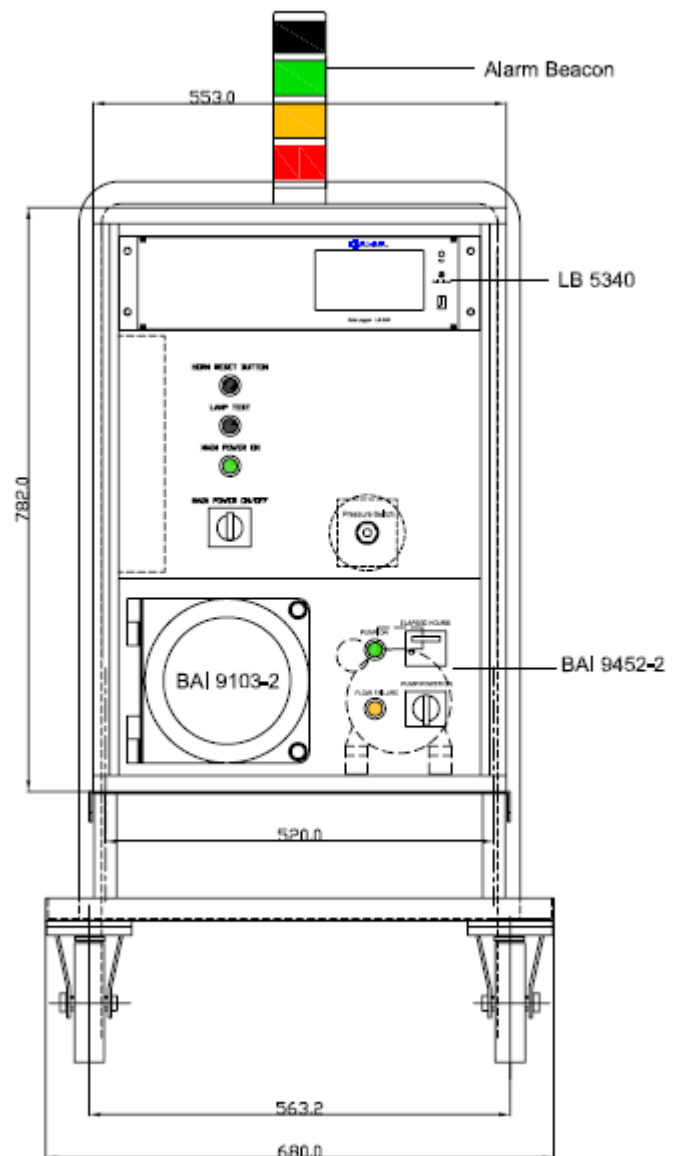


MOBILE CART FOR IODINE-131 MONITORING
(WITH LB5340 electronics)

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1. SAMPLE

- 1.1. **TYPE OF RADIATION** : Gamma radiation of gaseous fraction of I-131 measured over most abundant peak (364 keV)
System efficiency : 4% - typical
Energy range : 50 keV - 2.5 MeV

1.2. **DETECTION LIMIT - MEASURING RANGE - 2 WINDOWS**

Formulae and calculations for 2 separated windows i.e. theoretical approach according to DIN 25 482 Part 1, specified from monitor inlet.

- ▶ Confidence level 95%
- ▶ $k_{1-\alpha} = k_{1-\beta} = 1.96$

MINIMUM DETECTABLE CONCENTRATION (MDC) [Bq/m³] = DETECTION LIMIT x CALIBRATION FACTOR

Maximum of range calculated as : R_{sat} x Calibration factor

$$\text{CALIBRATION FACTOR} \left[\frac{\text{Bq}}{\text{m}^3} \text{ per cps} \right] = \frac{1}{\Delta T} \times \frac{1}{E} \times \frac{1}{F} \times C = 21600 \text{ (without T)}$$

$$\text{DETECTION LIMIT [cps]} = 2 \times 1.96 \times \sqrt{2} \times \sqrt{2} \times \sqrt{\frac{4 \times R_A}{T} + \frac{R_B}{T}}$$

with : T = Measuring time = Sampling time [s]
 R_A = Background in (328-400) = 1 cps - typical
 R_B = Background in (291-437) = 2 cps - typical
 E = Average detector efficiency = 4 % - typical
 F = Nominal sample flow = 3 m³/h
 C = ECN correction factor = 1.2 (losses of iodine in tubing and measuring vessel)
 and : R_{sat} = Maximum (saturation) count rate = 4×10^5 cps - typical

Meas. time [s]	Det. limit [cps]	MDC [Bq/m ³]
600	0,784	28,224
1800	0,453	5,432
3600	0,320	1,920
7200	0,226	0,679

Meas. time [s]	Sat. count rate [cps]	MAX. [Bq/m ³]
600	4,00E+05	1,44E+07
1800	4,00E+05	4,80E+06
3600	4,00E+05	2,40E+06
7200	4,00E+05	1,20E+06

1.3. **DETECTION LIMIT - MEASURING RANGE - SINGLE WINDOW**

Formulae and calculations for 2 separated windows i.e. theoretical approach according to DIN 25 482 Part 1, specified from monitor inlet.

- ▶ Confidence level 95%
- ▶ $k_{1-\alpha} = k_{1-\beta} = 1.96$

$$\text{DETECTION LIMIT [cps]} = 2 \times 1.96 \times \sqrt{2} \times \sqrt{2} \times \sqrt{\frac{R_0}{T}}$$

with : T = Measuring time = Sampling time [s]
 R_0 = Background in (291 – 437) keV window = 2 cps – typical (I-131 ± 20%)

MINIMUM DETECTABLE CONCENTRATION (MDC) [Bq/m³] = DETECTION LIMIT x CALIBRATION FACTOR

$$\text{CALIBRATION FACTOR} \left[\frac{\text{Bq}}{\text{m}^3} \text{ per } \Delta \text{cps} \right] = \frac{1}{\Delta T} \times \frac{1}{E} \times \frac{1}{F} \times C$$

with : E = Average detector efficiency = 4% - typical (for above window settings)
 F = Nominal sample flow = 5 m³/h
 C = ECN correction factor = 1.2 (for above window settings)
 (=losses of iodine in tubing and measuring vessel)

Maximum of range calculated as : $R_{sat} \times \text{Calibration factor}$

with : R_{sat} = Maximum (saturation) count rate = 4×10^5 cps - typical

Calibration factor (without T) = 21 600 Bq/m³ per s²

Meas. time [s]	Det. limit [cps]	MDC [Bq/m ³]	Meas. time [s]	Sat. count rate [cps]	MAX. [Bq/m ³]
600	0,453	16,295	600	4,00E+05	1,44E+07
1800	0,261	3,136	1800	4,00E+05	4,80E+06
3600	0,185	1,109	3600	4,00E+05	2,40E+06

1.4. AMBIENT :

Temperature range sample air : -20°C to +45°C
 Humidity for sample air : 10% < RH ≤ 95% (non-condensing)
 (May require inline heating at extremes)
 Sample must be free of caustic and acid vapours, solvents

2. MEASURING VESSEL

2.1. CONSTRUCTION MATERIAL

Stainless steel 304L (all wetted parts)
 Designation : BAI 9103-2

2.2. CARTRIDGE

Type : TEDA impregnated carbon TC-12
 Retention : 90% - typical (ICH₃)
 Dimensions : Ø2-1/4" ; 1" thick ; 8 - 16 mesh
 Distance to detector : 7 mm

2.3. CARTRIDGE CARRIER

Construction material : Chemically nickle-plated MS 58 DIN 2.0401
 Standard : MIL-C-2607B ; Class 2
 Filter supporting ring with coarse thread
 Access to filter :

Front loading, access port with lead shield, 2 points hinged
 Painting : RAL 7003 autocryl
 Construction material : Steel A360 + Lead
 Closing : 2 grip latches : Buna shore 60° sealing ring
 Weight : approx. 20 kg

2.4. AIR COUPLINGS

Internal tubing :

Type : Chiyoda touch tube TP-12
 Dimensions : OD Ø12 mm ; ID Ø8 mm
 Material : Polyurethane - black coloured

Connectors :

Connection to the outside : 1/2" female pipe thread BSP - Muffler at outlet
 Connections to the measuring vessel : Serto female connector 278.1201.390 12-3/8
 Connections to the pump unit : SISA male connector : Imperial Eastman 12x1/2" (2x)
 Connection to the differential pressure switch : 3 x 1/2" Female-T
 1 x Reduction 1/2" M - 1/4" F

2.5. LEAD SHIELD

Type : 96% Pb + 4% Sb

Solid angle : 4π ; Thickness : 5 cm

Construction : 6 rings incl. door and end

Weight : 120 kg (lead only)

Assembly : horizontal with mounting set :

- 1 set of large supporting brackets
- 1 set of small supporting brackets
- 3 long thread rods
- 3 short thread rods
- 1 fixation bracket around rear lead rings with small diameter

3. DETECTOR**3.1. DESIGNATION : BAI 9317**

Type : NaI (TI)-PMT integral line scintillator 51S51 / Ø2" x 2" with

Diameter : 68 mm ; Length : 254 mm (without connectors)

Gamma sensitive detector

Detector housing : Aluminium

System efficiency at 7 mm : Ba-133 : 4% - typical

Detector resolution : Better than 8 % for 662 keV

Background : Window 1 : 1 cps - typical (measured in system lead shield 5 cm)

Window 2 : 2 cps - typical (measured in system lead shield 5 cm)

Measurement conditions : Temperature : 20°C

Pressure : 1013 mbar

Ambient : 0.1 µSv/h

Status signals for failure and alarm via software

3.2. TEMPERATURE STABILITY

Measured in temperature range of +10°C to +40°C

Temperature drift in window (320 - 400) : -0.43% / °C - typical

Temperature drift in window (596 - 728) : -0.41% / °C - typical

Temperature drift in window (962 - 1232) : -0.20% / °C - typical

Temperature drift in window (1118 - 1386) : -0.67% / °C - typical

Typical value given by manufacturer for detector : -0.7% / °C for the range of 20°C to 40°C. A drift of -0.4 to -1% / °C is not exceptional.

The temperature drift is caused by the variation of amplification of the photomultiplier, meaning that the amplification drops by increasing temperature.

Drift calculated as :

$$\frac{\text{cps [10°C]} - \text{cps [40°C]}}{\text{cps [referencetemperare]} * [\Delta T]}$$

Temperature gradient : max. 5°C/h

3.3. USED HARDWARE

Integrated in LB5340 electronics

3.4. COMPENSATION TECHNIQUE

Noble gas rejection with two window compensation method (Kr/Ar)

Window 1 : 328 - 400 (10% around 364)

Window 2 : 291 - 437 (20% around 364)

With Netto cps = 2 x cps (window 1) - cps (window 2)

4. FLOW SAMPLING UNIT

4.1. PUMP UNIT :

Designation : VP 0935A

Type : Nitto Kohki Vacuum pump

Nominal flow : 4.4 m³/h (230 V / 50 Hz) (Open air inlet at pumphead)

Nominal flow : 3.3 m³/h (230 V / 50 Hz) (At approx. 150 mbar pumphead)

Weight : ± 5 kg

Consumption : Approx. 1A

Maximum outlet temperature : 80°C

Noise level : < 55dBA with muffler

Indicator : On / Off switch and power on : Green / front panel ; Type : AX-A0163E

Elapsed hour counter (0.1 - 99999.9 hr) ; Type : Graeslin FWZ 55K

4.2. PRESSURE SENSOR PUMPHEAD

Type : Huba 625.6941

Function : Filter clogged detection

Accuracy : ± 5% of setpoint - typical

Setpoint : 65 + 18 mbar (filter change for filter paper Nr. 10)

Material : Membrane ; NBR base

Range : 50 mbar to 600 mbar

Hysteresis : 10 mbar

Enclosure : Aluminium

Output signals : NO ; NC

Connections : G 1/4

4.3. VORTEX VF563AA: flowmeter (not included, optional)

Factory measurement nominal sample flow, specified in calibration sheet

5. ENCLOSURE

Mobile cart to enclosure fore mentioned equipment

6. AMBIENT

Temperature : 0°C to + 40°C

Humidity : 10% < RH ≤ 95% (non-condensing)

Cooling : Ventilation forced with ventilator fan

Type : Papst 8550 - with finger guard : LZ 22N

Flow rate : 50 m³/h - Nominal

Consumption : 10.5W

Protection degree : IP20

Not qualified for applications requiring shock / seismic / vibration certification (IEEE 304)

Noise level : 60 dBA

System inleakage conform to IEC 579 5.4.7. (<5%)

Response raised gamma field : 0.5 cps per μSv/h Co-60 radiation in 328-400 window - typical
0.6 cps per μSv/h Cs-137 radiation in 328-400 window - typical

7. MAINS

Voltage : 230V +6% / - 10% single phase / 50Hz

Stability / Brown out : conform to ECMA

Earth requirements :

Section : min. 4 mm²

Resistance : ≤2Ω

Upstream fusing : 16A

Power cord : section : min. 1.5 mm²

8. ELECTRONICS

Designation : LB5340-1

- ▶ Microprocessor electronics of modular design integrated in 3 HE rack
- ▶ Self diagnosis software to monitor detector and system conditions (healthy / fault)
- ▶ Data storage of measurement data and parameters in memory buffer with battery backup
- ▶ All measurement parameters settable either locally or from remote system (file upload)
- ▶ Free adjustable parameters for : Alarm thresholds (2), Integral threshold (1), Failure, Registration times short time; long time ; release rate; integral release (determine the printout, data transfer interval and storage into FIFO for normal, alarm or failure conditions), Background subtraction, Dead time correction
- ▶ Local result read-out and parameter input with 7" TFT Graphical Touch panel display with 800x480 dots resolution display or external USB keyboard
- ▶ Password protected parameter settings
- ▶ Calculation of results in physical units i.e. $\mu\text{Sv/h}$, Bq/m^3 , m^3/h , ...
- ▶ Interfaces
 - ▶ Front panel : 2xRS232C/RS485 potential isolated, Ethernet and 1xUSB Host/Device switchable
 - ▶ On PC board
 - ▶ Side panel :USB Host (keyboard-mouse, printer or memory stick) / Ethernet RJ45 on enclosure
 - ▶ Internal communication between modules via CAN BUS
- ▶ Data buffers contain 1000 latest measurements available for up to 8 different central systems
- ▶ Automatic start-up of measurement after power up

Computer board

Designation module : Single Board computer with ARM9 CPU
32-64 MB SDRAM, 32-64 MB Flash Memory,
SD card slot 1GB

Operating system : Embedded OS (Windows CE)
Application : 8 channels (of which 2 analog input flow channels)
Read out in Bq/m^3 or $\mu\text{Sv/h}$ (Channel 1 to 6)
Read out in m^3/h (Flow Channel)
Power fail protection : Parameter storage in Flash or SD Memory
Communication with peripheral boards via CAN Bus
Short & Long sampling time adjustable between 1 and 100000 s
Integration time adjustable between 0 and 10^{20}
Station Identification 4 digits freely selectable via software

Optional boards:**DAQ Ampli-discriminator module LB39414 (included in this version)**

For connection of NaI detector,
1 HV-supply unit up to 4 kV, 12 Bit Resolution
Preamplifier for GM-, Proportional-Counters and Scintillation detectors.
Software controlled Main Amplifier (8 Bit)
2 x Single Channel (Window), 1 x Integral Discriminator
3 Internal Counting Channels
2 HV-Outputs (1 x direct and 1 x over Voltage Tripler stage HVx3)
1 BNC Counter Input and 1 BNC Counter Output

Multi I/O board LB39417-01(not in this configuration)

4 Counter inputs
2 analogue Inputs 0/4-20 mA/0-5V
2 analogue Outputs 0/4-20 mA
4 digital Inputs
4 Detector HV control signals 0-5V
8 Open coll. Outputs
Connection peripherals via Phoenix 48-pole connector

Counter inputs

Function : detector / counter inputs

Number of inputs : 4

Signal type : CMOS +5V Schmitt trigger inputs, overvoltage clamping 5.1V, 1 kOhm input

Connection : Terminal strip back side of electronics rack

Digital signal inputs

Function : status inputs

Number of inputs : 4

Signal type : Opto coupler input connected to +5V, 390 Ohm series resistor, Low input = inactive

Connection : Terminal strip back side of electronics rack

Digital signal outputs

Function : status outputs

Number of outputs : 8

Output type : open drain SIP MOSFET, clamped to max. 18V with arrestor

Assignment : via software setup matrix

Connection : Terminal strip back side of electronics rack

Max. rating : 1.8W dissipation per output

Output max. ranges : Idrain max. < 650mA continuous; series resistor 33 Ohm

Analog signal inputs

Function : Input for flow signals

Number of inputs : 2

Input resistor : 243 Ohm, clamped at 18V with arrestor

Signal input 0-20 or 4-20 mA by software selection

Analog signal outputs

Function : Output for Channel data

Number of outputs : 2

Both outputs galvanically separated from rest of circuitry

Output series resistor : 200 Ohm, clamped at 18V with arrestor

Signal output 0-20 or 4-20 mA by software selection, active (+12V) or passive

HV Ctrl signals

Function : control signals for HV unit

Plateau take-up via software

Number of outputs : 4

Output series resistor : 100 Ohm,

Signal output 0-5 V

Pseudo coincidence board LB39415 (not in this configuration)

Function : Provide Signal proportional to natural activity contents

Pseudo-coincidence board with α, β, γ -counter

BNC Inputs for Radon progeny compensation.

Signal type : CMOS +5V Schmitt trigger inputs, overvoltage clamping 5.1V, 1 kOhm input

Connection : BNC connectors α, β, γ -counter

High Voltage outputs : dual 0-1.4 kV or 0-4.2 kV outputs for proportional counters.

5-fold Relay euroboard IDN° 55806 (included in this version)

5 x double pole, double throw relay (C,NO,NC), potential free

24VDC power supply, I_{max} 175 mA

CAN bus controller

Embedded software with *Watchdog* function (firmware V1.1)*8-fold Relay board IDN° 49762 (not in this configuration)*

8 x double pole, double throw relay (C,NO,NC), potential free, external

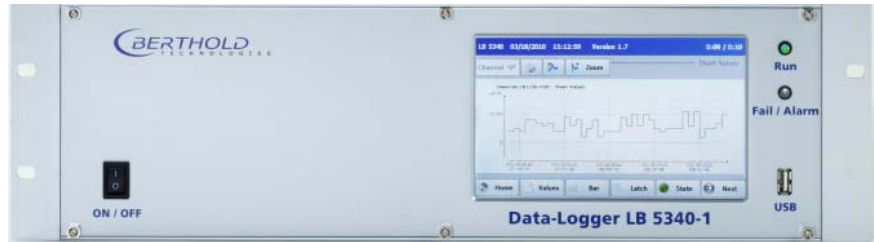
24VDC power supply, I_{max} 175 mA

CAN bus controller

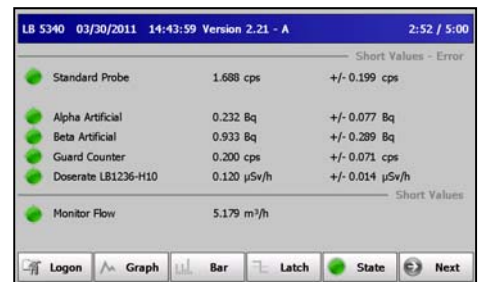
Embedded software with *Watchdog* function (firmware V1.1)*LB 39418 Power supply 90-254VAC, 5V,15V,15V (9TE) (included in this version)*

Evaluation Electronics LB5340-1

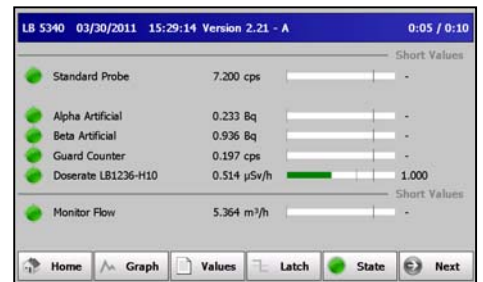
The versatile Electronics LB5340 with 7" TFT touch screen Display and trackball keyboard is used as Data logger electronics. It serves as data processing and evaluation unit with ABPD/AERD application program for parameter entry and visualisation of the Measurement results.



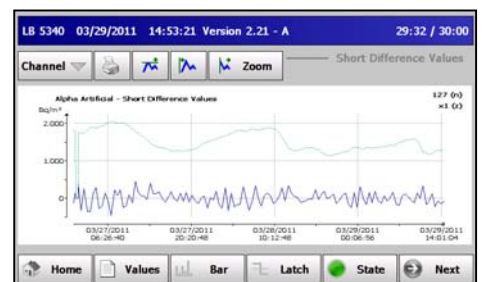
Averaging algorithms (ratemeter or moving average) can be selected. Pre-alarm and alarm thresholds can be set on short and long time values, activity on filter (Bq/Filter), volumetric activity (Bq/m³) and derived units for the different counting channels.



Different screens are available to present the measurements and graphics. They can show bar graphs with embedded thresholds for short, long, difference, sub integral and integral values as well as time based graphs with measured values.



All screens are predefined and the user has the possibility to select which screens are shown.



An scrollable Alarm and status page gives an event log of the monitor status.



A zoom function can be set to show an enlarged view of up to 4 measurement values. This feature enhances the display readability from a greater distance.



Intelligent μ -controller modules with field proven CAN-Bus interface are used for front end signal processing and detector interfacing. Five different intelligent boards (modules) are available for measurement applications. In the basic version of the LB150DR monitor the LB5340-1 contains an ABPD module, a Multi I/O module and a power supply module. If additional analogue or relay outputs are required simply adding extra modules allows for the extension. The LB5340 application software allows to perform Service & maintenance functions such as Plateau take-up, Background measurement, Efficiency calibration, automatic determination of Pseudo-coincidence factors, recurrent testing.

For data communication or print out of all relevant Measurement data and Parameters several interfaces are available. The data are kept in a FIFO data buffer of up to 1000 results deep.

- ▶ 2 Password protected levels : user & administrator
- ▶ FIFO Data buffer with 1000 results per Channel
- ▶ Embedded Watchdog function when Relay board is used
- ▶ Module communication via proven CAN-Bus technology
- ▶ Intelligent, self monitoring Modules with μ -Controllers
- ▶ Single board computer with 7" TFT-Monitor and Touch screen
- ▶ Relais board with 5 potential free Relais with dual changeover contacts
- ▶ Remote access and configuration import & export is supported via USB and Ethernet ports and LB5340 remote configuration utility software.
- ▶ Interfaces :
- ▶ Back panel: 2 x RS 232/RS 485 electrically insulated, Ethernet, 1 x USB (Host/Device switchable)
- ▶ Front panel: USB Host (keyboard-mouse, printer or memory stick)

9. STANDARDS

EN61010-1 / 61326-1 +A1
2004/108/EC EMC
2006/95/EC LVD
VDE System Safety test – EN60601-1

Radiological : IEC60761 part1, part 4

10. Dimensions

