User's Manual

Electronic Personal Dosimeter (For Gamma(X)-ray and neutron)

NRF51

Introduction

This User’s Manual explains the operation of the Electronic Personal Dosimeter NRF51 (For Gamma(X)-ray and neutron). It provides descriptions of parts, functions and operational instructions for optimal use. Please make sure that you read this manual carefully before operation.

In the event of product malfunction, contact Fuji Electric representative immediately.

Handling Precaution

Please observe the following handling precautions to ensure that you use the NRF51 Electronic Personal Dosimeter safely and avoid injury/damages. Failure to comply with the instructions contained in this manual may reduce the safety of the instrument. Please read this User's Manual carefully to understand all the precautions before using the NRF51 Electronic Personal Dosimeter.

	Precautions for Use
⚠Attention	・ The Dosimeter is a precision instrument. Do not drop it or subject it to impact. ・ Keep the Dosimeter in a plastic bag for protection when use in an environment where chemical fumes, splashes/steam, full of dust and wastes are present. ・ Handle the Dosimeter with clean, dry hands. If becomes tainted, clean it with dry cloth. ・ Do not place the Dosimeter and metal objects in the same pocket. It may cause the Dosimeter breaking. ・ Avoid use where high frequency noise. Pay attention when use near the following devices: 1. Mobile phone 2. Local wireless phone such as Personal Handy-phone System (PHS) 3. High power transceiver 4. Microwave oven 5. Radar 6. Welding machine 7. Any other spark discharging or high intensity radio wave emitting devices Especially keep the Dosimeter at least 5cm away from any mobile/ wireless phones ・ When the battery level is critically low, read the displayed value within 10 minutes. ・ Use AA alkaline battery only. During replacement, align the battery polarities correctly. ・ Prior to disposal of the used battery, protect exposed terminals with insulating tape to prevent shorting that may cause possible heating, rupture, or burning. Otherwise, injury or fire may result. ・ Do not throw the Dosimeter or battery into a fire. Do not disassemble them. ・ Keep a certain distance between the buzzer and ears to avoid the injury. (Buzzer makes the sound over 90dB at 30 cm distance) ・ Do not use the Dosimeter as a survey meter. ・ If a hard impact is made on the Dosimeter, it is possible that there is a crack on the Dosimeter. In this case, deteriorations to the capabilities in a waterproof and a resistance of radio wave may happen.

Contents

1. Overview 5
2. Contents 6
   2.1 Standard product package 6
   2.2 Model 6
3. Precautions 7
   3.1 Operational conditions* 7
   3.2 Other requirements 7
4. Description of Parts and Functions 8
   4.1 Part names 8
   4.2 Display function 10
   4.3 Buzzer function 11
   4.4 Communication function 26
5. Parts Replacement 31
   5.1 Battery replacement 31
   5.2 Clip replacement 32
   5.3 USB connector cap replacement 32
6. Operational Instruction 33
   6.1 When starting to use 33
   6.2 During use (Normal operation) 35
   6.3 During use (When alarm is generated) 44
   6.4 During use (When communicating) 48
   6.5 After use 48
7. Care and Maintenance 49
   7.1 Daily check and maintenance items 49
   7.2 Consumable supplies 49
8. Specification 50
   8.1 General Specification 50
   8.2 Storage data 51
9. Appendix 52
   9.1 Trouble shooting table 52
   9.2 Disposal 54
   9.3 Calibration 55

1. Overview

The Electronic Personal Dosimeter NRF51 (hereinafter referred to as NRF51) is designed to provide measurement of personal dose equivalent of external exposure to gamma-ray and neutron separately (hereinafter referred to as dose). NRF51 indicates accumulated dose or dose rate. When measured dose (rate) value exceeds preset dose (rate) alarm threshold, NRF51 will activate audible alarm and flashes LED.

By using the Dosimeter Configuration Tool and a PC, it is able to write PC-edited setting values to NRF51 and read measurement trend data from the NRF51 via communication with the device.

If it’s worn tightly to the body, energy characteristic of the NRF51 enables direct reading of personal dose equivalent Hp(10).

2. Contents

2.1 Standard product package

(1) NRF51 1 pc

(2) Accessory

- Battery (AA alkaline battery) 2 pcs

2.2 Model

NRF51

3. Precautions

⚠Attention

3.1 Operational conditions*

Item	Conditions
Temperature range	-10 °C to +50 °C
Relative humidity	95 % or less (No condensation)
Storage temperature	-25 °C to +50 °C

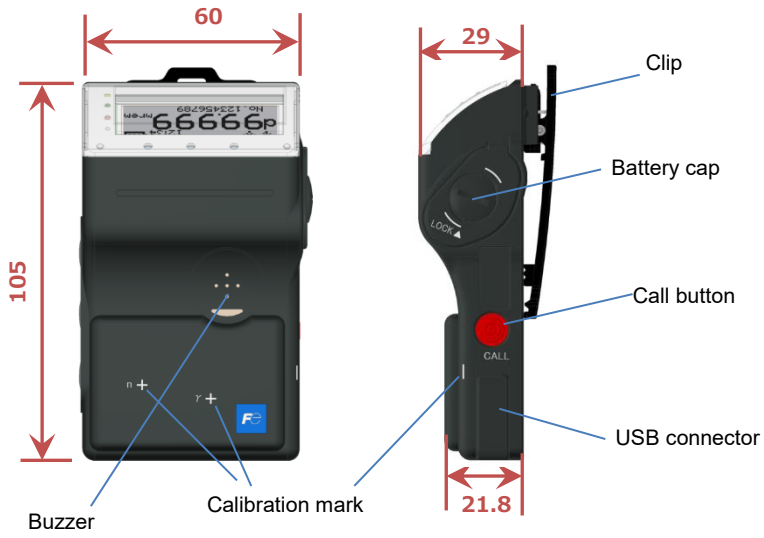
*Batteries are not included above. Please contact battery vendors for terms of use.

3.2 Other requirements

(1) See User's Manual of "Dosimeter Configuration Tool" for information on parameter writing and data reading via the device and a PC.
(2) Try turn OFF & ON the NRF51 if you encounter technical problems. See the "Troubleshooting Table" if the problem is not recovered.
(3) Accumulated dose cannot be reset if the power-on-reset setting of NRF51 is "OFF". In this case, please reset the accumulated dose through the Dosimeter Configuration Tool.

4. Description of Parts and Functions

4.1 Part names



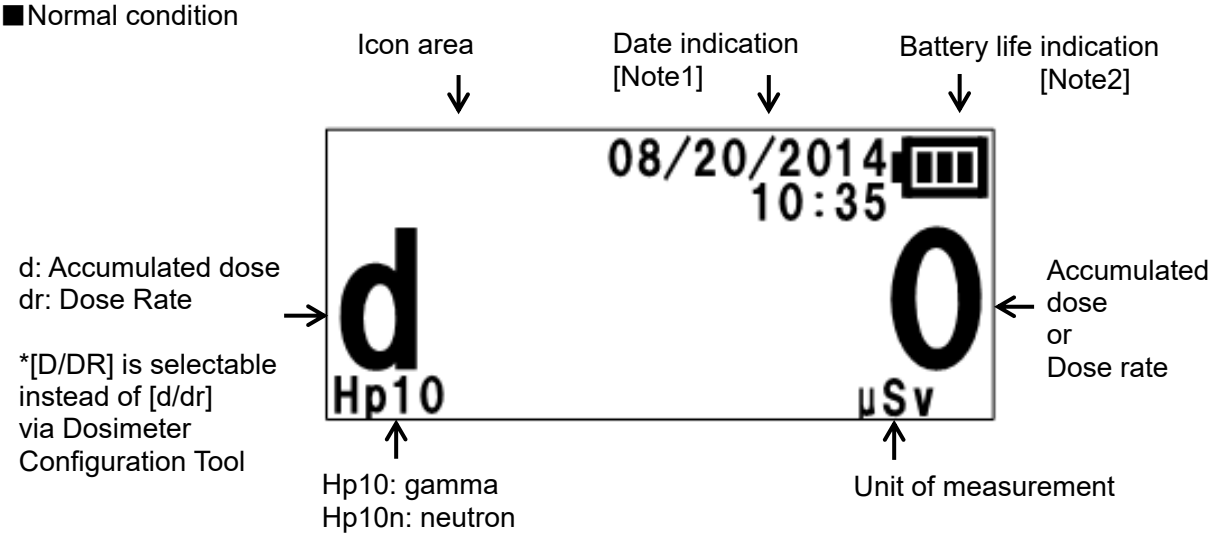
Functions

1. Buzzer : It sounds when NRF5 starts its operation, alarm and monitoring sound is generated.
2. Flash LED : Red LED on top of LCD flashes during alarm generation.
3. Auxiliary LED : Green LED flashes along to monitoring sound. Red LED flashes along to alarm. Yellow LED flashes along to preliminary warning alarm.
4. LCD : Liquid Crystal Display Indicator.
5. Battery Cap : Cap of battery compartment.
6. Operating Buttons : Switch indication screen. Also, some operation parameters such as alarm threshold can be changed by these buttons.
   “◎” Button ⋯ Power ON/OFF, Screen switching
   “△” / “▽” Button ⋯ Accumulated dose / Dose rate switching, Scrolling
7. Calibration Mark : Shows location of calibration reference point. (Sensor position)
8. USB Connector : For power supply or communication by connecting USB cable.
9. Infrared Window : For communication with infrared communication device.
10. Call Button : Emergency alarm button. Press for more than 3 seconds to generate warning sound and indication. If user does not use this emergency alarm, the function can be made void by the Dosimeter Configuration Tool.
11. Clip : To fix the NRF51 on the chest pocket or on the waist belt.

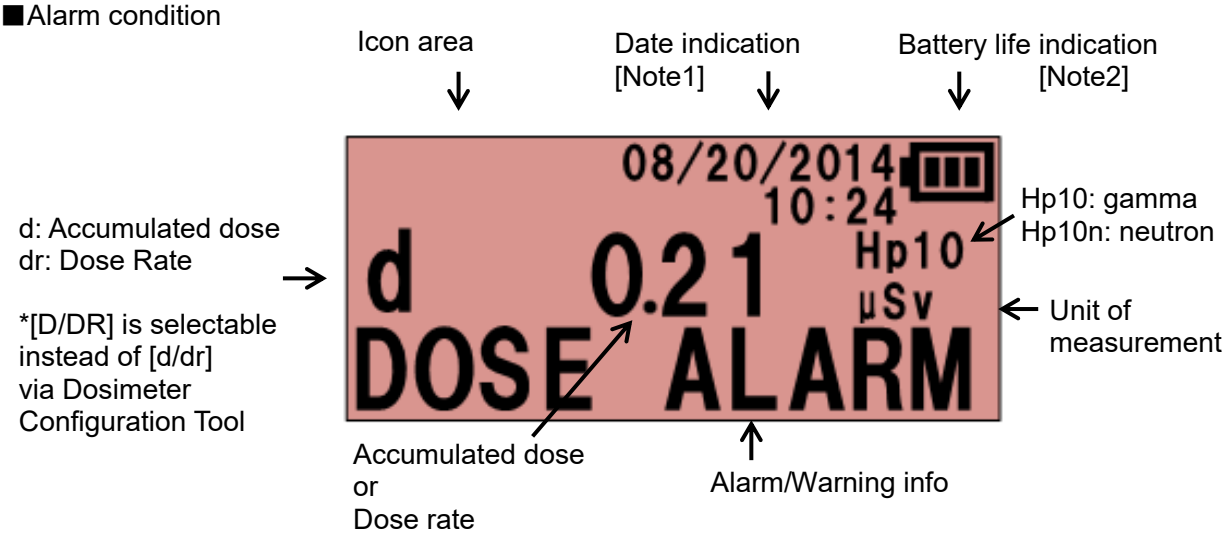
4.2 Display function

LCD Indication

■Normal condition

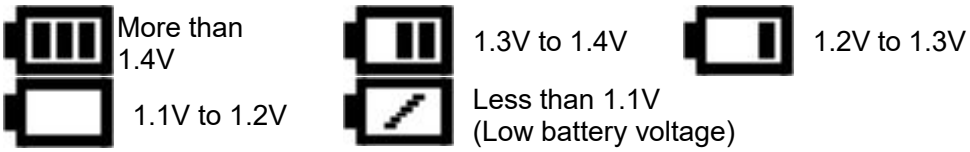


■Alarm condition



Note1: During normal operation, ":" for time indication flashes.

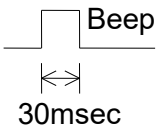
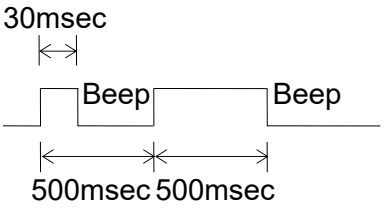
Note2: Battery life indicates remaining voltage as follows.



4.3 Buzzer function

4.3.1 Audible signal

Audible signals sound under the following circumstances:

Circumstance	Audible signal sounds when	Beep pattern
Turn ON/OFF	NRF51 is turned on	
Data changed successfully	Setting values of NRF51 have been changed using a Dosimeter Configuration Tool	

4.3.2 Audible alarms

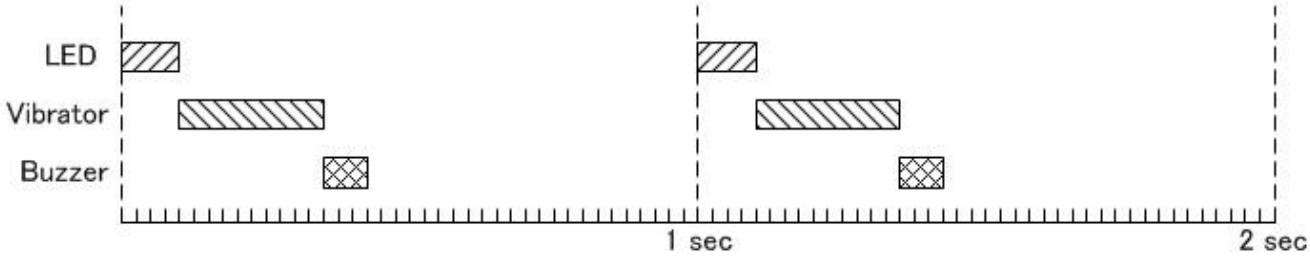
Alarm activation and beep pattern are configurable by user with Dosimeter Configuration Tool.

The items that can be set are as follows:

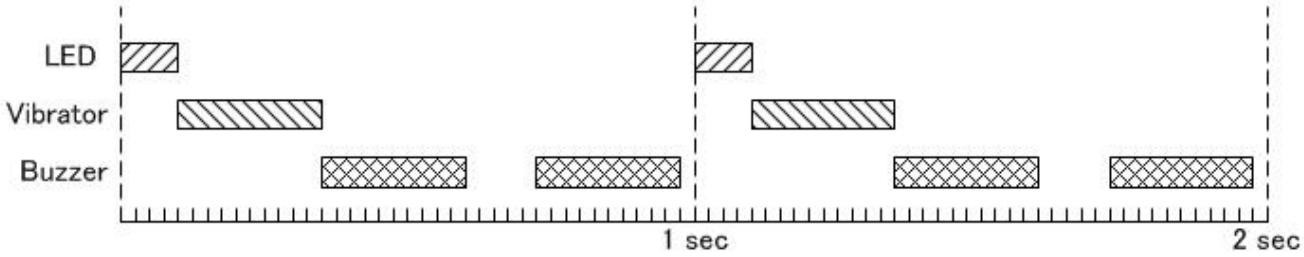
(1) Operation timing of LED, Vibrator and Buzzer

Operating timing setting is selectable from the following 6 patterns for each alarm type, but pattern No.6 can be selected by “Low battery voltage” only.

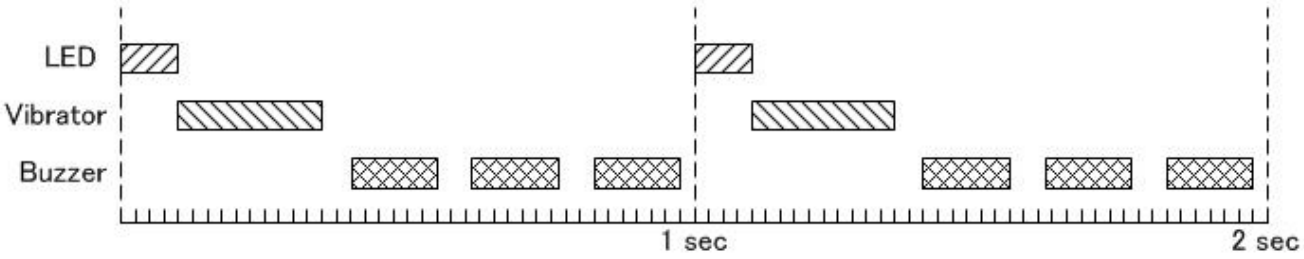
[Pattern No.1] … When alarm is generated, the operating timing is showed below.



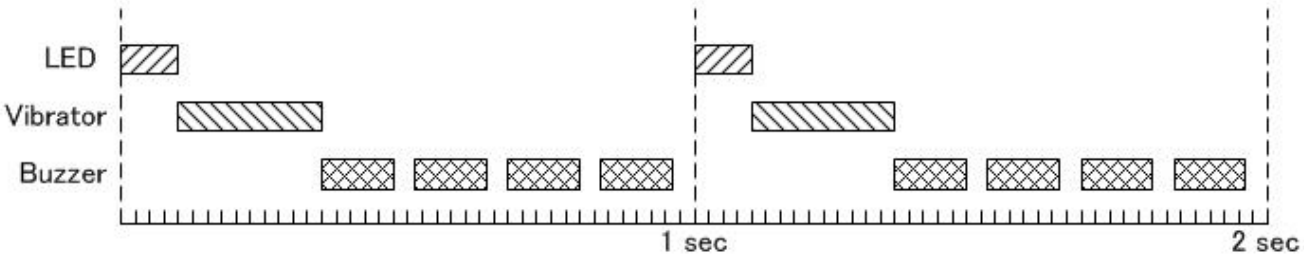
[Pattern No.2] … When alarm is generated, the operating timing is showed below.



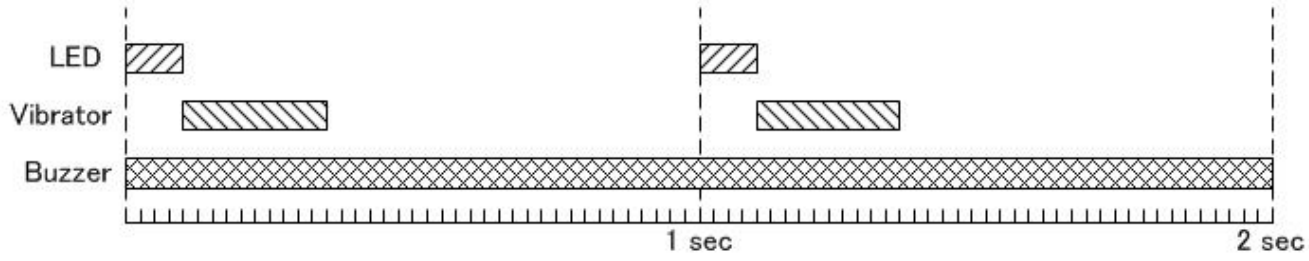
[Pattern No.3] … When alarm is generated, the operating timing is showed below.



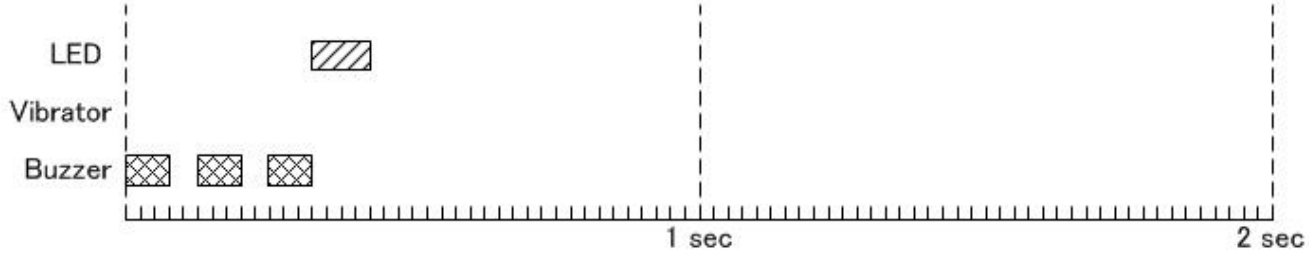
[Pattern No.4] … When alarm is generated, the operating timing is showed below.



[Pattern No.5] ⋯ When alarm is generated, the operating timing is showed below.



[Pattern No.6] ⋯ When alarm is generated, the operating timing is showed below.



(2) Buzzer frequency

Buzzer frequency setting is selectable from the following two settings for each alarm type.

[High] ⋯ When buzzer sound setting is “ON”, High frequency sound is generated in alarm condition.

[Low] ⋯ When buzzer sound setting is “ON”, Low frequency sound is generated in alarm condition.

(3) Buzzer sound

Buzzer sound setting is selectable from the following two settings for each alarm type.

[ON] ⋯ When alarm is generated, buzzer sounds.

[OFF] ⋯ When alarm is generated, buzzer doesn’t sound.

(4) Backlight

Backlight color setting is selectable for the following four settings for each alarm type.

[OFF] ⋯ When alarm is generated, backlight doesn’t turn on.

[RED] ⋯ When alarm is generated, red backlight and white backlight flash. Red auxiliary LED flashes in conjunction with the red backlight.

[YELLOW] ⋯ When alarm is generated, yellow backlight and white backlight flash. Yellow auxiliary LED flashes in conjunction with the yellow backlight.

[WHITE] ⋯ When alarm is generated, white backlight flashes.

(5) Sounding time

Sounding time setting is selectable from the following settings for each alarm type.

[Continuous] ⋯ When buzzer sound setting is “ON”, buzzer sounds continuously in alarm condition.

[1 min] to [15 min] ⋯ When buzzer sound setting is “ON”, buzzer sounds for set period and then buzzer stops.

(6) Mute

Mute setting is selectable from the following two settings for each alarm type.

[Available] ⋯ Buzzer can be stopped by pressing “◎” button when buzzer sounds.

[Not available] ⋯ Buzzer cannot be stopped when buzzer sounds.

(7) Vibrator

Vibrator setting is selectable from the following two settings for each alarm type.

[ON] ⋯ When alarm is generated, vibrator operates.

[OFF] ⋯ When alarm is generated, vibrator doesn’t operate.

(8) Flash LED

Flash LED setting is selectable from the following two settings for each alarm type.

[ON] ⋯ When alarm is generated, flash LED on top of the display turns on.

[OFF] ⋯ When alarm is generated, flash LED doesn’t turn on.

(9) Latch

Latch setting is selectable from the following two settings for “Dose rate alarm/ Dose rate warning”.

[ON] ⋯ When alarm is generated, alarm operation continues for 10 seconds or continuously according to the setting if the alarm condition is canceled.

[OFF] ⋯ When alarm is generated, alarm operation stops if the alarm condition is canceled.

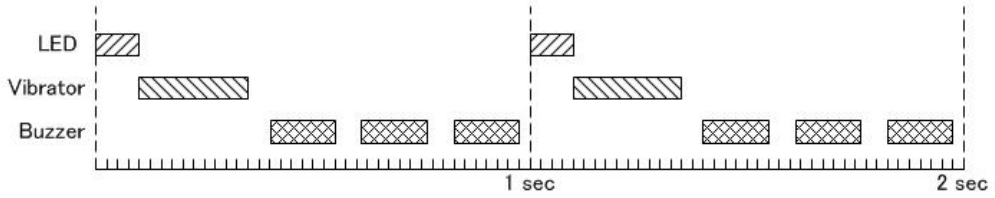
When multiple alarms happen, alarm pattern is determined by alarm priority.

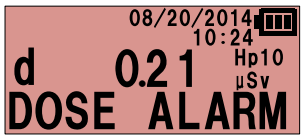
Alarm priorities are as follows:

Priority	Alarm	Remarks
1	Memory error	Breakdown
2	RTC error	Breakdown
3	Device error	Component failure
4	Battery empty	
5	Emergency alarm	
6	Detector optical check error	
7	Neutron accumulated dose overload	
8	Gamma-ray accumulated dose overload	
9	Neutron dose rate overload	
10	Gamma-ray dose rate overload	
11	Neutron accumulated dose alarm	
12	Gamma-ray accumulated dose alarm	
13	Neutron dose rate alarm	
14	Gamma-ray dose rate alarm	
15	Neutron accumulated dose warning	
16	Gamma-ray accumulated dose warning	
17	Neutron dose rate warning	
18	Gamma-ray dose rate warning	
19	Low battery voltage	
20	Time alarm	
21	Calibration due expiration	
22	Communication error (radio, BT, USB)	Component failure

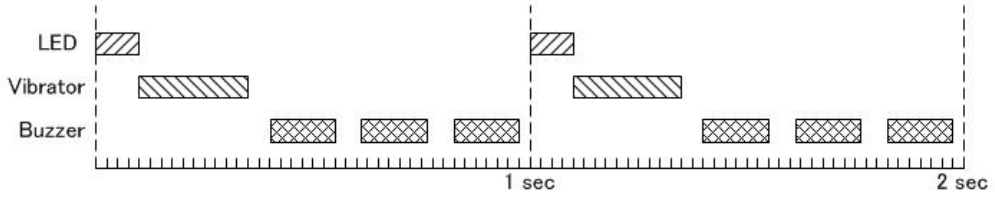
Initial settings of alarm operation for each alarm type are as follows:

1. Dose (rate) alarm

<table>
<tr><td>Alarm type</td><td>Initial setting of alarm operation</td></tr>
<tr><td>Accumulated dose alarm</td><td>(1) Operation timing
[Pattern No.3]
 

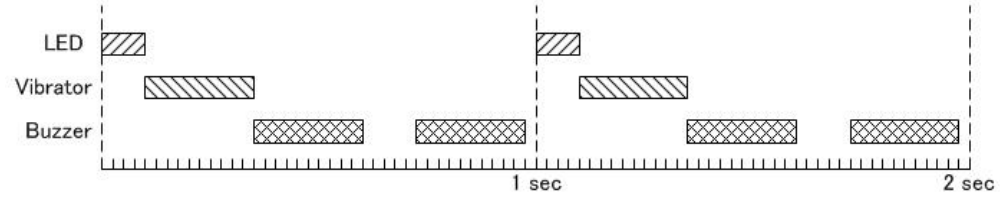
<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample
 

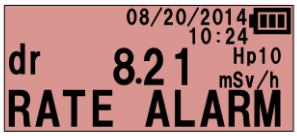
Accumulated dose alarm

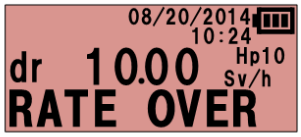
Overload</td></tr>
<tr><td>Accumulated Dose warning</td><td>(1) Operation timing
[Pattern No.3]
 

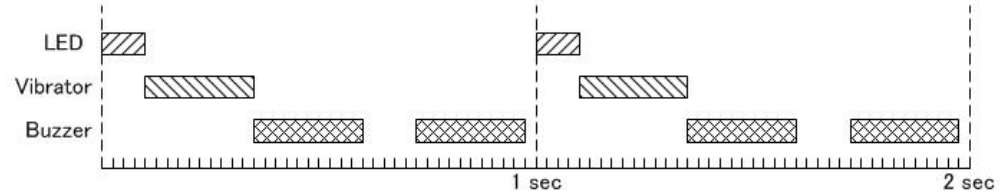
<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

Accumulated dose warning</td></tr>
</table>

<table>
<tr><td>Alarm type</td><td>Initial setting of alarm operation</td></tr>
<tr><td>Dose rate alarm</td><td>(1) Operation timing
[Pattern No.2]
 

<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
[ON]</td></tr>
</table>
(10) LCD indication sample
 

Dose rate alarm
 

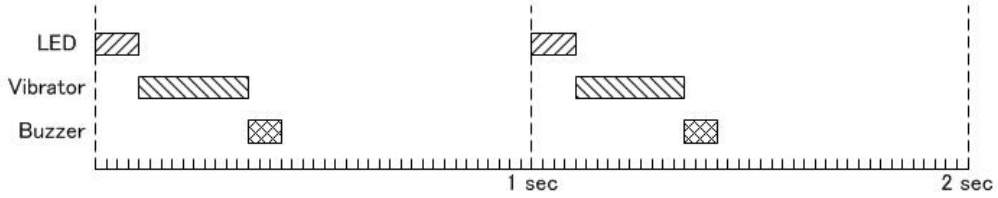
Overload</td></tr>
<tr><td>Dose rate warning</td><td>(1) Operation timing
[Pattern No.2]
 

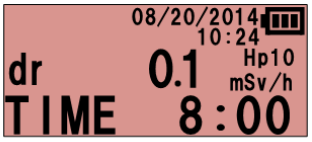
<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
[ON]</td></tr>
</table>
(10) LCD indication sample

Dose rate warning</td></tr>
</table>

*When “Accumulated dose alarm/ Accumulated dose warning” and “Dose rate alarm/ Dose rate warning” are generated at the same time, operation timing switches alternately. (e.g. pattern No.3 and pattern No.2 are switched every second in above case)

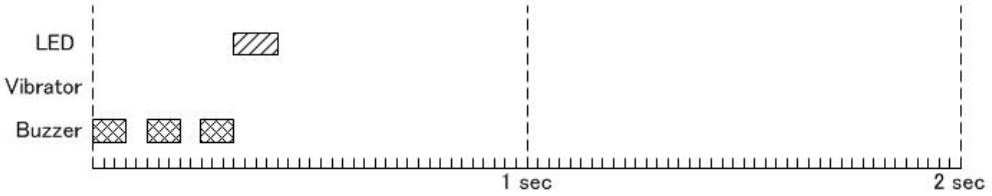
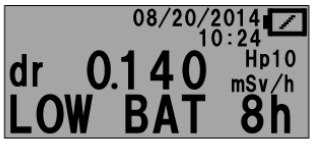
2. Operation time alarm

<table>
<tr><td>Alarm type</td><td>Initial setting of alarm operation</td></tr>
<tr><td>Time alarm</td><td>(1) Operation timing
[Pattern No.1]
 

<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample
 

*Indication (HH:MM) is operating time (increasing)
Time alarm</td></tr>
</table>

3. Low battery voltage

<table>
<tr><td>Alarm type</td><td colspan="4">Initial setting of alarm operation</td></tr>
<tr><td rowspan="5">Low battery voltage</td><td colspan="4">(1) Operation timing
[Pattern No.6]
 
</td></tr>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[OFF]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[OFF]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
<tr><td colspan="4">(10) LCD indication sample
 

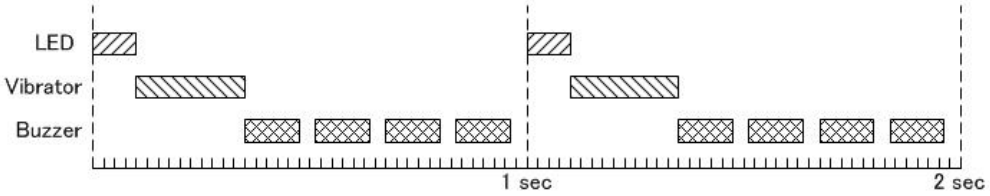
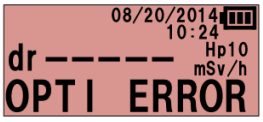
*Count down remaining operation time to turn off
Low battery voltage</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="5">Battery empty</td><td colspan="4">(1) Operation timing
N/A</td></tr>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[OFF]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[OFF]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
<tr><td colspan="4">(10) LCD indication sample

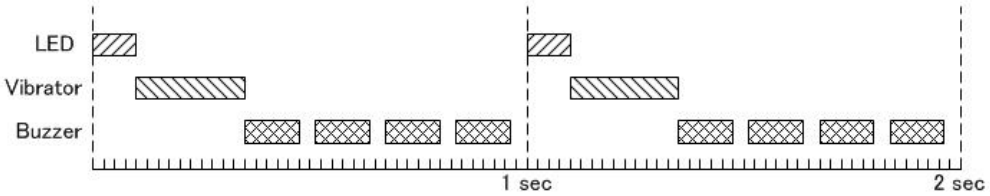
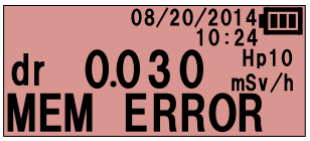
Battery empty</td></tr>
<tr><td colspan="4"></td></tr>
</table>

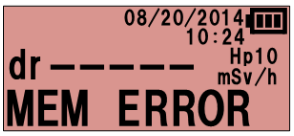
*If “Battery empty” is displayed, please replace the batteries with new ones immediately.

*Only dose measurement function is active in “Battery empty” condition.

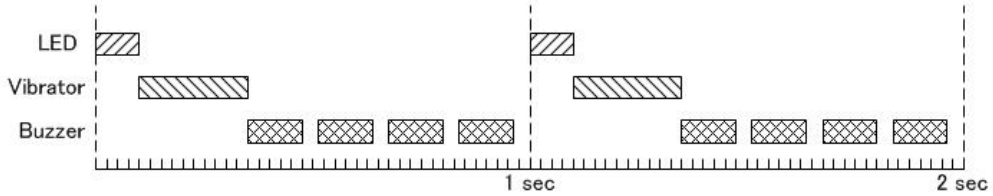
4. Indication of abnormality

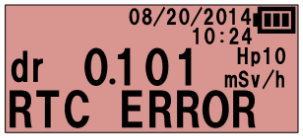
<table>
<tr><td>Alarm type</td><td colspan="4">Initial setting of alarm operation</td></tr>
<tr><td rowspan="6">Detector optical
Check error</td><td colspan="4">(1) Operation timing
[Pattern No.4]
 
</td></tr>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
<tr><td colspan="4">(10) LCD indication sample
 

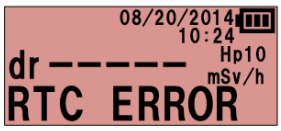
Detector optical check error</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Memory error</td><td colspan="4">(1) Operation timing
[Pattern No.4]
 
</td></tr>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
<tr><td colspan="4">(10) LCD indication sample
 

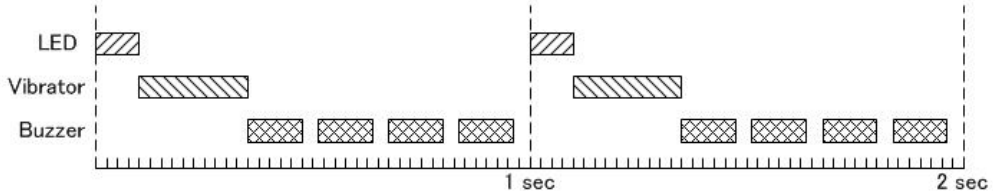
Memory error
 

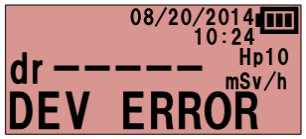
Measurement stops</td></tr>
</table>

<table>
<tr><th>Alarm type</th><th>Initial setting of alarm operation</th></tr>
<tr><td>RTC error</td><td>
(1) Operation timing
[Pattern No.4]


<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample


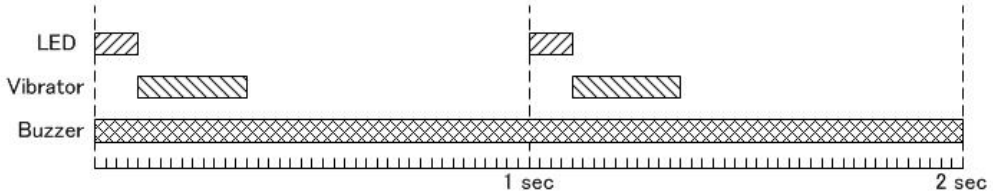
RTC error


Measurement stops
</td></tr>
<tr><td>Device error</td><td>
(1) Operation timing
[Pattern No.4]


<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample


Device error
</td></tr>
</table>

5. Call button action

<table>
<tr><td>Alarm type</td><td>Initial setting of alarm operation</td></tr>
<tr><td>Emergency alarm</td><td>(1) Operation timing
[Pattern No.5]
 

<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[RED]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

Emergency alarm</td></tr>
</table>

*Operation by pressing call button is selectable from the following four settings by user with Dosimeter Configuration Tool.

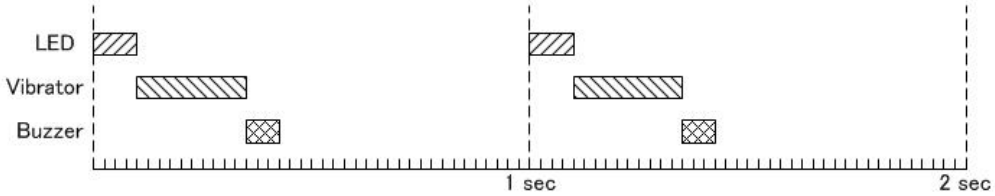
[Emergency alarm] … When call button is pressed, the above alarm operation generates and emergency data is delivered to upper management system if radio telemetry setting is “ON”.

[Support assist] … When call button is pressed, the above alarm operation generates (the same as “Emergency alarm”). Emergency data is not delivered to upper management system if radio telemetry setting is “ON”.

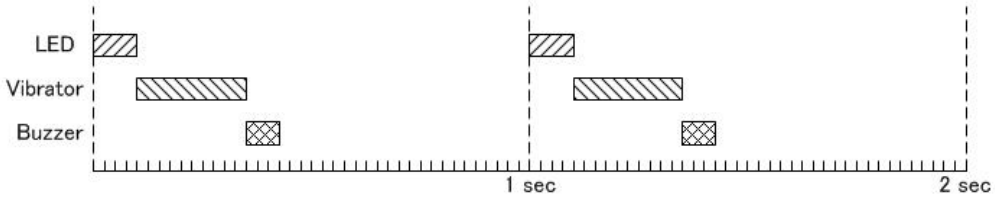
[Test] … When call button is pressed, test sequence for display, LED, vibrator and buzzer is performed in the same way as startup

[OFF] … When call button is pressed, nothing happens.

6. Notification

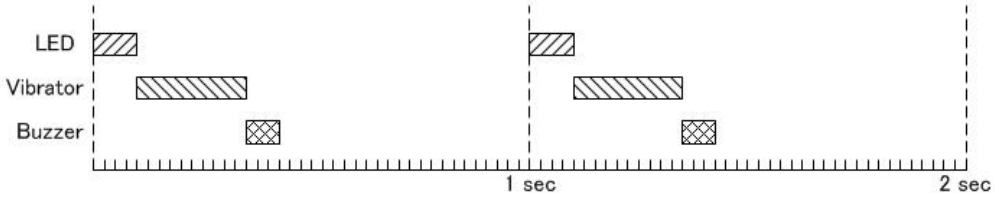
<table>
<tr><td>Alarm type</td><td>Initial setting of alarm operation</td></tr>
<tr><td>Calibration due expiration</td><td>(1) Operation timing
[Pattern No.1]
 

<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[ON]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[ON]</td><td>(8) Flash LED
[ON]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

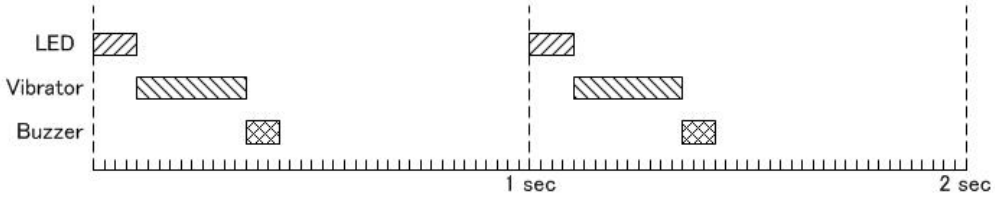
Calibration due expiration</td></tr>
<tr><td>Radio communication error (Component failure is detected at startup)</td><td>(1) Operation timing
[Pattern No.1]
 

<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[OFF]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[OFF]</td><td>(8) Flash LED
[OFF]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

Radio communication error</td></tr>
</table>

<table>
<tr><th>Alarm type</th><th>Initial setting of alarm operation</th></tr>
<tr><td>Bluetooth communication error (Component failure is detected at startup)</td><td>
(1) Operation timing
[Pattern No.1]


<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[OFF]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[OFF]</td><td>(8) Flash LED
[OFF]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

Bluetooth communication error
</td></tr>
<tr><td>USB communication error (Component failure is detected at startup)</td><td>
(1) Operation timing
[Pattern No.1]


<table>
<tr><td>(2) Buzzer frequency
[High]</td><td>(3) Buzzer sound
[OFF]</td><td>(4) Backlight
[YELLOW]</td><td>(5) Sounding time
[Continuous]</td></tr>
<tr><td>(6) Mute
[Not available]</td><td>(7) Vibrator
[OFF]</td><td>(8) Flash LED
[OFF]</td><td>(9) Latch
N/A</td></tr>
</table>
(10) LCD indication sample

USB communication error
</td></tr>
</table>

4.3.3 Monitoring Sound

Buzzer sounds 1 time for a short period, if accumulated dose reaches a preset value of dose interval for monitoring sound. Monitoring sound interval can be chosen from six types, “OFF”, “100 uSv (10 mrem)”, “10 uSv (1 mrem)”, “1 uSv (0.1 mrem)”, “0.2 uSv (0.02 mrem)” and “0.1 uSv (0.01 mrem)”. Please see User’s Manual of “Dosimeter Configuration Tool” for details.

4.4 Communication function

4.4.1 Wi-Fi communication function

4.4.1.1 Instructions for use

(1) The following settings are required in NRF51 in order that Wi-Fi communication is active.

Transmission interval: [2 seconds], [4 seconds], [10 seconds], [30 seconds] or [1 minute] (selectable)

Data format: [Type1], [Type2] or [Type3] (selectable)

Encryption: [WPA], [WPA2], [WEP] or [No encryption] (selectable)

Protocol: [UDP] or [TCP] (selectable)

IP address mode: [DHCP] or [Fixed address] (selectable)

*If “Fixed address” is selected, Local IP address, Subnet mask and Gateway settings are needed.

SSID: Up to 31 characters (see access point label)

Network key: Up to 32 characters (see access point label)

Host IP address: [0 to 255, 0 to 255, 0 to 255, 0 to 255] (IP address of server)

Port No.: 0 to 65535 (Opened port No. of server)

(2) Wi-Fi communication setting should be “ON” by user with Dosimeter Configuration Tool.

(3) When the setting is “ON”, NRF51 starts connection with cloud server via Wi-Fi access point. After connection establishment, NRF51 sends telemetry data with selected transmission interval and data format.

4.4.1.2 Specification

Operating time: More than 8 hours (New alkaline two batteries are used and transmission interval is “10 seconds”)

*“Low battery voltage” alarm generates if Wi-Fi communication stops because of low battery in use. When the alarm occurs, please exit from radiation controlled area immediately and replace the batteries with new ones.

*Use of two batteries is recommended in order to keep stable communication status though NRF51 can be used by one battery.

4.4.1.3 Icon display

Wi-Fi icon

Communication prohibition icon

(1) Wi-Fi icon flashes: Connection processing in progress or searching for radio waves

(2) Wi-Fi icon turns on: Active (connection established)

(3) Communication prohibition icon turns on: Low battery voltage

(4) No icon: OFF

Attention	Please make sure that there is no obstacle such as a metal object between NRF51 and Wi-Fi access point in Wi-Fi communication. If there is the obstacle, communication may be unstable and sending data may be lost.

4.4.2 Bluetooth communication function

4.4.2.1 Instructions for use

(1) Bluetooth communication setting should be “ON” by user with Dosimeter Configuration Tool.

(2) When the setting is “ON”, NRF51 starts connection with heart rate monitor. After connection establishment, NRF51 receives the heart beat data from heart rate monitor and sends telemetry data with selected transmission interval and data format. Data format is according to the setting of Wi-Fi communication or USB communication.

4.4.2.2 Specification

Communication standard: BLE (Bluetooth4.0)

Heat rate monitor: H7 (Made by POLAR)

4.4.2.3 Icon display

Bluetooth icon

(1) Bluetooth icon flashes: Connection processing in progress or searching for radio waves

(2) Bluetooth icon turns on: Active (connection established)

(3) No icon: OFF

⚠ Attention	Please make sure that there is no obstacle such as a metal object between NRF51 and heart rate monitor in bluetooth communication. If there is the obstacle, communication may be unstable and sending data may be lost.

4.4.3 USB communication function

4.4.3.1 Instructions for use

(1) Driver file should be installed in PC before starting USB communication.
Driver: CP210x USB to UART Bridge VCP Driver (Made by Silicon Laboratories)
URL: https://jp.silabs.com/developers/usb-to-uart-bridge-vcp-drivers
*URL information as of year 2020

(2) NRF51 should be connected PC with USB cable.

(3) Setting parameter can be changed by user with Dosimeter Configuration Tool in the same way as using infrared communication. Also, NRF51 starts transmission of telemetry data periodically when USB telemetry mode setting is “ON”.
*It is recommended that USB telemetry mode “ON/OFF” setting is changed by using infrared communication. If USB telemetry mode is “ON”, setting configuration may be unstable by using USB communication.
*Power is supplied by PC under USB connection.
(NRF51 doesn’t have a function to charge batteries)

4.4.3.2 Specification

Communication standard: USB2.0
USB connector type: Micro-B
Recommended USB cable: CW-117MC (Made by Core Wave) or equivalent
*It may not work when use except for recommended USB cable

4.4.3.3 Icon display

USB icon

(1) USB icon turns on: Active (connection established)

(2) No icon: OFF

4.4.4 Infrared communication function

4.4.4.1 Instructions for use

(1) NRF51 should be placed so as that infrared window of NRF51 is opposite to Infrared.
(See P.8 and P.9)

(2) Setting parameter can be changed by user with Dosimeter Configuration Tool.

4.4.4.2 Specification

Communication standard: IrDA ver. 1.2 (Low Power)

Recommended infrared device: ACT-IR220LN9.6 (Made by ACTiSYS)

4.4.4.3 Icon display

Infrared icon

(1) Infrared icon turns on: Active (connection established)

(2) No icon: OFF

⚠ Attention	For infrared communication, be sure to communicate with one dosimeter at a time. Do not communicate with more than one dosimeter at a time, such as arranging multiple dosimeters. Also, do not communicate near objects that reflect infrared rays, such as mirrors. Otherwise, data may be written to other dosimeters by mistake, a data error may occur, or communication may become impossible.

5. Parts Replacement

5.1 Battery replacement

Follow these steps to replace the batteries:

(1) Press and hold “ ◎ ” button to turn NRF51 off.

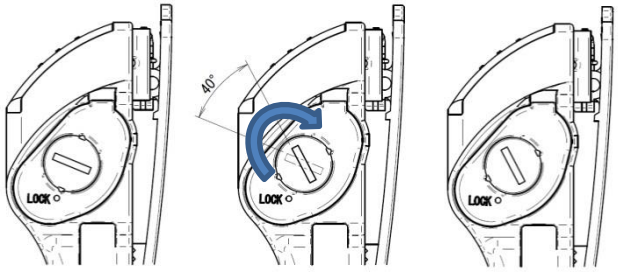
(2) Open the cap of battery compartment using a coin or coin driver.

(3) Replace the batteries.

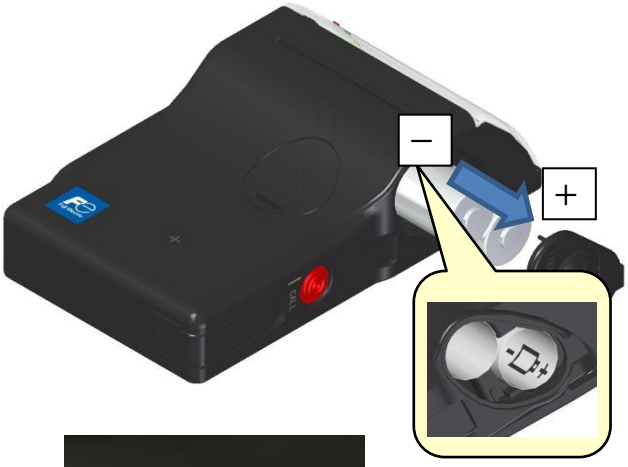
Insert new ones properly in the compartment with care to check the directions “+” and “-“.

(Both batteries are positioned in the same direction)

(4) Close the cap and tighten with a coin or coin driver.

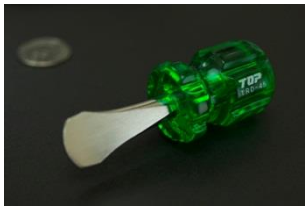


Close Use a coin to open Open



Battery polarity sign

* NRF51 can be operated even by one battery.



Coin driver

⚠ Attention	1. When replacing batteries, make sure to turn off NRF51. 2. During replacement, align the battery polarity correctly. 3. Use only AA Alkaline battery. 4. When replacing batteries, both batteries must be changed at the same time. 5. To ensure airtightness, make sure the cap is in close contact before closing.

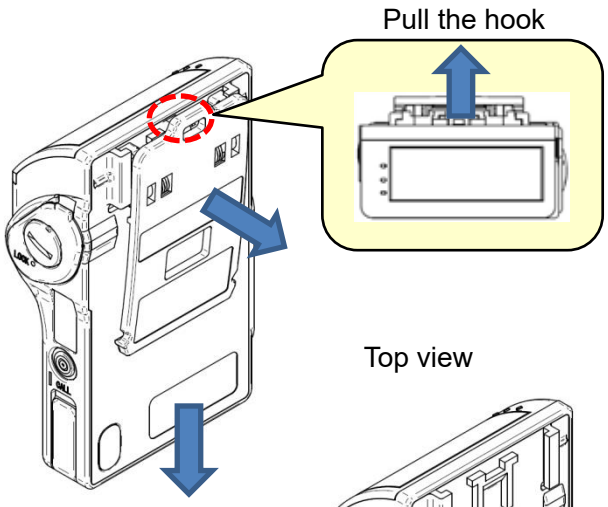
5.2 Clip replacement

Follow these steps to replace the clip:

[Removal of the clip]

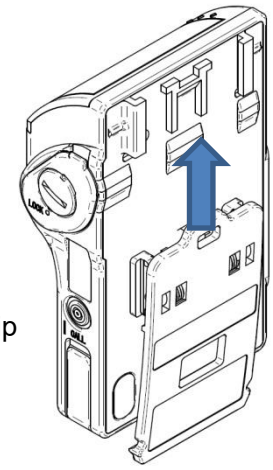
(1) Pull the clip hook.

(2) Pull the clip down keeping the clip hook away from NRF51.



[Mounting of the clip]

(1) Push the clip up until the clip hook closely inserted to NRF51.



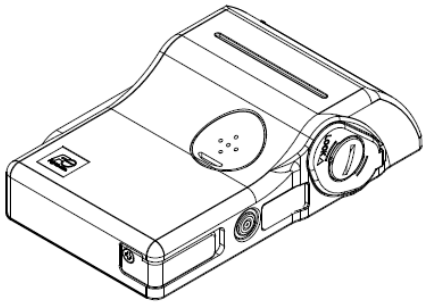
5.3 USB connector cap replacement

Follow these steps to replace the USB connector cap:

[Removal of the USB connector cap]

(1) Open the USB connector cap.

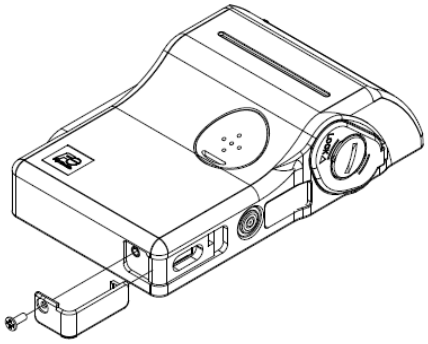
(2) Turn a screw down with a Phillips-head screwdriver and take off the USB connector cap.



[The way of put on the USB connector cap]

(1) Put on the USB connector cap and turn a screw up with a Phillips-head.

(2) Close the USB connector cap.

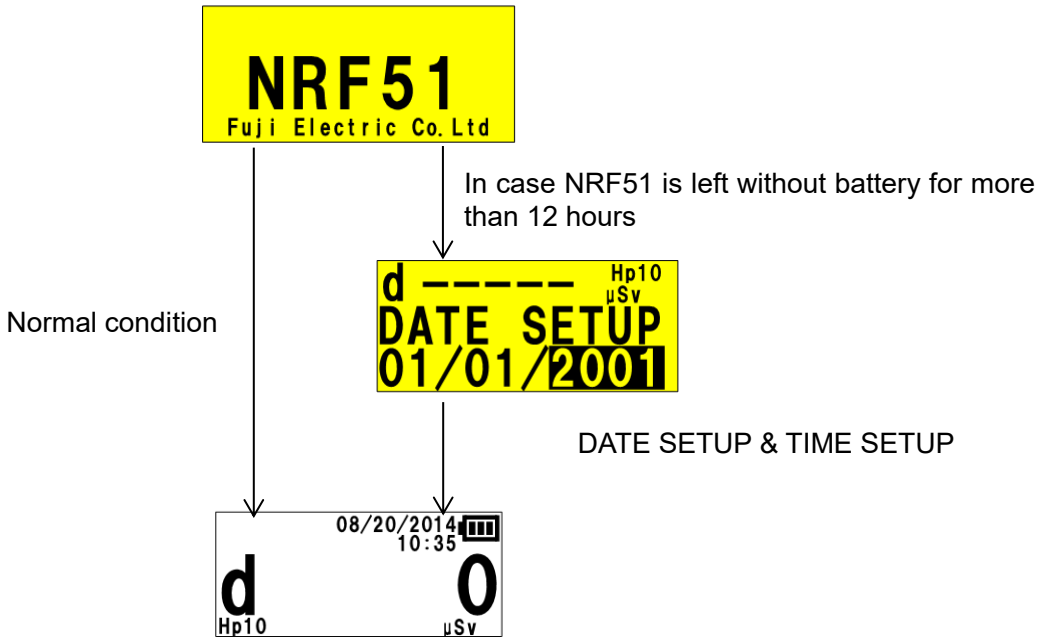


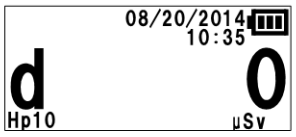
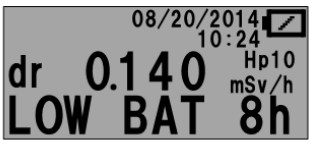
6. Operational Instruction

6.1 When starting to use

(1) Press and hold “◎” button for more than 3 seconds to start the NRF51.

Confirm the power is ON (Backlight, Vibrator and LED check, one time short beep sound) and LCD displays an initial screen.



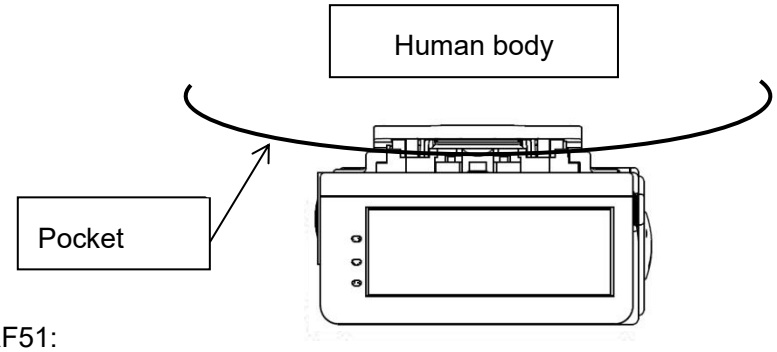
Check items	Confirmation method	
Audible signal (1 beep)	Short beep sound is generated when dosimeter is turned on.	
Indicated dose value	0 uSv or 0 uSv/h (Accumulated dose may not be 0 uSv if the power-on-reset setting of NRF51 is “OFF”.)	
LCD	〔Normal display〕  When accumulated dose is 0 uSv	〔Example of abnormal display〕  When generating alarm for low battery

(2) White backlight turns on by pressing any of “◎”, “△” or “▽” button.

Display of accumulated dose (Sv or rem) and dose rate (Sv/h or rem/h) can be switched by p ushing the button of “△” or “▽”. “◎” button can also switch the display to other screens.

Please see section 6.2 in details for screen change methods by “◎” button.

(3) Put NRF51 in the chest pocket as shown below.

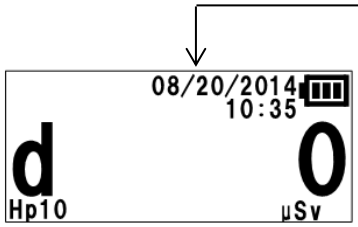
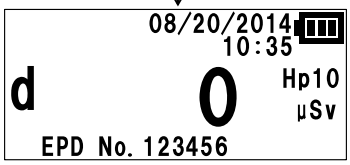
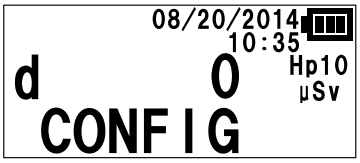
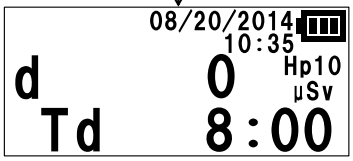


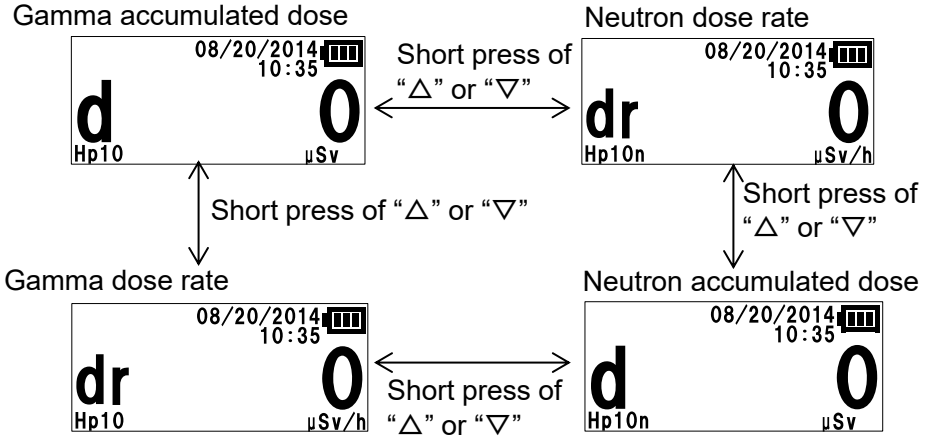
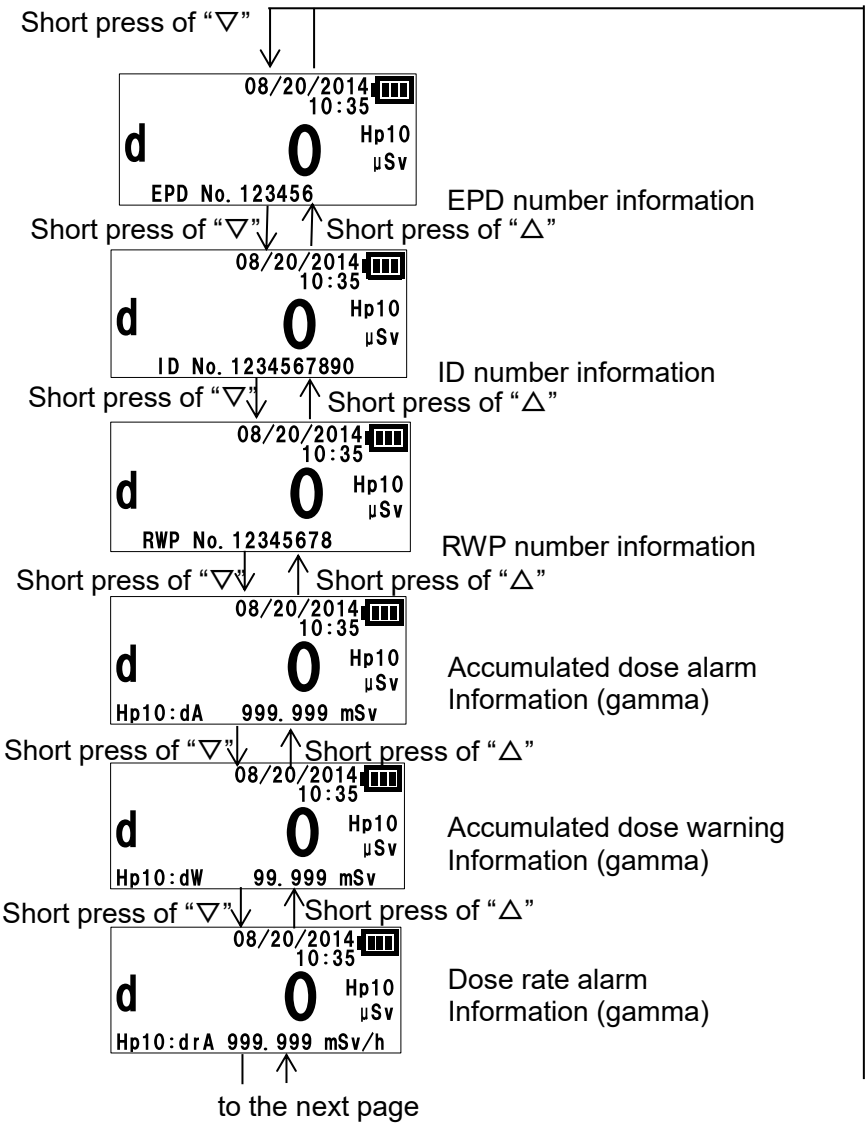
※Direction of NRF51:

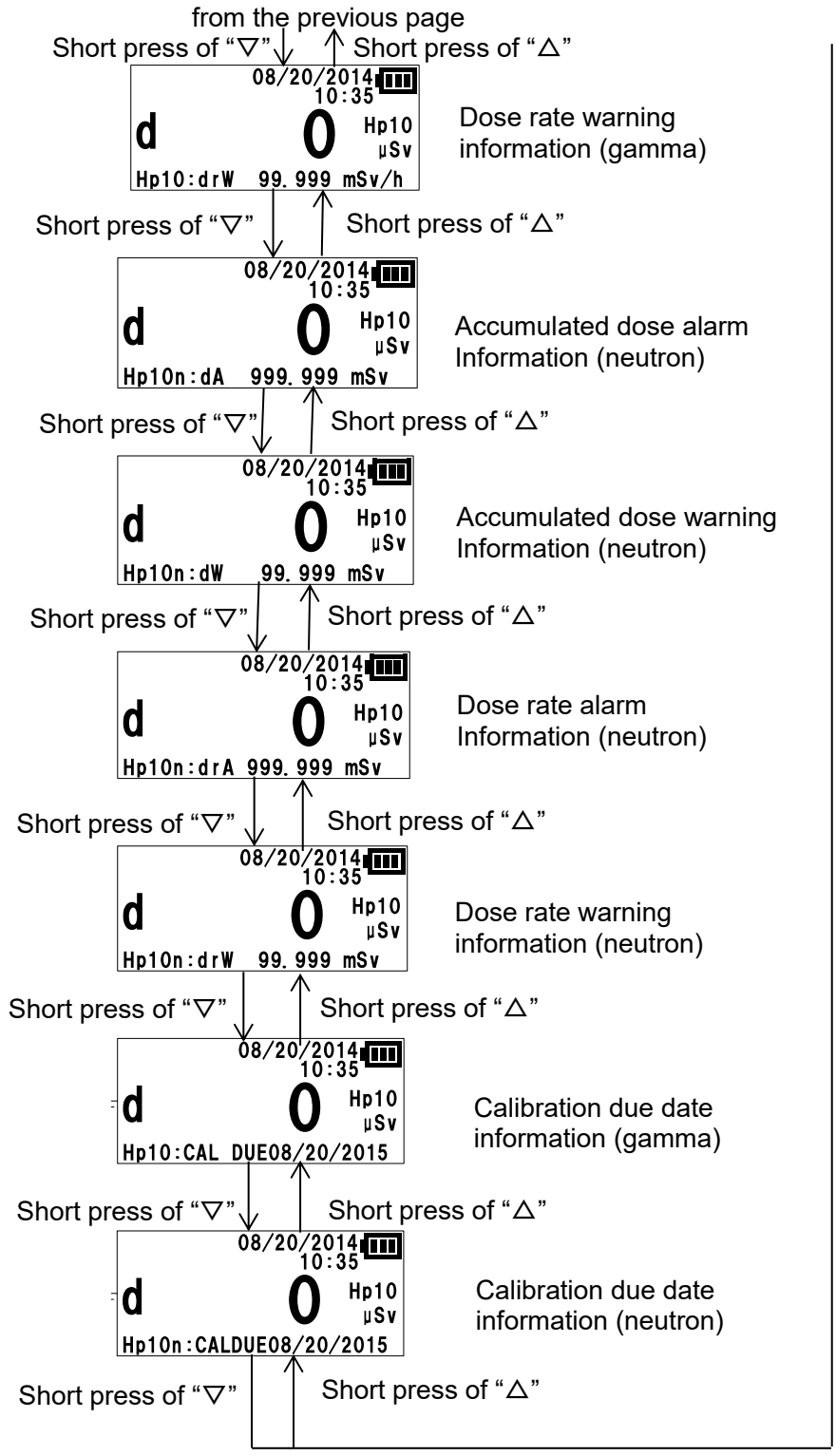
As NRF51 is viewed from wearer, operation button and auxiliary LED must be positioned so that they are in the right side from wearer’s point of view, and buzzer faces outward.

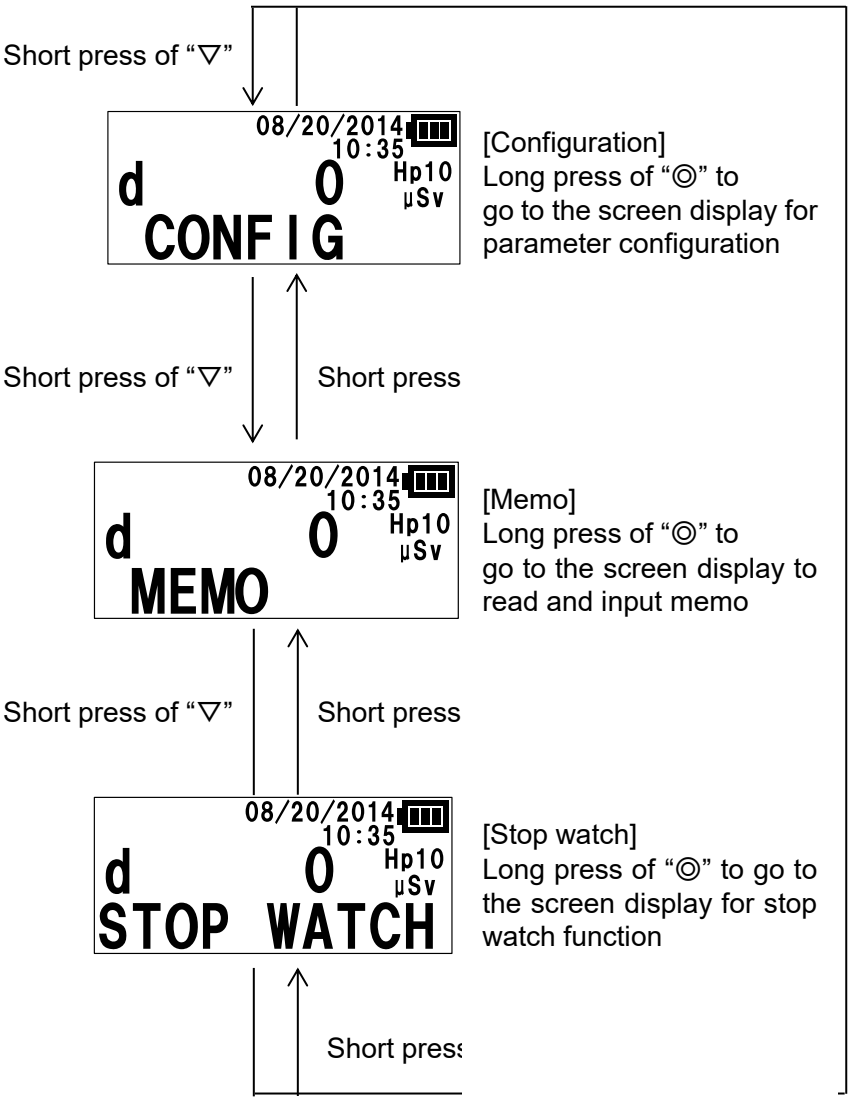
6.2 During use (Normal operation)

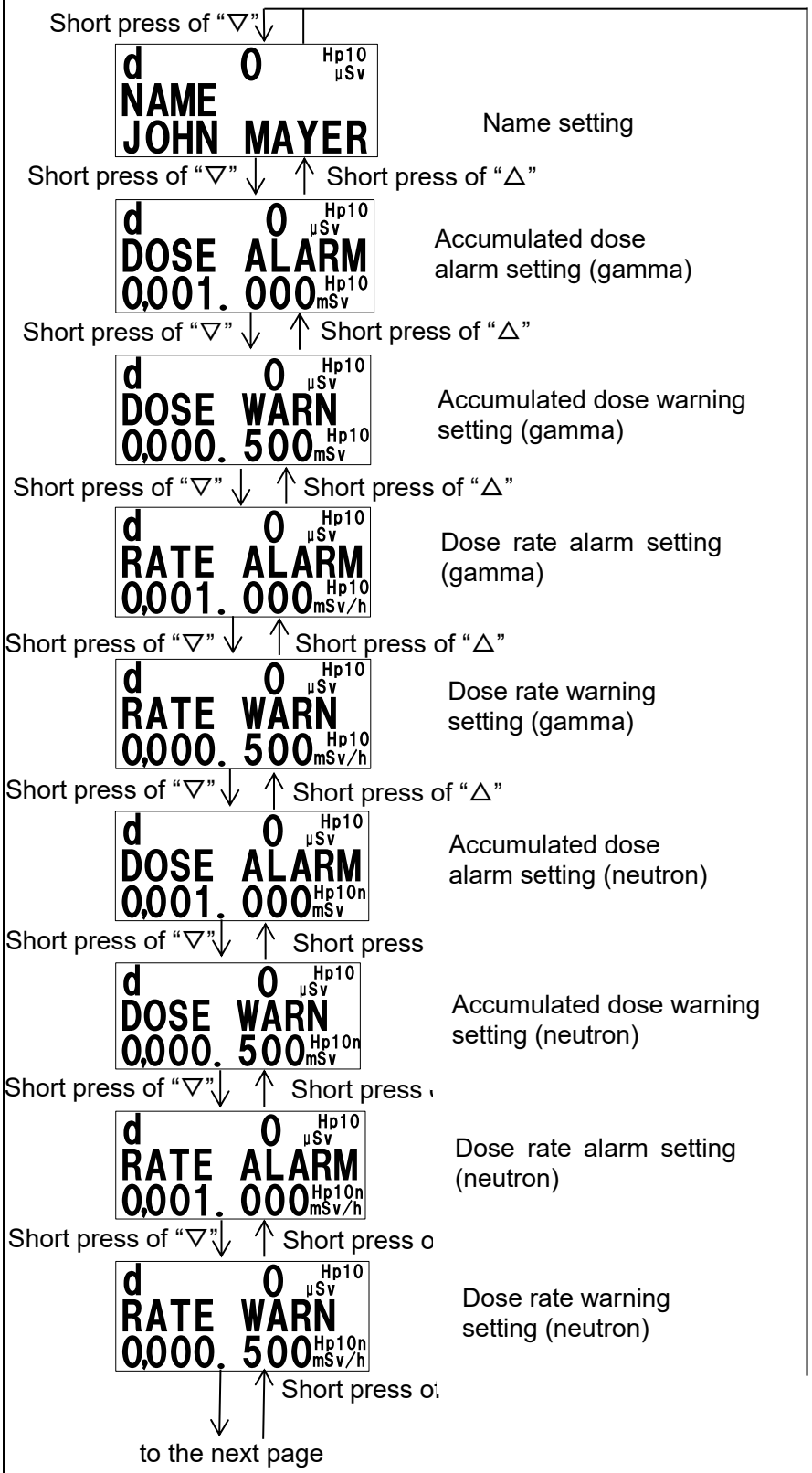
LCD display change flows by operation of button are as follows:
*If either of the operation buttons was pressed when LCD backlight is turned off, LCD backlight would be turned on. Then, LCD display will be changed as the following table shows.

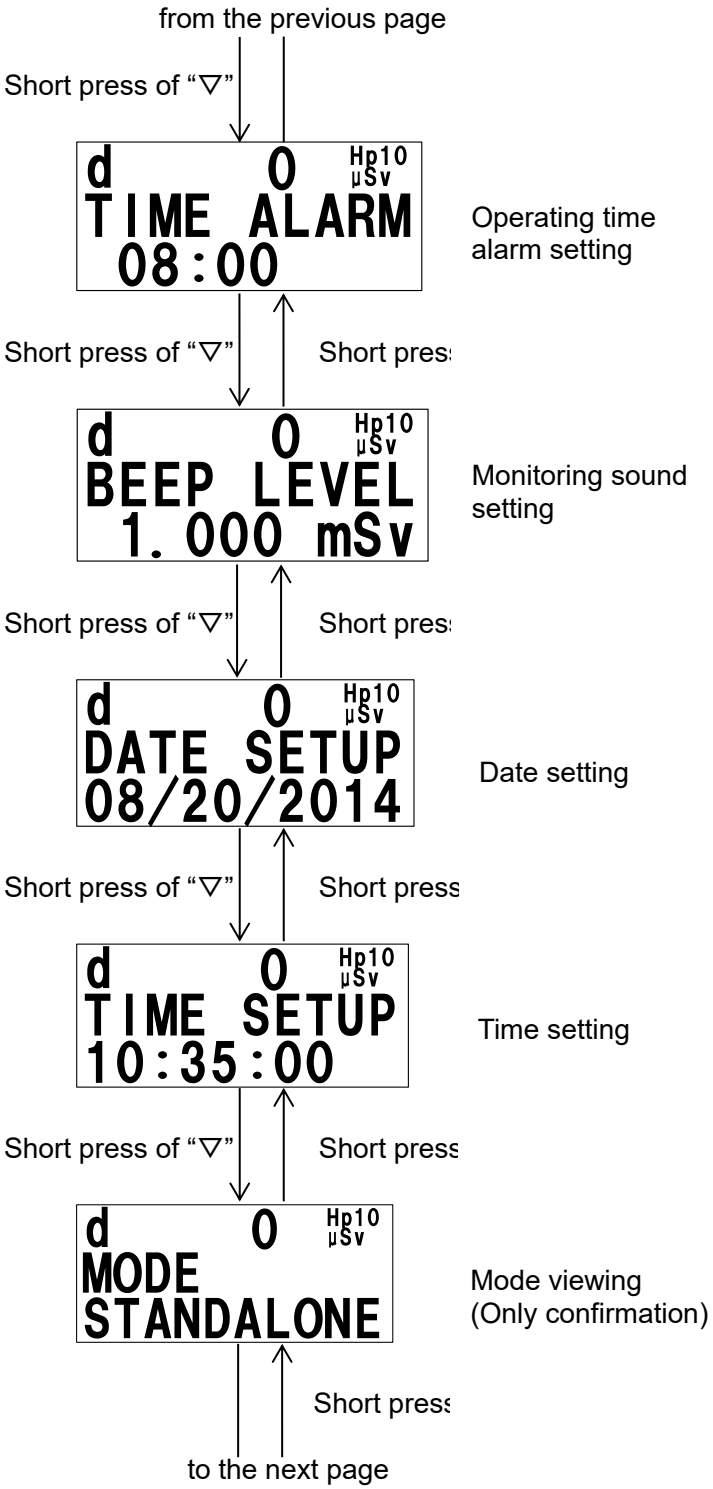
No.	Display	Remarks
1	[Basic display] ⇨ To No.2  [Information display] Short press of "◎" ⇨ To No.3  [Configuration/Accessory display] Short press of "◎" ⇨ To No.4  [Operating time display] Short press of "◎" ⇨ To No.8  Short pressing of "◎"	Power turns off by long press of "◎" button. (In Basic display or Information display) Indication is changed by short press of "△" or "▽" button in each display. See the following pages for detailed flow.

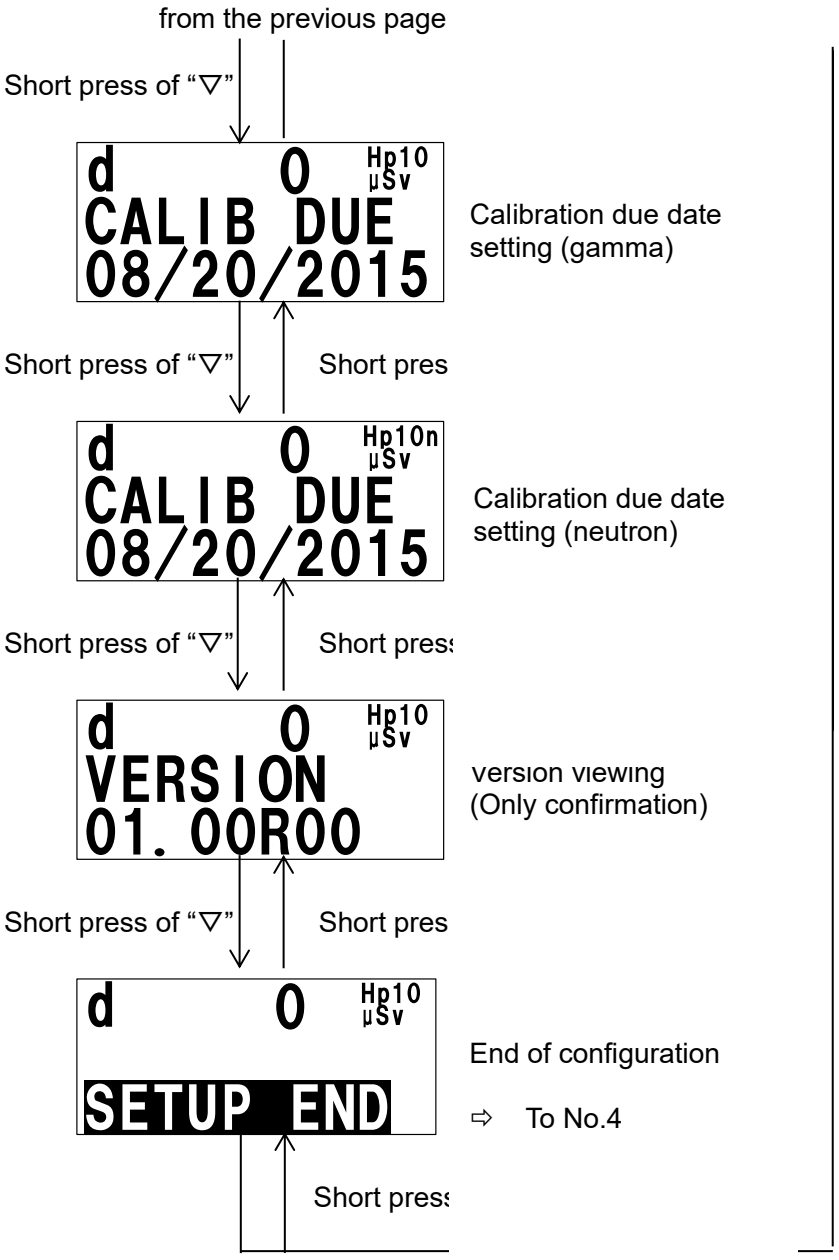
No.	Display	Remarks
2	[Basic display] Switching 	Power turns off by long press of "◎" button.
3	[Information display] Switching 	Power turns off by long press of "◎" button. Each indication can be selected to show/hide via Dosimeter Configuration Tool.

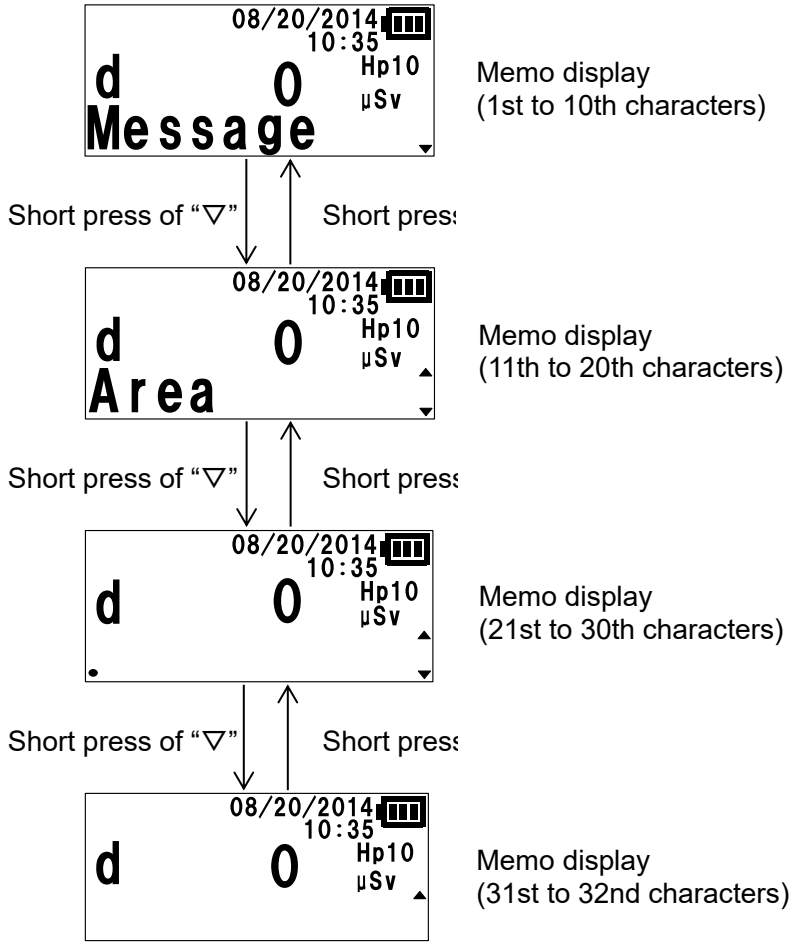
No.	Display	Remarks
3	[Information display] Switching (continued) 	Power turns off by long press of "◎" button. Each indication can be selected to show/hide via Dosimeter Configuration Tool.

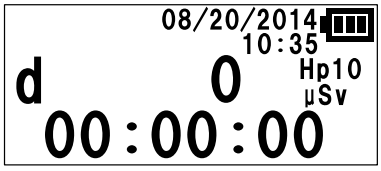
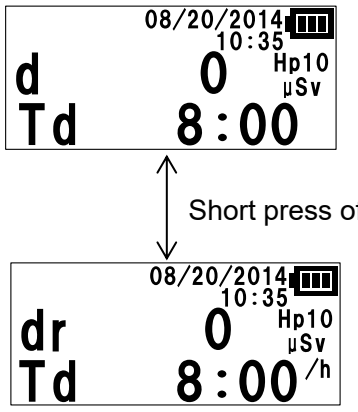
No.	Display	Remarks
4	[Configuration/Accessory display] Switching  	Long press of "◎" to go to each screen display.

No.	Display	Remarks
5	[Parameter configuration display] Switching  	Short press of "◎" to change a displayed parameter. (Yellow backlight turns on) Long press of "◎" to confirm the parameter change. Name can be entered with 10 characters from A to Z. Alarm value can be set with numbers of 0 to 9.

No.	Display	Remarks
5	[Parameter configuration display] Switching (continued)  	Short press of "◎" to change a displayed parameter. (Yellow backlight turns on) Long press of "◎" to confirm the parameter change. Alarm setting, date and time setting can be set with numbers 0 to 9. Monitoring sound can be selected.

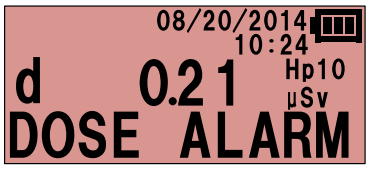
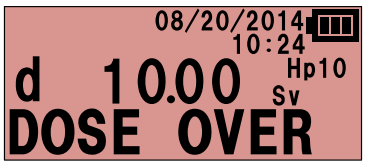
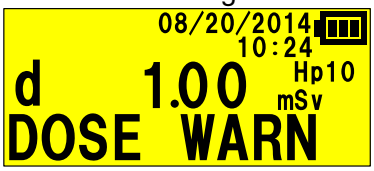
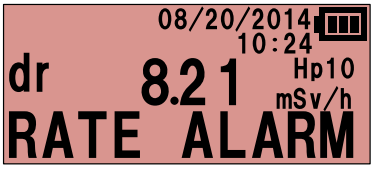
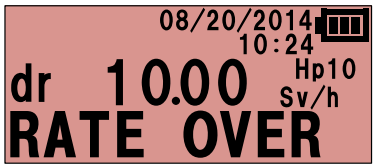
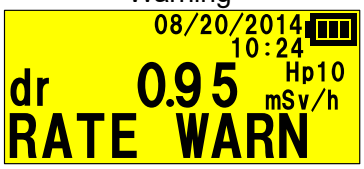
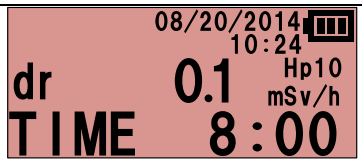
No.	Display	Remarks
5	[Parameter configuration display] Switching (continued)  	Short press of "◎" to change a displayed parameter. (Yellow backlight turns on) Long press of "◎" to confirm the parameter change. Calibration due date setting can be set with numbers 0 to 9. Return to Configuration/Accessory display by short press of "◎".

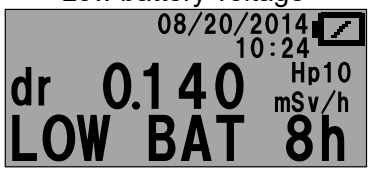
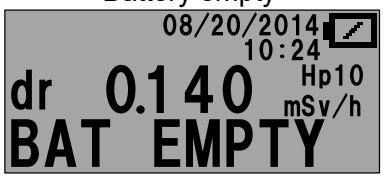
No.	Display	Remarks
6	[Memorandum]  Memo display (1st to 10th characters) Memo display (11th to 20th characters) Memo display (21st to 30th characters) Memo display (31st to 32nd characters)	Return to Configuration/Accessory display by long press of "◎".

No.	Display	Remarks
7	[Stop watch]  Stop watch display [Start]/[Stop] : Short press of "△" when white backlight turns on [Clear] : Short press of "◎" when the stop watch does not run and white backlight turns on	Return to Configuration/Accessory display by long press of "◎". (It is possible even when time counting up)
8	[Operating time display] Switching  Indication of accumulated dose and operating time (Td : time remaining, decreasing from operating time alarm value) Indication of dose rate and operating time (Td : time remaining, decreasing from operating time alarm value) [Ti : time increasing from beginning o instead of [Td] via Dosimeter Configu...	Power cannot turn off by long press of "◎" button. Return to Basic display by short press of "◎" button.

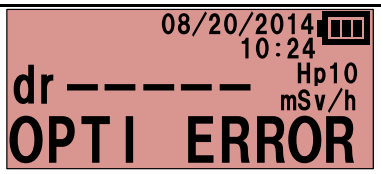
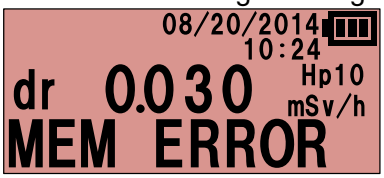
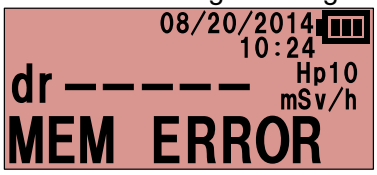
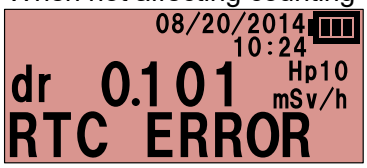
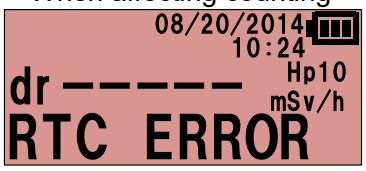
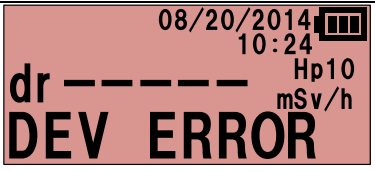
6.3 During use (When alarm is generated)

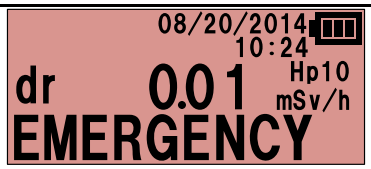
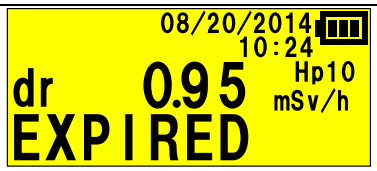
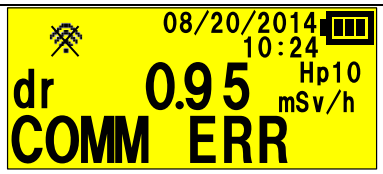
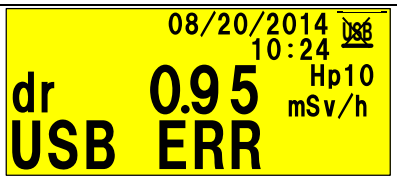
When some alarms are generated, LCD displays are as follows:
*See Chapter 4 for operation of buzzer, vibrator and LED/Backlight during alarm generation.

No	Item	Display	Remarks
1	Accumulated dose alarm/warning	Alarm  Overload  Warning 	Warning alarm is generated when exceeding dose warning set value. Alarm is generated when exceeding dose alarm set value. Also, display is changed when overload happens. For neutron alarm/warning, Hp10n is displayed instead of Hp10.
2	Dose rate alarm/warning	Alarm  Overload  Warning 	Warning alarm is generated when exceeding dose rate warning set value. Alarm is generated when exceeding dose rate alarm set value. Also, display is changed when overload happens. Alarm is canceled when dose rate reaches down at 80% of warning/alarm value or less. For neutron alarm/warning, Hp10n is displayed instead of Hp10.
3	Operation time alarm		When exceeding operating time alarm set value, time alarm is generated.

No	Item	Display	Remarks
4	Low battery voltage Battery empty	Low battery voltage  Battery empty  	Low battery voltage alarm is generated when battery voltage reaches less than 1.1V. Remaining operational hours is displayed with numbers 1 to 9 h, then power OFF after 1 hour. Battery empty alarm is generated when the batteries are empty. Only dose measurement function is active. Please replace the batteries with new ones immediately.

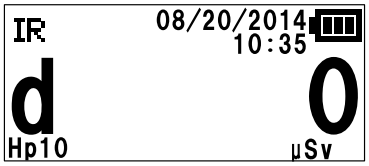
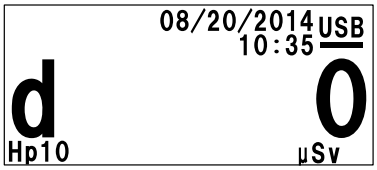
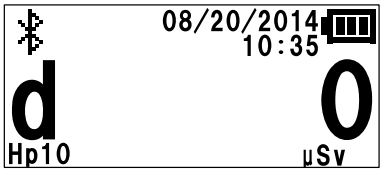
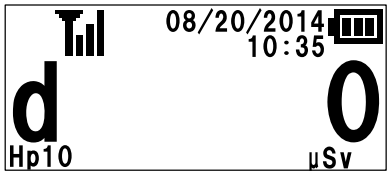
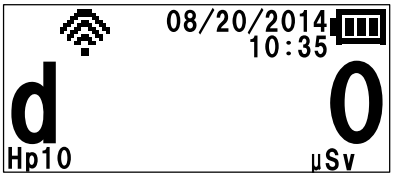
⚠ Attention	1. Replace the battery promptly when generating low battery voltage alarm. 2. Buzzer, LED, Backlight, Vibrator and other function may not work after low battery voltage alarm is generated.

No	Item	Display	Remarks
5	Detector optical check error		When detector failure is detected by internal LED optical pulse check, detector optical check error alarm is generated.
6	Memory error	When not affecting counting  When affecting counting 	When memory failure occurs during data backup, memory error alarm is generated. When the failure does not affect counting function, operation continues. Meanwhile, when the failure affects counting function, operation stops and the dose (rate) value would be lost.
7	RTC error	When not affecting counting  When affecting counting 	RTC error alarm is generated, when Real Time Clock (RTC) IC error is detected. When the error does not affect counting function, operation continues. Meanwhile, when the error affects counting function, operation stops and the dose (rate) value would be lost.
8	Device error		Device error alarm is generated, when the electronic components except for detector, memory or RTC are failure.

No	Item	Display	Remarks
9	Emergency alarm		Emergency alarm is generated, when “call” button is pressed for more than 3 seconds.
10	Calibration due expiration		Expiration alarm is generated when calibration due date is passed.
11	Radio communication error		Radio communication error is generated, when the electronic component which is related to radio communication is failure.
12	Bluetooth communication error		Bluetooth communication error is generated, when the electronic component which is related to bluetooth communication is failure.
13	USB communication error		USB communication error is generated, when the electronic component which is related to USB communication is failure.

6.4 During use (When communicating)

LCD display indications during communication are as follows:

No	Item	Display	Remarks
1	Infrared communication		“IR icon” is displayed on the upper left of screen during infrared communication.
2	USB communication		“USB icon” is displayed at battery life position during USB connection and communication.
3	Bluetooth communication		“Bluetooth icon” is displayed on the upper left of screen during Bluetooth communication.
4	900MHz wireless telemetry (900MHz radio type only)		“Radio icon” is displayed on the upper left of screen during communication with 900MHz wireless telemetry.
5	Wi-Fi telemetry (Wi-Fi type only)		“Wi-Fi icon” is displayed on the upper left of screen during communication with Wi-Fi telemetry.

6.5 After use

Turn OFF by long press of “◎” on basic display or information display.

7. Care and Maintenance

Check the NRF51 as specified below to ensure quality of the product performance.

7.1 Daily check and maintenance items

No	Check items	Procedures	Check point
1	Appearance	Check the NRF51 visually. When to check；Before use and after battery replacement Check purpose；Check if there is no abnormality with the case and battery cap.	No signs of crack, damages or breakage on the case. No signs of gap between case and battery cap.
2	Indication error/ calibration	To confirm the indication error within 10% to the reference dose equivalent using Cs-137. When to check: 1 year or less Check purpose: To ensure a valid dose measurement by dosimeter	If indication error is greater than 10%, please configure calibration factor correctly. If the error is unusually large, please contact Fuji Electric representative.

7.2 Consumable supplies

Please Contact Fuji Electric representative for the following consumables.

No	Parts name	Replace criterion	Drawing number	remarks column
1	Battery cap	2 years	TQ403907C1	
2	USB connector cap	2 years	TQ504089C1	
3	Clip	When clip is broken	TQ403901C1	

8. Specification

8.1 General Specification

NOTE: UOM can be changed to rem.

Model : NRF51
Detector : Silicon semi-conductor
Radiation type : γ(X) rays (30 keV to 7.0 MeV) and neutron (0.025 eV to 15 MeV)
Dose display range: 0 uSv to 10 Sv, 0 uSv/h to 10 Sv/h for gamma
0 uSv to 10 Sv, 0.0 mSv/h to 10 Sv/h for neutron
Gamma effective measurement range: 20 uSv to 10 Sv, 0.5 uSv/h to 10 Sv/h (accumulated dose)
100 uSv/h to 10 Sv/h (dose rate)
Neutron effective measurement range: 500 uSv to 10 Sv, 5 uSv/h to 10 Sv/h (accumulated dose)
50 mSv/h to 10 Sv/h (dose rate)
Rated range : Gmha-Na (category for IEC61526)
Indication error : Within ±10 % (Cs-137, 20 uSv to 10 Sv)
Within ±15 % (Cf-252, 500 uSv to 10 Sv)
Energy characteristic : Within ±20 %（Cs-137, 50 keV ～ 6 MeV）
Within ±50 %（Cf-252, 250 keV ～ 4.5 MeV）
Direction characteristic : Within ±20 %（Cs-137, Vert. and horz. to ±75°）
Within ±30 %（Cf-252, Vert. and horz. to ±75°）
Energy and direction response: Relative response 0.71 to 1.67 (60 keV to 6 MeV, 0° to 60°) for gamma
Temperature characteristic: Within ±5 % (20 °C, -10°C to +50°C, outdoor use possible)
Water proof : IP65/67
Pollution degree : 2
Dimensions : approx. 105 mm(H) × 60 mm(W) × 29/21.8 mm(D) (excluding protrusion)
Weight : approx. 170 g (2 Batteries included), approx. 120 g (Battery excluded)
Battery : AA alkaline battery (x 2)
Continuous operating time: more than 1800 hours (under normal temperature, no alarms, new battery)
Reference standards: IEC61526 Ed3.0(2010), ANSI N42.20(2003)
USB interface : USB2.0, micro-B（Use with power supply and communication
*NRF51 does not have a function to charge batteries.
Recommended USB cable・・・CW-117MC（Core wave）or equivalent
* It may not work when use except for recommended USB cable
RoHS compliant

8.2 Storage data

1. List of storage data (Updated value is stored in EEPROM every 1 minute)

・EPD number
・Current time
・Current accumulated dose
・Current dose rate
・Operating time
・Alarm setting values (Accumulated dose, Dose rate : 2 for each)
・Time alarm setting value
・Calibration factor
・Error flag
・Condition flag
・Other setting parameter values

2. Trend data storage

Following data is stored at preset interval of trend data. (max. 4000 : gamma data 2000 and neutron data 2000 / gamma data 4000)

・Measurement date and time
・Accumulated dose
・Maximum dose rate

9. Appendix

9.1 Trouble shooting table

Error Indication	Possible Cause	Suggested Solution
“OPTI ERROR”	(1) Sensor unit malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
“MEM ERROR”	(1) EEPROM malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
“RTC ERROR”	(1) RTC malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
“DEV ERROR”	(1) Electronic component malfunction (except for the above)	(1) Contact Fuji Electric representative.
“COMM ERR”	(1) Radio module malfunction	(1) Contact Fuji Electric representative.
“BT ERROR”	(1) Bluetooth module malfunction	(1) Contact Fuji Electric representative.
“USB ERROR”	(1) CPU malfunction	(1) Contact Fuji Electric representative.

When returning the item to Fuji Electric representative, please provide with precise details of problems.
Note: This table is applied only to the malfunctions that occur during or after proper use, handling and storage.

Symptom	Possible Cause	Suggested Solution
No indications on LCD	(1) Defective battery connection (2) Mode switch malfunction (3) LCD malfunction (4) CPU malfunction	(1) Check battery polarity and there is no exogenous material. (2) to (4) Contact Fuji Electric representative.
Characters on LCD are garbled.	(1) LCD malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
Backlight does not light when pressing a mode switch.	(1) Mode switch malfunction (2) LCD malfunction (3) CPU malfunction	(1) to (3) Contact Fuji Electric representative.
Dose error ・Dose accumulation does not work ・Displayed dose is high ・Displayed dose is low	(1) LCD malfunction (2) Sensor unit malfunction (3) CPU malfunction (4) Calibration factor trouble	(1) to (3) Contact Fuji Electric representative. (4) Check calibration factor. Contact Fuji Electric representative for calibration method.
Buzzer does not sound	(If display operation is correct) (1) Attached Exogenous material (2) Set frequency failure (3) Buzzer lead wire is broken (4) CPU malfunction	(1) Check if there is no dust. If it is not improved after removing a dust, contact Fuji Electric representative. (2) to (4) Contact Fuji Electric representative.
Vibrator does not work	(1) Vibrator malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.

Symptom	Possible Cause	Suggested Solution
LED does not light	(1) LED unit malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
Operational hour is short Battery voltage alarm is always displayed	(1) End of the battery's life (2) Increase the current consumption (3) CPU malfunction (4) Failure of voltage decline detection	(1) Replace with new batteries. See "5.1". (2) Check the proper contacts in the battery compartment and there is no exogenous material in the battery case. If trouble continues, contact Fuji Electric representative. (3),(4) Contact Fuji Electric representative.
Infrared communication is unable	(1) Communication distance is too far (2) Communication port is dirty. (3) CPU malfunction (4) Malfunction of Dosimeter Configuration Tool (or PC)	(1) Set the distance between communication port of NRF51 and the Dosimeter Configuration Tool within 5cm. Also confirm that these windows are face to face. (2) Clean the communication part with soft cloth. Check if there is no exogenous material. If trouble continues, contact Fuji Electric representative. (3) Contact Fuji Electric representative. (4) Refer to the instruction manual of Dosimeter Configuration Tool to check if software operation is proper.
USB communication does not work	(1) Cable malfunction (2) Connector malfunction (3) CPU malfunction	(1) Check conduction to confirm there is no problem with the cable. (2),(3) Contact Fuji Electric representative.
Bluetooth communication does not work	(1) Module malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
Telemetry communication does not work	(1) Module malfunction (2) CPU malfunction	(1),(2) Contact Fuji Electric representative.
Crack, breakage, damage on the case	(1) Breakage due to drops, etc.	(1) Contact Fuji Electric representative.

9.2 Disposal

Please follow the local raw and regulation for disposal of the product.

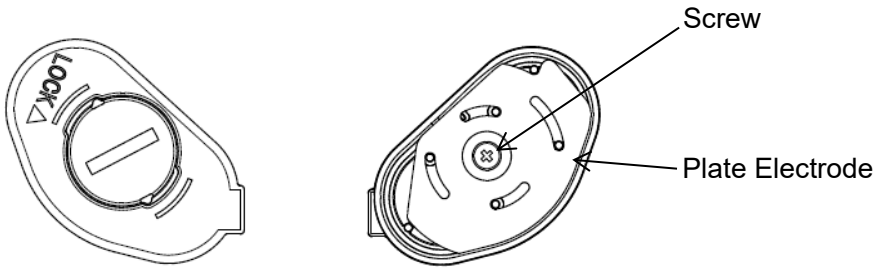
NRF51 includes recyclable parts.

Recycle the recyclable parts for efficient use of resources and environmental protection if it's appropriate at the location of product disposal. Dispose of other parts as industrial waste.

Recyclable Parts

No.	Name	Quantity	Substance	Surface treatment	How to dispose
1	Screw	1	SUS	N/A	Turn a screw down with Phillips-head screwdriver.
2	Plate electrode	1	SUS	Gold plate	Plate electrode can be removed when the screw is removed.

Battery cap



Front surface Reverse side

9.3 Calibration

This section describes the calibration procedures for NRF51.

Expose NRF51 to the gamma-ray sources such as ^{137}Cs and ^{60}Co and neutron sources such as ^{252}Cf or Am-Be.

A dose should be measured by placing the source at a certain distance (calibration distance) from reference point of NRF51 so that true value of the dose is traceable to the National Standard.

(1) Determination of a reference dose value (R_0)

- Determine a reference dose value (R_0) by the following method:

a. Calculate R_0 from the reference source activity, the distance between the reference source and reference point of NRF51 (calibration distance) and irradiation time.

b. Or the dose rate value at the reference point may be simply well-known by field calibration/characterization. In this case, reference dose value (R_0) can be calculated by the known dose rate value and irradiation time.

(2) Dose value (R_1) measurement

- Place the source at the calibration distance from reference point of NRF51.
- Take the dose reading (R_1) after irradiation which gives enough statistical stability. (e.g. 1 mSv)

(3) Calculation of the calibration factor

- Compare the reference dose (R_0) and the dose reading (R_1). If there is an unacceptable difference between R_0 and R_1, change the calibration factor.

  In general, the calibration factor (C_1) is calculated by the following formula:

  $C_1 = C_0 \times R_0/R_1$

  C_0: Original Calibration Factor

(4) Setup of the calibration factor

- To change the calibration factor, perform the following procedures:

a. After the irradiation, connect NRF51 with the Dosimeter Configuration tool and run configuration software.

b. Click on “Calibration”, enter the calculated calibration factor (C_1) to the new value of gamma-ray calibration factor or neutron calibration factor.

c. Press the “Write” button.

d. Confirm the current value is set to the new value.

*Also, the calibration due date should be changed at the time of calibration.

See User’s Manual of “Dosimeter Configuration Tool” for detail procedures

★ Your Comment ★

Dear customers,

Any comments/ requests/ suggestions regarding our instruction manual? Please feel free to contact us by filling out this form and give to our sales representative.

Document No	TN5A4215	Date		/ /
Name of manual	Electronic Personal Dosimeter NRF51 User's Manual	Submitted by	Company	
			Dept	
			Name	

Page	Line	Description
		Comments, requests, questions, doubts (error, more info needed, terminology not consistent, typos) ……Put with ○

Manufacturer	Received by		Received date	/ /	Receipt #	

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