User Manual

Better Geiger
Radiation Detector
Model S-1

Read entire manual and all warnings before use

www.bettergeiger.com

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1. Warnings

This device is intended to be used only for educational purposes. There is no guarantee of performance specifications, accuracy, or reliability. The detector should not be used for activities or decision-making related to health and/or safety. Any use of the device not in accordance with this user guide voids any applicable warranty.

The detector should never be dropped or otherwise mechanically shocked, nor subjected to moisture, vibration, or dust. Operating environment should be between -10°C and 40°C (14°F to 104°F) and relative humidity <80%. Long periods of direct sun exposure should be avoided. Battery terminals and compartment should be kept clean, dry, and free of debris. Batteries should be removed for long-term storage of the detector due to risk of leakage and contamination.

Unless authorized by the manufacturer, enclosure screws should not be removed, and internal components should not be modified or accessed.

2. General Information

More details about the detector technology, capabilities, and limitations are available at: www.bettergeiger.com

The Better Geiger Model S-1 is designed to measure X-ray, gamma, and to a limited extent beta ionizing radiation. It is not sensitive to alpha radiation, including elevated radon concentrations in air. The sensitive element inside the S-1 is a solid scintillator. X-ray/gamma radiation tends to easily penetrate the plastic enclosure of the S-1 and reach the scintillator. Beta radiation may or may not reach the scintillator and be detected depending on the energy and incoming direction of the beta particles. Compared to a radiation detector with a traditional Geiger-Mueller (GM) tube, the Better Geiger will typically exhibit **higher** sensitivity to X-Ray/gamma and **lower** sensitivity to beta particles. When the detector is inside the rubber shock protector and/or the waterproof enclosure, beta sensitivity is further reduced.

“Dosimetry” means measuring radiation levels specifically in the context of human health effects.

Except for very specialized applications, dosimetry only involves X-ray/gamma measurement and **not** alpha/beta measurement. If a detector is reacting to alpha or beta in significant quantities, then this will almost always result in an extremely over-estimated and invalid dose rate indication. Due to the Better Geiger having relatively low sensitivity to beta, it is unlikely to exhibit this over-estimation. Typical GM detectors, however, do have a high sensitivity to beta radiation, therefore they are at high risk for extreme over-estimation of dose rate in environments where beta particles are present in significant quantities. Examples of objects which might be primarily beta emitters where this behavior can be be seen include some "Fiestaware" style antique ceramics, some antique "uranium glass" items, and some naturally occurring radioactive minerals such as uranium ore.

The preferred direction for measuring a localized beta emitter with the Better Geiger is towards the bottom of the detector, exactly opposite the printed symbol indicating the scintillator position.

3. Technical Specifications

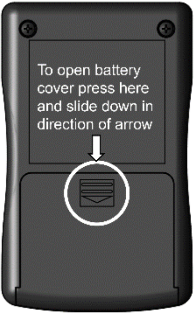
Values are approximate and subject to change.
(10 µSv/hr = 1 mrem/hr)

- Dimensions without rubber protector:
  73 x 26 x 118 mm^3
  (2.9 x 1.0 x 4.6 in^3)
- Weight, detector only without batteries:
  120 g (4 oz)
- Allowed range of operating conditions:
  -10°C to 40°C (14°F to 104°F)
  <80% relative humidity
- OLED display 27x19 mm^2 (1”x0.75”)
- Power supply: 2x standard AA batteries, typical life >40 hours for alkaline type
- Sensitive to X-ray/gamma and beta
- Minimum sensitive energy: 50 keV
- Maximum CPM (counts/min): 750,000
- Approximate maximum dose rate
  @ 1250 keV (Co-60 average energy):
  7,000 µSv/hr (= 700 mrem/hr)
  @ 662 keV (Cs-137 energy):
  4,000 µSv/hr (= 400 mrem/hr)
- Estimated dose rate uncertainty ±30%

- Qualitative dose rate indications
  NORMAL: 0-1 µSv/hr
  HIGH: 1-10 µSv/hr
  DANGER: >10 µSv/hr
- Screen update interval 1-4 s
- Cumulative measured values (time, average CPM, average µSv/hr, total µSv) are calculated over the entire time period since the device was last powered on, and those values are reset to zero when the device is powered off

4. Basic Operation

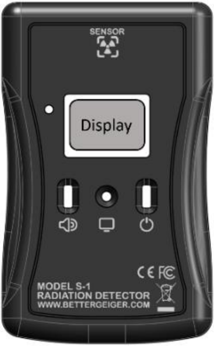
The detector is powered by two AA batteries. The battery holder is on the back side of the device, accessible by a slide-away cover as shown here →



Care should be taken to orient the “+” and “-” ends of the batteries so that they match the “+” and “-” marked positions on the case.

Alkaline or lithium batteries are preferred but the device will also work with most standard rechargeable AA batteries. When approaching the end of battery life, the first indication will be a reduced volume coming from the speaker (less loud clicking noise). After that, the device will eventually shut down. When in doubt test with fresh batteries.

- Scintillator location (sensitive area)
- Sound on/off switch
- Display mode change
- Power on/off switch



The display mode button cycles between the six display modes (described in the following section). When the device powers on it begins in the first display mode. From the first mode, each button press changes to the next mode unless the device is in the 6^{th} mode. After the 6^{th} mode, another button press will either return the device back to the first mode or to a device information display mode, depending on when the detector was manufactured. When in device information display mode, another button press will return to the first display mode.

5. Display Modes

<u>Mode 1</u>: Bar graph displays dose across the top of the screen scaled logarithmically from 0.01 to 10 µSv/hr. Main number displays current dose rate in µSv/hr. Lower left word indicates qualitative range (“NORMAL”, “HIGH”, or “DANGER”). Bottom right indicates display number unit (indicated as “uS/h” on screen)

Mode 2: Same as mode 1 but display number is mrem/hr (indicated as “mr/h” on screen)

Mode 3: Same as mode 1 but display number is raw counts per minute (CPM) interaction rate before dose rate estimate is calculated.

Mode 4: Larger graphical bar graph display of dose rate from 0.01 to 10,000 µSv/hr, scaled logarithmically with each decade indicated.

Mode 5: Shows cumulative measured values since power was turned on – time, average CPM, average µSv/hr, total µSv.

Mode 6: “Dark” mode, reduced power mode, only shows a small flashing circle.

6. Understanding Display Numbers

Counts per minute (CPM) gives the raw rate of detected interactions in the scintillator. Incoming X-ray/gamma photons can have higher or lower energies, but the CPM value only counts interactions.

Radiation dose is a unit related to the health effect on the human body of radiation. For X-rays and gammas it depends not only on the quantity of photons entering the human body but also the energy of those photons (among other factors). Higher energy photons have a larger effect on the body in terms of dose and health hazards. Values of dose displayed by the detector take the energy of interactions in the scintillator into account to improve accuracy of dose estimates.

Sievert (Sv) or rem are generally the basic units of radiation dose. One Sievert is equal to 100 rem. More commonly used are microsievert (µSv, one millionth of a Sievert) or millirem (mrem, one thousandth of a rem). One mrem is equal to 10 µSv. A dose rate is the amount of dose which is being delivered per unit time, typically per hour (µSv/hr or mrem/hr). Dose generally refers to various types of exposure but in this document it refers to *effective dose* and essentially assumes the whole body is exposed uniformly to a given radiation field strength.

All people are exposed to background radiation from natural and unnatural sources. The amount can vary widely but 2,000-3,000 µSv per year is common. At the time of writing this document, in the US the annual whole-body limit allowed for workers exposed to radiation is 50,000 µSv.

The qualitative limits displayed of "NORMAL", "HIGH", and "DANGER" are arbitrarily defined with thresholds of 1 µSv/hr for "HIGH" and 10 µSv/hr for "DANGER". The ALARA principle – As Low As Reasonably Achievable – is intended to guide all radiation exposure. In other words, "NORMAL" and "HIGH" do not mean an absence of danger. To reach the previously described 50,000 µSv occupational dose limit throughout the course of a year would require about 6 µSv/hr exposure 24/7 for the entire year.

For comparison, a typical medical chest X-ray might expose a person to 100 µSv while a medical CT (computerized tomography) scan might expose a person to around 10,000 µSv.

Acute radiation syndrome (ARS) or "radiation sickness" can result if an extremely large radiation dose is received in a short amount of time. The U.S. CDC (www.cdc.gov) indicates that ARS can occur with a dose above approximately 1 Sv or 1,000,000 µSv. The acute dose at which the chance of death is around 50% is 4 Sv.

7. General Tips

To measure general X-ray/gamma dose rate levels in a uniform radiation field, the detector orientation is typically not important. If there is a strong point-like radiation source then the detector response will strongly depend on distance from the source. This is because the intensity of a radiation field coming from an X-ray/gamma source tends to decrease roughly according to $I=1/D^2$ where "I" is intensity and "D" is distance. For example, if distance is doubled, then intensity is 1/4 as much, if distance is tripled, intensity is 1/9 as much, or if distance is increased 10x then intensity is about 1/100 as much. Therefore, when searching for radioactive material or attempting to verify whether not an object is radioactive, the sensor position should be placed as close as possible to the potentially radioactive material.

For ordinarily encountered radiation levels the display will update every 4 seconds. At very high levels it will update faster, as quickly as every 1 second. Except for Mode 5, the values shown are usually averaged over the last 10 to 40 seconds, and the detector automatically attempts to balance accuracy with responsiveness. For best accuracy in Modes 1-4 it is generally best to place the detector in one place for at least 40 seconds.

For the best accuracy it is recommended to place the detector in a location to be measured, turn it on, then leave it there for at least five minutes. Then, the values in Mode 5 can be checked to see average behavior over the measured time period. To measure whether or not an object is radioactive, it is generally best to perform one such a measurement with the detector far from the object (one meter or a few feet away) then another with the detector as close as possible to the object. If the difference is roughly 30% or more, then one can be relatively confident that the object is significantly radioactive. If the difference is smaller than 30%, then longer measurements might be needed to be certain. Doing two such pairs in series (far, close, far, close) is a good way to confirm a measurement.

8. Troubleshooting

There is no low battery indicator on the display. If the clicking sound coming from the speaker begins to decrease noticeably in volume, if the dose rate or count rate value seems abnormally low, if the device loses power quickly after being powered on, or if the device will not power on at all then the batteries might need to be changed. When in doubt, test with new batteries. Similar behavior can appear if power switch is fully in the "on" position. Battery contacts should also be checked in case of failure to power on. If alkaline batteries leak in the battery compartment, then this can cause problems. If battery orientation is not correct (+/- switched) or if the batteries are not fully seated in their positions, then the device may fail to turn on. In case of any other problems contact the manufacturer directly via: www.bettergeiger.com

9. Raw Signal Access

Access unauthorized by manufacturer voids any applicable warranty and results in the user being responsible for damage. The raw signal access is located near the hole next to the display. There are four contact points:

1. Ground connection
2. Analog dose. This is an **uncalibrated** analog signal from 0 to 5V outputting dose values up to ~10 µSv/hr, scaled logarithmically. User should perform calibration measurements at multiple dose levels to calibrate.
3. Analog pulse. This is an analog signal from 0 to 5V with a variable width of roughly 60 µs. Higher amplitude pulses are wider. The amplitude is approximately proportional to the energy deposited in the scintillator for a given radiation interaction.
4. Digital pulse, 5V indicating one count of radiation has taken place. The signal has a variable width roughly 0.5-2 µs depending on energy deposition.

10. FCC User Guide Statement

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC rules.

11. Declarations of Conformity

FCC Supplier's Declaration of Conformity
47 CFR § 2.1077 Compliance Information
Product Name: Better Geiger S-1 Radiation Detector
Description: Handheld portable radiation measurement deviceResponsible Party: www.bettergeiger.com
This device complies with the following regulations: 47 CFR Part 15, Subpart B – Unintentional Radiators, Class B
1. 15.107 Conducted emissions

2. 15.109 Radiated emission limits; general requirements
FCC Compliance Statement - This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Location: Denver, CO, USA

Signed:

Date: Feb 8, 2022, Printed Name: Robert Adams, Title: Owner

Declaration of Conformity

In accordance with EN ISO/IEC 17050-1:2010

Manufacturers Name: 136 Technology, LLC.

Manufacturers Address: Denver, CO 80219, U.S.A.

Application of Council Directives:

Low Voltage 2014/35/EU

EMC 2014/30/EU

RoHS 2 2011/65/EU

Standards:

EMC - EN 61326-1:2013 , EN 55011:2016

Safety - IEC 61010-1:2010, EN 61010-1:2011

RoHS2 Technical Documentation- EN 63000:2018

Product Name: Better Geiger S-1 Radiation Detector

Product Model Number: S-1

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Location: Denver, CO, USA

Signature:

Date: Feb 8, 2022. Full Name: Robert Adams. Title: Owner