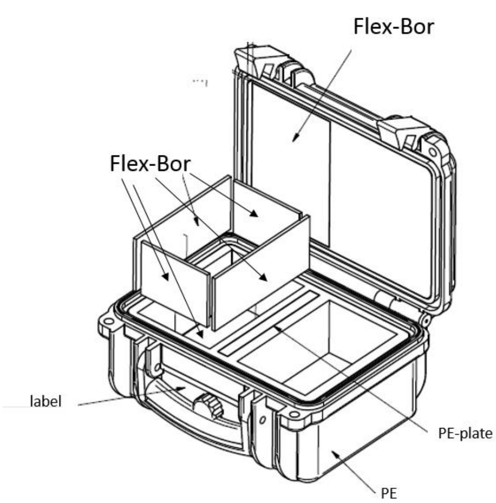
Neutron calibration and response verification of RadEye SPRD-GN

1. Introduction

In order to verify the good performance of radiation detection instruments, access to a suitable radiation source is required. Neutron sources however are much less common than gamma sources and consequently neutron detection instruments are often checked infrequently if at all. Since the neutron background count rate of those devices is extremely low, operators are accustomed to seeing a zero count rate in the display and may not get alerted by notice a defective neutron detector. In order to overcome this serious operational risk, a new verification and calibration concept (US 9,778,384) was developed for the RadEye SPRD-GN that can be performed anywhere by anybody. No neutron radiation check source is required and no cost for the verification process occurs other than the initial purchase price of the Cosmic Neutron Calibrator. Unlike conventional calibration at a calibration lab, the instruments are not out of reach since the measurement process happens locally and can be interrupted at any time in case a situation requiring usage of immediate access to the instrument occurs.

2. Description of the Cosmic Neutron Calibrator

The “Cosmic Neutron Calibrator” part number 42508/1218 consists of a rugged plastic-case with 2 compartments with each having a size that fits to the RadEye SPRD-GN. One compartment (right) is just surrounded by foam and the PE of the case housing. In this location, the RadEye instrument shows the maximum neutron background count rate.
The other compartment (left) surrounds the RadEye instrument completely by Flexboron plates, thus absorbing all thermal and low energy neutrons. In this position the neutron background count rate is typically reduced by approximately 85 %.



Weight: 960 g

3. Description of the Cosmic Neutron Calibration Process

The calibration and verification process can be done with one “Cosmic Neutron Calibrator” for up to 2 instruments simultaneously: One RadEye unit is placed into the left compartment where no thermal neutrons are present. The other instrument is placed in the right compartment where the full neutron background is present.

In order to get the highest resolution of the displayed (very low) average neutron count rate for the calibration process, the measuring unit “cpm” (= counts per minute) should be used (see user manual of the RadEye instrument). It is highly recommended to perform the measurement on the highest floor of a building in order to minimize the reduction of the cosmic neutron flux. If this is not possible, the measurement can be done e.g. in the trunk of a parked car. Prior to closing the cover of the calibrator, the average and peak neutron count rate needs to be reset. This can be done via the info button of the RadEye instruments.

Left: Shielded position *Right: Unshielded position*

4. Data recording

At the end of the calibration measurement, both average and peak count rate should be noted. Now the position of both instruments is interchanged, the neutron peak and average readings are reset and the calibration process is repeated. As a result of this calibration and verification process, both the absolute response as well as the nature of the detected radiation (thermal neutrons) is verified.

Furthermore, as a byproduct, the recorded peak neutron reading can be compared to the alarm setting for the neutron channel in order to verify the reasonable alarm point setting at the current location.

Example: result in unshielded position

Serial #	Location	Date (end of measurement)	Measurement time (hhh:mm)	Position	Peak R (cpm)	Mean R (cpm)	Count rate ratio (shielded/ unshielded)
10567	Room 123	June 3, 2019	007:04	unshielded	13,4	0,72	
10567	Room 123	June 4, 2019	013:33	shielded	6,5	0,11	15%

5. Interpretation of the calibration result / Verification of good instrument function

5.1 Absolute count rate value in the unshielded compartment

➔ ***Verification of uncompromised neutron response, no detector fading***

Depending on altitude (factor a) and the magnetic latitude (factor b) of the location, a typical background count rate R can be estimated in the unshielded position of the cosmic calibrator:

$$R \text{ (cpm)} = 0{,}6 * a * b$$

Altitude (m)	0	200	400	600	800	1000	1200	1400	1600	1800	2000
factor a	1.0	1.2	1.4	1.7	2.0	2.3	2.7	3.2	3.8	4.5	5.4

Magnetic latitude (°)	0…20	25	30	35	40	45	50	55	60	65…90
factor b	0.3	0.35	0.45	0.55	0.65	0.75	0.85	0.9	0.95	1

Factor a and b were derived from UNSCEAR 2000 report (and references therein) and are listed for information only. It is recommended to always perform an initial measurement with good statistics at the chosen location.
As a good approximation, for Europe, the magnetic latitude can be approximated by the geographic latitude. For the USA, the magnetic latitude can be estimated by adding an offset of 9° to the geographic latitude.

5.2 Relative count rate reduction in the shielded compartment
➔ *Verification of measured radiation*

Only low energy neutrons can cause a significant response change from the unshielded to the shielded position. For a correctly operating instrument a strongly reduced background count rate (by app. 85 % for the RadEye SPRD-GN) is expected in the second compartment.

A significantly lower reduction in the boron shielded compartment indicates a problem: The displayed background count rate may be influenced by other kind of background radiation or electronic noise.

5.3 Peak count rate
➔ *Determination of a suitable alarm threshold*

The peak count rate for the recommended time constant of 10 s typically reaches about
15 cpm for a 10 h calibration measurement in the unshielded compartment at sea level.
The measured peak value can be compared to the set alarm threshold for the neutron count rate. Setting the alarm threshold (Alarm 1) approximately 20 % higher than the recorded peak count rate typically provides false alarm free operation in the current location.

ThermoFisher SCIENTIFIC

Thermo Fisher Scientific Messtechnik GmbH

Frauenauracher Straße 96
D-91056 Erlangen

info.rmp.erlangen@thermofisher.com
www.thermofisher.com