

1 General

The newly developed RaTec Hand Foot Clothing Monitor HFK1 serves the recording of surface contaminations of hands and feet. With the help of a clothes detector (option) clothes or other surfaces can be measured manually.

HFK1

- was developed above all as a **compact and inexpensive system** for laboratory use
- has outstanding characteristics, it is **easy to handle**, very user friendly and it comes in a **robust construction** for a rough and demanding everyday business
- **meets without restriction all modern requirements**, which are put to a hand foot clothes monitor in accordance to international or national radiation protection laws
- represents a modern synthesis between **approved detector technology and high tech electronics**
- was developed by a team of professionals on a basis of more than 20 years of practical experience in development, construction, production and business of contamination monitors
- **differentiated calibration possible:**
 - counts / s (net, background subtracted)
 - or **Bq / cm²** "surface related contamination" [on 100cm²]
 - or (e.g.) **pCi / cm²** 'surface related contamination' [on 100cm²]
 - or (e.g.) **nCi / inch²** 'surface related contamination'
- **every single detector can be calibrated separately:** 16 fixed calibrations on the most common nuclides, 8 sets of calibration independently programmable by user
- provides **programmable alarm thresholds for each detector:** 16 pre-determined thresholds (e.g. 0.37 / 0.5 / 3.7 / 5.0 / 37 / 50 [Bq/cm²] [units])
8 free for user (e.g. 0.01... ..9,999.99 [Bq/cm²] [units])
- equipped with an especially **large area detector for hands** (2 * 500 cm²)
- „problem areas“ e.g. wrists and cuffs, are detected automatically



HFK-1

- advantage: **clearly better sensitivity as comparable products**, working mostly with smaller detectors of only approx. 2 * 250cm²
- **identical detector types for hands and feet**, simpler reserve stand of spare parts
- stores all calibrations and parameters non volatile

2 Electronics concept

The electronics concept is based on one of the most modern and safe field bus systems, the "**CAN-Bus**", which is based on a multi-master microprocessor technology. CAN dominates the modern motor vehicle technology for several years now due to the perfect combination of inexpensive components, extreme reliability and high capability.

Each detector with the HFK1 carries an "intelligent" CAN-Bus-knot, which provides the autonomous storage of detector specific parameters and calibrations, e.g., the control of the ratemeter functions, high voltage and communicates with the central "display-knot".

The "CAN-display-knot" contains the LC-display, the keypad control and main LED status signals as well as the acoustic alarms. All useful information is shown on an illuminated graphic LC-display, for example the measurement countdown.

On standard applications the RaTec HFK1 can be operated extremely simply and is easy to setup. For detailed calibrations, function-tests, plateau plots, creating detailed protocols, etc. There is a IRDA interface for wireless communication with host computers. (IRDA = InfraRedData exchange, a serial data transfer with infrared interface, well known with modern laptops, palmtops as well as "Organizers".)

3 Technical data

width:	38cm	~15 inches
depth:	70cm	~30 inches
standing depth :	75cm	~32 inches
height:	160cm	~63 inches

The height of the hand detector is adjustable by means of simple tools. Hereby, the monitor can be adjusted ergonomically to the average body size of the laboratory personnel.

power:	110V~/120V~230V ~ approx. 40VA,	stand-by,,: approx. 25VA;
cos -phi:	approximately 0,9	
weight:	approximately 36kg	

4 Detectors

- **Hand and foot detector: RXD 1000T**
Size: 394 * 310 * 24 mm, height incl. electronics: 57 mm
Surface, effective: 1000 cm² (~155 sq. inch)

Detector window: Titan foil, approximately 15µm, surface weight: approximately 6.75mg/cm². Foils are also available in 10µm

- Clothes probe: (Option) RXD 270
Size: 258 * 162 * 24 mm, height incl. electronics: 57 mm
Surface, effective: 270 cm² (~42 sq. inch)
Detector window: Titan foil, approximately 10µm, surface weight approximately 4.5mg/cm². Foils also available in 15µm
- Each detector is equipped with a framed protection grill;
transparency: approximately 83%; additional contamination protection with additional mylar foil is possible; weight=0.8mg/cm²

5 Hardware components

On the reverse of detectors, the CAN-Bus electronic is installed, which contains the twin discriminator and a high voltage generator. The CAN-processing unit, an 8-bit single chip microprocessor controls the high voltage and counts the detector signals recognized by the discriminator by two 16-bit-counters in 2 ms cycle times.

The communication with the other CAN-bus knots and the power supply are connected via the CAN-bus connectors. CAN-bus is totally galvanically insulated, by means of optocouplers. Bus connection is made by Sub-D connectors.

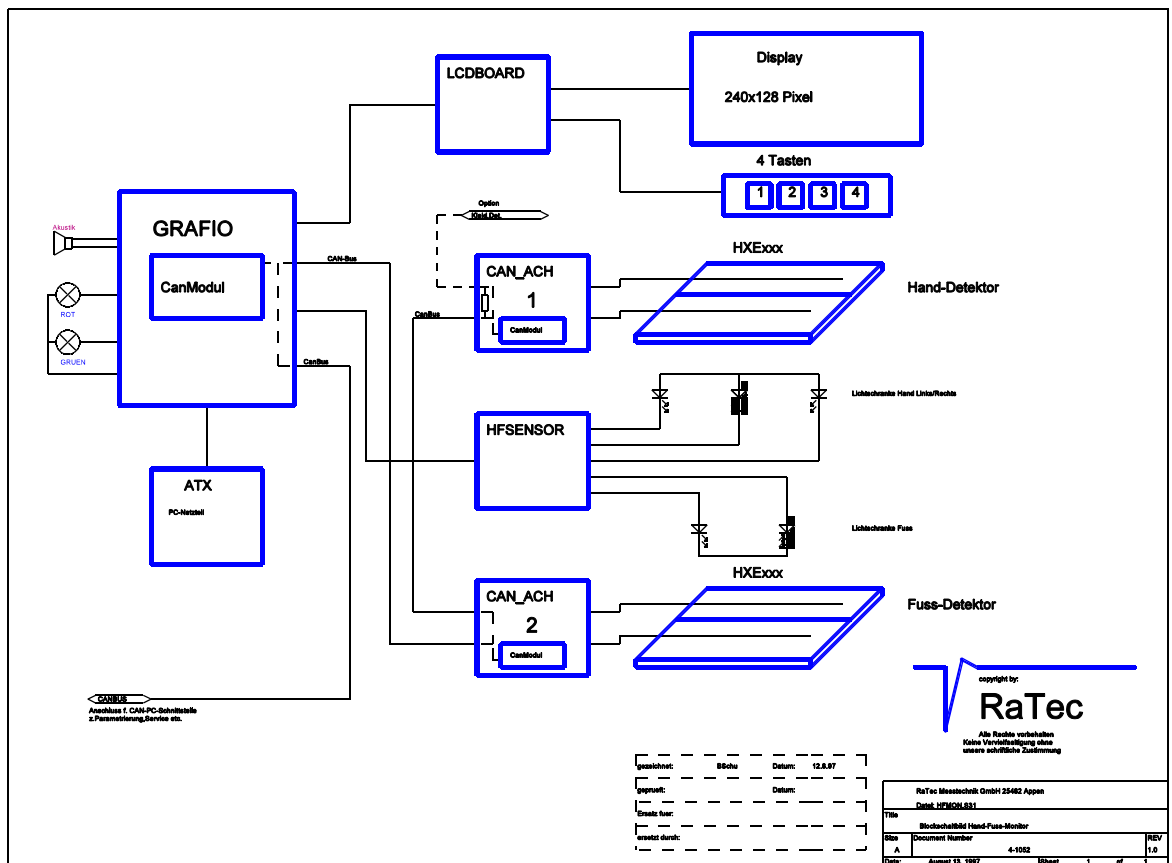
HFK-1 parameters can also set up using the PC with distances up to 100m. In this case the PC is equipped with a CAN-PC-interface.

The central knot (so called "GRAFIO" unit) consists of a module, that acts as the interface to binary signals and connects the LC display and the 4 key buttons keypad for setup and service functions.

The display unit contains a graphics-capable, illuminated LC-Display with 240 x 128 pixel and a keypad connection. The illumination can be switched on/off via software.

For power supply, a standard PC-ATX-power supply is used, easily matching all national safety requirements.

Principle of hardware and operation



6 Short Description

6.1 Detectors / Meter Channels

So called "twin-detectors" are employed as hand and foot detectors. Two measuring surfaces are integrated in a common casing dividing the casing at the longest axis, which allows separate measurement and analysis of both detector halves. This makes individual output and display of values for the right and left hand possible.

After switching on, the HFK-monitor automatically takes on the status

Ready-to-measure

This requires correctly set parameters and perfectly working detectors. A status line on the HFK-monitor display shows the current device status in an inverse view. In addition a green or red visual indication in the front panel indicates the monitor's state.

The HFK-monitor can take on 2 states of

Readiness for Measurement:

With the message in the status line

READY-TO-MEASURE

or during

MEASURING

In both cases the light indicates "**ready**" = green.

Ready-to-measure-status is reached after completing the first background measurement unless there is no interference with the detectors and the measurement is not interrupted, e.g. by entering the monitor.

The display may show possible errors in plain text messages.

The current background counts are calculated mathematically with the aid of digital filters using the measured data. The filter's attenuation characteristics are set using the "attenuation factor"-parameters (T_{NE}). The current background values are delayed with a shift register first. Therefore a filtered background value delayed by the time interval (t_{retard}) can be used for personal measurement. This feature is essential for suppressing potential influences on the background value in the case of extremely contaminated persons approaching.

When stepping onto the foot pedestal the monitor's status switches to **MEASURING**. However, measurement only starts after activating the hand light barriers.

After completing measurement the determined background values are subtracted from the gross measurement value while again using digital filters with individual time constants (T_{Mess}). Each channel's net value calculated this way is compared with the individual alarm thresholds.

When exceeding one or several thresholds a warning is generated. In addition to a plain text display an acoustic sound is generated and the red visual indication "**alarm**" is set.

In order to identify potential detector-malfunctioning the counting rates are checked on minimum or maximum thresholds even during measurement. This is also done during background measurements.

During nuclide specific calibration of the device, values are converted in Bq/cm² with the help of the individual detector's calibration factors. According to international radiation protection standards the conversion basis refers to 100cm².

The result is displayed in Bq/cm².

7 Menu Structure and Views

The HFK-monitor program starts automatically when switched on. It automatically goes from the main menu to the "MEASUREMENT" option and starts the background measurement in order to get ready for measuring.

7.1 Selecting Operational and Test Menus

When pressing the "▽" and "Δ" keys together the main menu is displayed. Using the up and down arrow keys you can access the different service functions. Selecting "OK" starts a function or the respective submenu.

You can exit a menu by pressing "Esc". After waiting for 5 minutes the program switches automatically to the <Measuring> menu. When using a key in the meantime the waiting time is prolonged again by 5 minutes.

7.2 Measurements

7.2.1 Personal Measurement

The device status switches from "READY-TO-MEASURE" to "MEASURING" when stepping onto the foot detector or putting your hand on the hand detector which triggers a foot light barrier or a twofold hand light barrier.

"MEASURING" displayed in the status line indicates the beginning of the measurement. At the same time the measuring countdown starts and sounds an acoustic signal every second.

During the measuring the light barriers for hands and feet are monitored.

The measuring time is interrupted when the correct position of hands or feet is abandoned. A message is shown in plain text asking to correct the position. Measurement is pursued when the indicators are active again, however, when abandoning the foot detector measurement has to be restarted.

After finishing measurement the message "No contamination" or "Contamination" appears, indicating location and value of the contamination. The measurement result can be viewed as long as foot and hand detectors are active.

Then the HFK-monitor is ready-to-measure again, the following background values are now rejected for 30s. This is to avoid faulty background measurements due to (contaminated) persons being around. After this measurement break the HFK-monitor automatically continues the background update as long as no detectors are activated.

After a certain waiting time without personal measurement the LCD back lighting is switched off which reduces the monitor's power consumption.

7.2.2 Clothing Measurement

OPTIONAL The device can be furnished with a flexible clothing detector (RXD270). This allows measurement of wider surfaces, parts of the body, and so on. When withdrawing the detector off the mounting the mode "MANUAL" is selected automatically. This mode is independent of personal measurement.

7.2.3 Status "NOT READY-TO-MEASURE"

When the HFK is switched on the device is "NOT-READY-TO-MEASURE" in the first place since the latest background has to be determined for each meter channel. While the background values settle down after filtering, the parameterizable background measuring time expires. It displays as a value with T:xxx in the display. If there is no interference the green visual indication "Ready" is activated.

If due to an error the HFK is no longer ready to measure the green light is extinguished and the cause of error is displayed in plain text. In the status line the message "CAUTION" in alternation with "NEW BACKGROUND MEASUREMENT" is displayed. This is to try to reach a valid measuring status. When the error is eliminated the monitor reaches the status "READY-TO-MEASURE" again after passing one background measuring time.

7.2.4 Backgrounds

In normal operation in "READY-TO-MEASURE" state the single channel background measurement values are continually transferred to a shift register after passing through the recursive digital filter.

The main menu provides the option <Backgrounds> for controlling the background values used in "MEASUREMENT" for calculating the net values. The background values shown there are updated every second synchronically to shift register transferal.

To inform about the background measurement's update status, i. e. whether the digital filters are properly "settled down", the background measuring time countdown displays when a new measurement starts. Pressing "New" the old filter values are rejected, the state ready-to-measure is revoked, and a new background measurement phase starts. During the filter's settling down a countdown is displayed.

An active sensor (foot or hand) interrupts updating or background computing.

After the measuring time has expired the state ready-to-measure is reached again, if no errors were detected.

As a "sign of life" the countdown is repeated. The following measurement values result from the calculations from the shift register. They are updated every second.

7.2.5 Parameter

All relevant parameters are saved in serial EEPROMs (electrically erasable memory chips). Even with web interruptions of any length of time parameters are saved non-volatile. It is possible to edit or change them via the IRDA- or CAN-interface. Parameters are displayed when selecting <Parameter> in the main menu. A list of two pages is displayed. The value's validity is checked and only the valid range is accepted.

7.2.5.1 Parameters Dialogue Measurements

Page 1 contains values for:

parameter description	value range		dimension
	min	max	
measuring time	1	9999	second ; [s]
background measuring time	10	9999	second ; [s]
time constant for measurement	0.1	999.9	counts / s ; [s ⁻¹]
time constant for background measurement	0	32000	counts / s ; [s ⁻¹]
adjustable high voltage	approx. 500	2800	voltage ; [V]

7.2.5.2 Parameters Dialogue Alarms

Page 2 contains values for:

parameter description	value range		dimension
	min	max	
minimum threshold	0.001	0.999	---
maximum threshold	1	999	---
contamination alarm channel 1+2 (hand left/right)	0.1	999.9	counts / s ; [s ⁻¹]
contamination alarm channel 3+4 (foot left/right)	0.1	999.9	counts / s ; [s ⁻¹]
contamination alarm channel 5 maximum Option: (clothing channel)	0.1	999.9	counts / s ; [s ⁻¹]

7.2.5.3 Nuclide selection

Page 3 contains values for calibration values (see 7.2.8)

No.	nuclide description	calibration value
1 ... 8	Mx-001 ... 008	fixed steps
9 ...24	C-14 ... XX1	nuclide-dependant

7.2.6 Counting Rates

The menu option <Counting Rates> displays incoming rates from detectors as "raw values". The recorded impulses are sent to the central-node by the detectors in a period of 1000 ms, so values are displayed in [cps].

7.2.7 Counting Rate Statuses

The channel statuses are shown in text format after the unit [Imp/s] with the following descriptions:

ok	=	everything ok
MIN	=	remain under minimum level
MAX	=	exceed level of increased background

If one of these levels is triggered in measurement mode the status ready-to-measure is revoked.

7.3 Alarm Thresholds

The HFK provides 16 preset alarm threshold rates, 4 values are selectable. Values can be edited via the PC-Interface (CAN or IRDA, Options).

The following table contains the threshold rates:

edit alarm thresholds [Bq/cm²]				
alarmset-No.:	1	2	3	4
detector 1: channel 1/2	0.01..9999.99	0.01..9999.99	0.01..9999.99	0.01..9999.99
(detector 1: channel 2)	0.01..9999.99	0.01..9999.99	0.01..9999.99	0.01..9999.99
detector 2: channel 3/4	0.01..9999.99	0.01..9999.99	0.01..9999.99	0.01..9999.99
(detector 2: channel 4)	0.01..9999.99	0.01..9999.99	0.01..9999.99	0.01..9999.99
detector 3: channel 5	0.01..9999.99	0.01..9999.99	0.01..9999.99	0.01..9999.99
fixed alarm thresholds [Bq/cm²]				
alarmset No.:	5	6	7	8
detector 1 ..3 channel 1 .. 5	0.05	6	0.8	0.10
alarm number:	9	10	11 ^[1]	12
detector 1 ..3 channel 1 .. 5	0.20	0.37	5	1
alarm number:	13	14 ^[2] ^[3]	15	16
detector 1 ..3 channel 1 .. 5	3.7	50	10	37
alarm number:	17	18	19	20
detector 1 ..3 channel 1 .. 5	50	100	370	500

[1] Surface contamination limit for "other radio nuclides", i.e. beta emitter and electron capture emitter "outside operative surveillance areas", excluding nuclides mentioned in note [2].

[2] Surface contamination limit for beta emitter and electron capture emitter, which have a set allowance rate of $5 \cdot 10^6$ Bq according to the german radiation protection laws, "outside operative surveillance areas", as well as for C-14, P-33, Ca-45, Fe-55, Ni-63, V-48 and Pm-147.

7.3.1 Manual Measuring (Check)

This menu provides the option to run a manual measurement with a higher integration time for careful review and test purposes ("Start"-key). In this case all incoming impulses are added up every second and settled with the expired measuring time. The measuring time used can also be parameterized via the CAN-interface.

Measurement can be stopped any time by pressing "Stop". Impulses are displayed every second again by pressing "Reset".

7.3.2 Detector-High-Voltage

The detector's current voltage of every single channel is displayed for checking. The default value is parameterized in the serial EEPROM. However, it can be changed in the "HIGH-VOLTAGE" section of the test menu.

7.4 Test Menu

The test menu provides features for monitoring hardware components connected to the HFK-monitor. Via service features detectors and binary signals are monitored or reset.

7.4.1 CAN-Node

The basic HFK-monitor model comprises three intelligent CAN-network nodes. Each node and its data is displayed in one line:

7.4.1.1 Central CAN-Node

The central node's type designation is "GRF". It controls the LC-display and edits the in- and output of binary signals. Its position designation is "HfKIO".

7.4.1.2 Detector-Nodes

The two detector-nodes are labelled "ACH" and each tracks a large-area-proportional-probe. The position description informs about the detector's mounting-position: "hand" or "foot". Moreover, the manufacturer's serial number and the software version number are listed.

7.4.2 Entries and Exits (I/O)

The entry/exit-menu provides a feature for monitoring the device's sensor technology. The light barrier's state is represented with "0" or "1" (0 = "not interrupted"). The binary exits for controlling the lamps (red, green) and the acoustics can be set manually via keys.

7.4.3 High-Voltage

The high-voltage-menu provides a feature for monitoring the detector-high-voltages. The desired value and the actual value are displayed. When exceeding a certain error-tolerance an error status is displayed in the respective line. Measurement resolution is +/- 5 Volt.

For testing the desired high-voltage can be temporarily adjusted in rates of 5 volts. The new selected value is kept when returning to the <Measuring> menu. This feature facilitates the recording of measurement values with different high-voltage values in the <Counting Rates> menu. For constantly keeping a new high-voltage value press the "Return" key in the high-voltage menu. The value is then written into the EEPROM. The feature is also accessible via the CAN-interface.

No new high-voltage values are stored when leaving the menu by pressing "Esc".

8 Operation

8.1 Current Supply

The supply unit is accessible from the master unit's bottom side. Socket and mains switch are located here.

Caution: the socket can be switched over to 125V~ power supply. Operation with 230V~ leads inevitably to destruction of the device!

Insert the mains cable in the 230V~- main power plug at the HFK master unit's bottom side, switch the mains switch to "On". The display is illuminated, the device provides messages.

8.2 First Background Measurement

After switching on „First Background Measurement“ starts.

The display shows the following:

Please wait for READY

First Background Measurement

T : xxx

A measuring time countdown (T : xxx) starts displaying the remaining time for reaching ready-to-measure status.

8.3 Ready to Measure

After completing the first background measurement the display shows the following:

READY

Background Measurement

The green LED "ready" is on.

The monitor is ready for measurement and can be entered.

In case of interference the monitor is not ready for measurements.

8.4 Measurement

When stepping onto the foot detector a foot light barrier is activated. The status "READY-TO-MEASURE" switches to "MEASURING".

The same feature is triggered when placing both hands onto the hand detector which is monitored by twofold light barrier.

The hand light barrier detects and monitors both hands however, it is not distinguished which hand may be placed incorrectly.

When both hands are detected correctly but not the feet, the following message is displayed:

Please position feet!

The reversed case: The feet are detected correctly, the hands are not. This triggers the following message:

Please position hands!

The message "MEASURING" in the status line indicates the beginning of measurement. At the same time the countdown for measuring time and an acoustic signal in one second intervals starts.

8.4.1 Interrupting Measurement

During measurement the light barriers for hands and feet are monitored. Measurement is interrupted if the correct positions are left. A message in the display asks the person to correct his or her position. As soon as the initiators are actuated again measurement is continued. When leaving the foot detector a new measurement has to be started.

8.5 Measuring Result

After measurement is completed either the message

"No Contamination"

or

"Contamination"

displays indicating the measuring point and measuring value. For information purposes in parallel the nuclide forming the basis of the area activity calculation is displayed.

The measuring result is displayed in "Bq/cm²". The chosen nuclide calibration forms the basis of the calculation.

Is the HFK-1 "calibrated" in impulses/s the measuring result is also displayed in imp/s.

The result is displayed as long as hand or foot detectors are active.

8.6 Waiting Time after Measuring

After completing measurement the HFK is immediately ready for the next measurement. The background measurement results following measurement, however, are rejected for the next 10s. This ensures that no faulty measurements occur due to (contaminated) persons being around. After this break HFK automatically continues updating the background if no sensors are activated.

8.7 Not Ready To Measure

After starting the HFK is not ready to measure because the background has to be determined for every meter channel first. During parameterizable background-measuring-time the background values balance after filtering. The measuring time displays as countdown with T:xxx. If there is no interference the green visual indication "ready" is activated after this period.

In case of the HFK losing measurement readiness due to errors the green visual indication is switched off and the cause of error is displayed in plain text. The status line contains the message "CAUTION" in alternation with "NEW BACKGROUND MEASUREMENT". This is to reach valid measuring readiness again. If the error is rectified the monitor is ready-to-measure after passing the background measuring time.

8.8 Increased Background

Increased background values aggravate detection of contamination or might even make it impossible. In any case with higher background rates the statistical probability of a false alarm increases.

The following reasons are possible:

- General **Elevated Background Radiation**
e.g. due to radioactive sources close to the monitor.
In this case all detectors are affected similarly. Remedial measures at the HFK are only possible when decreasing detecting sensibility (by selecting higher alarm threshold values). This can be done together with increasing the threshold for maximum surveillance of background radiation, the maximum threshold and/or expanding measuring times.
Hints / Remedial Measures:
 - Please check the counting rates of every single meter channel in the audit menu.
Remove / relocate / transfer the radiation source or shield it.

- **Contamination** of Detectors
In most cases only one detector i. e. only one meter channel is concerned. To solve the problem exchange the detector and decontaminate it.
Hints / Remedial Measures:
 - In case of frequent contamination we recommend to cover the detectors with additional foils e. g. usual commercial cling film.

8.9 Minimum-Threshold

Meter channels are constantly tested for minimum counting rates – the underlying parameter is the "minimum-threshold". If one (or several) meter channel(s) remain under this threshold the HFK won't reach measurement readiness. The cause of error is displayed.

Hints / Remedial Measures:

- Remaining under the minimum-threshold is an indication for the following causes of errors:
- Gas leak-off, change detector
- false high-voltage (too low), please check and compare with must values,
- error in electronics, e.g. discriminator damaged.

8.9.1 Acknowledgement feature; conditionally ready to measure

In the short term until a faulty channel is fixed permanently the monitor can be set ready to measure using the "Acknowledgement Feature". In this case the faulty channel is not evaluated. The message „Conditionally Measuring Readiness" is displayed at the HFK. However, the meter channel is continuously tested for returning to normal state.

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