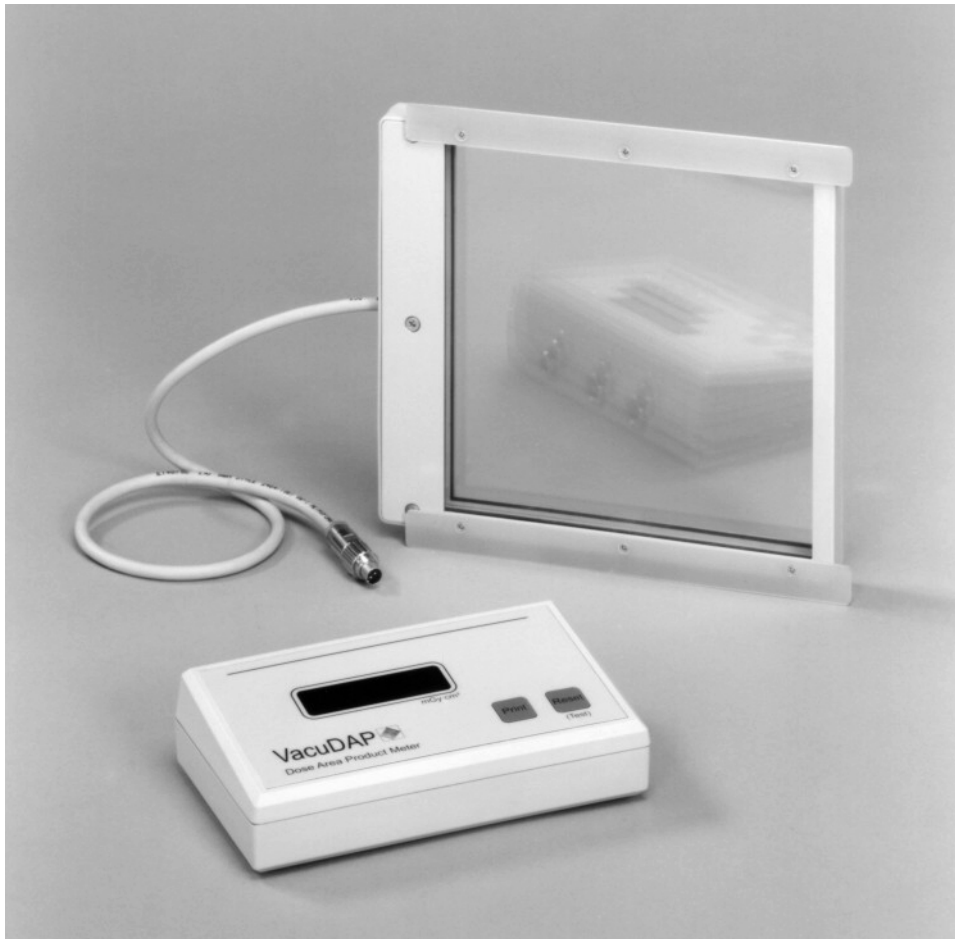


Operation Manual

Dose Area Product Measuring System

VacuDAP 2004

valid from software version: 9.6



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Introduction

Despite the improvements in X-ray technology as a whole and the progress made in reducing the required radiation dose levels, X-ray diagnostics continues to be a major source of radiation patients are exposed to. For this reason, the European Council Directives 96/29/EURATOM (basic safety standard), 97/43/EURATOM (protection of patients) and the amended German X-ray ordinance require that patients be not unnecessarily exposed to radiation and that the radiation doses applied be measured and recorded. The VacuDAP 2004 measuring system is a convenient means of doing this.

The VacuDAP 2004 measuring system is used for determining the dose area product (DAP), a parameter that comes in very useful when measuring the radiation doses patients are exposed to in a radiological examination.

The VacuDAP 2004 comprises a transparent, square ionization chamber and a display unit.

By changing settings and parameters on the display unit, the measuring system can be easily adjusted to individual measuring conditions. In detail, the following adjustments can be made:

- Selection of measuring mode (radiography/fluoroscopy)
- DAP rate displayed during radiation in fluoroscopy mode
- Selection of one out of two calibration factors (e.g. measurement with/without bucky table)
- Variation of calibration factors (re-calibration)
- Selection of printout language (German, English, French, Spanish, Italian)

The VacuDAP 2004 measuring system is designed for radiological standard methods. With the paediatry option (Order-No.: 156 00 95 or 157 00 95) a ionization chamber with a ten times higher response is offered, which has been developed especially for paediatric methods (see 6, *Accessories and options*).

Used symbols:



Notes with this warning symbol must be heeded



Message displayed on the display unit



Press these keys on the display unit

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1 General information for the operator

1.1 Application

The VacuDAP 2004 dose area product measuring system is used for measuring the radiation dose the patient is exposed to during an X-ray examination.



The measuring unit must not be used for the primary determination of characteristics of X-ray equipment (constancy checks).

1.2 Classification

According to the 93/42/EEC Directive on medical devices (MDD), the VacuDAP 2004 dose area product measuring system is an active medical device of class 1 with measuring function.

The measuring system is designed for continuous operation.

Protection against the ingress of water: class IPx0.



The system is not designed for use in the vicinity of inflammable mixtures.

1.3 Electromagnetic compatibility (EMC)

This medical device complies with the European IEC 60601-1-2 standard (limit values to IEC 55011, group 1, class A) and satisfies the EMC protection requirements as specified in the law on medical devices.

1.4 Protection against electric shock

At the power supply end, all poles must be disconnectable from the mains, or the external power supply unit must be completely disconnectable from the mains.

The power supply shall be in compliance with the European standard on medical electrical devices **IEC 60601-1-1** (see 2.2, *Supply voltage*). The plug-in power pack offered with the VacuDAP 2004 measuring system complies with IEC 60601-1-1 and has the following safety class:

- safety class II system to IEC 601 - 1 HA 3.

The components of the measuring system VacuDAP 2004 (measuring chamber, display unit) work on a safety extra-low voltage.

1.5 Accessories



Any accessory equipment connected to the serial interface shall comply with the applicable office machine standard IEC 60950 (VDE 0850).



Only original parts or parts complying with the regulations specified by the manufacturer may be used on the measuring system.

See Chapter 6, *Accessories and options*, for a list of accessory parts offered.

1.6 Handling, transport, shipment

The ionization chamber and integrated electronics are highly fragile components and therefore need to be handled with utmost care.

The original or an equal packing should be used for any transports and when returning the system.



Because of the risk of damage to the ionization chamber, the transparent electrodes of the measuring chamber must not be subjected to mechanical pressure.

For transportation the following conditions have to be kept:

| | |
|---------------|--|
| Temperature | 0°C-50°C |
| Rel. humidity | 10% - 80% (max. 20g/m ³ ; not condensing) |

1.7 Cleaning



Do not use scouring or solvent-containing cleansing agents (e.g. benzene, alcohol, stain-remover) or organic solvents for cleaning the measuring chamber.

Using such agents may result in damage to the conductive layers on the electrodes or in reducing the transparency of the ionization chamber. Cleaning the measuring chamber with a cloth soaked in water with a mild washing-up liquid added is possible.



While cleaning, make sure no moisture gets into the ionization chamber. The chamber must be dry before starting the system again.



Clean the display unit by wiping it with a disinfectant.

1.8 Storage, operating conditions



The dose area product measuring system inclusive of power pack and accessories may only be used indoors.

Moisture may deposit on the ionization chamber and electric terminals when the relative humidity is greater than 80%. This would lead to an increased leakage current and the error message ERR : xxxx appearing upon completion of the system test.

This trouble, which is due to reduced insulation levels, can be eliminated by drying the chamber at an increased temperature (max. 50°C).

1.9 Disposal

The measuring system contains electronic components and has to be disposed according to the valid national regulations or it has to be sent back to the manufacturer.

2 Preparation of operation

2.1 Preparation

The VacuDAP 2004 measuring system comprises the following components:

- Ionization chamber with integral electronics
- Display unit
- Cable (signal line) for connecting the measuring chamber to the display unit
- Plug-in power pack
- Optional accessories (see 6, *Accessories and options*)

Remove the packing material carefully. Should any components found to be damaged, contact the supplier or manufacturer. Damaged components may not be used.

2.2 Supply voltage

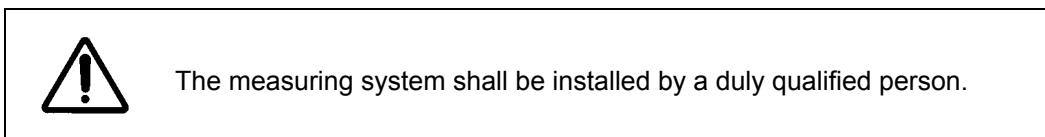
For powering the measuring system VacuDAP 2004, a plug-in power pack is offered which meets the **IEC 60601-1-1** standard. The length of the power pack's connecting cable is approx. 2 m.

Alternatively, an extra-low voltage ranging between **+15 V ... +24 V** can be tapped from the X-ray unit provided this power supply complies with the European standard for medical electrical devices IEC 60601-1, is short-circuit-proof, and has a current-carrying capacity of **≥ 300 mA** (in case of a 2-channel measuring system 956 00 01: ≥ 500 mA). Further requirements can be found in Chapter 1.4, *Protection against electric shock*.

The supply voltage is applied by means of a power pack connector (outer diameter: 5.5 mm; pin diameter: 2.5 mm) the centre contact (pin) of which carries the positive potential (+15 V ... +24 V). The reference potential (ground, GND) is that of the metallic housing parts of the display unit and the measuring chamber.

The measuring system is provided with an internal polarity reversal protection.

2.3 Installation



The dimensions of the ionization chamber are dependent on the specifications of the X-ray unit. The following sizes are available:

| Designation | Order-No. | Active area | Notes |
|-------------|------------------------|-------------------------|-------------|
| 70 156 | 156 00 15 156 00 95 | 123x123 mm ² | transparent |
| 70 157 | 157 00 15 157 00 95 | 147x147 mm ² | transparent |

Table 1: Square ionization chambers

By means of the interchangeable guide rails, the measuring chamber is pushed into the accessory support at the radiation outlet end of the beam limiting device.

Various guide rails and adapters of suitable dimensions are available for the different support rail widths (see 6, *Accessories and options*).

The compact design of the ionization chamber with electronics even allows the chamber to be installed within the collimator (behind the beam limiting device).

The display unit should be put up or installed in a suitable place.

The female connector of the signal line (cable 953 00 40) is connected to the male connector of the ionization chamber and screw-locked, whereas the male connector of the signal line is plugged into the 4-pole socket of the display unit.



Make sure the cable is laid such that it is stress-relieved. The cable must not restrict the movement of the arm supporting the X-ray source.

The cable may only be laid within dry rooms. Its standard length is 15 m. Other lengths (up to 40 m) are available on request.

2.4 Function test



All components of the measuring system should have reached room temperature before the function test is started.

If the VacuDAP 2004 measuring system was correctly installed the supply voltage can be applied.

After an initialisation phase, the measuring system starts the POWER-ON TEST (see 3.3.3, *TEST function*) during which the correct connection and function of all system components are automatically tested.

When the function test is correctly performed, the following messages - among others - will be displayed:

VACUDAP

:

TEST OK

RESET

0

and the VacuDAP2004 measuring system switches to the MEASURE mode.

If the POWER-ON TEST failed the installation of the system has to be rechecked. Troubleshooting should be performed as described in Chapters 3.3.3, *TEST function* and 5.1, *Error codes and troubleshooting*.

2.5 Calibration test




After installation the calibration has to be tested at installation conditions; (see 4.4, *Checking the overall calibration*).

2.6 Installation and testing of accessories

Any accessories supplied with the system (e.g. a printer) are connected to the serial interface of the display unit with the associated cable (see 6, *Accessories and options*) which is plugged into the 5-pole socket of the unit. For any other installation work see the descriptions supplied with the respective equipment.

The correct installation of a printer can be verified by a test. For this purpose, the system must be set for the MEASURE function, i.e. the POWER-ON TEST was successfully executed.

Press key  for starting the test (see 3.3.6, *PRINT function*).

2.7 Stabilization time

The ionization chamber is a highly sensitive detector. After application of the chamber voltage, it needs some time to form and stabilize before the performance characteristics specified in the data sheet are met. This time is called stabilization time.



Unless otherwise specified in the data sheet for the ionization chamber, a stabilization time of 3 minutes is required.

The measuring system is ready for measurements before this time has elapsed.

2.8 Factory calibration

By means of a calibrated reference system (IEC 61674), the VacuDAP 2004 measuring system is calibrated by the manufacturer in line with IEC 60580:2000, and meets all specifications as detailed in the annexes.

The calibration is carried out at 70 kV, 100 mAs, with a 2.5 mm aluminium filter (total) and **without any additional absorber** in the beam path between the measuring chamber and the patient.



For a correct measurement of the dose area product, no additional accessories such as absorbers or beam limiting devices may be inserted in the beam path between the ionization chamber and the patient.



In case an absorber is permanently arranged between the ionization chamber and the patient, it needs to be taken into account in the dose area product measurement.

The display unit has two different calibration factors (CF_ABOVE , CF_UNDER), which can be selected by switching parameter $POSITION$ to either $ABOVE$ (above table, without absorber) or $UNDER$ (below table, with absorber). This selection is described in Chapter 3.3.9. *Changing of parameters*. The factory-set values for the calibration factors are shown in Table 7: *List of parameters*. The second calibration factor, CF_UNDER was determined with an additional 0.5 mm aluminium absorber for type tests (see annex: *Data sheet of ionization chamber*).

For regular switching between radiological examinations with and without absorber, the required calibration factor must be selected by switching parameter $POSITION$ accordingly.


By a **re-calibration** procedure authorized personnel can adjust the two calibration factors to the prevailing installation conditions; see the instructions in Chapter 4.4, *Checking the overall calibration*.

3 Operating instructions

3.1 General

The VacuDAP 2004 measuring system is used for measuring the dose area product (DAP), which is a direct measure of the radiation a patient is exposed to.

The measuring chamber is inserted in the collimator, or pushed into the accessory support at the radiation outlet end of the beam limiting device; it does not affect routine operation in any way.

As compared with measuring the incident radiation dose, the measurement of the dose area product allows the influencing variables, dose rate, irradiation time and field size used to be determined. The system measures the entire radiation received by the ionization chamber and accumulated within a time which is started by pressing .

3.2 Components and measuring principle

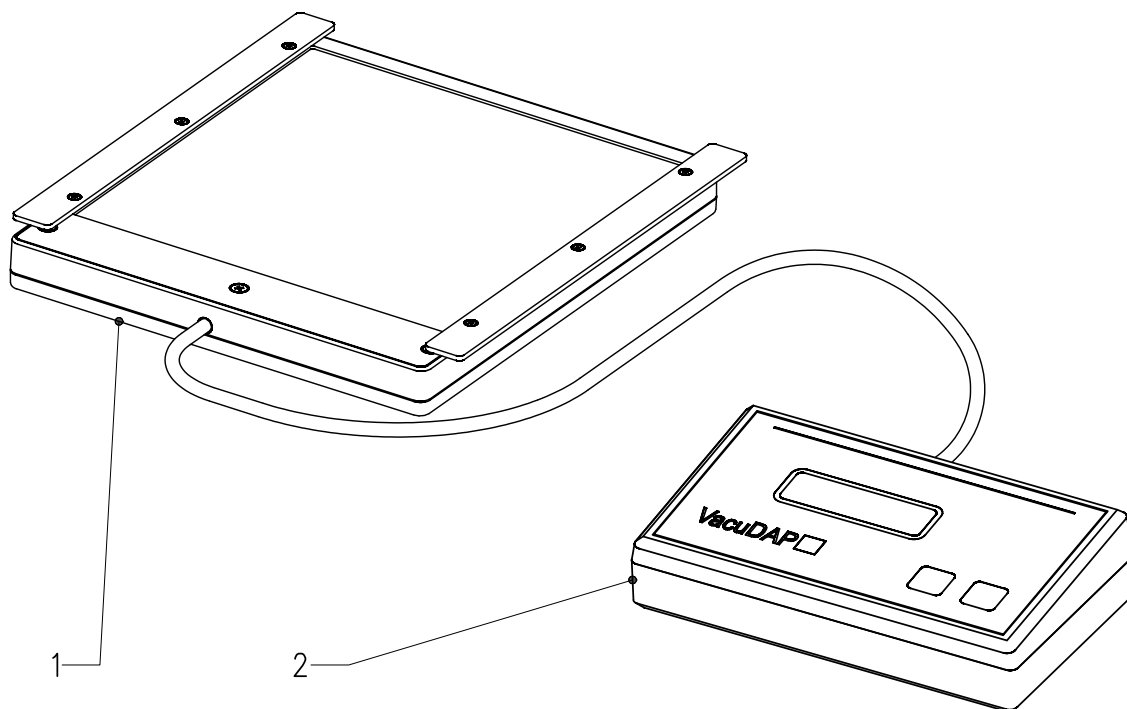


Fig. 1: Components of the VacuDAP 2004 measuring system

Within the ionization chamber (1), the X-rays produce charge carriers which are proportional to the product of dose and X-rayed ionization chamber area. The small measuring currents so generated are amplified and digitised by the integrated electronic components. The digital measuring signal is transmitted to the display unit (2) where it is further processed and displayed.

3.2.1 Ionization chamber

The transparent ionization chamber is intended for use on X-ray equipment with light beam diaphragm. It is of a very compact design. In addition it incorporates the electronic detector components which include, among others, the chamber voltage generator, a charge amplifier and a microprocessor.

A signal cable is used for transmitting the measuring signal to the display unit.



3.2.2 Display unit, connections and control elements

Display units can be supplied with different housings; see *Table 2*.

The following connections are found on the rear sides of the units:

- Input: voltage supply (plug-in power pack)
- Input (4-pole socket): measuring signal from the ionization chamber
- Output (5-pole socket): serial interface RS-232 (for printer or PC)

The measured values (in $\text{mGy}\cdot\text{cm}^2$) are displayed by a high-intensity, 8-digit LED display. The readout resolution of the standard system is $1 \text{ mGy}\cdot\text{cm}^2$, whereas that of the paediatry option is $0.1 \text{ mGy}\cdot\text{cm}^2$.

The measuring system is operated by using the two keys  and  on the keypad.

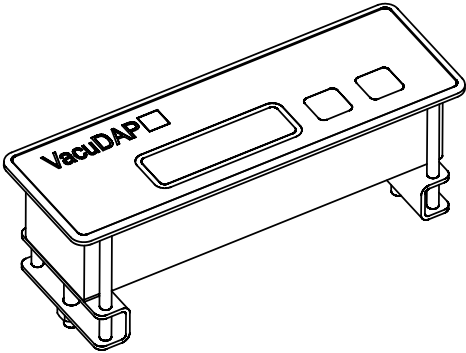
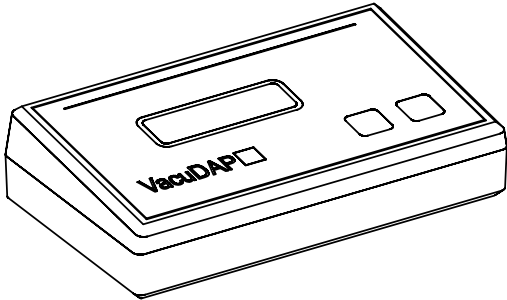
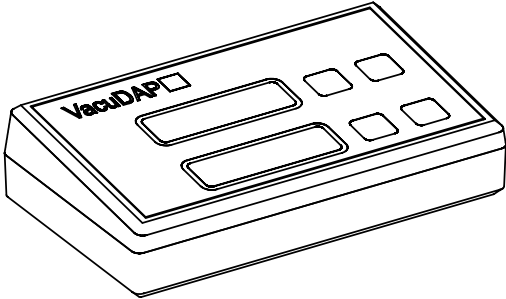
| | |
|---|--|
|  | <p>Built-in unit 952 00 02</p> <ul style="list-style-type: none">• for incorporation in operator consoles• sturdy, compact housing• RS-232 for printer or PC |
|  | <p>Table-top unit 953 00 01</p> <ul style="list-style-type: none">• standard unit• compact housing• RS-232 for printer or PC• alternatively, as wall-mounted unit (953 00 02) |
|  | <p>Table-top unit 956 00 01</p> <ul style="list-style-type: none">• for 2-channel measuring system• simultaneous, independent measurements• compact housing• common RS-232 for printer or PC |

Table 2: Display units

3.3 Operation

The VacuDAP 2004 measuring system may be operated by all persons who are authorized to operate medical X-ray equipment.

3.3.1 Schematic diagram

Figure 2 shows the program flowchart of the measuring system. The various functions will be described in detail in the following sections.

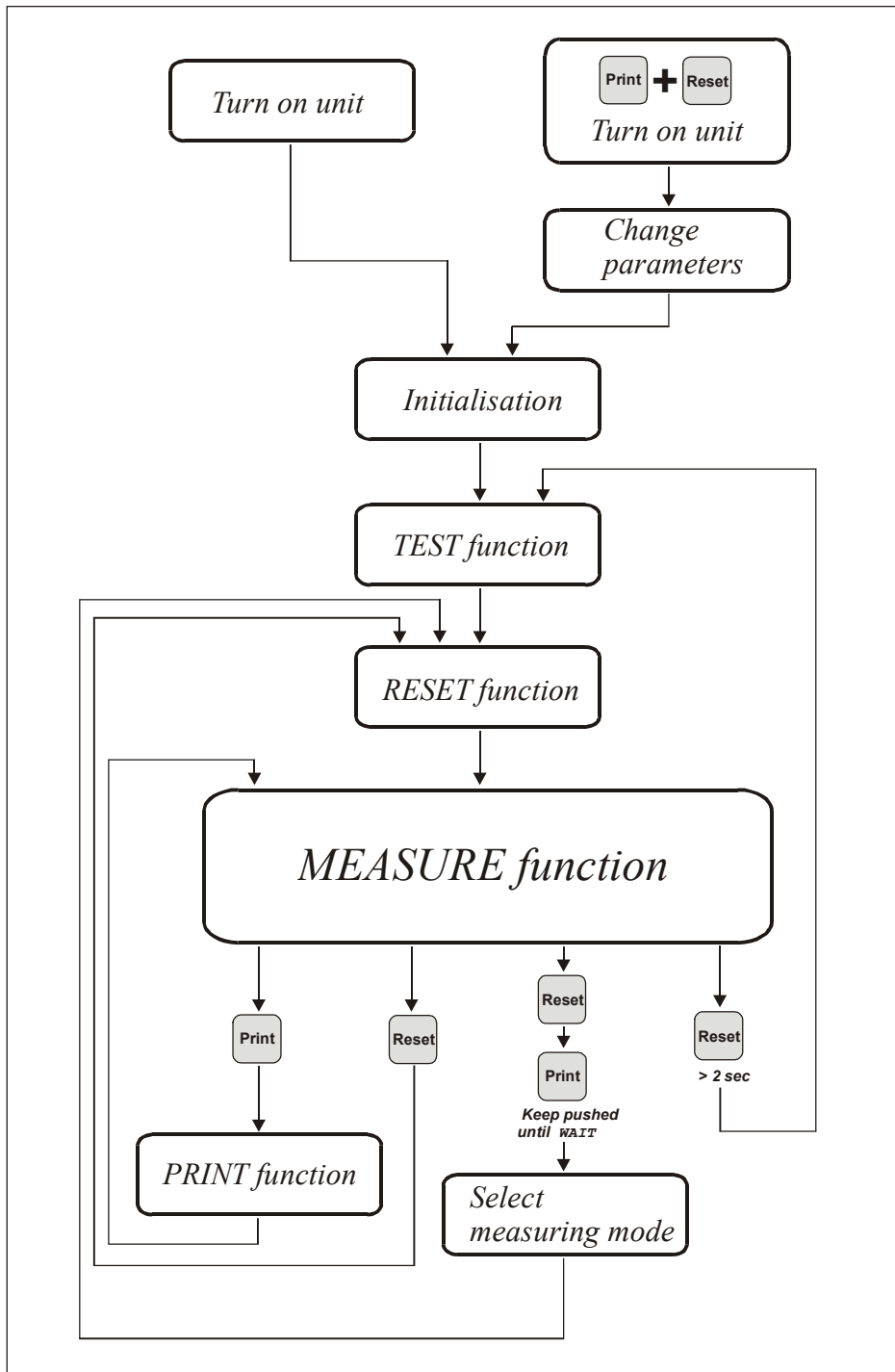


Fig 2: Program flowchart

3.3.2 Turning the unit on


The unit is turned on and the measuring system started when the operating voltage is applied. The following messages will appear on the display:

VACUDAP
9.6x
RADIOGRA
TEST

The software version (e. g. 9.6x) and measuring mode are displayed in this initialisation phase. In the example, the mode is set to radiography (RADIOGRA; see 3.3.8, *Selection of measuring mode*). This phase is followed by the POWER-ON TEST (see 3.3.3, *TEST function*).

3.3.3 TEST function

The system test can be started in two ways:

- Turn on the unit (POWER-ON TEST).
- Press key  and keep it pressed for at least 2 seconds (max. 4 seconds, thereafter abortion)

During the test, **all system components** including the ionization chamber are tested under measuring conditions. A $TEST_{ACT}$ value is determined and compared with a $TEST_{NOM}$ value. The $TEST_{NOM}$ value is ascertained in the course of the factory calibration, stored as a system parameter in the display unit, and entered in the calibration certificate handed over to the customer.

During the TEST function, the following data will be displayed:

TEST
11111111
22222222
:
00000000
WAIT 1s
yyyyxxxx
TEST OK
RESET
0

After a display test, the residual time of the TEST function (in seconds) is indicated (WAIT x s). The total time required for the system test is dependent on the chamber type; for the VacuDAP 2004, it is approximately 10 seconds.


At the end of the TEST function, the determined $TEST_{ACT}$ value (flashing, represented by xxxx) is compared with the $TEST_{NOM}$ value (represented by yyyy). The system has passed the test (TEST OK) if the $TEST_{ACT}$ value lies within a given tolerance range. Upon completion of the automatic RESET function, the VacuDAP 2004 is ready for measurements (MEASURE function).

If the TEST_{ACT} value is outside the tolerance range without affecting the MEASURE function the display will show WARNING. During the MEASURE function the last digit is flashing to indicate the warning state. To cancel the warning call the TEST function again after the stabilization time (see 2.7 *Stabilization time*).

In case of a trouble, an error message is displayed which includes the measured TEST_{ACT} value (which is represented by xxxx):

ERR : xxxx

The system set-up should be checked and the system test repeated if the TEST function could not be correctly carried out. See Chapter 5.1, *Error codes and troubleshooting* for a list of error codes and information on how to eliminate troubles.

When the TEST function is called after the stabilization time (see 2.7 *Stabilization time*) of the system by pressing the  key the complete measuring system with all components is tested as it is done by the POWER-ON-TEST. The tolerance range for deviation of TEST_{ACT} and TEST_{NOM} value is ±2 % in accordance to IEC 60580.


3.3.4 MEASURE function

The measuring system is ready for performing the MEASURE function when a figure is displayed on the display unit. For example, a zero is displayed upon the correct completion of the TEST function (standard version):

0

For the paediatry option the display shows:

0.0

Upon activation of the MEASURE function, the system starts to measure all X-rays incident as from the last pressing of key .

The digital measuring signal of the measuring chamber is transmitted to the display unit where it is multiplied by a calibration factor (see 2.8, *Factory calibration*). The choice of the calibration factor (CF_{ABOVE} or CF_{UNDER}) used for the calculation of the dose area product depends on parameter POSITION (see Table 3). Chapter 3.3.9, *Changing of parameters*, describes how the parameters can be changed.


| POSITION | Effective calibration factor | Notes |
|----------|------------------------------|--|
| ABOVE | CF _{ABOVE} | Standard conditions (above-table installation) |
| UNDER | CF _{UNDER} | Use of additional absorber (below-table installation) |

Table 3: Calibration factors




For the correct measurement of the dose area product, the MEASURE function must have been activated. **Inactive states** are indicated by the respective displays (e.g. RESET).


3.3.5 RESET function

The RESET function is activated - i.e. all internal measured data memories are cleared and the display is reset to 0 - by briefly (< 2 s) pressing .


Thereafter, the MEASURE function is carried out (see 3.3.4, *MEASURE function*). The RESET function can be considered to be the START signal for the MEASURE function.



The RESET function is recommended to be called up before any measurement.

Also, any displayed error messages can be cleared by pressing the  key (see 5.1, *Error codes and troubleshooting*).

3.3.6 PRINT function

Pressing key  causes the printer, which is connected to the serial interface (RS-232), to put out the relevant data. A typical printout is shown in *Figure 3*.

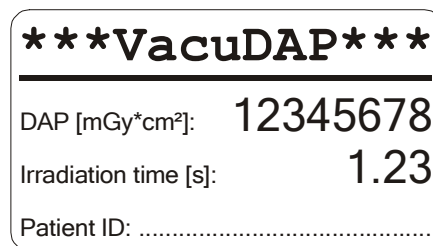


Fig. 3: Printout with label printer AXIOHM, English

It is also possible to send the measured data - in the form of ASCII characters - to a PC. To do this, parameter `PRINTER` must be set accordingly (see *Table 4*). A special interface cable is required for the purpose (see 6, *Accessories and options*).

The type of data printout is preset. Parameter `PRINTER` can be used for selecting the printout type (ASCII protocol or printer type and language); see 3.3.9, *Changing of parameters*. When sent to a PC (Parameter `PRINTER` = 0 or 1) the measured data will be separated by a tabulator (Tab). The respective units of measurement are shown in *Table 4* in square brackets ([...]).

| PRINTER | Printout in file (PC) |
|----------------|---|
| 00 | DAP [mGy*cm ²] Tab DAP power [Gy*cm ² /s] Tab irradiation time [s] |
| 01 | DAP [mGy*cm ²] |
| | Printout with printer |
| 1x | Printer SEIKO (thermal printer), printer EPSON (dot matrix) |
| 2x | Lable printer DYMO |
| 3x | Label printer AXIOHM |
| x1 | Printout in German |
| x2 | Printout in English |
| x3 | Printout in French |
| x4 | Printout in Spanish |
| x5 | Printout in Italian |

Table 4: `PRINTER` parameters

For the example shown in *figure 3* the parameter `PRINTER` has to be set to 32.

Should the measured data be sent to a PC, the serial interface of the computer must be configured as shown in *Table 5*.

| | |
|-----------|-------|
| Baud rate | 9 600 |
| Data bits | 8 |
| Stop bits | 1 |
| Parity | none |
| Printout | none |

Table 5: RS-232 settings (COM)

3.3.7 Remote control

It is possible to control the measuring system from a PC and transmit the measured data to the PC via the serial interface (RS-232). The software for the computer is offered under accessories (see 6, *Accessories and options*). Also available is a detailed description of the interface module.

3.3.8 Selection of measuring mode

In order to meet the different requirements encountered in radiographic and fluoroscopic applications, the VacuDAP 2004 measuring system allows two measuring modes to be set (see *Table 6*).

| Measuring mode | Display | Readout during RESET function | Displayed value during radiation | Display interval |
|----------------|----------|-------------------------------|----------------------------------|------------------|
| Radiography | RADIOGRA | RESET | DAP | 0.5 s |
| Fluoroscopy | FLUOROSC | RESET FL | DAP rate | 1.0 s |

Table 6: Measuring modes



While the radiographic measuring mode (RADIOGRA) is best suited to short irradiation times and high DAP power levels, the fluoroscopic mode (FLUOROSC) should be selected when long irradiation times and low DAP power levels prevail.

In the fluoroscopic mode the dose rate product is displayed during radiation. The measuring value is displayed in the measuring unit mGy*cm²/s. In order to distinguish between the measuring values DAP and DAP rate for the DAP rate the appendage "/s" is shown:

123456/s


If DAP value stops increasing the display switches automatically to the accumulated DAP value and the appendage "/s" isn't displayed any longer.

Changing from one mode to the other is explained with reference to the program flowchart (see *Fig. 2*). To change the mode, the measuring system must be set to the MEASURE function.

1. Press key .
2. Press  during RESET (or RESET FL) and **keep pressed** until WAIT appears.

Thereafter, the newly set measuring mode is displayed (see *Table 6*), and the RESET function is carried out.

3.3.9 Changing of parameters

 Parameters or settings may only be changed by authorised persons and after carefully reading the respective chapters of these operating instructions.

By changing settings and parameters of the display unit, the measuring system can be adjusted to individual measuring conditions.

Table 7 lists all parameters and settings with their factory-set values and permissible ranges.


| Parameter | Factory setting | Setting range | Notes |
|----------------------|------------------|---------------|---|
| CHAMBER ¹ | 10 | 00 - 19 | Chamber type (VacuDAP 2004: 10) |
| TEST_VAL | 275 ² | 50 - 9999 | TEST _{NOM} value (as in calibration certificate) |
| POSITION | ABOVE | ABOVE, UNDER | Position of measuring chamber |
| CALIB | | | Changing calibration |
| CF_ABOVE | 1.00 | 0.50 - 1.75 | Calibration factor, above table |
| CF_UNDER | 0.85 | 0.25 - 1.50 | Calibration factor, below table |
| PRINTER | 12 ³ | 00 - 99 | Printer type |
| DEFAULT | | | Reset to factory settings |

¹ not available for paediatry option


² Example; depends on measuring chamber (see *calibration certificate*)

³ Example; depends on printer type and language (see *table 4, PRINTER parameters*)

Table 7: List of parameters

 Parameter CHAMBER is set to 10 for the VacuDAP 2004 measuring system and must not be changed!

In other system configurations (e.g. VacuDAP 2002) the chamber type (CHAMBER) is used to adjust the display unit to different ionization chambers. For the VacuDAP 2004 measuring system it has to be set to 10.

 Parameters POSITION, CF_ABOVE and CF_UNDER have a decisive influence on the indicated value of the measuring system.

As shown in the program flowchart (Figure 2), the parameter changing menu

SETTINGS

can be accessed by **simultaneously** pressing



and applying the supply voltage (plugging the power pack connector into the socket of the display unit).

For the further operations see the program flowchart *Figure 5, Changing settings*.

Figure 4, Changing a parameter, shows how the value of a parameter can be changed (example: entering a new test value TEST_VAL). Parameter TEST_VAL is required to be changed when the ionization chamber of the measuring system needs to be replaced (e.g. for repair work).

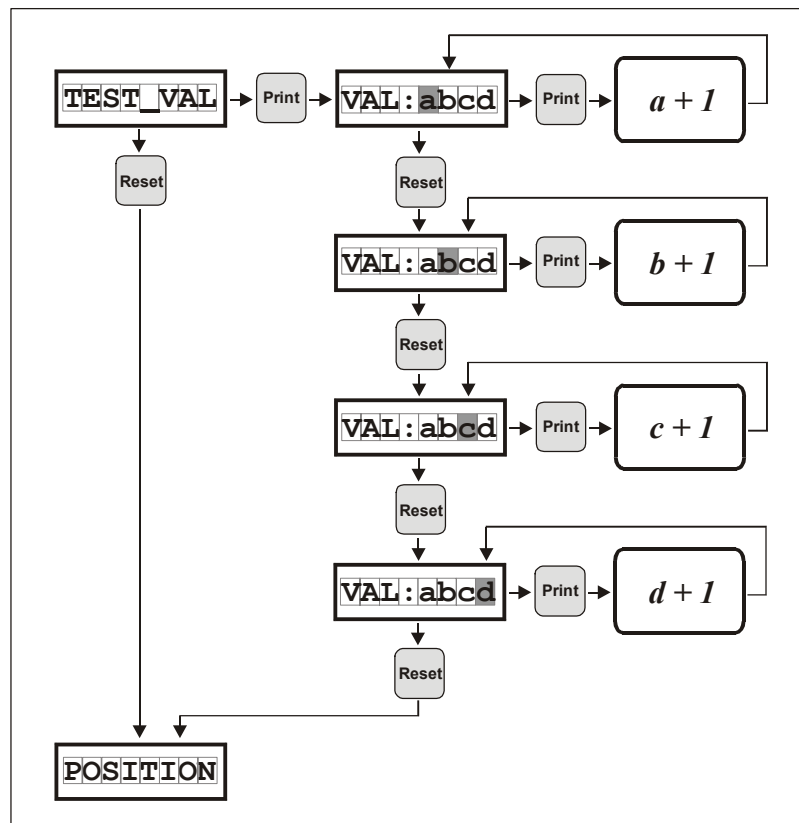




Fig. 4: Changing a parameter (example: TEST_VAL)

During the process, the digit, which flashes, i.e. a (in Fig. 4: grey), can be changed. Pressing  increases the digit (1, ... 9, 0), while  selects the next digits b, c and d.



Changed Parameters have to be saved with **SAVE** (see *Fig. 5, Changing settings*), otherwise they will be ineffective.

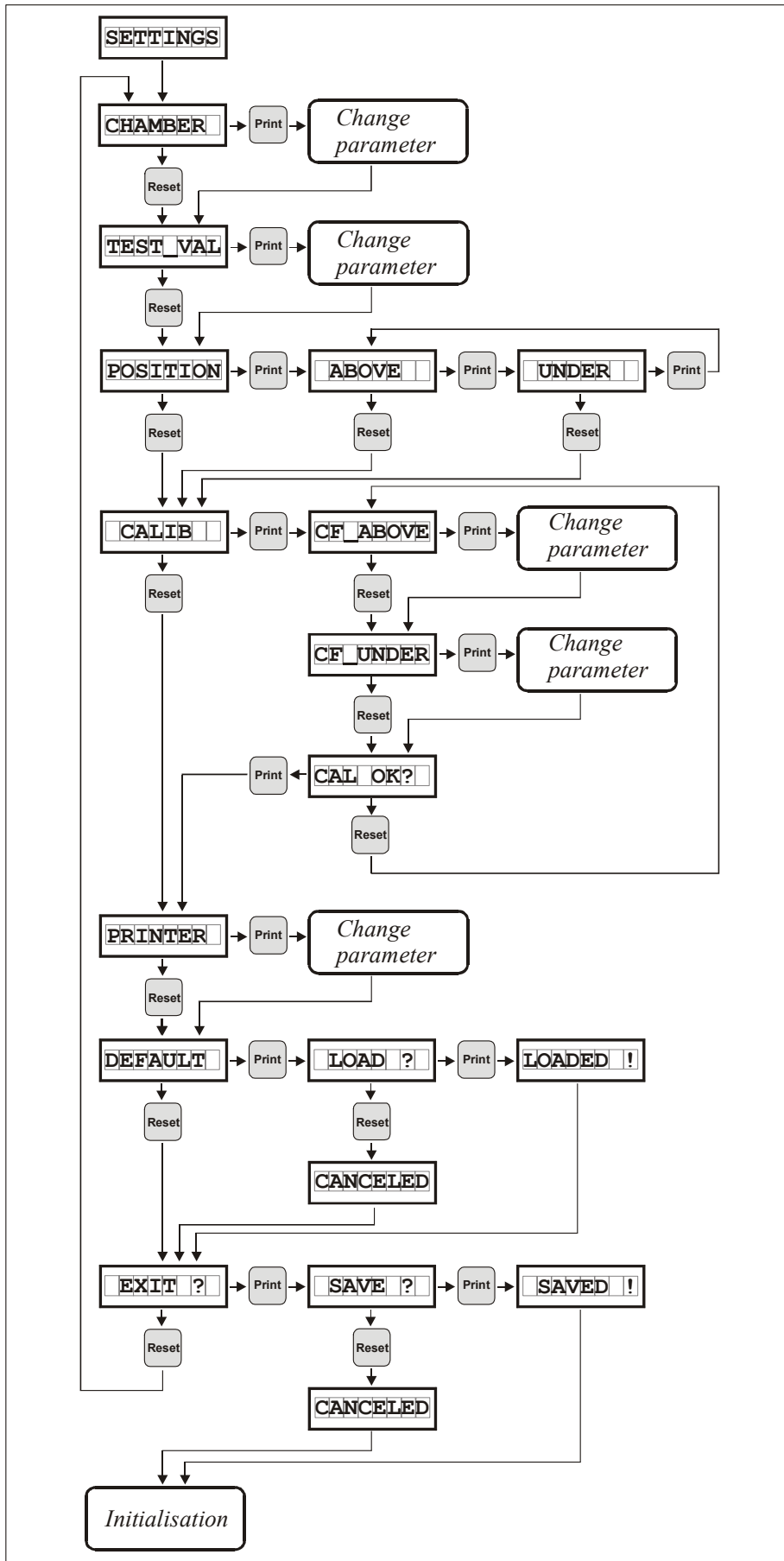


Fig. 5: Changing settings

4 Preventive maintenance and checks/tests

4.1 General

Under normal operating conditions, the air-open ionization chamber and the display unit are not subjected to any wear.

In the interest of a high measuring accuracy, the operational reliability and serviceability of the system shall be checked within the framework of the X-ray equipment maintenance which is required to be performed at certain intervals (RöV, X-ray Ordinance). During such checks, the patients' leakage currents must be measured.

4.2 Stability test

Regularly, the stability of the entire system is automatically tested during the POWER-ON TEST. When it is necessary, the test can be repeated in the MEASURE function phase by calling up the TEST function (see 3.3.3, *TEST function*).

4.3 Checking the indicated values for drifting

A drift check of the indicated values can be made after the stabilization time (see 2.7, *Stabilization time*) as follows:

1. Call up the RESET function (see 3.3.5, *RESET function*).
2. With typical X-ray equipment settings, direct a defined radiation on the measuring system.
3. Wait 3 seconds, then note down the indicated value.
4. Leave the measuring system in the MEASURE mode for a rest period of at least one hour, without exposing it to radiation.
5. After this time, read the value a second time and compare it with the first value.

For every hour of the rest period, the second value may deviate from the first value by a maximum of 1 mGy*cm² (0.1 mGy*cm² for paediatry option).

If the deviation is greater and cannot be reduced even after drying the ionization chamber at max. 50°C, have the measuring chamber checked by the manufacturer (see 5.2, *After-sales service and repairs*).

4.4 Overall calibration test

Before its delivery, the VacuDAP 2004 dose area product measuring system was calibrated in line with IEC 60580 by means of a calibrated reference unit (IEC 61674); see 2.8, *Factory calibration*).



The overall calibration test of the measuring system should be made every two years at the latest.



It is recommended to record all testing conditions, measured data and calibration factors.

In checking the calibration of the measuring system, the dose area product is determined as the numerical product of the cross-sectional area of the useful beam and the dose measured in the cross-sectional plane (air kerma), with the variables measured successively at the same distance from the focal spot. The dose area product so measured is compared with the indicated value on the VacuDAP 2004.

When doing this, the following requirements should be met:

- Adjust the field size of the useful beam at a suitable focal distance (e.g. bucky table) to approx. 10 cm x 10 cm.
- Expose the X-ray film (without a supporting foil, where possible) to the radiation at this focal distance (high contrast, optical density ≤ 0.5).
- Measure the dose (air kerma, K') in the centre of this field at an uncertainty of $\leq 5\%$ (keep the influence of back scattering as low as possible).
- Set the X-ray equipment to 70 kV; (20-100) mA.
- Make the test with the VacuDAP 2004 measuring system completely installed.



If measurements are made both with and without an absorber (see 2.8, *Factory calibration*), the test and, where necessary, re-calibration must be made separately for the two calibration factors.

Provided the above requirements are satisfied, the following test procedure can be applied:

1. Measure the room temperature T and the atmospheric pressure p .
2. Find the correction factor for the air density $k_\rho = f(T, p)$ (see data sheet).
3. Expose and process the X-ray film, and accurately measure the field edge lengths $l_1; l_2$.
4. Measure the dose K' in the same plane as in the previous exposure of the film, and simultaneously determine the dose area product $K \cdot A$ using the installed VacuDAP 2004 measuring system.
5. Calculate the reference value for the dose area product $K' \cdot A'$ from:

$$K' \cdot A' = K' \cdot l_1 \cdot l_2 \quad ; \text{ where } K' \dots\dots \text{dose (air kerma) in mGy}$$

$$l_1; l_2 \dots\dots \text{edge length of exposed area in cm}$$

6. Determine the deviation, F , of the indicated value $K \cdot A$ from the reference value $K' \cdot A'$:

$$F = \frac{k_\rho (K \cdot A)}{K' \cdot A'} \quad k_\rho \dots\dots \text{correction factor (see data sheet)}$$

If the deviation does not exceed $\pm 10\%$, i.e.: $0.9 \leq F \leq 1.1$, a re-calibration is not necessary.

If the deviation is greater, calculate the new calibration factor, CF_ABOVE_{new} (or CF_UNDER_{new}) as follows:

$$CF_ABOVE_{new} = \frac{CF_ABOVE_{old}}{F}$$

The old calibration factor CF_ABOVE_{old} (or CF_UNDER_{old}) can be read from the display, when the display unit is in the parameter changing menu (SETTINGS, see 3.3.9, *Changing of parameters*) at the appropriate step (CALIB, CF_ABOVE , see fig. 5, *Changing settings*). If necessary, the new calibration factor can be entered there as well.



After the calibration factor has been changed, the calibration must be re-checked.

5 Troubleshooting

5.1 Error codes and troubleshooting






| Error code | Meaning | Hints for troubleshooting |
|----------------------------|---|--|
| Last digit flashing | <ul style="list-style-type: none"> Warning state (TESTACT value outside tolerance range without affecting MEASURE function) | <ul style="list-style-type: none"> Call TEST function again after stabilization time |
| ERR: 0 | <ul style="list-style-type: none"> No signal from measuring chamber No supply voltage Signal line defective | <ul style="list-style-type: none"> Check signal line between measuring chamber and display unit Connect measuring chamber directly (without signal line) to the display unit; repeat TEST function |
| ERR: 10 | <ul style="list-style-type: none"> Measuring chamber defective | <ul style="list-style-type: none"> Measuring chamber must be repaired (see 5.2. After sales services and repairs) |
| ERR: xxxx | <ul style="list-style-type: none"> TEST_{ACT} out of tolerance range | <ul style="list-style-type: none"> Check if the TEST value in the calibration certificate agrees with parameter TEST_VAL (see 3.3.9, Changing of parameters). Repeat TEST function after drying the measuring chamber (at max. 50°C) Measuring chamber must be repaired (see 5.2. After sales services and repairs) |
| ZC-ERROR | <ul style="list-style-type: none">  was pressed during exposure Chamber leakage current too high | <ul style="list-style-type: none"> Repeat  without irradiation Repeat RESET function after drying the measuring chamber (at max. 50°C) Measuring chamber must be repaired (see 5.2. After sales services and repairs) |
| HV-ERROR | <ul style="list-style-type: none"> Chamber voltage failure | <ul style="list-style-type: none"> Press  If failure occurs again measuring chamber must be repaired (see 5.2. After sales services and repairs) |
| OVERFLOW | <ul style="list-style-type: none"> Measuring range is exceeded (DAP > 99 999 999 mGy*cm²) | <ul style="list-style-type: none"> Press  |
| BAD TYPE | <ul style="list-style-type: none"> Wrong printer type selected | <ul style="list-style-type: none"> Check if parameter PRINTER agrees with one of the values in table 4: PRINTER parameters (see 3.3.9, Changing of parameters). |
| Display flashing | <ul style="list-style-type: none"> Max. DAP power level is exceeded (see annex: data sheet of ionization chamber) | <ul style="list-style-type: none"> !!! Indicated value is <u>lower</u> than actual value !!! Check if correct chamber type is set (CHAMBER: 10) Press  |

Table 8: Error codes

5.2 After-sales service and repairs

In the case of malfunctions, only the manufacturer or authorised after-sales service personnel are entitled to do any diagnostic and, where necessary, repair work on the system. The maintenance instructions required for the purpose will be made available to them.

For inquiries please have the following data at hand:

- Order-No. of measuring chamber and display unit (see device affixed label)
- Serial number of measuring chamber and display unit (see device affixed label)
- TEST_{NOM} value (displayed on the left at the end of the TEST function)
- TEST_{ACT} value (displayed flashing on the right at the end of the TEST function)

If defective systems or components must be returned to the manufacturer, they should be sent in their original or equal packing and together with a description of the defect.

6 Accessories and options

Among others, the following accessory equipment and options are offered for the VacuDAP 2004 measuring system.

| Designation | Order-No. | Notes |
|-----------------------------------|-----------|--|
| DAP chamber type 70157 | 157 00 95 | Paediatry Option for paediatric methods (10 times higher response) |
| Guide pair 170 | 157 00 41 | Width 170 mm |
| Guide pair 175 | 157 00 42 | Width 175 mm |
| U-guide pair | 157 00 38 | Width 140 mm |
| U-guide pair | 157 00 39 | Width 147 mm |
| Universal adapter | 157 00 74 | Adjustable width 142-188 mm |
| Adapter | 157 00 79 | Adapter made of plastics (width 176 mm) with additional slide-in for paediatric filter |
| Power supply | 950 00 57 | with plug: EURO |
| Power supply | 950 00 51 | with plug: UK |
| Power supply | 950 00 59 | with plug: North Amerika/Japan |
| Display unit 70 952 | 952 00 02 | Built-in unit |
| Display unit 70 953 T | 953 00 01 | Table-top unit (standard) |
| Display unit 70 953 W | 953 00 02 | Wall-mounted unit |
| Counter unit DAPmeter 70 954 | 954 00 01 | without display and keys; with RS-232 |
| Counter unit DAPmeter 70 954 | 954 00 02 | without display and keys; with RS-485 |
| Display unit 70 956 | 956 00 01 | Table-top unit for 2-channel measuring system |
| Printer SEIKO | 950 00 02 | Thermal-printer; Type: DPU 414 |
| Printer cable SEIKO/AXIOHM | 952 00 40 | Standard length 2.5 m (max. 15 m possible) |
| Printer EPSON | 950 00 03 | Dot-matrix-printer; Type: TM-U210D |
| Printer cable EPSON | 952 00 44 | Standard length 2.5 m (max. 15 m possible) |
| Label writer DYMO | 950 00 04 | Label-Writer; Type: SE 300 |
| Labels | 950 00 05 | for Label writer DYMO (DYMO-99014: 1 roll, 220 pieces; 101 x 54) |
| Printer cable DYMO | 952 00 46 | Standard length 2.5 m (max. 15 m possible) |
| Label writer AXIOHM | 950 00 07 | Label-Writer; Type: A 711 |
| Labels | 950 00 08 | for Label writer AXIOHM (DYMO-11354: 1 roll, 1000 pieces; 57 x 32) |
| Interface cable RS-232 | 952 00 41 | for data transfer to PC, standard length 2.5 m (max. 15 m possible) |
| Interface cabel RS-232 for 70 956 | 956 00 41 | for data transfer to PC with display unit 70 956, standard length 2.5 m (max. 15 m possible) |
| Software DAP-Monitoring | 950 00 20 | Data display and storing with PC (remote control from PC) |
| Software DAP-Storing | 950 00 21 | Data storing with PC |

Table 9: Accessories and options