chapter 3.3) and maintenance instruction (Chapter 3.5). Failure to adhere to these instructions or improper installation and instrument operation may imperil your safety or result in damage of the instrument and neighbouring equipment.

- The electric connection of the dust particle sampler should be performed according to provisions of DIN VDE 0100 and its applicable special provisions. In particular, the principles shall be obeyed as listed below;
- box earthing ;
- preparation of protective insulated, waterproof power supply;
- equipment of the mains connection with FI switch with I(DN) <= 30 mA.
- In case of lack of expertise, the installation is required to proceed by a professional electrician.
- In order to ensure protection for over-voltage due to atmospheric discharge, follow DIN VDE 0100 part 443. If the field instrument is connected to a remote measurement booth via a communication line, e.g. for status inquiries or for remote control, the communication line shielding and earthing of the line shield has to be abided.
- When roof bushings are used, the steps have to be followed as listed below: set up an electric connection to the air-sampling inlet tube from the roof bushing earthing terminal, in order to lead away possible atmospheric discharges.
- If not, discharges can occur via a windmast, as well as lightning hits into the container power supply overhead lines. For protection, there should be considered a lightning arrester or protective shielding lines according to DIN VDE 0100 section 18 or part 443.
- Before assembly or disassembly the instrument components, the instrument should be permanently isolated from the power supply.
- Prevent penetration of liquids into the instrument.
- Please observe keeping the prescribed power supply voltage value.
- Observe correct fusing (10 A) of the power supply. Before switching the instrument on, make sure all connectors are plugged in a correct manner.
- Except for interventions explicitly provided in the manual, never try to repair the instrument on your own. Otherwise, you are exposed to parts under the mains voltage. All repairs may only be carried out by expert staff.
- Only genuine Digitel pre-separators are allowed to be connected to the connector for pre-separator heating. Upon applying unauthorised pre-separators, burns may occur upon touching a pre-separator due to its overheating.
- Replacement of defective fuses in the instrument can be carried out only by trained experts. Hereby, there should be observed that only fuse types authorised by Digitel may be applied (see chapter 3.4.4.) If so, get in contact directly with Digitel or call a competent local branch-office.
- The instrument should be isolated from the mains and handed over to a service engineer in the following cases:
- if a mains cable or a plug is worn or damaged;
- if the instrument, despite following the stated operation instructions, does not properly work. Use only those controls which are mentioned in the manual, as improper instrument operation may cause damages;
- if the instrument fell down or the case was damaged;
- if the instrument shows conspicuous deviations from normal operation.
- Ensure that the instrument is permanently closed during unattended sampling periods.
- If you need assistance, please, do not hesitate to contact us. We would be pleased to advise you.

2.2 Proper use

- The instrument is designed for industrial use.
- The instrument is built-up in compliance with all applicable state-of-the-art and safety/technical standards. Nevertheless, the use of the instrument can still endanger the instrument itself or other valuable things.
- The instrument meets the EMC requirements (electromagnetic compatibility) directives and harmonised European standards. Any variation of the system may affect EMC behaviour.

It is a first-class equipment. This equipment may induce high-frequency interference in residential area. In this case, the operator might be required to take appropriate measures.

2.3 Target group

- All designing, programming, installing works, initiation, operation and maintenance in relation to the sampling system should only be carried out by trained staff (e.g. electricians, electrical engineers).
- Designing and programming staff should be familiar with safety concepts of automation technology.
- Operators have to be instructed on handling the instrument and have to know the operation instructions.
- The staff in charge of installation, putting under operation and maintenance should have professional background to be authorised intervening in automation systems.

2.4 Abbreviations

cM Correction factor for air flow through the filter (related to a average air pressure and average air temperature in the measurement tube during the sampling period);

cs Correction factor for air flow on the measurement tube related to the set standard conditions (standard air pressure and standard air temperature);

cA Correction factor for air flow on a pre-separator (related to a average air pressure before and after sampling and to a average temperature on the measurement tube - 3 K during he sampling period. Calculation of this correction factor is based on simplified assumptions, whereby smaller deviations from the actual correction factor on the suction head can occur (see chapter 7.4 Flow calibration)).

VM Air volume transported through the filter during the sampling period (related to an average air pressure and to the average air temperature in the measurement tube during the sampling period);

Vs Air volume transported through the filter during the sampling period (related to the set standard conditions);

VA Air volume transported through the pre-separator during the sampling period (related to the average air pressure before and after sampling and to the average air temperature in the measurement tube - 3 K during the sampling period of time. Calculation of this volume is based on a simplified assumption, whereby small deviations from actually transported volume can occur at the air inlet (see chapter 7.4 Flow calibration));
p (uncal) Non-calibrated air pressure measured by the measurement system;
pM Actual air pressure by the measurement system;
paM Average air pressure by the measurement system during the sampling period;
ps Standard air pressure (the air pressure to which the output of values for cs and Vs have to be related);
TM Current air temperature at the measurement system;
TaM Average air temperature at the measurement system during the sampling period;
Ts Standard air temperature (the air temperature to which output of values for cs and Vs have to be related);
pA Current air pressure at the air inlet (operation pressure);
paA Average air pressure at the air inlet during the sampling period (average operating pressure);
p/T Air pressure/temperature;
HVS High volume sampler

3 System description

3.1 System overview

The Digitel High Volume sampler DH-77 is a part of the systems to sample dust and aerosol particles for later assessment and analysis. The sampler operation range in standard execution is 100 to 1000 litres per minute (6 to 60 cubic metres per hour). The system is usually called „High Volume Sampler“.
Various models of samplers are available from different applications. Generally, they differ by the number of processing filter, by the type of logging failure indications and status messages as well as by the type of remote control via various interface protocols.
A survey of available models is shown in the chart of chapter 12.
Airborne-dust parts in the sampled air are separated onto 150 mm diameter filters. The flown filter diameter is 140 mm. Sequent gravimetric and analytical analysis could be conducted depending upon the pollutants of interest. Filter material and structure selection (deep filters, porous filters, glass fibres, silica fibres, pulp, Teflon, porosity....) will depend on the analysis purpose. The filter conditioning is important in order to achieve reproducible results. The DH-77 is a single filter device.
A rotameter controls the selected air flow rate. This value should be calibrated at the beginning of a measurement session first, using a gasmeter or a secondary standard, e.g. an additional rotameter. During air sampling, the pump flow rate is dynamically controlled, so that this value is kept at good reproducibility and at a long-term stability despite the deposited filter flow resistance and the sampled ambient air pressure/temperature variation.
An integrated microprocessor unit controls the filter changes at the exact preset time and collects all relevant data and events. Hereby the air quantity flowing through the filter is defined with high accuracy.
All mechanical components of the changing automatics, as well as the units needed for measurement as sampling probe, pipeline, flow chamber and filter holder, have been improved: they are coated with highly corrosion-resistant and extremely smooth „Ematal“.

2.5 Typographic conventions

Text parts in `Courier New` without a framework show a thermo-printer memory card or serial interface output
Example:

```
Fr 05.09.03        11:02:47
Work
```

Text parts in `Courier New` with a framework show an integrated display output.
Example:

```
Fr 05.09.03 11:02:50

Work    01440  00547
 954 mbar    23,7 °C
```

2.6 Contact consulting

In case of any questions concerning Digitel High Volume sampler DH-77, please, contact the corresponding Digitel representation office or apply directly to one of the Digitel branch-offices. Postal addresses, phone and fax numbers or e-mail addresses are shown on the cover page.

For total suspended particulates (TSP) sampling, there are two differently designed sampling probes available:
- a cylinder probe (EMPA/UBA probe); and
- a probe of „open ring slot“ according to VDI as described in GMBI 1983 regarding non-fractionated dust sampling.

Sampling probes PM10/PM2.5 are designed as single-stage impactors. They are intended for operational/volume flow of 30 cubic metres per hour.
Sampling probes PM1 are designed as double-stage impactors. They are designed for operational volume flow of 22.1 cubic metres per hour.
Various remote-control interfaces are built in for operation in automated measurement networks.
The High Volume sampler DH-77 is described in the VDI directive No. VDI 2463, sheet 11.

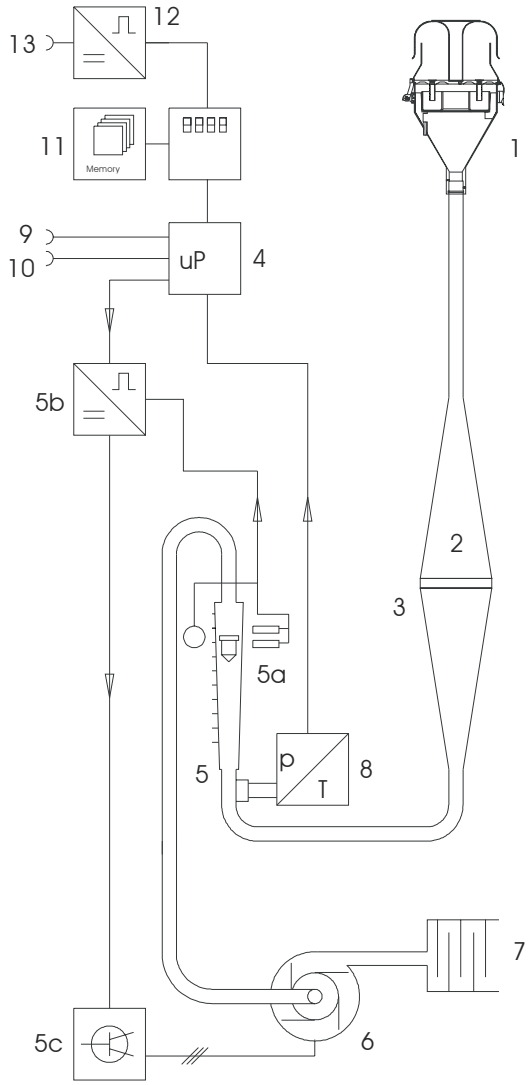
3.1.1 Connections

3.1.1.1 DH-77

In addition to the power-supply connector (3-pole instrument plug according to IEC 320), the standard execution of DH-77 has a connection option for a serial interface (RS-232 C). The connector is placed in the compartment of the filter container at the side. For pin allocation see 9.1 „Pin allocation of D-Sub-9 (terminal interface)“.
Connection to a PC can be made via a commercially available zero-mode cable (crossed cable). For cable lengths and installation requirements, please, adhere to the general specifications RS-232C.

3.2 Operating mode

The below-stated figure No. 1 illustrates the mode of operation.



1 Pre-separator
2 Separator chamber
3 Current filter
3a Filter stock
3b used filter
3c Exchange electronics
4 Microprocessor control
5 Flow meter
5a Flow sensor
5b Flow control
5c Frequency converter
6 Blower
7 Noice damper
8 Pressure & Temperature measurement unit
9 Printer interface
10 RS-232C Interface
11 PC-Card interface
12 Wind data converter
13 Wind data interface

The air is sampled via a sampling probe (1), using a sampling tube, vertically from the top to the bottom through the filter (3) placed in the flowing chamber (2). With DHA-80, the changing of filters is done automatically. After the filter, the transported air quantity is measured using a rotameter with a floater (5). Its double photo-sensor (5a) optically senses the floater position. In connection with the control electronics (5b, 5c), the capacity of the pump (6) is adapted to the rpm control, so that the air quantity keeps the set-point value.
Air pressure and temperature are measured upstream the flow meter and continuously averaged by the controller. A real-time protocol states sampling volumes yielding from the sampling time and controlled volume flow as the core information. The air is released from the instrument with reduced noise through noise baffle (7).

3.3 Assembly

3.3.1 Transport

Generally the instrument should be transported in vertical position.
Digitel DH-77 is provided with two handles (sunk on the cas sides) and two rollers. The instrument can be slipped or pulled by tilting it slightly backwards on a smooth compacted ground (e.g. asphalt, concrete) on the rollers using grips. Unless rolling is possible using the integrated rollers, the instrument can be lifted and carried using both the handles.
Don't lift the instrument using the open instrument door as a handle.

3.3.2 Field installation

Digitel DH-77 is equipped with a protection class IP 54 field case. For this reason it is immediately suitable for direct open-air installation under European standard weather conditions.
To avoid collection of rainwater or ice on the instrument front door upper edge, a water beak should be installed.
In the field, the instrument should be placed in such a way that penetration of surface water in case of heavy rain or snow melting into the instrument from the ground upwards is prevented.
The sampler has to be secured against tilting. In mobile applications, an extension of sufficient stiffness of a one meter long instrument-feet is advisable. For this purpose, e.g. two rectangular tubes can be screwed on the short feet of the instrument.
If stationary operation is planned, the sampler should be installed higher on a concrete base (e.g. width = 600 mm x depth = 300 mm). The door opening should not face the weather side and the sampler feet should be screwed using two angle sections with a base.
If sampling is discontinued for a long term during winter operation, a case heater (optional) should be installed to prevent icing of the automatics.
Digitel aerosol samplers should be connected to the mains of 1 x 230 V/50 Hz (at least 3 x 1.0 mm2, 10 A, 250 V). The maximum input current is 7 A without a probe heater (maximum 160 W) and a case heater (approx. 60 W). The increased input power at running up the blower is avoided by a soft run-up. For the electric connection of the aerosol sampler see 2.1 „Safety instructions".
WARNING
In any case, the instrument should be installed or built in, in such a way that the instrument can be continuously disconnected from the mains easily by pulling out the supply cable at any time. The main switch on the front side does not assure complete instrument electrical isolation!

3.4 Consumables

3.4.1 Filter paper

Round filter of 150 mm diameter
Selection of filter material and filter structure (deep filters, porous filters, glass fibres, quartz fibres, pulp, Teflon, porosity...) depends on the aim of examination.

3.4.2 Thermo-printer paper

Thermo-rolls 57 x 25 x 10 mm

3.4.3 Sealing rings

Sealing rings with a special finish and various sizes are used for sealing at various places in the instrument. If you find that the instrument tightness is not satisfactory any more or the surface of sealing rings shows small cracks or other damages, they should be replaced. You can get individual sealing rings sets from us.

3.4.4 Fuses

WARNING:
Fuse replacement can only be performed by an authorised specialist. Before opening the instrument, it should be isolated from the mains! Further, it is necessary to assure that the fuse types only authorised by Digitel are used. In case of necessity, please, contact Digitel or an appropriate local representation branch-office directly.
In the supply unit, two fuses can be replaced:
Main heating: Schurter type FSD 5 x 20; 1.2 AT, rated voltage 250 V;
Controller supply unit: Schurter type FSD 5 x 20; 100 mAT, rated voltage 250 V;

3.4.5 Mains cable

WARNING:
Use only mains cable supplied by our company or an equivalent mains or extension cable complying with applicable standards. When using the rolled extension cable, make sure that the cable is completely unwound from the cable reel. Otherwise, cable reels without a thermo-fuse have a risk of fire because of too strong heating of the wound-up cable!
Use a Euro-instrument cable with a SCHUKO-plug of at least 3 x 1.0 mm2, 10 A.

3.4.6 Grease for sampling heads (impactors)

As grease you can use for example: BAYSILON paste, high-vacuum grease, medium-viscous (35 g tube) and silicon high-vacuum grease medium, Merck 100 g,
CAS Nb. 107922.

3.5 Maintenance

Digitel aerosol samplers need minimum maintenance. However, depending on the degree of air pollution and climatic load upon the installation site, an inspection of the sampler associated with cleaning is necessary.
In particular, the following activities should be performed:

3.5.1 Cleaning

High-volume samplers must be cleaned on regular basis. Cleaning intervals strongly depend on particulars of installation site and they have to be determined by the operator. They may range from a month up to a year.
During cleaning, the instrument should be off power!
To clean the instrument, a dry cloth should be used. At heavy contamination, the cloth should be wetted with a commercial window cleaning agent. Make sure that the instrument is dried up before putting under operation, again.
Avoid using solving agents and scrubbing cleaning products!
The rotameter glass tube has to be inspected visually. In case of a broken filter or negligent sampler operation without a filter inserted, contamination can also occur. In case of any doubt, the tube has to be removed and cleaned.
Due to its difficult accessibility, the upper part of the funnel-shaped flow chamber located before the filter, can only be cleaned in combination with possible changer unit service works. As this section of air-sample path shows much larger inner diameter, as a rule, it is less affected by deposits.
The air inlet tube interior has to be inspected for wall deposits and in case of doubt, cleaned, using a cloth. As a cleaning liquid, we recommend water and/or spirits.
TSP sampling probes („open ring-slot“ according to VDE or „EMPA/UBA“ - cylindrical probes) have to be checked for dust deposits and cleaned, if possible. Normally, cleaning with the use of a wet cloth is sufficient. Probes PM10, PM2.5 and PM1:
to avoid effects of released separated rough dust particles, the cannon surface of the impactor plate has to be permanently covered with a thin fat layer. It has to be renewed periodically. Thereby the life cycle depends upon the proportion of rough dust in the sampled exterior air. It is recommended to clean the impactor plate after 14 sampling days, by the time the average total dust volume (TSP) on the installation side is approx. 70 to 80 μg/m3. With lower TSP, the cleaning interval can be longer. You can extend the cleaning interval results by rotation of the moveable impactor plate resting on the heating holder by about 15° (approx. 2 cm). Acceleration nozzles then point at the „clean“ areas between rough dust deposit settled in a circular form of the previous sampling operation.
The impactor plate can be removed simply after opening the probe upper part. It has to be cleaned with a clean cloth and its cannon surface has to be greased. A 5 cm long band of grease should be equally spread on the area, using a spatula. To relieve this maintenance in the field, the impactor plate can be replaced by another plate prepared in the laboratory.
Acceleration nozzles, probe casing liners, as well as liners behind the impactor plate with the above-mentioned TSP condition have to be cleaned after 30 flowing days.
In case of longer sampling in foggy environment it is recommendable to inspect the impactor plate for water condensate.

3.5.2 Exchange of sealing rings

The transition areas between the above-stated air probe path separate sections are equipped with sealing rings.
Special attention has to be paid to the sealing ring of 43 x 3 mm at the sampler air inlet muffle, as well as to the glass measurement tube sealing rings (50.4 x 3.53 mm). These sealing rings have to be checked and replaced after 2 to 3 years of operation.
The sealing ring of 150 x 3 mm at the bottom flange of the flowing chamber upper part should be inspected (by a DIGITEL service engineer) and replaced after 2 to 3 years of operation.
Sealing rings (150 x 3 mm) at the filter holder bottom part have to be equipped with an anti-friction layer. They have to be regularly checked when a new filter is inserted and rubbed, using a dry cloth. If this layer is worn out or in case of increasing sticking tendency, it should be renewed. We recommend to replace these sealing rings annually.

3.5.3 Tightness test. Checking of volume-flow calibration

Blower charge and the required convertor frequency indicated for a particular flow rate and filter type have to be noted at the beginning of instrument operation. Sudden insufficient blower capacity under the same conditions, is caused by leakage in the air-sample path (after the filter).
Another very simple option for testing the sampler tightness consists in closing the sampler at the air inlet muffle with air inlet tube removed resp. by inserting an air-impenetrable cardboard instead of the filter paper to the filter holder and switching the blower on. In both cases,

rotameter floater must not be lifted from its resting position at the bottom of the measurement tube. Hereby the blower must be run up to its maximum capacity in order to reach the overload condition.
Checking of the volume flow simultaneously represents a check of tightness. These procedures have to be taken about every two months.
The second rotameter of the same type as in the sampler itself, used to check the volume flow in the sampler itself and has to be installed onto the sampler sampling probe/tube as „transfer standard“. With a new round filter paper inserted, the positions of floaters are compared by switching the blower on. With deviations of the set point originally calibrated on the rotameter of the sampler, the checking of tightness should be performed.

3.5.4 Dusty round filter homogeneous deposit

Upon removing dusty filter papers or during weighing, the filters have to be subject to visual inspection for homogeneous deposits. Drop-like spots in the filter centre, as a rule, indicate inoperable probe heating, or/and a defective air inlet muffle sealing ring. Bright spots on the filter paper rim are attributable to defective sealing of the flowing chamber upper part with the filter holder upper surface (service works are definitely required!).

3.5.5 Blower

The applied blower has the average MTBF (average time between failures) of 36 000 hours. It is maintenance-free. However, for instruments under operation for longer than two years, an occasional acoustic inspection of the blower by an open room blower is recommended to prevent a possible blower locking.
Special attention has to be paid to excessive, unusual noises generated by the blower (scrubbing, screeching).

4 Controls

Controls are ordered in a sequence according to their functional relevance on the front panel.

4.1 Front panel

Display and operations:
- LED status indication of:
  End of program
  Last filter in service
  Changer in operation
  Changer jammed
  Changer switched off
  Remote control
  Blower running
  Blower overloaded
  Blower switched off
  Feeder
  Power on
  Heating
- Push-buttons or switches:
  Start
  Manual change
  Changer off
  Blower off
- Display and keypad:
  Matrix pad (16 keys)
  Four-line alpha-numeric LCD display (20 characters per line; background light)
- Blower current load rate. Analog display.
- Operation-hours counter

Programming:
- using LCD display and keypad

4.1.1 Microporcessor control

This module, „µP-Steuerung“, is dedicated to the HVS programming such as outputs or display status messages.

4.1.1.1 Display

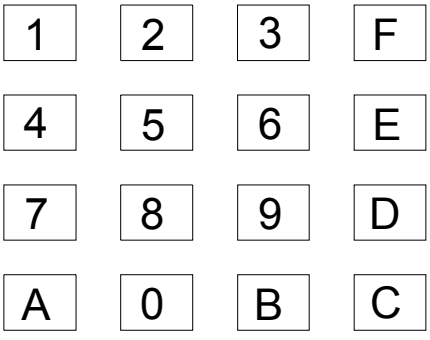
At the normal operating screen, a four-line display shows the instrument current status and possible existing failure indication messages.
Further, in association with the keypad, programming of HVS can be performed.

```
Mo 27.03.98 10:32:17
R:001     753,395Sm3
Pause  01440   00547
 954 mbar    23,7 °C
```

Both numbers in the third line are of the following meaning:
the left number: a pre-set status time in minutes for the current status
the right number: the time already worked off in minutes for the current status.
Ensure that, in the pause status, the right number (the already worked-off time) can be higher than the pre-set status time (the left number). In this case the program is completed (and now there can't be exchanged any filter) or the changer is blocked. Using this indication, the failure time can be traced back by reverse calculation. If there is no failure indication information and the programming allows so, the fourth line indicates the current air pressure and current air temperature in the measurement system. Please note, that especially with the blower switched on, this value differs from the ambient air pressure and temperature.
The fourth line indicates an additional failure indication and status information, the different display data are shown alternatively within seconds.

4.1.1.2 Keypad

The keypad consists of 16 keys. Keys layout is shown in the next figure:



The keys have the following functions:
1 Figure value „1“
2 Figure value „2“
3 Figure value „3“
4 Figure value „4“

5 Figure value „5“
6 Figure value „6“
7 Figure value „7“
8 Figure value „8“
9 Figure value „9“
0 Figure value „0“, switching function at options „on“/“off“
A Cursor control to the left (corresponds to the arrow key left on the PC keyboard)
B Cursor control to the right (corresponds to the arrow key right on the PC keyboard)
C Enter (corresponds to the Enter key on the PC keyboard)
D Return (corresponds to the Esc key on the PC keyboard)
E Manually (currently not applied)
F Menu (displays the main menu)

5 Function description

5.1 Status messages

Please read the following text for description of which status messages may appear during HVS control and how are they displayed and logged. The logging (showed below) corresponds to the logging made by an optionally connectable printer. If no special protocol is programmed for the RS-232 C interface, in addition to that, the log data will be put out parallel in the same format on the RS-232 C interface.
The type of logging at various special protocols can be found in the annex.

5.1.1 Remote control

If the remote control (analogue remote control via remote control connector or remote control via serial interface) is activated, it is logged as follows:

```
Fr 05.09.03         11:05:28
extern
```

The display shows the status message consisting of four lines.
Example:

```
Fr 05.09.03  11:05:30
R:001
Work    01440   00547
Extern
```

The status message is deleted as soon as the remote control is deactivated.

5.2 Failure indication messages

The following is a description how the HVS control failures may occur and how they are displayed and logged. The messages provided in the following protocols correspond to those of the optionally connectable printer. If there is no special protocol programmed for the RS-232 C interface, in addition to that, the log data will be put out parallel in the same format on the RS-232 C interface.
You can find the type of logging in various special protocols in the annex.

5.2.1 AC Power supply failure

After a power breakdown, the start and the end of the power supply is displayed as follows:

```
Power cut from :
Fr 05.09.03         10:56:23
until :
Fr 05.09.03         11:02:45
```

The special keys A to F detailed functions are explained in the chapter of the programming of HVS.

4.1.2 Power supply

In „power supply“ panel, the power connections and a power-supply unit are monitored.

4.1.2.1 Main switch

Input switch for 230 V power supply

4.1.2.2 Status display „Power on“

The status display is lit as soon as the main switch is placed in the position „on“ (or „1“) and no failure is shown in the power-supply unit.

If invalid characters (special characters) occur in date or in time, or the date or the time indicate an invalid value, it suggests that the back-up battery is empty. At a power supply breakdown, the clock module cannot preserve its data! In this case, the back-up battery should be recharged (switch HVS on for several hours) or check the battery and the control unit for damages.
After the display of the time of breakdown, the actual status of control will be displayed (working, pause...):

```
Fr 05.09.03         11:02:47
Work
```

After starting up the control, the basic menu is displayed on the display:

```
Fr 05.09.03 11:02:50
R:001
Work   01440   00547
 954 mbar    23,7 °C
```

5.2.2 Overloading

If a blower overload status is detected, the blower is automatically switched off and the overload message is displayed:

```
Fr 05.09.03         11:04:12
Overload
```

If the program setting also allows an indication of blower capacity, switching off the blower is also shown on the display:

```
Fr 05.09.03         11:04:15
Blower off
```

In this status, upon the first occurrence of overloading, the control remains for several seconds. Upon next occurrence of the same filter overloading, the status „Blower off“ remains for approx. 15 minutes. Then the blower is switched on again.

```
Fr 05.09.03         11:05:28
Blower on
```

There are three successive attempts to insert the filter during the pre-selected working period. After the third occurrence of overloading, the blower will be turned off for 2 hours. Afterwards the blower starts again and a new occurrence of overloading will be handled in the same manner as described above.
The display shows a failure indication message consisting of four lines.

Example:

```
Fr 05.09.03 11:04:50

Work  01440    00547
Overload
```

The failure indication message is cancelled, if a new filter is inserted, the program is restarted or a power breakdown occurs.

5.3 Status change

Status changing at the HVS control occurs, if the timer achieves the pre-set value. The logging (showed below) corresponds to the logging of the optionally connectable printer. If there is no special protocol programmed for the RS-232 C interface, additionally, the log data will be put out in parallel in the same format on the RS-232 C interface.
You can find the type of logging in various special protocols in the annex.

5.3.1 Arbitrary status ⇒ Start time

The HVS control stays in this operation condition, until the pre-set start time is reached. Hereby, the start time can be determined for the period of sampling time (if e.g. sampling of daily samples has to be started at midnight). The following logging will be displayed:

```
Fr 05.09.03         11:03:13
Wait
```

The starting point is determined at the menu point „Starting date/time“ (see the menu structure).
At first there is asked how often the program “Work-Pause” has to be run through, before the program is finished.

```
running cycles: 001
```

If running cycles = 0 ➔ endless continuous work-pause-work operation (no end of program).
Then the starting point has to be put in:

```
Start date/time
1 YY.MM.DD hh:mm:ss
  03.09.05 11:03:20
2 immediately
```

In the entry menu for the starting time, it can be selected whether the starting time is to be determined or whether program starting is to proceed immediately.
If the menu point is opened, the cursor is on figure „1“ in the second line. By using the key „1“ or using the enter key (key C), you get to the third line where you can determine the starting time now. Starting time input is completed by using the enter key (key C) and the starting time has been transferred, if the cursor is placed in the one-digit position of the second value. Caused to the data transfer, the display switches to the main menu again.
After you pushed key „2“ or moving to the figure „2“ in the fourth line with the cursor using the cursor key B after opening the menu point and afterwards using the enter button (key C), the program is started immediately and the display switches to the main menu.
If the control was previously in the working condition and the blower was switched on, the automatic switching-off of the blower and determined values are logged (only if the programming enables so, too):

```
Fr 05.09.03         11:04:15
Blower off

Part c.time[min]:  1012,46
# Blower on/off :      1
paM        [mbar]:    929
TaM          [°C]:     20,0
cm                :      1,053
cs( 15/1013)      :      0,949
ca( 17/ 996)      :      0,972
Vm           [m3]:    539,268
Vs( 15/1013)[m3]:    492,990
Va( 17/ 996)[m3]:    497,842

Collecttime[min]:  1012,46
# Blower on/off :      1
paM        [mbar]:    929
TaM          [°C]:     20,0
cm                :      1,053
cs( 15/1013)      :      0,949
ca( 17/ 996)      :      0,972
Vm           [m3]:    539,268
Vs( 15/1013)[m3]:    492,990
Va( 17/ 996)[m3]:    497,842
at  512 l/min
--------------------------
```

After reaching the starting time, the program is automatically started up. No filter change is carried out. The program starts the sampling period using the just inserted filter.

5.3.2 Waiting for starting time ⇒ Work:

When the pre-set starting point is achieved, the HVS control switches the program condition on to work, switching the blower on:

```
Fr 05.09.03         12:00:03
Work
```

When the programming allows to return the blower status message, the following is returned within several seconds after blower running up:

```
Fr 05.09.03         12:00:10
Blower on
```

After approx. 1 minute, the current blower capacity is returned (if the program allows it, as well):

```
Fr 05.09.03         12:01:23
Motor load : 65 %
```

If the blower capacity, during operation, is changed by an adjustable value (in percentage), the current blower capacity is returned again

```
Fr 05.09.03         18:04:43
Motor load [%]: 68
```

The blower capacity returning is made via measured values slightly delayed averaging.

In the working condition, the basis display shows related time information:

```
Fr 05.09.03 12:02:50
R:001
Work    01440  00002
 954 mbar    23,7 °C
```

When the pre-set working time is reached, the program will switch condition from work to pause.

5.3.3 Work ⇒ Pause

When the pre-set working time is achieved, the HVS control switches the program condition to the pause and the blower will be switched off:

```
Sa 02.09.98        12:00:00
Pause
```

When the programming activates to display the blower status message and time information, the following log is displayed:

```
Sa 02.09.98        12:00:05
Blower off

Part c.time[min]:   506,06
# Blower on/off :     1
paM       [mbar]:   930
TaM         [°C]:    20,2
cM                :     1,053
cs( 15/1013)      :     0,949
cA( 17/ 996)      :     0,972
VM          [m3]:   269,634
Vs( 15/1013)[m3]:   246,495
VA( 17/ 996)[m3]:   248,921
at  512 l/min
--------------------------
```

```
Sa 02.09.98 12:00:03
R :001    246,495Sm3
Pause   01440  00000
 954 mbar    23,7 °C
```

Now the HVS control is waiting until the set pause time is reached. In connection with programmed running cycles there are different possibilities of the program continuation:

1) Running cycles = 1: programme reach the “end of program” state when pause time is elapsed.
2) Running cycles > 1: continuous work-pause-work operation for the number of running cycles . At every change from “work” to “pause” the filter data for the last working section is logged. (part of the collect-time = collect-time of the last work-cycle, pressure– and temperature averageing for the last work-cycle...) When the number of set running cycles is reached and the program is finished, all filter data are logged (complete collect-time exixting of all work-periods, average pressure- and temperature values of all work-periods, accumulated volume values of all work-periods,...)
3) Running cycles = 0: endless continuous work-pause-work operation. At every change from work to pause the filter data for the last working section are logged. There will be no accumulation of a single work-cycle. Every work-cycle should be regarded as an independent program sequence. It is acted on the assumption that in every pause cycle a manual filter change is effected.

5.3.4 Pause ⇒ Work

When the set pause-period is reached and the program is not completed yet (the programmed running cycles are not reached), the HVS control switches the program condition to work and the blower will be switched on:

```
Sa 02.09.98        12:00:07
Work
```

When the program activates to display the blower status message, the following is displayed within several seconds after blower run-up:

```
Sa 02.09.98        12:00:15
Blower on
```

After approx. 1 minute, the current blower capacity is displayed (this programming allows it as well):

```
Sa 02.09.98        12:01:23
Motor load [%]: 67
```

In the working status, the basis display shows the related time information.

```
Sa 02.09.98 12:02:50
R:002
Work    01440  00002
 954 mbar    23,7 °C
```

6 Programming

The programming is made, using the key pad integrated in the front panel. By switching on the instrument, a self-test is performed automatically. As a confirmation of the correctly performed self-test, the display indicates the main menu without any failure indication messages in the status lines.

```
Mo 27.03.98 10:32:17
R:001
Pause
End of program
```

If the instrument does not behave as described after being switched on, a service engineer has to be informed.

6.1 Operation, using the key pad

The key pad consists of an input unit (16-function keys) and a display (illuminated LCD display consists of 4 lines with 20 characters, each).
Using the key pad allows programming all the instrument functions or current settings could be programmed..
Some key- pad keys have multiple functions.
Six out of 16 keys are special keys with those the following special functions can be called up:

Menu key (F): Using this key, you will get from the main menu to the program menu. The overview of all input fields is shown in the annex.

Return key (D): Using this key, you will interrupt the running input without any change or you will exit the current input level. Using this key (multiple pushing, if necessary), you can leave the programming and return to the main menu.

Enter key (C): Using this key, you confirm the last input.

Cursor keys (A, B): Using these keys, you can move in input options quickly and without any change in the pre-set value.

For example, main menu display will look as follows:

```
Mo 27.03.98 10:32:17
R:001
Pause
End of program
```

If several status messages are displayed, the status messages are changing in seconds stroke.

The figures next to the status display (Work or Pause) indicate the pre-set status time or the time elapsed in this status, expressed in minutes.

6.2 Programming, using key pad and display

In this operation mode, you can set all important instrument operation parameters. To get to the programming mode, you have to be in the main menu and to push the key MENU (F).

```
0 Status
1 Record
2 Start programme
3 Enter parameters
```

With this display, the control is only accepted when the following keys are:

6.3 Status

Depending on the instrument programming, current status information is displayed. Because not all the information are indicated on the display at the same time, new information is shown every five seconds. Using the Return key (D), you can leave the status display at any time. Using the Menu key (F), you can switch to the programming status.
Example (program status = work or pause)
Displaying the current blower setting and flow metering system current pressure and temperature values :

```
Mo 27.03.98 10:32:17
Bl. Load[%]  :  54
TM.[°C]      :  32,6
pM [mbar]    : 978
```

After 5 seconds, the display will automatically switch to the actual sampling time indication and flow-metering system average pressure and temperature values determined during the actual sampling time (actual work periode)..

```
Mo 27.03.98 10:32:27
part c.time:  314,07
partTM [°C]:   30,8
partpM [mb]:  977
```

After 5 seconds, the display will automatically switch to air volume value transported during the actual sampling time (actual work periode).

```
Mo 27.03.98 10:32:32
partVM [m3]: 160,804
partVs [m3]: 153,759
partVA [m3]: 156,274
```

The second line displays transported gas volume at the flowmeter average conditions. The third line displays transported gas volume under standard conditions (e.g. 15°C, 1013 mbar). The fourth line shows transported gas volume on the suction head. However, this value is determined indirectly, while it can be read only as an order of magnitude (see also Chapter 7.5).

After 5 seconds, the display will automatically switch to the indication of the complete sampling time and averageing pressure and temperature values of the flow-metering system determined during the complete sampling time (values for all elapsed work periods).

```
Mo 27.03.98 10:32:27
Collecttime:  314,07
TaM [°C]   :   30,8
paM [mbar] :  977
```

After 5 seconds, the display will automatically switch to the air volume value transported during the complete sampling time (values for all elapsed work periods).

```
Mo 27.03.98 10:32:32
VM [m3]    : 160,804
Vs [m3]    : 153,759
VA [m3]    : 156,274
```

The second line displays transported gas volume at the flowmeter average conditions . The third line displays transported gas volume under standard conditions (e.g. 15°C, 1013 mbar). The fourth line shows transported gas volume on the suction head. However, this value is determined indirectly, while it can be read only as an order of magnitude (see also Chapter 7.5).

After displaying these information, the status display will start again with the first screen.

When the program has started, only the information which is related to all collect-periods of the inserted filter is displayed.

6.4 Record

In this menu, you can see the last status and failure indication messages which are stored in internal memory. Each event has a date/time information and an event description. You can get about 50 condition changes resp. status information. Using key “B” change the shown event to a later one. Using key “A” change the shown event to an older one. In the first line the number of the current event is displayed. If the latest event is being displayed and you use key “B” again, then the oldest event is being displayed. If the oldest event is being displayed and you use key “A” again, then the latest event will be displayed.

```
(01)
Sa 02.09.98 12:00:30
Work
```

You can leave the record menu at any time by using the Return key (D).

Clear record:
By using key “4” the record memory can be cleared during record display.

```
0 clear record
```

After using the key „0“, all event messages are cleared.

```
record cleared
```

You can leave this menu by using the Return key (D).

Valid input range : 0
Availabel input range : 0

6.5 Start programme

In this menu, you can select whether the program is to be started immediately or you wish to enter a particular date and time at which the program is expected to start.
Following programs could be chosen:

1. Running cycle = 0: endless continuous work-pause-work operation. At each change from Work to Pause the filterdata for the last work sequence are logged. There will be no accumulation of a single work-cycle. Every work-cycle should be regarded as an independent program sequence. It is acted on the assumption that in every pause cycle a manual filter change is effected.

2. Running cycle = 1: the inserted filter is charged with the chosen work period and the program is finished after the expiration of the pause period.

3. Running cycles > 1: After the expiration of the chosen pause period the program will be proceeded with work. This continuous work-pause-work operation will be repeated as long as the number of running cycles is defined
At each change from Work to Pause the filterdata for the last work sequence are logged. If the chosen number of running cycles is reached and the program is finished, the complete filter data are logged.

```
running cycles: 001
```

Furthermore you can choose if you want to start the program immediately or if you want to program a certain date and time for starting the program.

```
Start date/time
1 YY.MM.DD hh:mm
  98.03.27 10:32
2 immediately
```

If the cursor points at figure „1“, you get to the sub-menu for setting the start time, by using the key “Enter” or the key „1“.

```
Start date/time
1 YY.MM.DD hh:mm
  98.03.27 10:32
2 immediately
```

Now you can enter the required date and time to start up the program. If you push the key “Enter”, the time is acknowledged and the main menu is displayed.
The printer will give the following messages:

```
Mo 27.03.98  10:30:00
Wait
```

If you have selected „immediately“ the start time in the first selection menu or the pre-selected start time was reached, the following messages are sent to the printer:

```
Mo 27.03.98  10:30:00
Start of program

Mo 27.03.98  10:32:32
Work

Mo 27.03.98  10:32:42
Blower on
```

6.6 Enter parameters

```
Parameter number: 3
 3 date / time
 4 period setting
 5 operation mode
```

Using the key pad with cursor keys, you can scroll through all parameter fields or enter the figures of a required parameter field. If you push a figure key, you can move using cursor keys just within the input area (parameter figures) to correct the data input failure. The scrolling function of cursor keys is then disabled. At the end you will acknowledge the entered parameter figures using the Enter (key C). After that, the display switches to the corresponding parameter input.
If you enter „1“ as the first figure, the entry consists automatically of two digits. Then you can enter the parameter second figure number higher than 8.
Of course, you can exit the current input level at any time by using the Return key (D).
When you have achieved the required parameter figure by using cursor keys (A for lower parameter figures; B for higher parameter figures), you have to confirm the input using the C key. Then the display switches to the corresponding parameter input.
The complete ascending sequence from main menu in the parameter input appears as follows:
Push the F key:

```
0 Status
1 Record
2 Start program
3 Enter parameters
```

Push the „2“ key:

```
Parameternumber: 3
 3 date / time
 4 period setting
 5 operation mode
 6 version
 7 print mode
 8 default
 9 language
```

Input of parameters
The programmed operation parameters are saved in the battery back-up memory.
It means that they are not deleted in case of a power blackout.
Change the parameters only, if you received an overview of impact of respective changes upon the program run. Erroneous input may result in undesirable program runs!
At any time you can correct erroneous input by using cursor keys.
Important:
Change of a parameter from „on“ to „off“ or from „off“ to „on“ is carried out by using the key „0“!

6.6.1 Date/time

You are required to enter the date and time. Entering is accepted, only if you confirm entering by using the C key. Enter a time to be reached in several seconds and wait with entering of the confirmation (C key) until the time entered is reached.

```
Date / time

YY.MM.DD  hh:mm:ss
98.03.27  11:28:45
```

The displayed pre-set value corresponds to the time at which the display was set up. If the date and time are

matching, you can leave the data input by using the RETURN key without changing the saved time.
If the date (year) is lower than 80, the date is construed as a value between 1 January 2000 and 31 December 2079, otherwise it is construed as a value between 1 January 1980 and 31 December 1999!
Valid input range is: from 1.1.00 00:00:00 to 31.12.99 23:59:59
Available input range: from 1.1.00 00:00:00 to 31.12.99 23:59:59

6.6.2 Period setting

You are required to program the periods for two possible program settings. The “Work” period shows the time in minutes of the inserted filter to sample (blower on). The “Pause” time shows the time in minutes of waiting after work, before the filter is exchanged, and the “Work” time has to be re-processed.

```
period setting:

Work:  00000 min.
Pause: 00000 min.
```

Using the Return key, you can leave the data input without changing the saved time. The entered values are construed as minutes.
Valid input range: from 0 to 59 999 minutes

6.6.3 Setting of operation mode

You are required to select one of the configuration menus that can be selected:

```
0 Memory config.
1 Operating config
2 Record config.
```

In „Memory configuration“, you can determine, if the saving of the data set should be performed on the memory card. In the „Operation configuration“, you can determine how the instrument is expected to behave(which measurements are to be performed).
In the „Protocol configuration“, you can determine which communication record should be applied on the serial interface to the controlling computer.
Using the RETURN key, you can leave the input.
Valid input range: from 0 to 2
Warning :
If you have activated the saving of data on the memory cards, you cannot perform any change in the setting of the interface record to a controlling computer, since this interface is used by the memory cards of the writer/reader. That is why this menu point is not displayed in this case, either. The selection of the operation mode is as following:

```
0 Memory config.
1 Operating config
```

6.6.3.1 Memory configuration

If your instrument has integrated memory cards of writer/reader, you can activate the data saving on the memory cards in this menu.

```
PC-Card          off
```

Using the “Return” key, you can leave the data input.
Valid input range: „on“, „off“ (key „0“ acts as a switch)
If you have activated the saving, an additional menu point will appear:

```
PC-Card          on

1 PC-card config.
```

Using key „1“, you will get to the configuration sub-menu.
Using the “Return” key, you can leave the data input.

```
0 Memory card Info
1 Format memory card
2 additional print
```

In this menu, you select among brief information on an inserted memory card, new memory card formatting resp. an additional record transmission (here you can determine whether data saving should be performed on the memory card simultaneously with printing on a printer).
Using the “Return” key, you can leave the data input.
Valid input range: 0, 1, 2

6.6.3.1.1 Memory card info

If you have entered „0“, you obtain the memory card information :

```
Size [kB]:      256
File(s):          2
Memory used [%]:  1
```

„Size“ (Memory size) is shown in kBytes.
„File (s)“ indicates how many data files are on the memory card.
„Memory used“ indicates how much of the available memory space, expressed in percentage, has been already used.
Using the “Return” key you will leave this display.

6.6.3.1.2 Memory card formatting

If you enter „1“, you will move to the menu of memory formatting. To complicate unintentional memory card formatting, you have to confirm your decision to format the card a second time:

```
0 Format memory card
```

When you have entered „0“, the memory card is re-formatted.
Warning:
At formatting the memory card, you will completely lose the information saved on the card! After formatting, depending on the instrument setting, one or two data files are downloaded. Accurate structure of these data files can be found in the annex A.5.
Using the “Return” key, you will leave this display without formatting the memory card.

```
Memory card
is formated

Please wait
```

When you enter „0“, the memory card will be re-formatted. This procedure takes several seconds. After successful formatting, the memory information is displayed:

```
Size [kB]:      256
File(s):          1
Memory used [%]:  1
```

„Size“ (Memory size) is entered in kByte.
„File (s)“ (number of files) indicates how many data files are on the memory card.
„Memory used“ (memory occupation) indicates how much available memory space (in percentage) has been used.
Using the “Return” key you will leave this display.

6.6.3.1.2.1 Establishing additional log

If the logging is activated on the memory card, memory card failure indication messages are transmitted to the printer in addition to that. If you wish an output of sampling time, average pressure and average temperature, as well as correction factors or volume data are to be transmitted to the printer also, you can switch on or off this additional logging (Which particular values are to be logged, depends on the setting. The same values that are saved in the memory card are transmitted.)

```
additional print off
```

By using the Return key, you will leave this display.

6.6.3.2 Operation configuration

If you have entered „1“, the display switches to the sub-menu of „operating config.“.

```
0 glob. systemconfig
1 press./temp. meas.
2 special config
```

6.6.3.2.1 General operation configuration

If you have entered „0“, the display switches to the sub-menu of „glob. systemconfig.“.

```
pwr. fail stop   off
Repeat after 2h  off
F.ind.msg.only   off
Blower capacity  on
Blower cap.>=90% off
# Blower on/off  off
Bl. pwr sense[%]: 02
Printer          on
short messages   off
```

Line No.	Designation
1	Shall the time be held after a power breakdown in the “Work” status? „on”: The status time (“Wait”, “Work” or “Pause”) is held during power breakdown. It suggests that any filter (independent of a power breakdown) is deposited with the set “Work” time. Additionally it implies that any power breakdown shifts the next filter change time point by the period of power breakdown, so that the filter exchange time point cannot be defined any more. „off”: After a power breakdown finishes, a power breakdown period is added to the corresponding status time (“Wait”, “Work” or “Pause”). In this way the set cycle of filter exchange (e.g. filter changes always at midnight) is kept in any case. However in case of power breakdown, the inserted filter is not deposited at complete “Work”.
2	Shall the blower switched-on after 2h after an overloading? „on”: Restart after 2h after an overloading „off”: Wait the remaining Rest-Work Time with the blower switched-off
3	Shall we log the failure indication messages? „on“: Only failure indication messages will be logged (on the printer and interface). The following status are defined as failure indication messages: overloading, changer locked, last filter inserted, program started, program completed. „off“: All status and failure indication messages will be logged. The scope of status messages depends on further settings!
4	Shall we log the blower capacity (on printer, interface, memory card)? „on“: In addition to status messages „Blower on” and „Blower off“, the current blower capacity is logged. See lines 5 and 6, too. „off“: No blower capacity is logged.
5	Shall we log the blower capacity at values >=90 %, only? „on“: Logging of blower capacity is only performed at the values >=90 % (hereby the line 4 should be set on). „off“: Logging of blower capacity is performed independently of its value (hereby the line 4 should be set on).
6	How frequently shall the blower capacity be transmitted? Here the percentage rate can be pre-set at which variation of blower capacity the output is to be transmitted (the line 4 should be set on „on“). If a lower value (e.g. 1 %) is pre-set, there is a risk that the blower capacity will be transmitted too frequently, as any variation of conditions on the filter (e.g. moisture, temperature etc.) should be controlled. Pre-setting of a higher value reduces the frequency of messages concerning the blower capacity.
7	Shall the number „Blower on“ - „Blower off“ be transmitted at the end of the sampling time? „on“: After the “Work” time elapsing, besides others, the cycles number „Blower on“ - „Blower off“ is logged, too. As a rule, this value is only relevant at operations with wind control. „off“: No cycle number output „Blower on“ - „Blower off“.
8	Should logging be performed on the integrated thermo-printer ? „on“: Logging on thermo-printer. Warning: If logging is set on memory cards, only failure indication and status messages are transmitted to the thermo-printer to log data on the memory card. The following messages may occur: no R/W instrument, no memory card, memory card replaced. All other messages are logged only on the memory card. „off“: No logging on thermo-printer.
9	Shall logging be performed on the integrated thermo-printer in a brief form? „on“: Logging in a brief form. „off“: Normal logging.

If the cursor is on the setting for printer output, by using the key „9“ and the key „B“, an additional menu point can be activated:

```
pwr. fail stop   off
Repeat after 2h  off
F.ind.msg.only   off
Blower capacity  on
Blower cap.>=90% off
Bl. pwr sens[%]: 02
# Blower on/off  off
Printer          on
short messages   off
Set minutes     0000
```

As an additional menu point, „Set minutes“ can be selected. The display of the passed time for a particular status (Work or Pause) is set after using the Enter key to the pre-set value!
By using the Return key, you will leave this sub-menu.

6.6.3.2.2 Pressure/temperature correction

If you have entered „1“, the display switches to the sub-menu of pressure/temperature correction:

```
Press./Temp.corr.off
```

When the pressure/temperature correction is activated, further menu points are displayed:

```
Press./Temp.corr.on
corr. meas.      on
corr. stand.     on
corr. amb.       on
vol. meas. [m3]  on
vol. stand.[m3]  on
vol. amb.  [m3]  on
Press./Temp meas on
Temp. std.[°C]:   10
P. std. [mbar]: 1013
Flow through  : 1000
P(uncal)[mbar]: 0950
calibration      off
```

Line No.	Designation
1	Shall pressure and temperature measurement be performed? „on“: current pressure and current temperature of the flow-metering system are measured. Warning: This function can be set only if a corresponding measurement module is installed. „off“: No pressure and temperature measurement. Warning: If pressure/temperature measurement has been switched off, no correction factor or volume value can be calculated.
2	Shall a correction factor be transmitted for a pre-set flow? „on“: After elapsing the “Work” period, the correction factor for pre-set flow or the entire measurement volumes is logged (printer, interface, memory card). See chapter 7.5, too. „off“: No correction factor logging .
3	Shall the correction factor related to standard status be transmitted for pre-set flow? „on“: After elapsing of the “Work” period, the correction factor related to standard status for pre-set flow or total volumes is logged (printer, interface, memory card). See the Chapter 7.5, too. „off“: No standard correction factor logging .
4	Shall the operation correction factor related to the air inlet estimated conditions (the average air pressure value before and after sampling on the air inlet and the average value of flowmeter temperature - 3K) be transmitted for the pre-set flow? „on“: After the “Work” time elapsing, the correction factor related to estimated conditions on the air inlet for the pre-set flow or for total volumes is logged (printer, interface, memory card). See the Chapter 7.5, too. „off“: No operation correction factor logging.
5	Shall the volume measured value be logged? „on“: After the “Work” period elapsing, the volumes actually transported at the measured environmental conditions are logged (printer, interface, memory card). See the chapter 7.5, too. „off“: No volume measured value logging.
6	Shall the value of standard volume be logged? „on“: After the “Work” period, the standard volumes (volumes at the pre-set standard conditions) are logged (printer, interface, memory card), corresponding to the volumes actually transported (at the determined environment conditions). See chapter 7.5, too. „off“: No standard volume values logging .
7	Shall the value of operation volume be logged? „on“: After the “Work” period elapsing, operation volumes (volumes related to estimated conditions on the air onlet (average value of air pressure before and after sampling on the sampling head and average temperature - 3K of flow-meter)) are logged (printer, interface, memory card). See chapter 7.5, too. „off“: No operation volume logging.
8	Shall the average pressure and average temperature be logged during sampling? „on“: After the “Work” period elapsing, average pressure and average temperature during sampling are logged. „off“: No average pressure and average temperature logging .
9	Here the standard temperature can be entered, to which standard correction factor or standard volume calculation is related. By using key „F“, the sign can be switched between „+“ and „-“.
10	Here the standard pressure can be entered, towhich standard correction factor or standard volume calculation is related.
11	Here the flow can be entered, which is set in the flow-metering system. This value is required to calculate the measured volume or the standard volume value.
12	Here the flow measurement can be calibrated. The measured value without correction is displayed. The correction factor is calculated by entering the current environmental pressure considered in all other calculations. Warning: During the input, the blower should be switched off. The displayed value of air pressure (pM) can differ from the pre-set pressure value at +/-4 mbar! If semi-automated flow calibration is performed (see point 13), as well calibration of the pressure sensor is automatically performed.
13	Start the calibration procedure for accurate setting of the required flow value. Refer also to Chapter 6.3.3.2.2.1 Flow calibration.

6.6.3.2.2.1 Flow calibration

When starting up the calibration procedure, setting of an operation volume flow (500 litres per minute - this is the operation volume for which DIGITEL pre-separator is designed) can be carried out, using additional calibrated flowmeter via the menu and semi-automatically. All necessary calculations are performed by control, while calibration is distinctly streamlined.
For an accurate description procedure, see chapter 7.4.4 „Performing calibration“.

6.6.3.2.3 Special settings

When you enter „3“, the display changes into the sub-menu of special settings:

```
0 Instrument Id.
1 change pin code
2 Pin-Code timeout
```

In this menu, you select from among entering „instrument identification“, „change pin code“ or „pin-code Timeout“, i.e. the time elapsing after leaving the program menu until Pin-Code is required upon new attempt to enter the program menu.
By using the Return key, you can leave the data input.
Valid input range: 0, 1, 2.

6.6.3.2.3.1 „Instrument Id.“

When you enter „0“, the display switches to the instrument identification sub-menu.

```
Instrument Id.   off
```

When you log the instrument identification upon every sampling time transmission, you have to activate the instrument identification:
Warning:
The first 3 characters of the instrument identification are transmitted in the Bayern-Hessen protocol in „series no.“ field. If the Bayern-Hessen protocol is applied, the first three characters have to be numerical or blank.
When you set an instrument identification to „on“ by using the key „0“, you have to push the “Enter” key.
When you never have set an instrument identification, „-“ appears in the first place of the third column, while the cursor flashes below the character. Otherwise the last entered instrument identification is displayed and the cursor flashes under the first character.

```
Instrument Id.    on

ABCDEFGHIJKLMNOPQRST
```

Now you can define the instrument identification using at maximum 20 characters.
By using the keys „0“ and „8“, you can select from among all capital letters or figures and three special characters. When you select the required character, you may proceed using cursor keys to the next place. If the identification of your instrument is completely defined, then confirm by using the “Enter” key and the input will be accepted.

6.6.3.2.3.2 „change pin code“

In this menu, you can program an own PIN code. You have to enter your current PIN code first. Then you have to enter the new PIN code twice. The new PIN code is only accepted if it is entered twice and confirmed by using the “Enter” key twice.

```
old Code: ----
new Code: ----
new Code: ----
```

Using the “Return” key, you can leave input without changing the current PIN code.
Valid input range: from 0000 to 9999

6.6.3.2.3.3 PIN code timeout

In this menu, you define the time in seconds in which the input of the PIN code is still activated after leaving the programming menu. If you enter the programming menu within the set period of time, you are not required to enter the PIN code.
If you wish not to set the PIN code requirement before entering the programming menu, you have to program the time to 9999 seconds.
The factory setting of the code is 9999.

```
Pincode Timeout:0030
```

By using Return key, you can exit input without changing time.
Valid input range: 0000 to 9999

6.6.3.3 Protocol configuration

When you enter „2“, the display changes in the sub-menu of protocol configuration:

```
AK-protocol      off
Bayern-H.-prot.  off
```

Now you can select the required protocol format for the host interface:
AK-protocol: special protocol
Bayern-Hessen-P.: Bayer-Hessen protocol (1 200 Baud)
When you select no protocol type (both are „off“), the DIGITEL protocol will be applied (see the annex).

6.6.3.3.1 AK-Protocol

Here you define that the AK protocol will be used for communication with the host system.

6.6.3.3.2 Bayern-Hessen Protocol

When you set the „Bayern-Hessen protocol on“, the display changes to the Bayern-Hessen protocol sub-menu setting:

```
AK-protocol      off
Bayern-H.-prot.  on
Bay-Hes-P. B     off
Service          off
Blower capacity  off
act. collecttime off
Press. meas.     off
Temp. meas.      off
act. pA          off
act. TA          off
act. corr. meas. off
act. corr. std.  off
act. corr. amb.  off
collecttime      off
p avg.           off
Temp. avg.       off
p avg.amb        off
T avg.amb.       off
avg. cM/VM       off
avg. cs/Vs       off
avg. cA/VA       off
repeated print   off
Ident.           310
```

6.6.3.3.2.1 Bayern-Hessen Protocol B

Setting the „Bay-Hes-P. B on“, determines that a Bayern-Hessen protocol special extension is applied (2 400 Baud, varied occupation of operation-status bit, see the annex).

6.6.3.3.2.2 Service

Setting „Service on“, determines that a special input is inquired and that, at any status inquiry, the input status is determined on the host computer.

6.6.3.3.2.3 Output mode

Here you define which values are be shown in the protocol.

```
Blower capacity  off
act. collecttime off
Press. meas.     off
Temp. meas.      off
act. corr. meas. off
act. corr. std.  off
act. corr. amb.  off
Collecttime      off
p avg.           off
Temp avg.        off
p avg. amb.      off
T avg. amb.      off
avg. cM/VM       off
avg. cs/Vs       off
avg. cA/VA       off
```

Blower capacity: act. blower capacity
act. collecttime: elapsed collect time for the actual filter
Press. meas.: actual pressure in measurement system
Temp. meas.: actual temperature in measurement system
act. corr. meas.: actual correction factor for pre-set flow through measurement system related to measured environmental conditions in measurement system.
act. corr. std.: actual correction for pre-set flow through measurement system related to standard conditions.
act. corr. amb.: actual correction factor for pre-set flow through measurement system related to estimated conditions on the air inlet (air pressure average value before and after sampling on the sampling head and flow-meter average temperature - 3K).
collecttime: elapsed collect time of the last completed filter. This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.
p avg.: average pressure conditions in the measurement system of the last completed filter during the sampling periode. This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.
Temp avg.: average temperature conditions in the measurement system of the last completed filter during the sampling periode. This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.
p avg. amb.: average pressure conditions on the air inlet of the last completed filter during the sampling periode (air pressure average value before and after sampling on the sampling head). This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completition of the actual filter.
T avg. amb.: average temperature conditions on the air inlet of the last completed filter during the sampling periode (this is an estimated condition: flow-meter average temperature - 3K). This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.
avg. cM/VM: average correction factor for pre-set flow or volumes actually transported through measurement system of the last completed filter related to measured environmental conditions in measurement system. This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.
avg. cs/Vs: average correction factor for pre-set flow or volumes actually transported through measurement system of the last completed filter related to standard conditions. This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completition of the actual filter.
avg. cA/VA: average correction factor for pre-set flow or volumes actually transported through measurement system of the last completed filter related to estimated conditions on the air inlet (air pressure average value before and after sampling on the sampling head and flow-meter average temperature - 3K). This value will be shown only one time or until „C“ command is received (dependent of the parameter „repeated print“). If no „C“ command is received the value will be shown until completion of the actual filter.

6.6.3.3.2.4 Repeated print

Here you define if some values will be shown in the protocol only one time or until „C“ command is received. If no „C“ command is received the value will be shown until completion of the actual filter.

6.6.3.3.2.5 Identification

Here you set the identification (measurement instrument or measured value identification address). It is supposed that the set identification corresponds to the first measured value to be transmitted. The following measured values are provided with the next higher identification address (see the above-shown chart).
Ensure that the instrument address for HVS is set as „310“. If no identification has been entered, „310“ is similarly accepted for identification of the first measured value.
Valid input range: from 000 to 994

6.6.3.4 Remote control

If you operate the instrument using an external controller and you lose connection to this controller, you have to communicate with the HVS controller, that has to be re-switched into the autonomous operation condition. For that there is applicable menu point which is only visible if the remote control is activated. If you push the key „2“ or „3“ (depending on internal program status), the control switches to autonomous operation mode.

```
0 Memory config.
1 Operating config
2 Protocol config.
3 Rmt Off
```

or

```
0 Memory config.
1 Operating config
2 Rmt Off
```

6.6.4 Software version

The installed software version is displayed.

```
Version: 50.21
```

By using the “Return” key, you leave the display.

6.6.5 Mode printing

The current program settings are printed, such as:

```
Settings
are printed
```

After completion of printing a listing, this display is being left automatically.

6.6.6 „Default“ (factory setting)

All adjustable parameters are reset to the factory settings.

```
0 default
```

After you push the key „0“, all settings are reset.

6.6.7 Language

Here you are able to select a language.

```
0 Deutsch
1 English
```

After having selected a language all displays and loggings (printer, ext. Interface) will be shown in the requested language

7 Operation

7.1 Operation modes

HVS can be operated in two operation modes:

- Autonomous operation:
  The integrated microprocessor control performs fully automated sampling based on the status times set. Logging is performed on the printer, on the PC memory card or on the RS232C interface.
- Remote operation:
  The HVS control is performed via the RS232C interface. Logging is optionally performed on the printer or similarly on the RS232C interface or on the integrated memory card PCMCIA. In this operation mode, time control is carried out by the host computer. The programmed status times are not considered in the HVS.

7.2 Filter preparation

Reliable and reproducible measurement results can only be achieved by using filters that are conditioned carefully before and after sampling.
Filters are pre-weighed and provided with a date. In order to enable a checking during the operation by which a correct assignment of filters is possible, the filters are inserted into the filter holder marked according to respective dates. The spring collar is removed from the filter holder, using pliers, while a Teflon ring is laid on a clean surface by using forceps. New filters are removed from the filter magazine by using forceps and laid into the filter holder. Then the Teflon ring should be laid again (using forceps) on the ring and the spring collar is set, using pliers. Now the filter holder is ready for transport to the sampler. During transporting the filter, no impurities should get onto the filter (therefore refer to standard EN 12341 annex C).
The deposited filter is removed from the filter holder, using forceps, and inserted into a simply folded parchment envelope.
Warning!
It should be noted that a possible labelling of a filter holder is only permitted on its front, using a marker.
Any inscription on the filter holder on the upper or bottom sides, as well as sticking labels (on the filter holder entire surface) might cause problems with filter exchange and is prohibited!
Please mind that no sealing ring (on the filter holder and in the flowing chamber) get in touch with inscriptions. The solvents applied in various markers or pens destroy the applied sealing rings! Moreover, paint residuals may result in bonding the sealing rings!

7.3 Setting of operation conditions

7.3.1 Putting under operation or restarting of the sampling instrument

1. Main switch in the position „On“;
2. To perform setting of required status times (Work, Pause);
3. To perform settings of required general operation parameters (stop time at power breakdown, logging of status and failure indication messages, logging mode);
4. Setting pressure and temperature compensation, selection of values to be logged as well as pressure sensor calibration (required, only if semi-automated calibration of the instrument has been carried out!);
5. If necessary print applied settings;
6. To insert the filter holder into the flowing chamber
7. Possible to program a new start time and to restart the program.

So the sampler is programmed and sampling will start at the start time set

7.3.2 Instrument filter exchange and inspection

At the beginning, the instrument has to be inspected more frequently. It is necessary to make the checks as listed below:

- The display has to indicate the time in minutes elapsed since the beginning of the current filter program up to the current time; Mind: always CET!
- The floater of rotameter has to be in its set-point position.

7.4 Flow calibration

7.4.1 General information

In order to measure and to control volume flow, the rotameter accuracy class 2.5 (tolerance +/-2.5 % from the measurement range value) is used with the Digitel High Volume Sampler as a measurement value sensor.
To increase accuracy of the transported volume flow, it is possible to perform semi-automated calibration using an

external calibrated flow meter as described in the Chapter 7.4.4.
It is explicitly pointed out that no marks (e.g. own calibration marks as marker marks, labels...) may be applied on the flowmeter measurement tube. It might result in erroneous functionality or failures that can be hardly detected during calibration!
Moreover, ensure that the aluminium scale (with data on the flow in litre/min.) fitted on the flowmeter is adjustable! The values readable on that scale can be considered as rough benchmarks only. In order to be able to determine accurate flow values, it is necessary to determine the floater position in the divisions etched on the measurement tube. Accurate flow in liter/min. can be determined from this floater position, using the calibration table (chapter 7.6.1).

7.4.2 Calculation

Ratio of flow values of two gases is indirectly proportional to ratio of square roots of their densities.
- the rotameter principle:

$$(1)\quad \frac{Q2}{Q1} = \sqrt{\frac{\rho 1}{\rho 2}}$$

Q1: known flow value, reference status
Q2: searched flow value in operation status
ρ_1: known density, reference status
ρ_2: density of measured gas in operation status.

Because ρ ~ p/T , the operation volume flow gives Q_{loc} (at the place of installed rotameter) from the volume flow value Qscale read from the glass scale as:

$$(2)\quad Q_{loc} = Q_{Scale} \times \sqrt{(p_{ref} \times T_{loc}) / (T_{ref} \times p_{loc})}$$

Q_{Scale}: volume flow read on scale
p_{ref}: 1 013 mbar (pressure at which the scale was calibrated)
T_{ref}: 15°C or 288 K (temperature at which the scale was calibrated)
p_{loc}: operation pressure on the rotameter
T_{loc}: temperature on the rotameter

or

$$(3)\quad Q_{Scale} = Q_{loc} \times \sqrt{(T_{ref} \times p_{loc}) / (p_{ref} \times T_{loc})}$$

For operation volume flow of 500 l/min under station conditions the following conditions will be on the integrated flowmeter:
$T_{Station\ flowmeter} = T_{Station} + 3K$ (approximate value)
$p_{Station\ flowmeter} = p_{Station} - p_{fall\ at\ filter}$ (will be meassured automatically during calibration)
$p_{Station\ integrated\ flowmeter}$: average air pressure at the installation site minus pressure fall at filter at volume flow of 500 l/min. Which means: the air pressure of measuring system if the air pressure at the pre-separator is the same pressure as at the station.
$T_{Station\ integrated\ flowmeter}$: average temperature at the installation site plus 3K temperature increase at filter at volume flow of 500 l/min. Which means: the temperature of the measuring system if the temperature at the pre-separator is the same temperature as at the station.

from the general gas equation $Q_1 \times \frac{p_1}{T_1} = Q_2 \times \frac{p_2}{T_2}$ it follows:

$$(4)\quad Q_{loc\ buil\ -\ in\ flowmeter\ (Station)} = Q_{Ref} \times \frac{p_{Station}}{T_{Station}} \times \frac{T_{Station} + 3K}{p_{Station} - p_{fall\ at\ filter}} = Q_{Ref} \times \frac{p_{Station} \times T_{Station\ build\ -\ in\ flowmeter}}{T_{Station} \times p_{Station\ build\ -\ in\ flowmeter}}$$

Q_{Ref}: Air inlet volume flow of 500 l/min. under station conditions.
$Q_{loc\ indoor\ Station}$: volume flow in the integrated flowmeter for air inlet volume flow of 500 l/min. under station conditions.
$p_{Station}$: average air pressure at the installation site
$T_{Station}$: average temperature at the installation site

At the station conditions at the integrated flowmeter and from equation (3) and (4) follows:

$$(5)\quad Q_{Scala\ build\ -\ in\ flowmeter} = Q_{Ref} \times \frac{p_{Station}}{T_{Station}} \times \sqrt{\frac{T_{ref} \times T_{Station\ build\ -\ in\ flowmeter}}{p_{ref} \times p_{Station\ build\ -\ in\ flowmeter}}}$$

$Q_{Scala\ integrated\ flowmeter}$: Shown volume flow at integrated flowmeter under station conditions at pre-separator for air inlet volume flow of 500 l/min. This value is automatically taken over by the control software as a set flow.

At these settings the volume flow at the pre-separator is Q_{Ref} (500 l/min) if the station conditions are given. The volume flow for different conditions during calibration follows from equation (2) and (5):

$$(6)\quad Q_{Cal\ build\ -\ in\ flowmeter} = Q_{Scala\ build\ -\ in\ flowmeter} \times \sqrt{\frac{p_{ref} \times T_{build\ -\ in\ flowmeter}}{T_{ref} \times p_{build\ -\ in\ flowmeter}}}$$

$Q_{Cal\ integrated\ flowmeter}$: actual set volume flow (actual conditions) at the integrated flowmeter for volume flow of 500 l/min at the pre-separator under station conditions.
$p_{integrated\ flowmeter}$: actual pressure in the integrated flowmeter during calibration
$T_{integrated\ flowmeter}$: actual temperature in the integrated flowmeter during calibration

or

$$(7)\quad Q_{Cal\ build\ -\ in\ flowmeter} = Q_{Ref} \times \frac{p_{Station}}{T_{Station}} \times \sqrt{\frac{T_{build\ -\ in\ flowmeter} \times T_{Station\ build\ -\ in\ flowmeter}}{p_{build\ -\ in\ flowmeter} \times p_{Station\ build\ -\ in\ flowmeter}}}$$

From the general gas equation and from the equation (7) follows the volume flow on calibrated flowmeter:

$$Q_{Cal\,Ref} = Q_{Ref} \times \frac{p_{Station} \times T_{cal.\,flowmeter}}{T_{Station} \times p_{cal.\,flowmeter}} \times \sqrt{\frac{p_{build\,-\,in\,flowmeter} \times T_{Station\,build\,-\,in\,flowmeter}}{T_{build\,-\,in\,flowmeter} \times p_{Station\,build\,-\,in\,flowmeter}}}$$

(8)

$Q_{Cal\ Ref}$: flow on calibrated flowmeter (under actual conditions), so that reaching the operation volume flow of 500 l/min (at the pre-separator) under station conditions.

$P_{cal.\ flowmeter}$: actual air pressure in the calibrated flowmeter (during calibration is the same pressure at the separator)

$T_{cal.\ flowmeter}$: actual air temperature in the calibrated flowmeter (during calibration is the same temperature at the separator)

From the equation (3) and the equation (8) follows the flow to be set on calibrated flowmeter (under actual conditions), thus reaching the operation volume flow of 500 l/min (at the pre-separator) under station conditions.

(9)

$$Q_{ScaleCalRef} = Q_{Ref} \times \frac{p_{Station}}{T_{Station}} \times \sqrt{\frac{p_{build\,-\,in\,flowmeter} \times T_{Stationbuild\,-\,in\,flowmeter} \times T_{cal.flowmeter} \times T_{ref}}{T_{build\,-\,in\,flowmeter} \times p_{Stationbuild\,-\,in\,flowmeter} \times p_{cal.flowmeter} \times p_{ref}}}$$

$Q_{Scale\ cal\ Ref}$: flow to be set on calibrated flowmeter, so that reaching the operation volume flow of 500 l/min (at the pre-separator) under station conditions.

7.4.3 Error estimates

A frequent question emerges how errors in temperature or pressure measurements or deviation from assumption applied to the determination of the operation volume affect the calculated standard resp. operation volumes. The order of magnitude of these errors is illustrated below using several examples. Further, there are also stated affects of deviations of actual station conditions during the sampling period how the entered station conditions affect upon calibration of the instrument.

7.4.3.1 Accuracy of internal sensors

The pressure measurement in an integrated flowmeter is performed with an accuracy of +/-2 % from an indicated value within the entire temperature range of application.
The temperature measurement in the integrated flowmeter is performed with an accuracy of +/-0.75 % from the indicated value in K within the entire temperature range of application.

7.4.3.2 Flow settings accuracy on calibrated flowmeter

According to the UMEG test report examination in which also the accuracy of the flowmeter flow settings are examined (test of Digitel dust particle samplers DHA 80 with an pre-separator PM10 according to EN 12341; the UMEG report No. 6-08/00), the reproducible setting accuracy represents +/-0.45 %.

7.4.3.3 Flow calculation error due to the sensor error

The following example clarifies the effect of an internal sensor error:

$$Q_N = Q_{Scale} \times \frac{T_N}{p_N} \times \sqrt{(p_{ref} \times p_m)/(T_{ref} \times T_m)}$$

Q_N: average flow on standard conditions
Q_{scale}: the flow set on the flowmeter
p_N: standard pressure (1 013 mbar)
T_N: standard temperature (288 K)
p_{ref}: 1 013 mbar (the pressure at which the scale was calibrated)
T_{ref}: 288 K (the temperature at which the scale was calibrated)
p_m: average pressure on the integrated flowmeter during sampling period
T_m: average temperature on the integrated flowmeter during sampling period

The maximum error of Q_N caused by an error of T_m and p_m measurements is at maximum +/-1.66 % throughout the entire temperature range of application. As a rule, the error is significantly smaller, as the error of pressure measurement at the standard operation temperature range is considerably smaller.
Anyway, to this the uncertainty of flow determination of +/-0.45 % has also to be added.
Example:

Q_{Scale} = 520 l/min, p_m = 960 mbar, T_m = 295 K

from which the standard flow is calculated:

Q_N = 500.17 l/min.

if now the measurement of pm transmitted a value higher by 10 mbar (approximately 1.05 % error), it yields an actual standard flow of Q_N = 497.56 l/min. So the standard flow was entered approx. 0.52 % too high.
The result were similar, if the temperature was erroneous: Let us assume the measured temperature was approx. at 2 K (about 0.67 % higher), then it implies actual standard flow of Q_N = 50l.88 l/min. The standard flow was also entered about 0.34 % lower.

7.4.3.4 Error estimates for calibration

We have based our considerations upon the fact that values required for calibration are given with higher accuracy (current pressure and current temperature on a calibrated flowmeter are better than +/-0.5 %). Assuming that the total error of calibration remains below +/-1 % (+/-0.5 % due to pressure and temperature values and +/-0.45 % due to the accuracy of the setting of the floater in the calibrated flowmeter).
The flow value calculated for controlling depends only upon internal measurement magnitudes of Tm and pm. Herewith, to this value, the above-calculated maximum error of +/-1.66 % applies for this value. Because of the fact that at the moment of calibration the pressure sensor is also automatically calibrated, the error generated by pressure sensor leads in direction of a release limit of the internal analogue/digital convertor. Other considerable error sources (e.g. temperature drift of supply and reference voltages) are not relevant at the present time. Herewith the maximum error is reduced to +/-0.58 %. It should be noted that the uncertainty of flow setting of +/-0.45 % should be added to this value, whereas the maximum total error of automatically calculated flow yields to +/-1.03 %.
The accuracy of pressure and temperature value for station conditions do not result in absolute accuracy of calculated operation and standard volume values! Particularly the average actual operation volumes determined over a year do not correspond to required

operation volumes of 500 litres/min., if the average yearly pressure and temperature values don't correspond to the entered station conditions.
Example:
$P_{Station}$: average air pressure at the installation site
$T_{Station}$: average temperature at the installation site
$Q_{Station}$: average operation volume flow at the installation site (500 l/min.)
$P_{Station}$ = 990 mbar, $T_{station}$ = 282 K,
when calibration was performed under these station conditions and the average temperature over a year is deviated by 1 K upwards, general gas equation

$$Q_1 \times \frac{p_1}{T_1} = Q_2 \times \frac{p_2}{T_2}$$ yields:

$$Q_{Station\ new} = Q_{Station} \times \frac{T_{Station\ new}}{T_{Station}}$$ = 501.77 l/min. It was transported approx. 0.35 % more in yearly average. This deviation of the required flow, however, impairs the pre-separator separation degree only to a small extent.

7.4.4 Performing calibration

7.4.4.1 Preliminary notes

Semi-automatic flow calibration is only possible by using one of calibrated Digitel flowmeters designed for this purpose. If you wish to relate calibration to an other transfer standard, please contact Digitel directly or a local branch-office in order to get suitable calibration instructions. The same applies to a calibration for an operation volume flow different from 500 l/min.
Calibration for the operation volume flow of 500 l/min. at station conditions (estimated average air pressure and average temperature at the installation site during an expected sampling period) is done with regard to Digitel pre-separators (PM10; PM2.5) having their „cut point" of 10 µm or 2.5 µm always at this flow rate. At the same time, the comparison of sampling results of as many stations as possible is made simpler.
All calibrated flowmeters delivered by Digitel have a calibration marking (prevailing a red mark) for 500 l/min. at 15°C and 1 013 mbar.

For the performing of forthcoming calculations, the following parameters have to be entered:
- $p_{outdoor}$: current pressure at calibrated flowmeter
- $T_{outdoor}$: current temperature at calibrated flowmeter
- $p_{Station}$: estimated average air pressure at the installation site during expected sampling period
- $T_{Station}$: estimated average temperature at the installation site during expected sampling period;
- position of the calibration mark on the calibrated flowmeter in mm;
- position of the floater in the calibrated flowmeter before re-calibration;
- position of the floater in the integrated flowmeter after re-calibration.

The following values are automatically determined during calibration:
- p_{indoor}: pressure in the integrated flowmeter during calibration
- T_{indoor}: temperature in the integrated flowmeter during calibration

The values for $p_{Station}$ and $T_{Station}$ can only be estimated. As a rule the average annual values of air pressure and air temperature at the installation site are applied (presumed that the instrument will operate at the installation site for a period of at least one year).These values can only be taken from neighbouring meteorological stations. If no meteorological data are available, it is possible to refer to offices of local weather services. As a rule, required data can be determined with satisfactory accuracy (see also the chapter 7.4.3 Error estimates).

7.4.4.2 Preparation for calibration

1. Prepare a calibrated flowmeter with a matching coupling adapter.
2. Prepare a filter holder with an inserted new filter. The same filter material has to be used as the material used for the subsequent sampling.
3. Note the position of the calibration point on the calibrated flowmeter (as a rule, a red mark). The position reading is performed in mm (printed scale division).
3. Determine the data for $p_{Station}$ and $T_{Station}$ (yearly average values for pressure and temperature at the installation site).
4. Determine the data for P_{outer} and t_{outer} (current pressure and current temperature at the calibrated flowmeter; if the calibrated flowmeter is fitted in the measurement cabinet directly on DHA-80, the inner temperature of the measurement cabinet has to be applied; if the calibrated flowmeter is operated in open air, the current outer temperature has to be determined).
5. Set the switch probe, heating to the lowest degree.
6. If the sampler is just processing a program, follow the instructions shown under point 7. Otherwise skip to point 9.
7. Remove the already deposited filters from the filter magazine below the changer level (just check the sequence of filter holders, if the filters are not numbered).
8. Remove all the filters that are not sampled yet from the filter magazine. (here check the sequence of filter holders as well).
   The filter holders, processed and located presently in the flowing chamber, shall be changed during calibration. Therefore it is not required to remove this filter holder manually from the flowing position!
   Further, all data determined at the beginning of calibration are automatically logged to the currently active filter (printer, memory card, interface). It is not required to finish the program before starting calibration!
9. Now you can perform calibration (see the Chapter 7.4.4.3).

7.4.4.3 Performing of calibration

1. Start calibration in the menu „Program" (key „F") - „Enter parameters" (key „2") - „operation mode" (key „5") - „operating config." (key „1") - „Press./Temp. meas." (key "1") - „calibration" (12 times the key „arrow right" then key „0").
   Starting the calibration, a possible running sampling program is interrupted. The current filter data are logged.
   After data logging exchange for the interrupted sampling cycle, the display indicates a requirement to insert a filter holder with a new filter into the filter-holder magazine:

```
Insert filter
for calibration

0 ... continue
```

   Further on, the calibrated flow meter has to be set (fitting should be preferably carried out between the air inlet on DHA-80 and pre-separator).

3. Check if the filter holder is in the flowing position (see also figure in chapter 3.2). If yes, you can continue with point 5.
4. Before using key „0“, you have to push the filter collection tray upwards, as the filter change is performed immediately after pressing the key. If no filter holder is in the flowing chamber and the filter collection tray at filter changing is not pushed upwards, the filter holder with the filter intended for calibration will not correctly be changed!
5. Check if the switch „Blower off“ is not activated (not in the position „Blower off“) and the switch „Changer off“ is not activated as well. Using key “0“, you can go on.
6. Using key „0“, the empty calibration filter resting in filter magazine will be full automatically exchanged. Now you can remove a changed filter holder from the filter collection tray and re-insert it in the filter magazine after calibration and continue the sampling program. Within several seconds the blower will run up.
   Enter the calibration point position on the calibrated flowmeter (measurement tube has a scale division in mm from 0 to 270 units).

```
calibration point
at calibrated
flowmeter
pos. [mm]       :000
```

8. Please enter the annual average values of the air pressure and air temperature at the installation site.
   Warning: The temperature has to be entered in degrees of Kelvin!

```
average conditions
at station
p [mbar]      : 0000
T[K](0°C=273K):  000
```

9. Enter the current conditions in the calibrated flowmeter.

```
act. conditions at
reference flowmeter
p [mbar]      : 0000
T[K](0°C=273K):  000
```

10. If the floater assumed a stable position in the calibrated flowmeter, read the current floater position from the calibrated flowmeter in mm and enter the determined value:

```
actual uncalibrated
swimmer position at
reference flowmeter:
pos. [mm]      : xxx
```

11. After the entering of the value the instrument operates for approximately 15 seconds; during this period the temperature and pressure in the integrated measurement system are determined:

```
Please wait


                  15
```

12. After an elapsing of 15 seconds, the display indicates the data of scale value to which the floater has to be brought on the calibrated flowmeter (by sliding a photo-diode fork on the integrated flowmeter), so that the instrument is calibrated for the specified station conditions

```
swimmer position at
reference flowmeter:
pos. [mm]      : xxx
0 ... continue
```

13. Having carried out the setting, confirm the process on the control by using key „0“. Now you are required to read and to enter the current floater position in the integrated flowmeter:

```
swimmer position at
internal flowmeter

pos. [mm]      : 000
```

14. After entering this value (serving only for a check), all entered and internally calculated values are logged (printer, memory card, RS232). This log also transmits the percentage variation of the set flow.
    The display indicates either passed calibration confirmation.

```
calibration
successful

0 ... continue
```

    or an failure indication message:

```
calibration not
possible! see
manual
0 ... continue
```

    The failure indication message is transmitted, if the entered floater position of the integrated flowmeter deviates too much from the calculated set point. This happens, when leakage occurred in the instrument. If so, please contact the Digitel company or its local representation office urgently.
15. If you don’t want to start a new sampling program after calibration, please continue with point 19.
16. Now, insert the filter holders for the next sampling program in the filter magazine (as the first filter holder, e.g. such filter holder that flown just before calibration, then in sequence, filter holders in designated sequence). By using key „0“, you will leave the calibration menu and the inserted calibration filter is exchanged.
17. Enter the start time for the next filter that is not fully deposited yet in the menu point „Program“ (key „F“) - „Start programme“ (key „1“) - „Start date / time“ (key „1“) (as a rule, on the next day at 00:00 o'clock).
18. Start the program for the filter that is already half-deposited (previously having been automatically changed) in the menu point „Program“ (key „F“) for „prestart filter“ (key „3“) and push key „0“. This filter will be processed until the start time the next filter is reached! After having evaluated this filter, it should be checked that the sampling time is composed of the pre-calibration time and the time during the filter was processed in the pre-start filter program. Both the values have to be added manually!
    Herewith the instrument is reset into original sampling condition, and the selected program is processed.
19. Unless a new sampling program is to be started after calibration, the calibration filter holder has to be exchanged manually from the flowing position: switch automatic „changer off“ and push the push-button „Manual change“ for a short period of time (1 to 2 seconds). Then switch the automatic „changer off“ on again. Now the filter holder which is present in the flowing chamber, is automatically changed.

7.4.4.4 Logging of calibration

At the end of calibration, the entered and internally calculated data are logged on the printer memory card or serial interface (if available and activated). As an example, we provide here logging on the printer:

```
Di 19.03.02        08:36:43
calibration started

Di 19.03.02        08:37:53
Work

Di 19.03.02        08:38:15
Filter change

Di 19.03.02        08:38:31
Blower on

Di 19.03.02        08:40:43
Calibration for 500 l/min
at av. station conditions
p(act) outdoor [mbar]:  942
T(act) outdoor    [K]:  293
pM (500 l/min) [mbar]:  911
TM (500 l/min)    [K]:  296
p(average)     [mbar]:  930
T(average)        [K]:  283
p(standard)    [mbar]: 1013
T(standard)       [K]:  273
pos. cal. point  [mm]:125,5
Offset cal. point[mm]:- 3,9
cal. pos(Station)[mm]:120,6
pos. swimmer     [mm]:125,0
pos. int.(Input) [mm]:123,5
pos. int.(target)[mm]:127,8
Offset int. skale[mm]: -4,3
Offset filter    [mm]: -3,3
Q scale outd. [l/min]:  483
Q amb. act.   [l/min]:  505
Q scale indoor[l/min]:  494
Q standard    [l/min]:  443
Change            [%]:  3,6
calibration successsful

Di 19.03.02        08:43:17
Blower off

Di 19.03.02        08:43:17
end of calibration
```

Meaning of abbreviations:

`p(act) outdoor [mbar]`: Current pressure on the calibrated flowmeter

`T(act) outdoor [K]`: Current temperature on the calibrated flowmeter

`pM (500 l/min) [mbar]`: Current pressure on the integrated flowmeter

`TM (500 l/min) [K]`: Current temperature on the integrated flowmeter

`p(average) [mbar]`: Average yearly pressure at the installation site (station condition)

`T(average) [K]`: Average yearly temperature at the installation site (station condition)

`p(standard) [mbar]`: Standard air pressure

`T(standard) [K]`: Standard air temperature

`pos. Cal. Point [mm]`: calibration point position on calibrated flowmeter

`Offset cal. Point [mm]`: Difference between calibration point position and calibration table 500 l/min position

`Pos. Swimmer [mm]`: Floater position on calibrated flowmeter before calibration

`cal. pos(Station) [mm]`: Position of the floater calibrated for average station conditions on the installation site in calibrated flowmeter

`pos. int.(Input) [mm]`: Floater calibrated position in the integrated flowmeter

`pos. int.(target) [mm]`: Floater set-point position after calibration in the integrated flowmeter

`Offset int. scale[mm]`: Difference between integrated flowmeter scale and calibration table (at Q amb. act.)

Pos. int. (target) [mm] = Pos.int.(Input) [mm] – Offset int. skale [mm]

`Offset filter [mm]`: Difference between calibrated flowmeter and integrated flowmeter on the basis of the filter resistance (depends on lower pressure in integrated flowmeter). Pos. int. (target) [mm] = cal. pos.(Station) [mm] – Offset cal. point [mm] – Offset filter [mm]

`Q scale outd. [l/min]`: Flow rate on the calibrated flowmeter after calibration related to station conditions

`Q amb. act. [l/min]`: Current flow rate on the calibrated flowmeter after calibration at current conditions

`Q scale indoor [l/min]`: Set flow rate on the integrated flowmeter after calibration (this value should also automatically be taken over as an operation flow rate into control)

`Q standard [l/min]`: Flow rate after calibration related to standard conditions

`change [%]`: ((Actual value – Target value) / Target value) * 100
Actual value ... Pos. Swimmer
Target value ... cal. Pos (Station)
The flow rate variation of the previous calibration (positive values indicate an decrease, negative values indicate a increase in the flow rate due to re-calibration)

7.5 Determination of standard and operation volumes

Considering the pressure and temperature values determined during the sampling period on the integrated flowmeter, the values for $V_{Standard}$ (= Vs) or $V_{meas.system}$ (= VM) or in following for $V_{amb.}$ (= VA) are calculated from the equation (7) (Chapter 7.4.2) as listed below:
The equation (3) yields:

(8) $$Q_m = Q_{Scale\,indoor} \times \sqrt{(p_{ref} \times T_m)/(T_{ref} \times p_m)}$$

Q_m: average flow rate on the flowmeter during a sampling period
$Q_{Scale\,indoor}$: a set flow rate (e.g. automatically determined by calibration)
p_m: average pressure on the integrated flowmeter during a sampling period
T_m: average temperature on the integrated flowmeter during a sampling period

$$V_m = Q_m \times t_S$$

V_m: transported volume at the flowmeter
t_s: sampling time

resp.

(9) $$c_M = \sqrt{(p_{ref} \times T_m)/(T_{ref} \times p_m)}$$

c_M: correction factor for flow rate on the flowmeter

while from the general gas equation $Q_1 \times (p_1 / T_1) = Q_2 \times (p_2 / T_2)$ and the equation (3) it follows:

(10) $$Q_s = Q_{Scale\,indoor} \times \frac{T_N}{p_N} \times \sqrt{(p_{ref} \times p_m)/(T_{ref} \times T_m)}$$

Q_s: average flow rate at standard conditions
p_N: standard pressure
T_N: standard temperature

(11) $$V_s = Q_s \times t_S$$

V_s: transported standard volume on the flowmeter

resp.

(12) $$c_s = \frac{T_N}{p_N} \times \sqrt{(p_{ref} \times p_m)/(T_{ref} \times T_m)}$$

cs: correction factor for the standard flow rate on the flowmeter

For transported operation volume determination on the sampling head, not all required measurement values are available for the control at the moment. Nevertheless the following calculation can serve a good approximation:
Air pressure determination (operation pressure) on the sampling head is performed by pressure measurement before and after sampling with the blower switched off on the integrated flowmeter and by calculating the average of both measurements .

Moreover, it is supposed that air passing through the filter is warmed up approximately by 3 K. As a result of that, the temperature decreased by 3 K on the integrated flowmeter is taken as the average temperature on the air inlet (operation temperature).
Consequently according to the equation (11), the operation volume on the air inlet under determined conditions can be derived:

(13) $$Q_A = Q_{Scale\,indoor} \times \frac{T_A}{p_A} \times \sqrt{(p_{ref} \times p_m)/(T_{ref} \times T_m)}$$

Q_A: average flow rate at operation statuss on the air inlet
P_A: operation pressure (determined indirectly)
T_A: operation temperature (estimated)

Further, it implies:

(15) $$V_A = Q_A \times t_S$$

V_A: transported operation volume on the air inlet

or

(14) $$c_A = \frac{T_A}{p_A} \times \sqrt{(p_{ref} \times p_m)/(T_{ref} \times T_m)}$$

c_A: correction factor for operation flow rate at the air inlet.

7.6 Flowmeter tables

7.6.1 Calibration table

Metric Grösse 47 für 100-1000 l/min.Luft bei 15°C - 1013 mbar mit Aluminiumschwimmer											
Metric grandeur 47 pour 100-1000 l/min.air à 15°C - 1013 mbar avec flotteur en aluminium											
Flowrates (l/min. air at 15/760) against distance for 2000 series, size 47 tube, Dural free float (2000/47/410/AFG)											
Distance	**Flowrate**	**Distance**	**Flowrate**	**Distance**	**Flowrate**	**Distance**	**Flowrate**	**Distance**	**Flowrate**	**Distance**	**Flowrate**
Mm	l/min	mm	l/min	mm	l/min.	mm	l/min.	mm	l/min.	mm	l/min.
0	92.00	45	228.07	90	368.41	135	519.58	180	684.40	225	864.09
1	95.06	46	231.10	91	371.64	136	523.12	181	688.27	226	868.12
2	98.12	47	234.13	92	374.89	137	526.65	182	692.15	227	872.15
3	101.18	48	237.16	93	378.13	138	530.20	183	696.03	228	876.19
4	104.23	49	240.19	94	381.38	139	533.75	184	699.93	229	880.23
5	107.28	50	243.23	95	384.64	140	537.31	185	703.83	230	884.27
6	110.32	51	246.27	96	387.90	141	540.87	186	707.74	231	888.32
7	113.37	52	249.31	97	391.16	142	544.44	187	711.65	232	892.37
8	116.41	53	252.35	98	394.43	143	548.01	188	715.58	233	896.42
9	119.45	54	255.40	99	397.71	144	551.59	189	719.51	234	900.48
10	122.48	55	258.45	100	400.98	145	555.18	190	723.45	235	904.54
11	125.51	56	261.50	101	404.25	146	558.77	191	727.39	236	908.61
12	128.54	57	264.56	102	407.53	147	562.37	192	731.34	237	912.69
13	131.57	58	267.62	103	410.81	148	565.97	193	735.30	238	916.77
14	134.60	59	270.69	104	414.09	149	569.58	194	739.27	239	920.86
15	137.62	60	273.75	105	417.39	150	573.19	195	743.24	240	924.95
16	140.64	61	276.83	106	420.68	151	576.79	196	747.21	241	929.05
17	143.66	62	279.90	107	423.99	152	580.39	197	751.19	242	933.15
18	146.68	63	282.98	108	427.30	153	583.99	198	755.17	243	937.27
19	149.70	64	286.07	109	430.61	154	587.59	199	759.16	244	941.39
20	152.72	65	289.15	110	433.93	155	591.20	200	763.14	245	945.52
21	155.73	66	292.25	111	437.26	156	594.82	201	767.14	246	949.65
22	158.75	67	295.34	112	440.60	157	598.44	202	771.14	247	953.80
23	161.76	68	298.45	113	443.94	158	602.07	203	775.14	248	957.95
24	164.77	69	301.57	114	447.29	159	605.71	204	779.15	249	962.11
25	167.78	70	304.70	115	450.64	160	609.36	205	783.17	250	966.28
26	170.79	71	307.84	116	454.00	161	613.01	206	787.19	251	970.46
27	173.81	72	310.98	117	457.37	162	616.67	207	791.21	252	974.65
28	176.82	73	314.13	118	460.74	163	620.34	208	795.24	253	978.85
29	179.83	74	317.29	119	464.13	164	624.02	209	799.27	254	983.06
30	182.84	75	320.45	120	467.52	165	627.70	210	803.31	255	987.28
31	185.85	76	323.61	121	470.91	166	631.40	211	807.35	256	991.51
32	188.86	77	326.78	122	474.32	167	635.10	212	811.39	257	995.75
33	191.87	78	329.95	123	477.75	168	638.81	213	815.44	258	1000.00
34	194.88	79	333.13	124	481.19	169	642.53	214	819.49	259	1004.26
35	197.89	80	336.31	125	484.65	170	646.26	215	823.55	260	1008.54
36	200.90	81	339.50	126	488.11	171	650.00	216	827.61	261	1012.83
37	203.92	82	342.69	127	491.58	172	653.78	217	831.67	262	1017.13
38	206.93	83	345.89	128	495.05	173	657.58	218	835.74	263	1021.44
39	209.95	84	349.09	129	498.53	174	661.38	219	839.81	264	1025.76
40	212.96	85	352.30	130	502.03	175	665.19	220	843.88	265	1030.10
41	215.98	86	355.51	131	505.52	176	669.02	221	847.96	266	1034.45
42	219.00	87	358.73	132	509.03	177	672.85	222	852.04	267	1038.82
43	222.02	88	361.95	133	512.54	178	676.69	223	856.04	268	1043.20
44	225.05	89	365.18	134	516.06	179	680.54	224	860.06	269	1047.59
										270	1052.00

7.6.2 Pressure correction table

Pressure correction for gases at turbulent operation

Calculation of correction factor for measurement instrument applying pressure differing from an original one

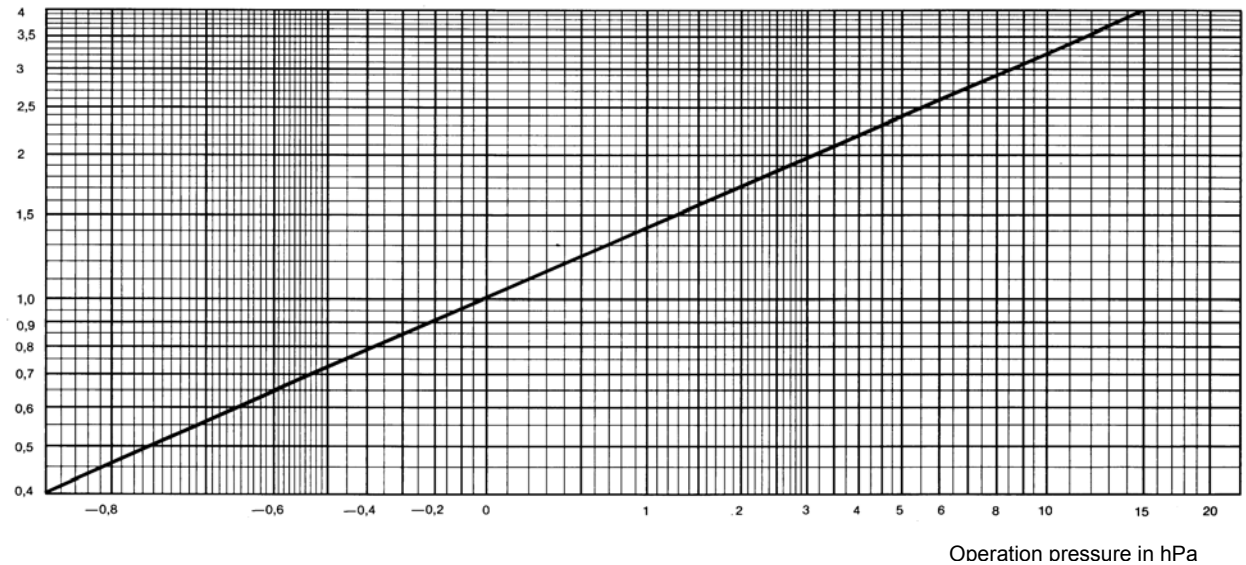
$$c = \sqrt{\frac{1.013 + Ps}{1.013 + Pe}}$$

c: correction factor to be multiplied with the reading of the flowmeter at calibration pressure Pe and operation pressure Ps

Ps = operation pressure in hPa
Pe = calibration pressure in hPa (indicated on the measurement tube)

Correction plot applied, if the measurement instrument is calibrated at 1 013 bar absolute, and now applied for another pressure.

correction factor c



Operation pressure in hPa

7.6.3 Temperature correction table

Temperature correction for gases at turbulent operation

Calculation of correction factor for a measurement instrument applying another temperature than the original temperature:

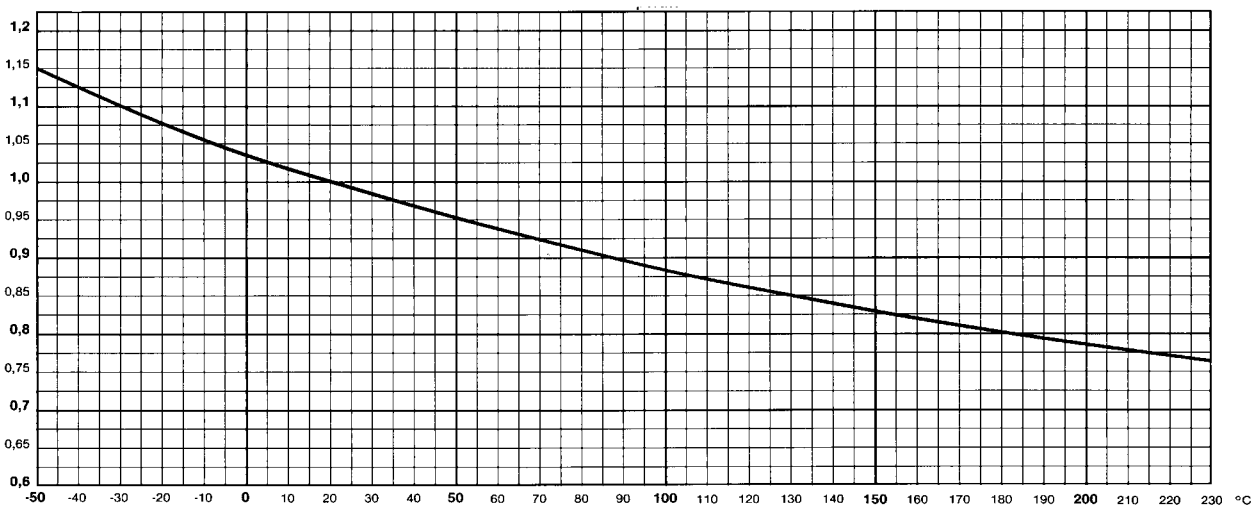
$$c = \sqrt{\frac{273 + Te}{273 + Ts}}$$

c: correction factor to be multiplied with the showed value of the flowmeter at a calibration temperature Te and an operation temperature Ts.
If Te = 20 °C, the below plot directly gives the correction factor c

Ts = operation temperature in°C
Te = calibration temperature in°C (indicated on the measurement tube)

Correction plot applied, if the measurement instrument is calibrated at 20°C absolute, and now applied for a different value of temperature.

correction factor c



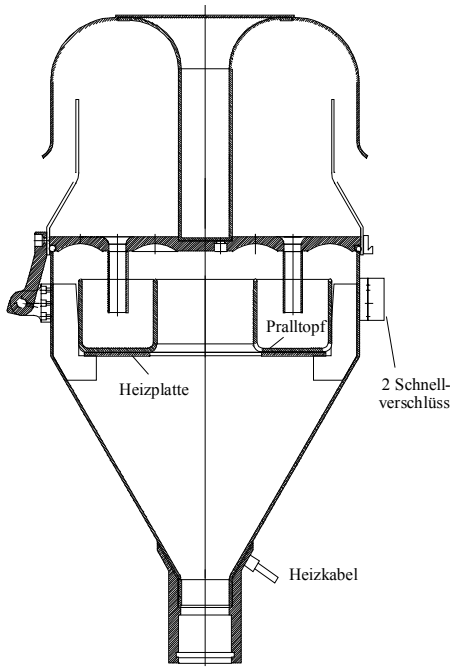
Temperature in °C ts

8 Sampling probe PM10 and PM2.5

8.1 General information

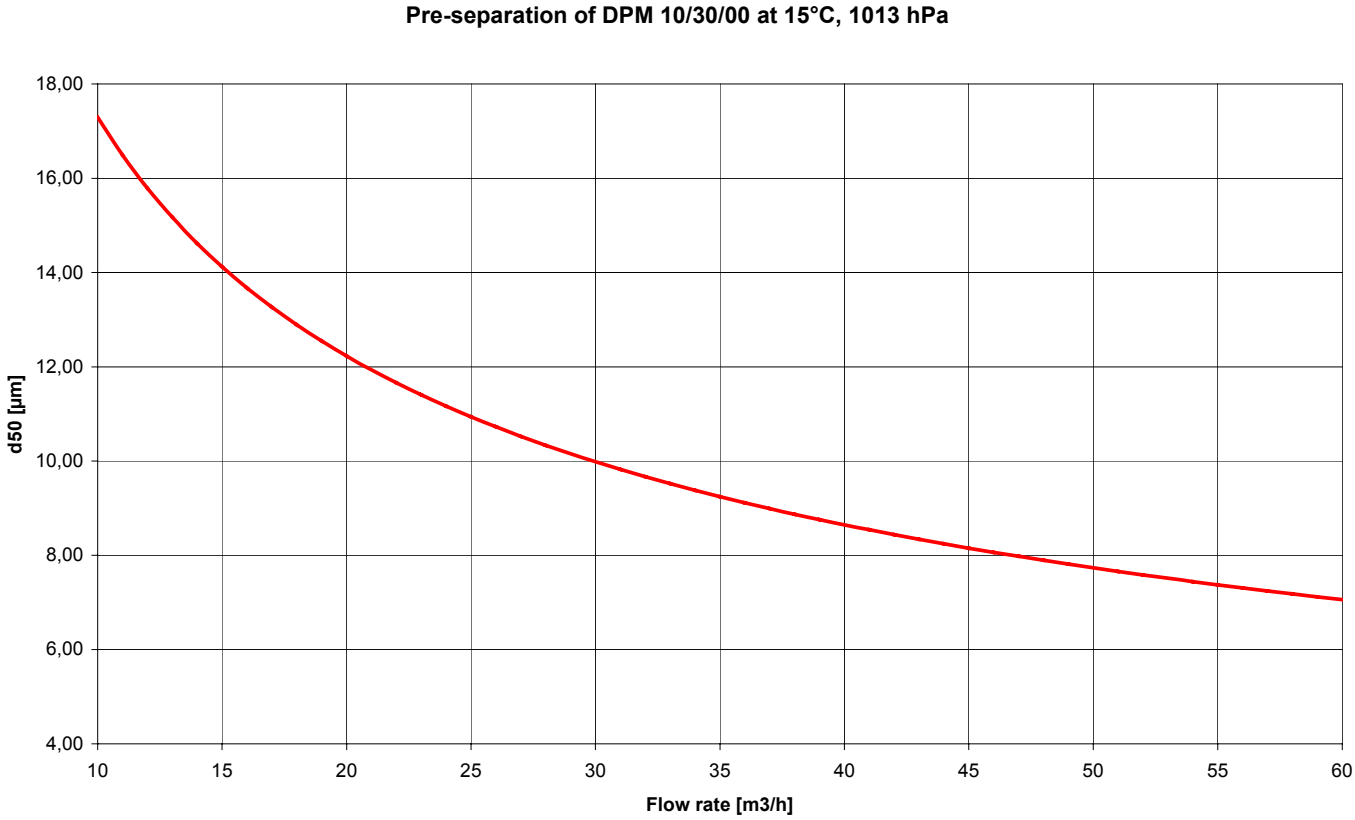
The sampling probe Digitel DPM10/30 or DPM2.5/30 is designed as a single-stage impactor. The median point Dp50 („cut point“) of the probe separation plot is of an aerodynamic particle of 10 µm or 2.5 µm diameter. A flow rate of 500 l/min. (30 cubic metres per hour) is achieved.
In order to keep the probe weight low, it is made of aluminium. All surfaces are treated with a the proven finishing process „Ematal“. Ematal surfaces have shown no variation effects on the dust substances subject to analysis so far.
The impactor plate can be taken out of the sampling probe when cleaning of the sampling probe is required.
To avoid surface icing of the baffler at low temperatures, the sampling head can be heated (thereby the high-volume sampler Digitel DHA-80 should be equipped with an option „Special heating“).

The PM10 air inlet tube fulfills the conditions of equivalence of the EN directive 12341.

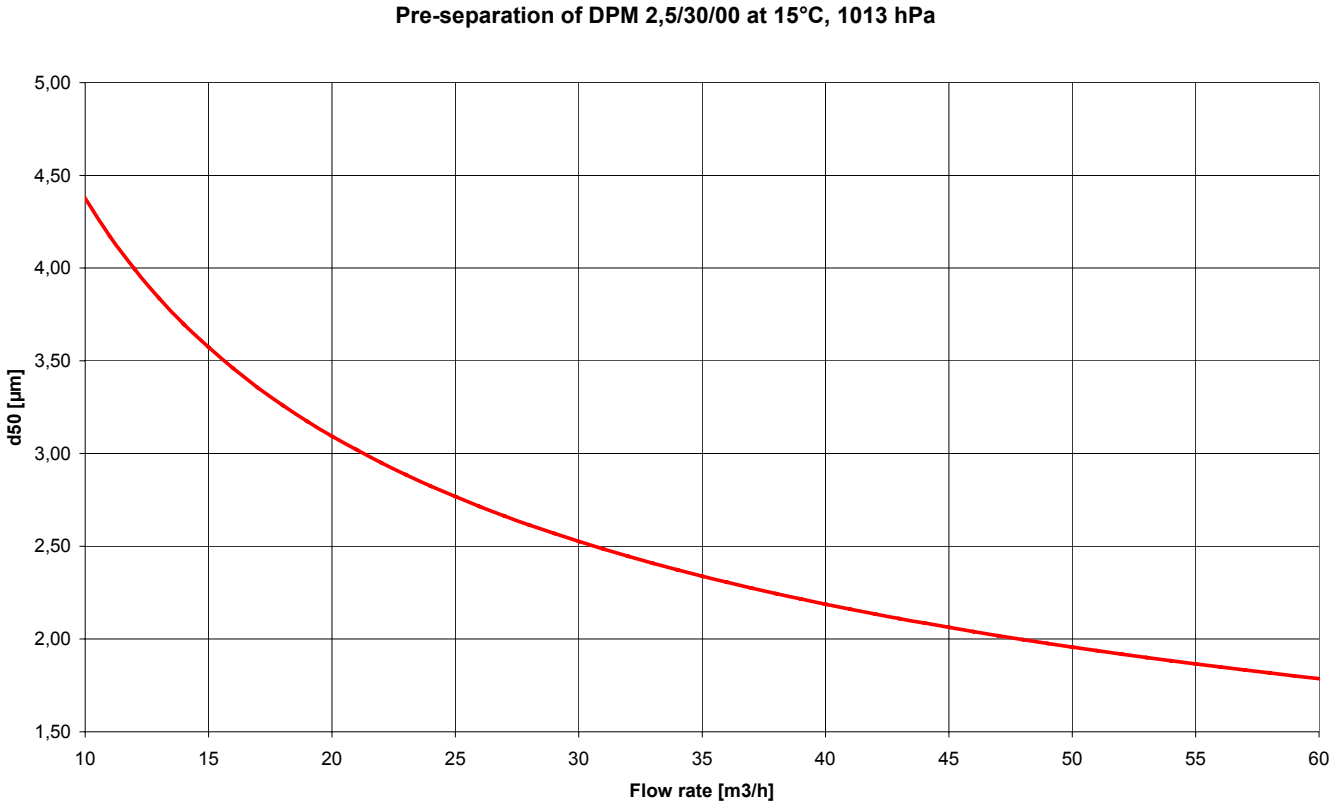


8.2 Separation performance

8.2.1 DPM 10/30/xx



8.2.2



8.3 Operation/maintenance

To avoid the release effects of separated rough particles, the baffler of the impactor plate has to be permanently covered with a thin grease layer. It has to be renewed periodically. The cleaning period depends on the proportion of rough dust in the ambient air sampled.
It is recommended to clean the impactor plate every 14 sampling days, when the average total dust contents (TSP) at the installation site is approx. 70 to 80 µg/m3. With a lower TSP, cleaning interval may be longer. An option to extend the cleaning interval results from the moveable impactor plate rotation fitted on the heater holder by approximately 15° (about 2 cm). The acceleration nozzles point at the still „clean“ areas between circularly deposited rough dust layers of the previous sampling operation.

The impactor plate can be simply removed by opening the probe upper part. It has to be cleaned, using a clean cloth, and the baffler area has to be greased repeatedly. About a 5 cm long band of grease should be equally spread on the area, using a spatula. To facilitate this maintenance, the impactor plate can be replaced by a substitute plate prepared in laboratory.
The acceleration nozzles, the liners of the probe casing, as well as a liner behind the impactor plate have to be cleaned under above-mentioned TSP conditions, after 30 sampling days.
At a time of longer sampling in foggy environment, it is advised to check the impactor plate for water condensation.

9 Failures/troubleshooting

9.1 Volume flow Functional circuit

9.1.1 Blower does not run up after switching the sampler on.

The dial pointer „Motor load“ overruns the entire scale. When reaching the range end, the failure indication status „Blower overloaded“ is displayed.
Cause:
Failure is in the power electronics (frequency convertor) and/or the suction unit. Control electronics is operational.
Failure fixation:
Remove the compartment cover of the suction unit/frequency convertor.

a) Check whether protection logics of the frequency convertor has responded. The corresponding failure indication message appears on the frequency convertor display. With blowers of a negligible running time (1 to 2 years), after resetting the frequency convertor, there can be immediately tried a new sampler start-up using the main switch of the instrument. Mind keeping the lower compartment still open. Upon running up, check the suction unit for suspect noise generation, while the display of the frequency convertor has to show the output voltage frequency (210 Hz as a maximum).

b) With older blowers (more than 2 years), first check the blower carefully before re-starting.
c) If the frequency convertor gets into the failure indication status immediately after trying to switch the sampler on and this occurs also with the hooked off blower, the frequency convertor is defective. This unit should be sent to the factory to get repaired resp. replaced.

9.1.2 Blower does not run up after switching the sampler on. The „Motor load“ dial pointer remains on zero

Cause
1. Possible operator's error:
   Time program is not in the “Work” status.
   Control signal was interrupted via the rocker switch „Blower off“ (LED „Blower switched off“ flashes).
   Sampler is in „Remote control“ mode.
   Rocker switch „Changer off“ is in the position „off“, the corresponding LED „Changer switched off“ flashes, and the LED „Changer in operation“ is lit (the switched off changer prevents the next filter exchange to be performed, and the blower remains switched on for this period of time).
2. The rotameter glass measurement tube is heavily contaminated, e.g. after the sampler ran in a heavily exposed environment without an inserted round filter for a longer time (remove and clean the glass measurement tube).
3. The printed circuit board (PCB) „flow control“ is defective (replace the board).
4. The infrared photo-sensors configuration on the rotameter is defective (call the service).

10 Communication

10.1.1 D-Sub-9 Pin allocation (terminal interface)

Pin allocation:

Pin No.	Signal
2	Receive Data (RxD)
3	Transmit Data (TxD)
5	Ground (GND)
7	Request to send (RTS)
8	Clear to send (CTS)
9	+12V (Res.)

To connect the Digitel HVS with a PC (9-pole connector D-Sub), a „crossed“ cable (zero modem) is required.

10.1.2 Digitel protocol

10.1.3 List of control commands

Control command	Averageing
hvs-rmton	Remote control on (this command is valid, only if remote control is off)
hvs-rmtoff	Remote control off (this command is valid, only if remote control is on)
hvs-status	Status inquiry; status response is permanently transmitted, independently of whether remote control is on or off
hvs-f	Filter changing in progress; this command is valid, only if remote control is on
hvs-work	Changer in the “Work” operation status; this command is valid, only if remote control is on
hvs-wait	Changer in the “Wait” operation status; this command is valid, only if remote control is on
hvs-pause	Changer in the “Pause” operation status; this command is valid, only if remote control is on
hvs-einst	Output current settings of the instrument

10.1.4 Interface format

Format: 1 startbit, 8 databits, 1 stopbit, no parity
Baudrate: 2 400
Handshake: RTS, CTS

10.1.5 Control commands description

10.1.5.1 Remote control

The first character of the control command is always a start character (#). The following command has to end up with a control character CR and LF (Carriage return and Line feed).

Response of HVS always starts with a start character (!) followed by a response and final CR, LF.
When HVS receives an unknown command, it responds with HVS-NACK!
The control characters can be written as capital or small letters.

Host:

# (start character)	control character 1	control character 2		
...	control character N - 1	control character N	CR	LF

Response by HVS:

Response character 1	Response character 2	...	
Response character N - 1	Response character N	CR	LF

10.1.5.2 HVS-RMTON

Host:
```
#HVS-RMTON
```

The command switches the HVS into remote control mode. In this mode, the control status of the HVS can be controlled by the host.
Response from HVS:
```
EXTERN
```

10.1.5.3 HVS-RMTOFF

Host:
```
#HVS-RMTOFF
```

The command switches the HVS to the normal operation mode.
Response from HVS:
```
INTERN
```

10.1.5.4 HVS-STATUS

Host:
```
#HVS-STATUS
```

The command causes the HVS a transmission of a status message.
Response from HVS (depending on operation status):

```
Status:
Do 17.11.96       14:23:54
Work
Blower on
```

```
Motor load: 67%

Collecttime[min]:   126,43
# Blower on/off :     1
paM       [mbar]:   929
TaM         [°C]:    20,0
cM                :     1,053
cs( 15/1013)    :     0,949
cA( 17/ 996)    :     0,972
VM          [m³]:   539,268
Vs( 15/1013)[m³]:   492,990
VA( 17/ 996)[m³]:   497,842
at 512 l/min
---------------------------
```

Moreover, failure messages are additionally transmitted, if so.
The range of the transmitted status information corresponds to the one specified on the printer for output.
It should be noted that each line has to end up with CR, LF. The length of the response string is not defined!

10.1.5.5 HVS-WORK

Host:
```
#HVS-WORK
```

The command brings the HVS to the “Work” operation status.
“Response” from HVS:

```
Sa 06.09.03        12:00:12
WORK, ext
```

10.1.5.6 HVS-WAIT

Host:
```
#HVS-WAIT
```

The command brings the HVS to “Wait” operation status.
Response from HVS:

```
Sa 06.09.03        12:00:12
WAIT, ext
```

10.1.5.7 HVS-PAUSE

Host:
```
#HVS-PAUSE
```

The command brings HVS to the “Pause” operation status.
Response from HVS:

```
Sa 06.09.03        12:00:12
PAUSE, ext
```

10.1.5.8 HVS-EINST

Host:
#HVS-EINST
The command causes the HVS to transmit current settings.
Response from HVS:
Current settings are transmitted to the terminal interface instead of to the printer.

```
Di 12.11.96        11:42:17
version:              50.18
Repeat after 2h         off
Stop time at pwr. fail  off
send failure msg. only  off
send blower capacity    on
send blower cap. >=90%  off
Blower pwr. sens.[%] :    2
send # Blower on/off    on
4 day sequence          off
Memorycard              on
Size [kB]            :  256
File(s)              :    1
Memory used [%]      :    1
Bayern-Hessen-Prot.     on
Bayern-Hessen-Prot. B   on
Bayern-Hessen-Address:  310
Blower capacity         on
act. collecttime        on
Press. meas.            on
Temp. meas.             on
act. corr. meas.        on
act. corr. stand.       on
act. corr. amb.         on
collecttime             on
p avg.                  on
Temp. avg.              on
p avg. amb.             on
T avg. amb.             on
avg. cM/VM              on
avg. cs/Vs              on
avg. cA/VA              on
repeated printout       on
printer                 on
short messages       :  off
Press./Temp. measuring  on
send corr. stand.       on
send corr. meas.        on
corr. amb.              on
send Volume stand.[m3]  on
send Volume meas. [m3]  on
send Volume amb. [m3]   on
send avg. Press./Temp.  on
Temp. stand.[°C]     :  - 8
Press. stand.[mbar]  : 1013
Press. (uncal) [mbar]:  985
Press. meas. [mbar]  :  993
send temp. meas. [°C]: 22,8
flow through [l/min] :  500
```

10.1.6 Bayern-Hessen protocol

10.1.7 Interface format

Format: 1 startbit, 8 databits, 1 stopbit, no parity
Baudrate: 1 200 (2 400 Baud in the Bayern-Hessen protocol B version)
Handshake: semiduplex operation, polling method
Checksum: (Block Check Character) XOR of all characters inclusive STX and ETX with the start value 0

10.1.8 Bayern-Hessen protocol Subset for Digitel HVS

10.1.8.1 Data inquiry structure

Field No.	Start position	End position	Content	Description
1	0	0	<STX>	Start of Text
2	1	2	DA	
3	3	3	<ETX>	End of Text
4	4	4	<BCC1>	High-Nibble BCC
4	5	5	<BCC2>	Low-Nibble BCC

10.1.8.2 Data transmission structure

Field No.	Start position	End position	Content	Description
1	0	0	<STX>	Start of Text
2	1	2	MD	Protocol ID
3	3	5	nn<>	Number of measurement instruments (01)
4	6	9	nnn<>	Measurement instrument ID
5	10	18	±nnnn±ee<>	Measurement value (blower capacity)

Field No.	Start position	End position	Content	Description
6	19	21	hh<>	Operation status
7	22	24	hh<>	Failure indication status
8	25	35	hhh<>hh hhhh<>	Serial No. of measurement instrument (000 000000)
9	36	36	<ETX>	End of Text
10	37	37	<BCC1>	High-Nibble BCC
11	38	38	<BCC2>	Low-Nibble BCC

Operation status in Bayern-Hessen protocol (1 200 Baud):
Bit 0: Remote control on
Bit 1: Maintenance
Bit 2: End of program
Bit 3: ---
Bit 4: Blower off
Bit 5: Work
Bit 6: Pause
Bit 7: ---

Operation status in Bayern-Hessen protocol B (2 400 Baud):
Bit 0: Maintenance
Bit 1: Blower off
Bit 2: Work
Bit 3: Pause
Bit 4: ---
Bit 5: Remote control on
Bit 6: End of program
Bit 7: ---

Failure indication status:
Bit 0: ---
Bit 1: Overload
Bit 2: ---

If more than one measurement value is transmitted , the fields 4 to 8 are repeated as frequently as the number of measurement values is defined.
Warning: The first three characters of the instrument ID are transmitted in the Bayern-Hessen protocol in the block „Seriennummer“ (serial No.). If the Bayern-Hessen protocol is applied, the first three characters have to be either numerical resp.blank characters.

10.1.9 Bay. Hessen control telegram for Digitel HVS

10.1.9.1 Control command structure

Field No.	Start position	End position	Content	Description
1	0	0	<STX>	Start of Text
2	1	2	ST	
3	3	5	310	Instrument address
4	6	6	x	Control command
5	7	7	<ETX>	End of Text
6	8	8	<BCC1>	High-Nibble BCC
7	9	9	<BCC2>	Low-Nibble BCC

Control command:
„E“ Remote control on
„W“ Wait
„B“ Work
„P“ Pause
„A“ Remote control off
„C“ initialisation of cM, cA, cs, VM, Vs, VA sampling time, filter-change flag; in the Bayern-Hessen protocol modes 3 and 4, the sampling time cM, cA, cs, VM, Vs, VA and filter-change flag values are transmitted until the control command „C“ is received. Herewith it is ensured that the receiver receives the data.

10.1.10 AK-Protocol

10.1.11 Implemented control commands

Control command	Description
AREG	Ask Register Command – actually implemented
EREG	Enter Register Command – actually not implemented
SFxx	Set Function xx Command – actually not implemented
ASTO	Ask Storage Command – actually not implemented
SSTO	Set Storage Command – actually not implemented

10.1.12 Interface format

Format: 1 startbit, 8 databits, 1 stopbit, no parity
Baudrate: 2400
Handshake: ---

10.1.13 Control command structure

10.1.13.1 General transmission format

The first character of a command is always a startchacter (STX). After that the next digits/figures will follow: stationnumber (ASCII), „AREG“, a blank, a two-digit channelnumber (ASCII), a blank, a one-3- digit program register code (ASCII). The string is closed by a final character (ETX).
The answer of the HVS has following format: the first character is always a start-character (STX). After that the next digits/figures are as follows: stationnumber (ASCII), „AREG“, a blank, a digit status (ASCII), a blank, a one 3-digit program register code (ASCII); length is not defined! The string is closed by a final character (ETX). Up to three figures could follow. The HVS sends a „CR“ and „LF“.
ATTENTION: Station number for HVS: „4“
Channel number for HVS: „K0“

Request:

STX	4	A	R	E	G		K	0		PRC	PRC	ETX

Respond:

STX	4	A	R	E	G		0		PRC	PRC
	Data			ETX		CR	LF			

Respond data format:
actual blower capacity: 000-100 till 3 digits [%]
act. Temp., avg. Temp. in measurment system : ±25,3 till 5 digits [°C]
act. pressure, avg. pressure in measurement system: 1006 till 4 digits [mbar]
Elapsed collecttime for the actual filter, Elapsed collecttime for the last completed filter: 12317,17 till 8 digits [minutes]
cM, cs, cA: 00001,034 till 9 digits
VM, Vs, VA: 12067,345 till 9 digits [m³]

Description of Programm Register Code:

PRC	Description
0	Actual blower capacity1
1	Actual temperature conditions in measurement system1
2	Actual pressure conditions in measurement system1
3	Elapsed collecttime of the actual filter1
4	act. cM1
5	act. cs1
6	act. VM1
7	act. Vs1
10	Operation status 2
11	Failure indication status 3

20	Elapsed collecttime of the last completed filter4
21	Average temperature conditions in measurement system during sampling periode4
22	Average pressure conditions in measurement system during sampling periode4
23	cM of the last completed filter4
24	cs of the last completed filter4
25	VM of the last completed filter4
26	Vs of the last completed filter4
30	act. cA1
31	act. VA1
40	Average temperature conditions on the air inlet of the last completed filter during the sampling periode (this is an estimated condition: flow-meter average temperature - 3K).
41	Average pressure conditions on the air inlet of the last completed filter during the sampling periode (air pressure average value before and after sampling on the sampling head) 4
42	cA of the last completed filter4
43	VA of the last completed filter4

1 Values for PRC: 0 till 2 are actual values. It averages that this are the last measured values.

Values for PRC: 3 till 7, 30, 31 are actually computed values.

2 Operation status:

State	Description
xxx0	Work
xxx1	Wait
xxx2	Pause
xx0x	Blower off
xx1x	Blower on
x0xx	No filter change
x1xx	Filter changed
0xxx	Remote off
1xxx	Remote on

3 Failure indication status:

State	Description
xx0	Changer OK
xx1	Changer jamed
x0x	No blower overload
x1x	Blower overload
0xx	Filter magazine filled
1xx	Filter magazine empty

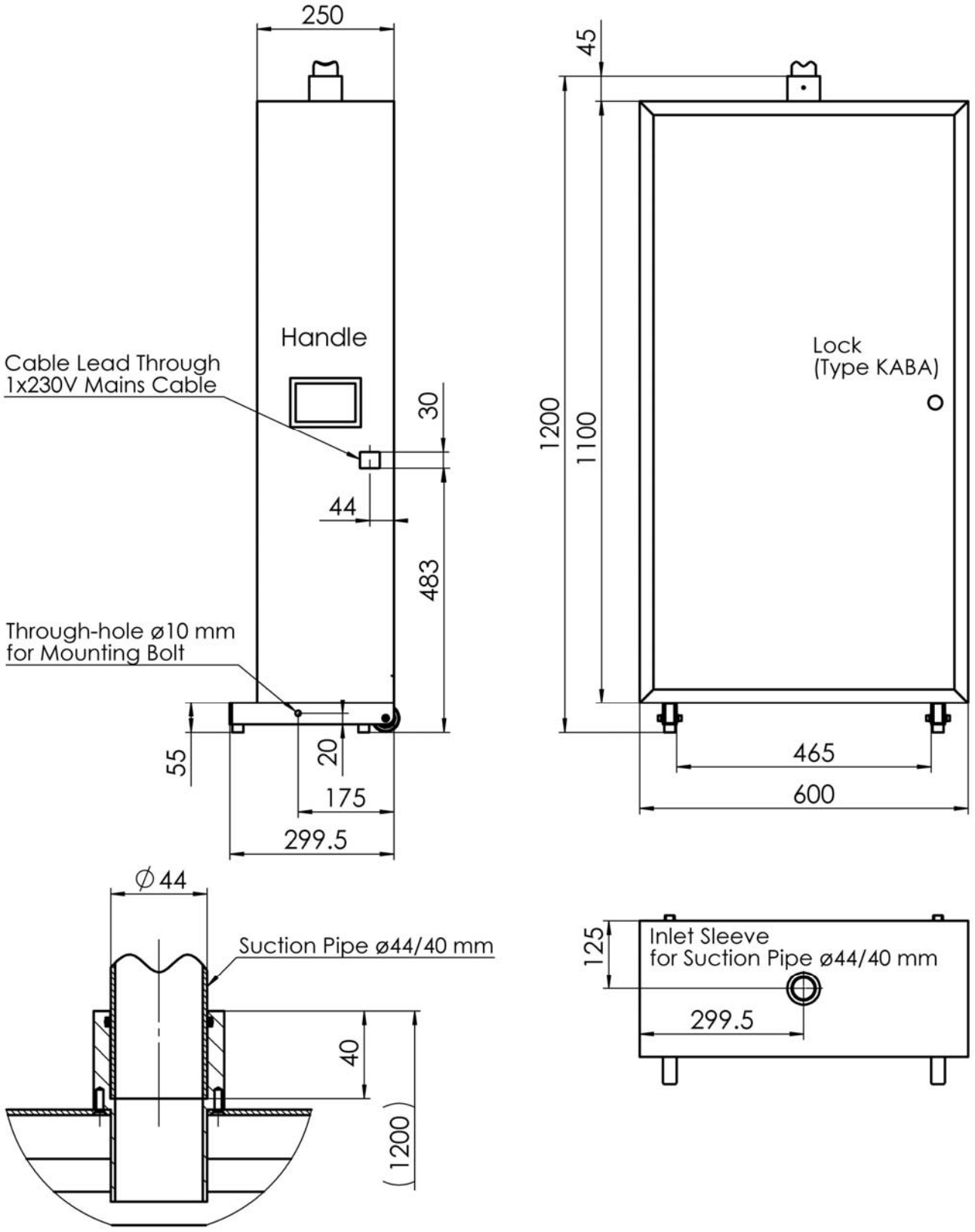
4 Values for PRC: 20 till 26, 40 till 43 are values for the last completed filter.

11 Technical data

Model	**DH-77**
Type	Field case
Power supply	230 V +6/-10 %; 50 Hz; max. 1700 VA
Fuse	10 A
Connecting cable	3 x 1.0 mm², 10 A, 250 V
Installation	Category II (standard mains)
Application range	5 to 40°C; 10 to 90 % RH or -20 to 40°C; 10 to 95 % RH with interior heating, maximum operation altitude of 2000 m above the sea level*
Flow rate	100 till 1000 l/min
„Volume flow“ Control accuracy	< 5 % of MBE
Suction unit, average life cycle	36 000 h
Settings reproducible accuracy (according to UMEG report No. 6-08/00)	+- 0.45%
Logged standard and measured volumes Accuracy	<+/- 2%
Time programs	Work, Pause (0 to 59999 minutes each); start time adjustable using date and time
Outer dimensions (H x W x D)	1300, 600, 250 mm
Weight	46 kg
Protection class	IP54
Filters	1 round filters of d = 150 mm (flowing area of d = 140 mm); filter material depends on the aim of analysis
Underpressure at 1,000 l/min.	max. 130 mbar
Manual filter exchange	✓
Analog remote control	✓
RS232C remote control	✓
RS232C logging	✓
Overloading switch-off	✓
Operation-hour counter	✓
Motor-load indication	✓
Multi-language logging	✓
Battery-backed data memory	✓
Battery-backed clock module	✓ (+/- 4 second daily
Pre-separator heating	30 V; 50 Hz; 60 VA max.
Pre-separator	TSP, PM10, PM 2.5, PM1 optionally with integrated heating and excess temperature protection
PAH cartridge holder	✓
Special cards (PCMCIA) on the RS232 interface	✓
Memory cards (PCMCIA) internal	✓
Log printer	✓
Interface protocols	DIGITEL, Bayern-Hessen protocol, customer-specific

* Special execution for operation altitudes above 2000 m upon request

12 Dimension drawings

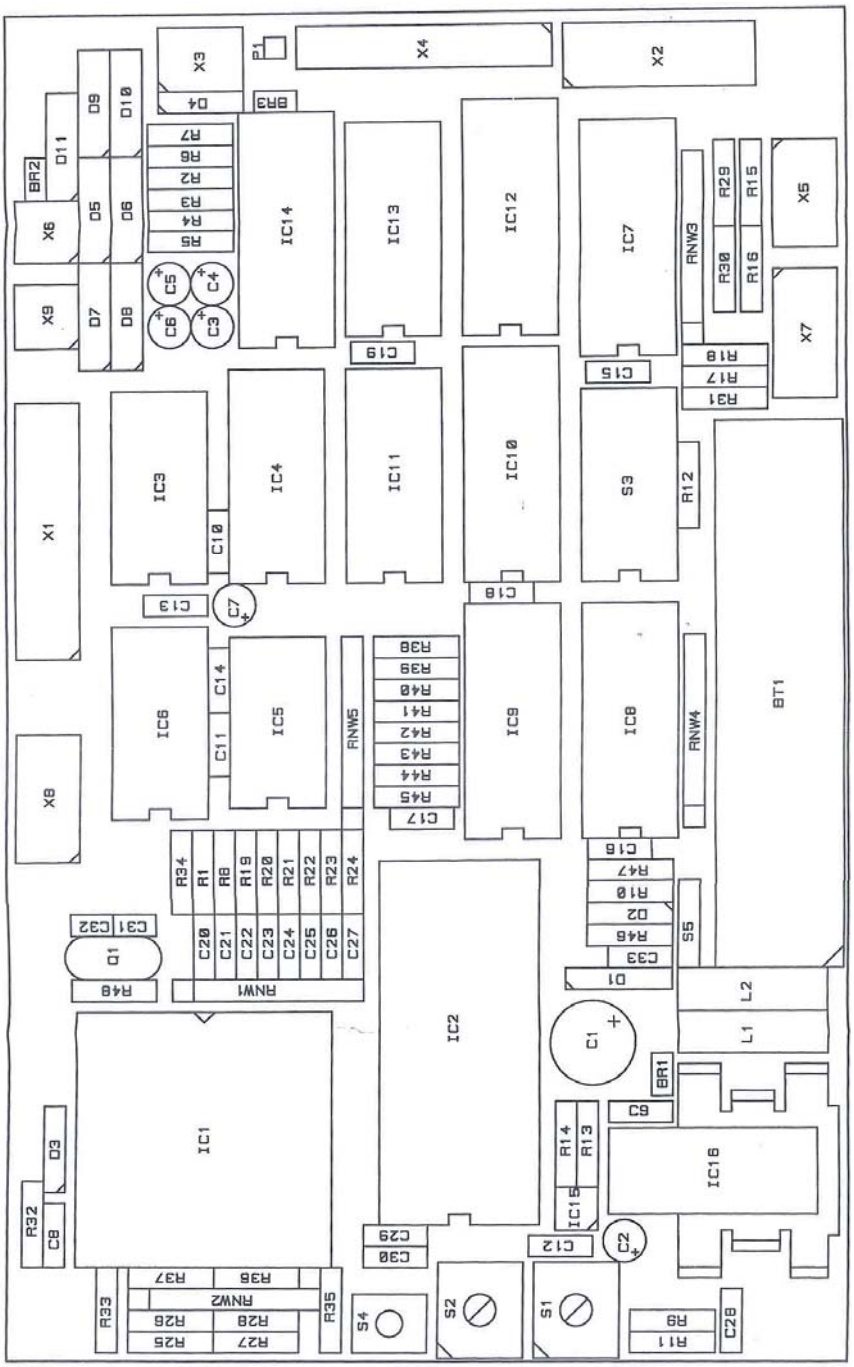


13 Appendix

13.1 Connectors list

Connector	Description
X1	Revolution control, heating control, changer control
X2	Data bus connector
X3	Power supply
X4	Operation PCB
X5	Remote control
X6	Printer connector
X7	Wind control/pressure and temperature compensation
X8	Reserve
X9	Terminal connector

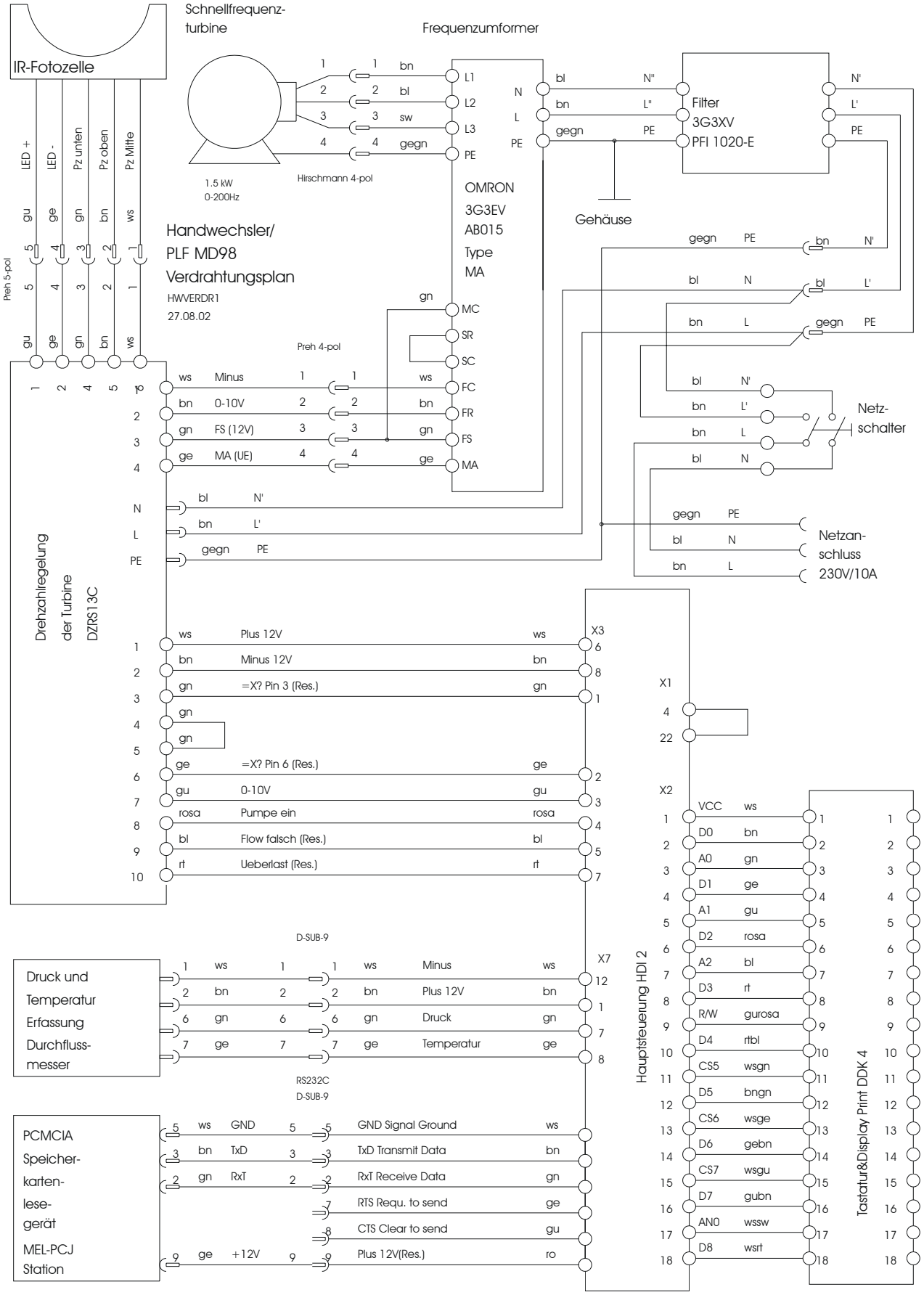
13.2 HVS-HDI2 Component layout



13.3 EPROM replacemen

The following is a description of the most important steps to be considered when replacing an EPROM:
print the current instrument settings;
switch the high volume sampler power supply off;
open the front panel;
remove the old EPROM. Use a special tool use for EPROM replacement or using a small screw-driver. Hereby the screw-driver is inserted between EPROM and its socket, and EPROM has to be carefully removed from the socket; set the new EPROM; you have to make sure that EPROM is set correctly into the designed socket (see the component layout, item IC2). On the EPROM there is a marking (a notch) is, defining its position, unambiguously. If the EPROM is set incorrectly, both EPROM, both the EPROM as well as the remaining circuit might be damaged. In this case it is necessary to demand a new EPROM;
close the front panel;
switch the power supply on;
select the menu point „factory settings" (Menu - 3 - 8 - 0). Now, after the program exchange, the instrument settings are reset to basic settings. This is necessary, because with old instrument settings the new program does not operate correctly.
New programming of instrument settings (using the printer protocol which was made before EPROM replacement). In order to be able to perform pressure-sensor calibration (pressure-sensor calibration is also reset), the current air pressure at the instrument installation site of has to be known!

13.4 Wiring diagram DH-77



13.5 PC cards Data files Structure

13.5.1 HVSDAT.DAT

The data in the file HVSDAT.DAT are saved in a table. As separators between the columns, the Tab character (HT, 09H) is applied. The line break is activated using CR, LF. For example, after formatting on the HVS, the file looks as follows:

Event	Date/ time	Sampling time (min.)	paM [mbar]	TaM [°C]	pA [mbar]
TA estimated [°C]		cM	cs (15°C / 1013 mbar)	cA	
VM (512 l/min) [m³]		Vs (15°C / 1013 mbar); (512 l/min) [m³]		VA (512 l/min) [m³]	

Columns Description:

Event
: status information (Blower on, Work etc.)

Date/time
: year, month, day, hour, minute, second

Collecttime
: inserted filter sampling time in minutes

paM
: average air pressure during sampling time in mbar at measurement tube

TaM
: average air temperature during sampling time in °C at measurement tube

pA
: average value before and after sampling of air pressure measurements

TA
: TmM - 3 K

CM
: flow rate correction factor on the measurement tube for average pressure and temperature conditions during the sampling time

cs (15°C/1013 mbar)
: flow rate correction factor related to entered standard conditions

cA
: air flow correction factor on pre-separator (related to the average air pressure before and after sampling and to the average air temperature on the measurement tube - 3 K during sampling time. The calculation of this correction factor is based on simplified assumptions with which small deviations to the actual correction factor on the air inlet might occur (see the chapter 7.4 Flow calibration).

VM
: transported air volume in cubic metres (related to determined measurement values on the measurement tube)

VM (15°C/1013 mbar)
: air volume that would have been transported in standard conditions; temperature (15°C) and pressure (1 013 mbar) depends on setting „standard temperature“ and „standard pressure“ during the formatting procedure.

VA
: air volume to be transported during the sampling time through a pre-separator (related to the average air pressure before and after sampling and to the average air temperature on the measurement tube - 3 K during the sampling period. This volume calculation is based on simplified assumptions leading to small deviations to the actually transported volume on the air inlet (see the chapter 7.4 Flow calibration).

It should be taken into account that only those columns are defined according to the parameters activated in the sub menu “Instrument setting”. If you have set no correction factors output, corresponding columns in the data file are not generated! It implies that memory cards used for this instrument have to be reformatted after each HVS new programming .

13.5.2 HVSWIND.DAT

The data file HVSWIND.DAT is set only when wind measurement is activated. Data in the file HVSWIND.DAT are saved in a table. As separators between the columns, the Tab character (HT, 09H) is applied. The line break is activated with the use of CR, LF. After formatting on HVS, the file looks as follows:

Date/time	Wind direction (grade)	Wind velocity (m/s)	Blast (m/s)

Columns description:

Date/time
: Year, month, day, hour, minute, second

Wind direction (grade)
: Average wind direction

Wind velocity (m/s)
: Average wind velocity

Blast (m/s)
: Maximum wind velocity during time of averaging

13.5.3 General instructions

When applying the memory cards PCMCIA the HVS power cable bushing has to be fixed !
The PCMCIA Write/Read instrument memory cards have to be switched on simultaneously with the Digitel HVS (only software release 30.xx).
Prior to the PC card formatting , all other settings required for an intended operation have to be set. Only then, the PC card can be successfully formatted.
The printer transmits the most important status information for operation with the PCMCIA Write/Read instrument. Further on, an additional logging can be printed simultaneously with the memory card logging. However, this additional logging is limited to the sampling period of time, average pressure, average temperature, correction factors and volume (if these output values are activated by programming). No instrument-specific status or failure indication messages are transmitted (Wait, Work, Pause, Overload etc.)! You have to ensure that printer operation is activated at additional logging!

13.5.3.1 Failure indication messages

„no R/W instrument“- Control cannot establish connection to the memory cards of the Read/Write instrument. Check whether the Read/Write instrument is on or whether there is an interface connection.

13.5.3.2 Status messages

„no memory card“ - No memory card in the Read/Write instrument!
„memory card changed“ - The Read/Write instrument identifies any card replacement, which is reported to the controller. After power breakdown this message is transmitted too for the card replacement cannot be proceeded during power breakdown.

13.5.3.3 Logging instrument settings

Logging of instrument settings is performed in the data file HVSDAT.DAT in its column „Event“ in the same format as on the printer (see 6.1 Settings in normal operation (mode 0)). Each line is established for any output line in the table, too. Logging of instrument settings is simultaneously performed on the printer, if it is activated.

13.5.3.4 Memory card replacement

Replacement of the memory card can be performed, unless the red LED „Busy“ is lit on the Read/Write instrument. This LED indicates if the memory card is currently accessed (on the memory card data are written). If the memory card is replaced during access, loss or destruction of data on the memory card might occur. Therefore, since the access to the memory card is possible at any time, it is recommended to replace the memory card only when the instrument is switched-off.

13.6 „short messages“ (applied abbreviations)

When „short messages“ is activated, failure indication and status information are transmitted to the printer using the following abbreviations (by applying a Digitel protocol, also transmitted to RS232 interface):

Abbreviation	Standard text
Work	Work
Wait	Wait
Pause	Pause
Wo ex	Work extern
Wa ex	Wait extern
Pa ex	Pause extern
PF St	Power breakdown from:
PFEnd	Power breakdown until:
B off	Blower off
B on	Blower on
B xx%	Blower capacity xx %
Overl	Overload
P End	Program completed
Start	Program started
ext	External
int	Internal

Logging to the memory card is not affected by that!

13.7 Structure of menu