Operating manual for dosimeter type DR020

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Notices

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1. Purpose of the device

This dosimeter is used to measure ionizing radiation in processes such as cross-linking of paints or plastics.
As a measurement instrument, it is extremely simple to use: a measuring film is exposed to radiation and then evaluated using the dosimeter in a matter of seconds. The measured value is displayed in kGy. By offsetting optical components, performing measurements using a 10-Bit A/D converter and averaging values over several measurements, the dosimeter offers a very high degree of accuracy. Measurement errors only occur if there are irregularities in the measuring film (thickness and color distribution). Thanks to these features, the dosimeter is a valuable tool in quality assurance.

1.1 Electron beam irradiation

When using electron beam equipments a three-dimensional determination of dose distribution is a must for reproducible production procedures.

In the case of low-energy electron beam equipment, the short range of the electrons causes considerable alteration in the absorbed dose with the penetration depth. One useful dosimeter employs polyvinyl butyral (PVB) with pararosaniline cyanide: this colors on irradiation with electrons or UV (red discoloration).
This very thin film (approx. 20 µm or 20 g/m^2) has good resolution in depth doses for measurements with low-energy electrons. As the film is supplied by the meter, it is also possible to measure the dose distribution across the effective width at high resolution, as follows: Radiation is directed onto a strip which corresponds to the beam width and evaluation then performed at cm intervals, for example.

2. Device design

The dosimeter is accommodated in a sealed high-grade steel housing which effectively shields it from interference. A keyboard overlay on the function keys and the display protects against dirt.
To allow a better view while working, you can tilt the device at an angle using the retractable stands. Just three keys are necessary to activate all of the device functions; all necessary data is shown on a 2 x 20 character display screen.
The measuring head, which has a measurement slot 0.5 mm in width, contains the transmitter and receiver optical components.
A processor the size of a check card is located inside the device: this controls all of the functions and dose calculation.

3. Power supply

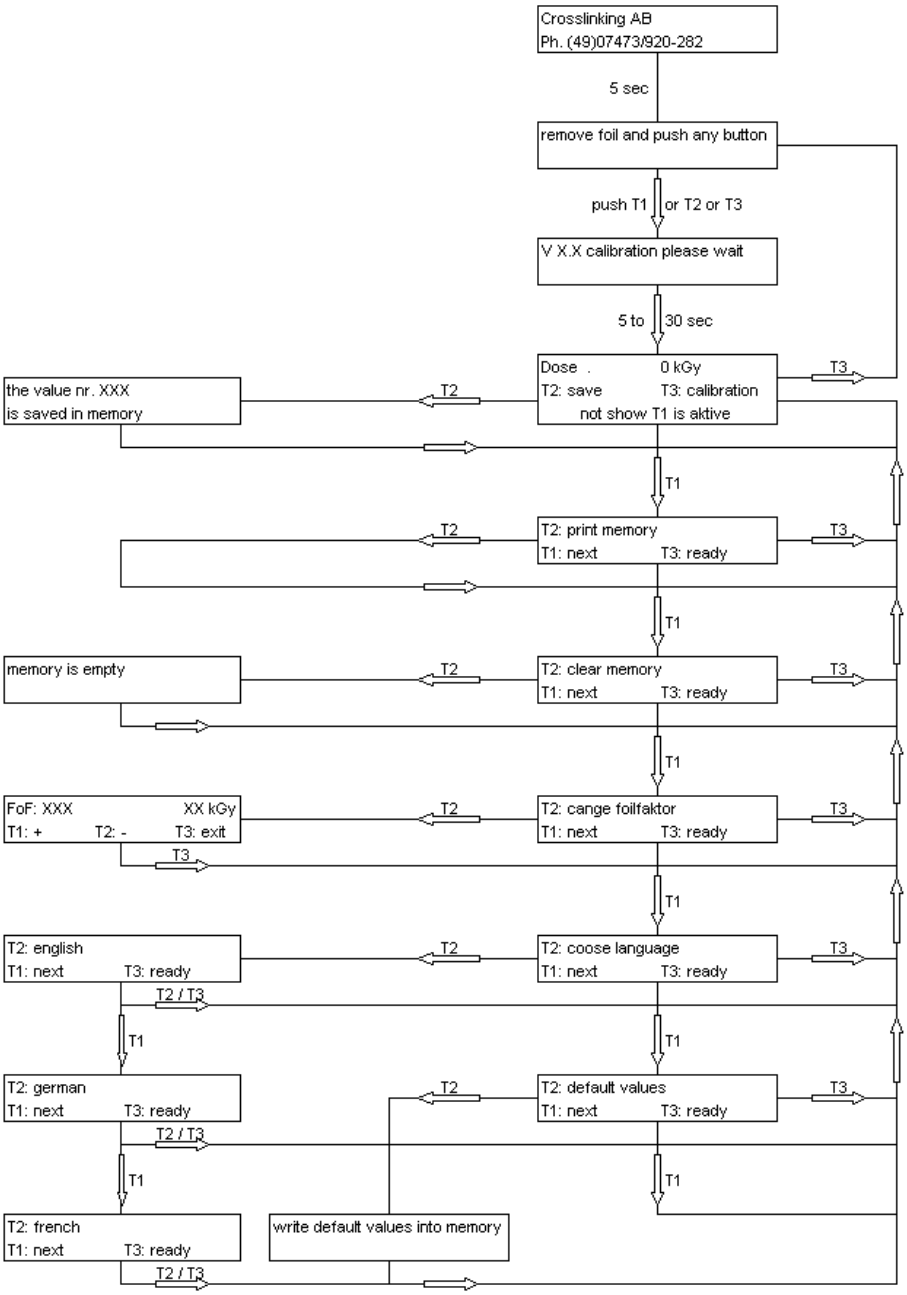
The power is supplied by a standard power supply unit. The measurement device is designed for continuous operation. The device can be switched off with the power switch located on the device.

The serial interface can be used to read the stored values into a PC for further processing.

4. Operation

The dosimeter is activated by means of the power switch. The user is then requested to remove any measuring film still in the measuring head and to press any key. Now calibration of the device takes place: the red and green intensities are adjusted to a particular value. Because optical components are subject to drift, you should switch on the device 30 min before use and then recalibrate it after the half hour. In this way, accurate measurements are achieved.
Once calibration is complete, the device is ready to perform measurements. When a radiated film (see item 10) is inserted, a dose reading immediately appears on the display. A constant measured mean value is displayed after 8 to 32 measurements. Constant values are identified by a colon displayed before the dose reading (after 8 measurements) or an asterisk (after 32 measurements).

Flow chart / menu structure



4.1 Menu 1 / main menu Dose reading, Save, Calibration

4.1.1 T1 Next
The T1 key is used to proceed to the next menu. Even though this function does not appear on the display, this key is active.

4.1.2 T2: Save
The T2 key is used to save the value that is currently displayed. The count value of the value (up to 8128 values can be stored) is displayed when the value is stored.

4.1.3 T3: Calibration
The device can be recalibarated after the turn-on time (in accordance with the procedure described in section 4) and while the device is in operation.

4.2 Menu 2 Print memory

4.2.1 T1 Next
The T1 key is used to proceed to the next menu.

4.2.1 T2: Print memory
See section 10 "Measured values via the interface"

4.2.3 T3: Ready
The T3 key is used to return to menu 1.

4.3 Menu 3 Clear memory

4.3.1 T1 Next
The T1 key is used to proceed to the next menu.

4.3.2 T2: Clear memory
The T2 key is used to erase all data from the memory. Subsequently the message „memory is empty“ is displayed and you are returned to menu 1.

4.3.3 T3: Ready
The T3 key is used to return to menu 1.

4.4 Menu 4 Change foil factor

4.4.1 T1 Next
The T1 key is used to proceed to the next menu.

4.4.2 T2: Change foil factor
Every new dosimeter film batch may have a different offset. This can be corrected by entering a film-specific value. The keys T1+ and T2- can be used to select a factor in the range of 0 to 255.

4.4.3 T3: Ready
The T3 key is used to return to menu 1.

4.5 **Menu 5** Choose language

4.5.1 T1 Next

The T1 key is used to proceed to the next menu.

4.5.2 T2: Choose language

This key calls up the menu that allows you to select a language. The following choices are available:

- German
- English
- French.
  - T1 To make a selection
  - T2 To confirm action and return to menu 1

4.5.3 T3: Ready

The T3 key is used to return to menu 1.

4.6 **Menu 6** Transmissions

4.6.1 T1 Next

The T1 key is used to proceed to the next menu.

4.6.2 T2: Default values

The T2 key is used to display the LED transmissions:

- Red channel	output value: XXX	input value: XXX
- Green channel	output value: XXX	input value: XXX

The intensity of both channels (input values) must be above 500. If this value is not reached, the device needs to be readjusted.

4.6.3 T3: Ready

The T3 key is used to return to menu 1.

5. Calibration

After starting, the device is calibrated. After prolonged operation, recalibration of the device is recommended to compensate for any thermal drifts of the optical components, for example, thereby ensuring accuracy of the dose evaluation.

5.1 Measurements with a dosimeter film WITHOUT supporting film

If this measurement method is used, ensure that there is no dosimeter film in the measuring head during calibrating.

5.2 Measurements with both dosimeter film AND supporting film together

As the dosimeter film is normally supplied with a supporting film, measurements can also be performed with supporting films. If this measurement method is used, calibration must be performed with the supporting film only (i.e. without the dosimeter film).

6. Application

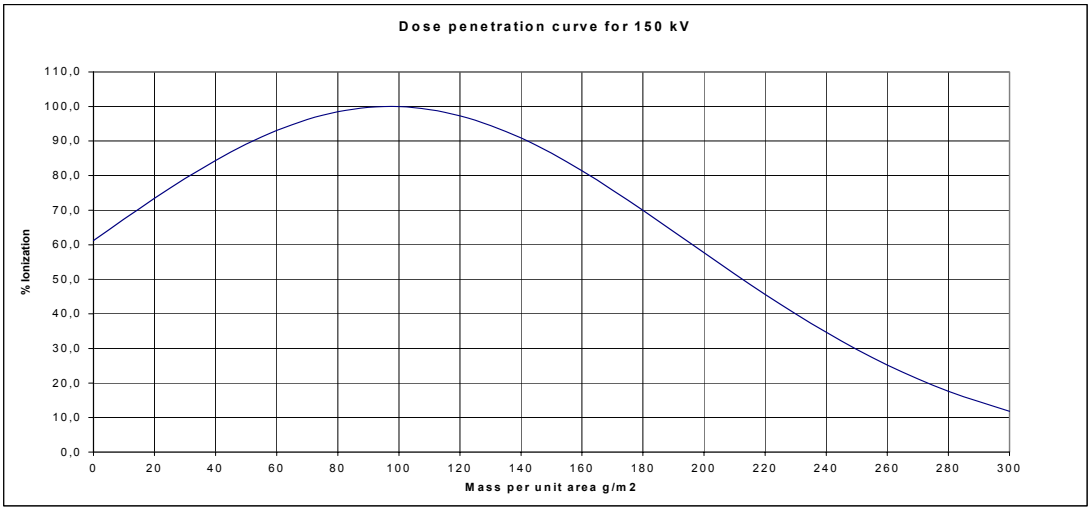
The dosimeter has been designed to perform measurements in the field of electron beam engineering. Nowadays, procedures in electron beam engineering are tested and implemented at an acceleration voltage of 50 keV up to the MeV range. At low acceleration voltages, it is important to measure not only the exact dose, but also the depth dose. This is only possible if the measuring film used is thin enough to enable the resolution in the layer thickness subjected to irradiation.

6.1 Depth dose measurement

In the case of most depth dose measurements, you simply need to superimpose layers of measuring film and then perform the evaluation. This results in a 20 g/m^2 grid.
Our thin measuring film (just 20 g/m^2) provides this resolution with a measuring system which is easy to use.

For accurate depth dose measurements, we recommend that you layer thin polyester film sheets (10 µm equal to 10 g/m^2) in individual stacks on the dosimeter film during irradiation. This method compensates for variations in the thickness (+/- 2 – 3 µm) of the dosimeter measuring film and yields improved resolution. A resolution of 10 g/m^2 is achieved with a correspondingly accurate dose at the end of the stack, via the measuring film of 20 g/m^2. At 20 g/m^2, dose loss is minimal, thus reducing the incidence of measurement errors.

Typical depth dose with a resolution of 20 g/m^2:



6.2 Measurements across the effective width

The dosing accuracy across the effective width can be evaluated by attaching a measuring strip across the effective width, e. g. at cm intervals.

6.3 Measurements in the conveying direction

In the case of EBC–units, which switch from roll to roll and use the track speed to control the beam of electrons (dose control), you can control the dosing accuracy when starting or stopping the unit simply by attaching a measuring strip in the track direction - e.g. 3 – 5 m measuring film - (control setting).

7. Method of Measurement

The film holder contains an optical transmitter which has a light emission of max. 635 nm (red) and 565 nm (green). The brightness of the LEDs in the red and green areas can be controlled using two digital /analog converters. The optical receiver, located opposite the transmitter, measures the intensity in both the red and the green areas.
During this measurement process, the film thickness is measured in addition to the discoloration in the red area of the film caused by the ionizing radiation. As a result, the dose readings determined via discoloration can be adjusted in accordance with the thickness of the film. Measurement of the dose and film thickness is performed at the same location, thus increasing the accuracy of the dose reading. The dosimeter displays the same dose if one film is used or two superimposed films, with the same dose in the measuring head.

After starting, the device tells the user to remove any film remaining in the holder.
First the dosimeter adjusts both colors to maximum brightness and then determines which of the colors has the highest intensity. The other color is reset until both of the measured intensities are roughly equivalent. These intensities are stored in the memory as the values I_{g0} and I_{r0}.

By comparing the difference between the intensities, scattered light are suppressed.

The measured values are evened out by software components and a mean value calculated using 8 of the evened values. A measurement period of 3 times 20ms is required for the evening process (red value, green value and dark value). If the mean value is constant, a colon is shown before the dose reading. A second mean value is calculated using 32 evened out measured values. If this mean value is constant, it is output and identified by a preceding asterisk.

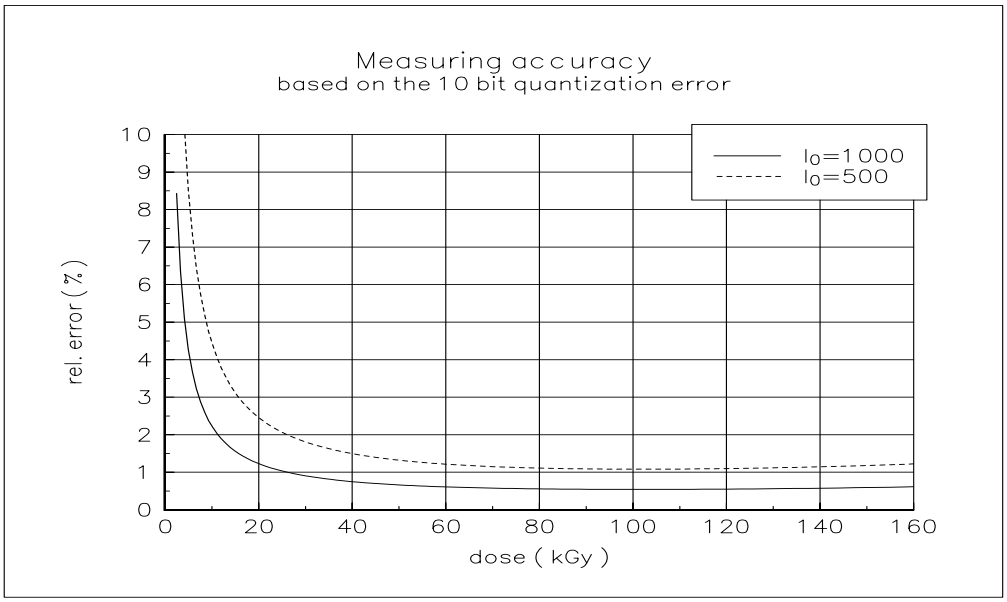
8. Principle of measurement

Light intensity is attenuated exponentially as it passes through an absorbent medium. Red light is only absorbed in the carbon-black section of the measuring film. The rosalinin which has been colored red by the dose absorbs only very little of the red light.

The intensity measurement I_r can also be used to determine the thickness of the film, if the other quantities are known.

Green light is also attenuated as it penetrates the film, due to the red discoloration.
However, this red discoloration is proportional to the energy dose (or more specifically the ion dose) to which the film has been exposed.

8.1 Quantization error



With a dose of 40 kGy and a measured intensity of 1000, the relative quantization error is 0.75 %.
With the same dose and a measured intensity of 500, the relative quantization error is 1.5 %.

9. Measuring film

Pararosanilin is also UV-sensitive and should therefore not be exposed to sunlight. The film should be stored away from bright light.
However, the film is not so sensitive that it has to be covered during the measurement process. No discoloration will occur if the film sheets are openly placed on the measurement surfaces in ordinary room lighting.

The measuring film is supplied in rolls 20 m long and 25 mm wide; it consists of 2 layers for ease of handling.

- the actual dosimeter film (thickness approx. 20 µm or 20 g/m^2) and
- a supporting film (thickness approx. 50µm) for better handling of the dosimeter film.

Please note that the dosimeter film must always lie on top when measuring doses with low-energy electrons.

The dosimeter film should be evaluated without the supporting film. If you wish to perform evaluation using supporting film, the dosimeter must first be calibrated with the supporting film and without the dosimeter film.

The maximum operating temperature must be taken into account during measurement. A maximum temperature of 50°C is specified for the film. At temperatures higher than this, the dosimeter film is prone to stronger discoloration than that caused by the ionizing radiation. In electron beam engineering, irradiation does not produce this temperature.

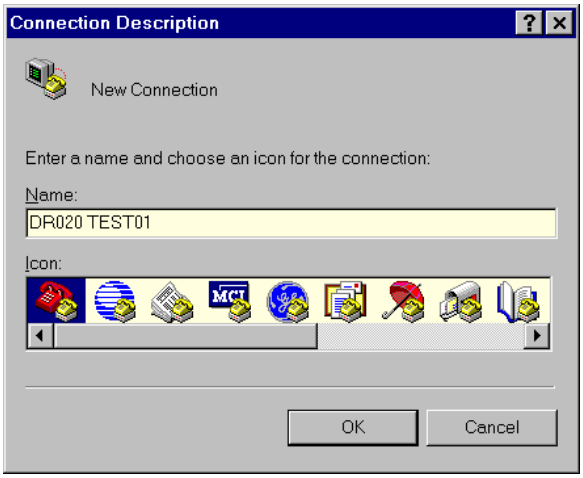
Delivery size:	20 m long x 25 mm wide rolls Article No: 6 710 022
Dosimeter film thickness:	approx. 20 µm
Supporting film thickness:	approx. 50 µm
Max. dose in the linear range:	80 kGy
Max. temperature:	50°C
Tempering:	15 min at 40°C, after irradiation, for artificial ageing at accurate measurements
Storage:	in dark places, sensitive to UV

10. Measured values via the interface

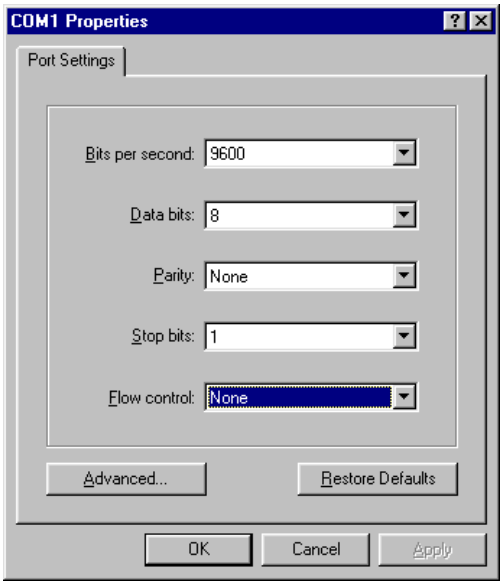
The device is equipped with a serial interface located on the rear of the device. This allows the stored data to be read into a PC using the Print Memory option. The Windows HyperTerminal program is used for this purpose. A null modem cable is used to connect the measurement device via the serial interface to the PC (normally using COM 1 or COM 2).

Carry out the following steps to print the data:

- Start the Windows program HyperTerminal.
- From the *File* menu, select New Connection and confirm your selection.
- Enter the name of the file into the *New Connection* window, e.g. MeasuredValues01 and confirm the name.
- In the *File name* window (e.g. MeasuredValues01), select Connect Using, choose Direct to COM 1 or COM 2 (or your interface) and confirm your actions.



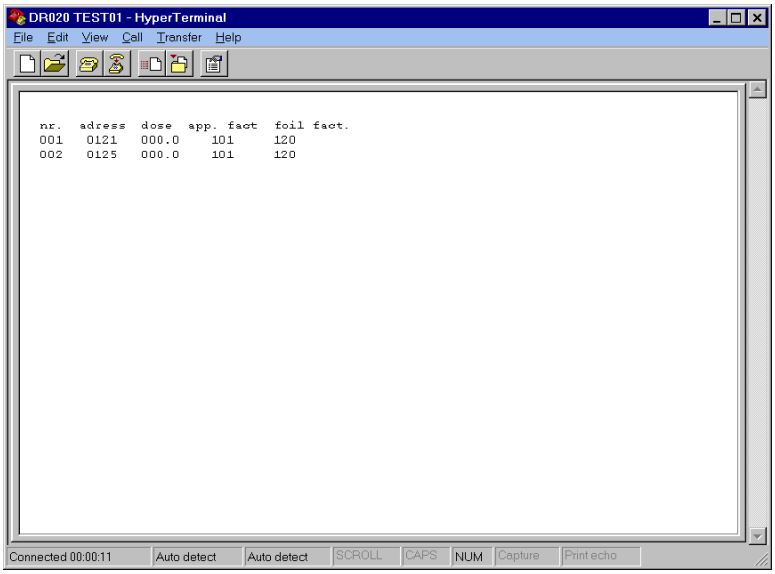
- In the *Port settings* window, select Restore defaults and confirm your selection. These are:
  - Bits per second 9600
  - Data bits 8
  - Parity None
  - Stop bits 1
  - Protocol None



- On the dosimeter DR020, press the "T2: Print Memory" function.

The information is printed in the following format:

No.	address	dose	App.factor	Foil factor
001	5D64	048.1	100	100
002	5D68	050.5	100	100
003	5D6C	051.7	100	100
004	5D70	052.7	100	100
005	5D74	055.2	100	100



- Select *Save as* from the *File* menu and place the file into the appropriate directory. This file can imported into a spreadsheet program, for example, for further processing.

11. Servicing / malfunctions

The device has three different modes for error detection and servicing.

- Service mode 1 automatic activation
- Service mode 2 manual activation
- Service mode 3 automatic activation

11.1 Service mode 1

If the device can no longer calibrate "Error T2: service program" is displayed. This function can be forced by placing a piece of paper into the measuring head during calibration.
In this mode,

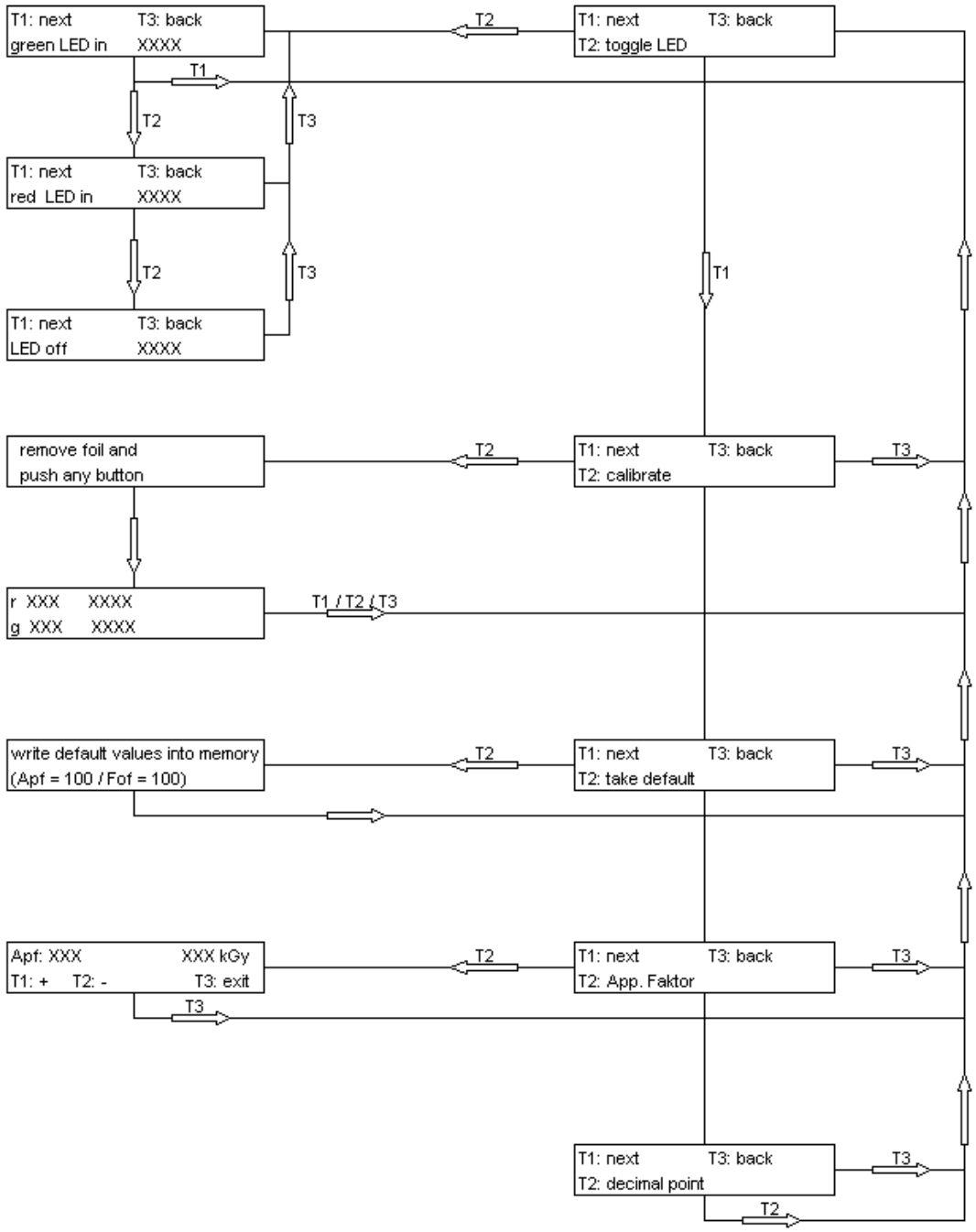
- red on (> 500)
- off (0)
- green on (> 500)

can be controlled separately. Check each displayed value which represents the intensity. This value must be above 500 for red and green with an empty measuring head. A value below 500 indicates that the device must be readjusted or is defective. These intensity values can also be displayed in the main menu (see section 4.6.2).

11.2 Service mode 2

If the keys T1 and T2 are pressed at the same time during start-up, the device is switched to service mode 2. This mode displays important data to simplify diagnostics.
The instrument-specific calibration factor (App.fact) which compensates for the hardware of different devices can also be set in this mode. Do not change the instrument-specific calibration factor! Adaptations regarding different dosimeter film batches can be made by modifying the film-specific calibration factor (foil fact).

Flow chart / menu structure



11.2.1 Menu 1 Toggle LED

The T2 key is used to set each LED separately to max. brightness and to display the transmissions:

- Red channel output value: max. input value: measured intensity
- Green channel output value: max input value: measured intensity
- Both channels off

11.2.2 T2 Calibrate

The T2 key is used to perform the calibration as in the main menu except with additional information being displayed.

- Red channel output value: 250 input value: measured intensity
- Green channel output value: 250 input value: measured intensity

11.2.3 T2 Take default

The T2 key is used to write the default settings into the memory:

- Instrument-specific calibration factor (app. fact) 100
- Foil-specific calibration factor (foil fact.) 100
- Language English
- Dose reading with one decimal place
- Memory start position

11.2.4 T2 App. fact (instrument-specific calibration factor)

T2 calls-up the menu which can be used to set the instrument-specific calibration factor. Any factor between 0 – 255 can be set. This allows differences in components to be compensated for thereby ensuring identical dose readings for different devices. This factor is retained when exiting with T3 and is not to be modified.
The device must be calibrated (see section 11.2.2) before the instrument-specific calibration factor is set.

11.2.5 T2 Decimal point

T2 can be used to determine whether the dose reading in the main menu is to be displayed with a decimal point or not.
The current setting can only be viewed in the main menu. The film or instrument-specific calibration factor settings are always displayed with one decimal point.

11.2.6 Service mode 3 (battery of SRAM is empty)

If the battery is empty, the defined variables (film or instrument-specific calibration factor) are lost after the device is switched off.
This is indicated by the message „no valid values in device“

12. Technical data

Dimensions:	Housing: L x W x H	295 x 135 x 55 mm
	Height with measuring head:	90 mm
	Measuring head: L x B x H	40 x 25 x 35 mm
	Device stands, retractable for tilting at an angle of approx. 23°	
Weight:	1.90 kg	
Power supply:	Voltage 8 – 12 V DC via power supply socket, center contact +, housing - Current 370 mA	
Keyboard:	3 mechanical keys covered with a keyboard overlay	
Display:	Dot matrix display, 20 characters 2 lines	
Optical transmitter:	Transmitter diode wavelength red 635 nm, green 565 nm	
Optical receiver:	Receiver diode wavelength 500 - 700 nm	
Interface:	Serial interface, Data output via 0 modem cable	
Electronics:	Check card sized processor with A/D converter 10 bit resolution battery-backed SRAM, battery life approx. 5 years	