Wireless Geiger-Muller Radiation Detector for Technologically–Enhanced Naturally Occurring Radioactive Material (TENORM)

DRAFT

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ALARA-Project -an initiative for fighting the hazardous effects of Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM)

http://www.alara-project.com

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What is Naturally Occurring Radioactive Materials (NORM)?

Almost everything in nature has some small amount of natural radioactivity. **Radioactive elements have always been present in the Earth's crust** and within tissues of all living beings.

NORM is an acronym for Naturally Occurring Radioactive Material, which includes **all naturally accrue radioactive elements found in the environment**.

Long-lived radioactive elements such as uranium, thorium and potassium and any of their decay products, such as radium and radon are examples of NORM.

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Where you can find Naturally Occurring Radioactive Materials (NORM)?

Many natural materials contain radioactive elements (radionuclides).

- The Earth's crust is radioactive and constantly leaks **radon gas** into our atmosphere.
- Most **coal** contains uranium and thorium, as well as potassium-40, lead-210, and radium-226. The coal-fired power stations emitted NORM radioactivity are light flyash or the bottom ash
- In the **oil and gas** industry radium-226 and lead-210 are deposited as scale in pipes and equipments
- **Mineral sands**, mined chiefly for titanium minerals and zircon, often have a significant proportion of monazite, a rare earth mineral containing thorium
- **Tantalum ores** comprise a wide variety of more than a hundred minerals, some of which contain uranium and/or thorium
- **Phosphate rock** used for fertilizer is a major NORM due to uranium and thorium

The minerals in the sands , tantalum ores and phosphate rock are subject to gravity concentration, and some concentrates are significantly radioactive.

- **Iron ore** contains lead-210 and polonium-210, which accumulate in dust during smelting
- **Building materials** can contain elevated levels of radionuclides including radium-226, thorium-232 and potassium-40
- The NORM can be brought to the Earth's surface in the formation **water** that is produced in conjunction with mines activities

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What is Technologically–Enhanced Naturally Occurring Radioactive Materials (TENORM)?

Exposure to **NORM** is often increased by human activities, eg. burning coal, making and using fertilizers, oil and gas production.

When resources are extracted from the earth, the natural radioactive material comes with those resources. In processing the desired resource, the radioactive material is removed and becomes a waste.
The radioactive wastes from extraction and processing **are called 'Technologically Enhanced Naturally Occurring Radioactive Material' (TENORM)** because human activity has concentrated the radioactivity or increased the likelihood of exposure by making the radioactive material more accessible to human contact.

The most common naturally radioactive elements are uranium, thorium, and radium. Common **sources of TENORM** waste are mining and mineral processing, oil and gas production, and drinking water and wastewater treatment.

There are two types of **TENORM waste**: discrete and diffuse.

- **discrete TENORM**, has a relatively **high radioactivity** concentration in a very small volume, such as a radium source used in medical procedures. Because of its relatively high concentration of radioactivity, this type of waste poses a direct radiation exposure hazard.
- **diffuse TENORM**, has a much **lower concentration of radioactivity, but a high volume of waste**. This type of waste poses a different type of disposal problem because of its high volume. The following are six sources of such naturally occurring radioactive materials.

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Is TENORM a health hazard?

NORM is not a problem unless it becomes concentrated in some manner. Some industrial practices involving NORM to a degree that they may pose risk to humans and the eenvironment if they are not controlled.

- Diffuse NORM **–TENORM may pose a health hazard** because of its many uses. For example, though most metal-mining waste is stored near where it is generated, small amounts have been used as construction backfill and road building materials. It is also used in concrete and wallboard.
- This TENORM waste may be disposed of in landfills or lagoons. It may also be used in agriculture as a soil conditioner. **Improper use or disposal of TENORM** can result in significant contamination of the environment and radiation exposure. This can adversely affect the health of those occupationally exposed, as well as the public in general.

A characteristic of TENORM is that because of their wide distribution from many sources, they give **rise to a very much larger radiological effect** to the public (by about four orders of magnitude) compared with that caused by the nuclear industry.

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Sources of TENORM waste stream

- The largest TENORM waste stream is **coal** ash carrying uranium-238 and all its non-gaseous decay products, as well as thorium-232 and its progeny.

- **Oil and gas** production may produce radioactive pipe scale (a residue left in pipes from drilling oil wells) and sludge that leave sites and equipment contaminated.

- In **gas processing** activities, TENORM generally occurs as radon gas in the natural gas stream. Radon decays Lead-210, then to Bismuth-210, Polonium-210 occur as a film on the inner surface of inlet lines, treating units, pumps, and valves principally associated with propylene, ethane, and propane processing streams.

- In **phosphates product** mainly used as a soil conditioner in sustainable agriculture.

- TENORM-**contaminated water** produced in conjunction with mines activities or residue accumulates when radioactive material is filtered out of drinking water during the purifying process.

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List of RENORM radionuclides

- TENORM decay products of **Uranium-238**
  - Uranium-238(radioactive) gamma-ray 0.066MeV HL=4.5*E9 year ⇒ alpha particle
  - Thorium-234 (radioactive) HL=27day ⇒ **beta- particle**
  - Protactinium-234 (radioactive) HL=27day ⇒ **beta- particle**
  - **Uranium-234** (radioactive) HL=245500year ⇒ alpha particle
  - Thorium-230 (radioactive) HL=75380year ⇒ alpha particle
  - **Radium 226** (radioactive) HL=1600year ⇒ alpha particle
  - Radon-222 (radioactive) HL=3.8day ⇒ alpha particle
  - Polonium-218 (radioactive) HL=3.1min ⇒ alpha particle
  - Lead -214 (radioactive) HL=26.8min ⇒ **beta- particle**
  - Bismuth-214 (radioactive) HL=20min ⇒ **beta- particle** ⇒ alpha particle
  - **Lead-210** (radioactive) HL=22.3year ⇒ **beta- particle**
  - Bismuth-210 (radioactive) HL=5 day ⇒ **beta- particle**
  - Polonium-210 (radioactive) HL=138day ⇒ alpha particle
  - Lead-206 (stable)
- TENORM decay products of **Potassium-40**
  - Potassium-40 (radioactive) HL=1.25*E9 year ⇒ **beta+ particle** ⇒ **gamma** Arcon-40 (stable)
  - Potassium-40 (radioactive) HL=1.25*E9 year⇒ **beta- particle** ⇒ Calcium-40 (stable)

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Legal regulations covering disposal of TENORM

TENORM is not regulated by the Atomic Energy Act and only indirectly by other domestic regulations.

- Control and regulation of TENORM is not consistent from industry to industry nor from country to country. About a dozen some country have some form of regulations addressing TENORM.
- The Health Physics Society has published a technical standard for control and release of TENORM and the Conference of Radiation Control Program Directors has published draft regulations to adopt. Proposed regulations are moving from concentration-based standards to **dose-based standards**.
- Many professionals and industrial representatives are questioning the risk from low doses of chronic radiation, whereas at the same time, the environmental community and some regulators are **concerned that the risks from low level radiation** are more dangerous than previously thought.

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What's the predominating ways of TENORM contamination

transport

elicit

prospecting

TENORM

processing

storage

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Our solution for TENORM monitoring

PT10109 GSM/GPRS Wireless Geiger-Muller Radiation Detector

http://www.pelczar.com.pl/PT10109-GSM-Wireless-Geiger-Muller-Radiation-Detector.pdf

The PT10109 is a wireless sensor, which integrates a GSM/GPRS modems and a Geiger-Muller detector. It has been designed for surveying petroleum, natural gas, and LPG production facilities for Naturally Occurring Radioactive Materials (NORM).

The instrument is sensitive to gamma radiation with energy levels from 50keV to 1.25MeV with an effective dose rate measurement range between 0.01-200 µSv/h.

The PT10109 is designed to operate within harsh industrial environments as well as hazardous areas ATEX ZONE-1.

It can be permanently attached to field infrastructure and operated from an internal battery without the need for costly cabling and conduit runs, thus eliminating most of the permit and labour costs for layout planning and installation.

The typical mode of operation is that the PT10109 automatically performs a few readings of effective dose radiation per day and after each reading transmits the measurement data to a remote PLC/RTU by GSM/GPRS infrastructure.

Preliminary spec released for educational purpose only. PT00109 and PT10109 specifications are covered by patents application in EU.

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Our solution for TENORM monitoring

PT00109-1 ISM Wireless Geiger-Muller Radiation Detector

http://www.pelczar.com.pl/PT00109-ISM-Wireless-Geiger-Muller-Radiation-Detector.pdf

The PT00109-1 is a wireless sensor, which integrates an ISM radio and a Geiger-Muller detector. It has been designed for surveying petroleum, natural gas, and LPG production facilities for Naturally Occurring Radioactive Materials (NORM).

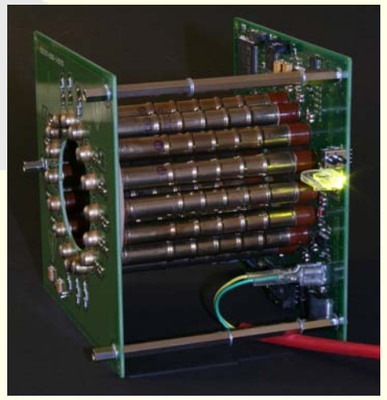
The instrument is sensitive to beta and gamma radiation with energy levels from 50keV to 1.25MeV and measure low level radiation emission sources. It can be used to estimate NORM energy distribution by “Half-Value Layer” method.

The PT00109-1 is designed to operate within harsh industrial environments as well as hazardous areas ATEX ZONE-1. It can be permanently attached to field infrastructure and operated from an internal battery without the need for costly cabling and conduit runs, thus eliminating most of the permit and labour costs for layout planning and installation.

The typical mode of operation is that the PT00109-1 automatically performs a few readings of radiation emission in [Bq/l] per day and after each reading transmits the measurement data to a remote PLC/RTU by ISM radio.

The PT00109-1 Geiger-Muller Sensor allby oneself, can be configured as a desktop instrument and use to measure gamma and beta activities of liquid and bulk materials (food) directly in counts per second per sample volume [cps/l] on low contamination level usually masked by background radiation.

PT00109-1 Geiger-Muller Sensor
(without enclosure and shield)



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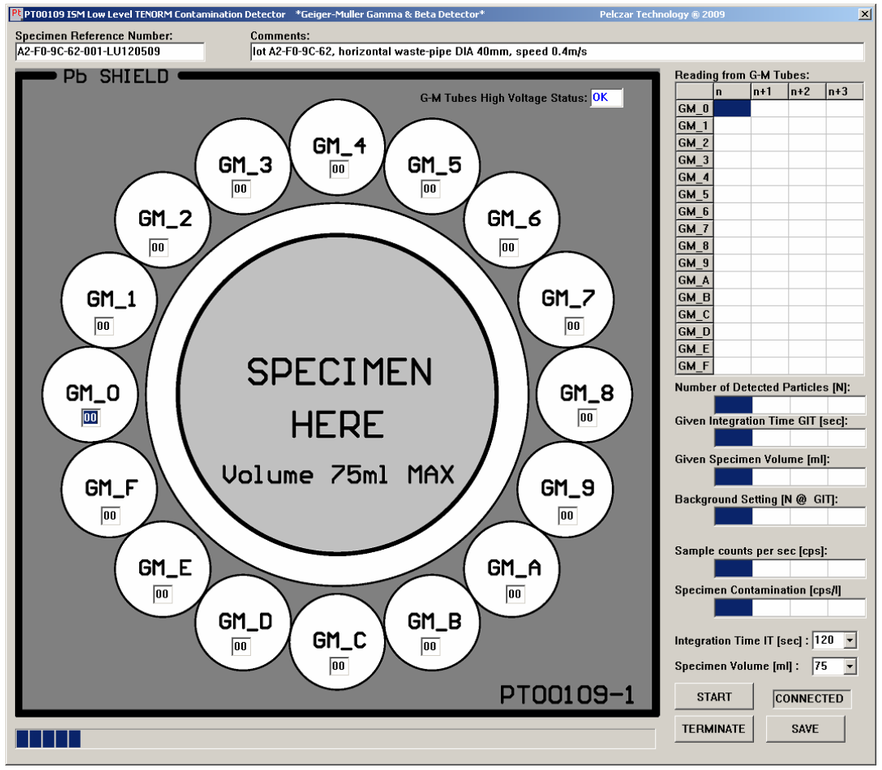
TENORM Detector

PC Development Tool for PT00109-1 Wireless Geiger-Muller Radiation Detector



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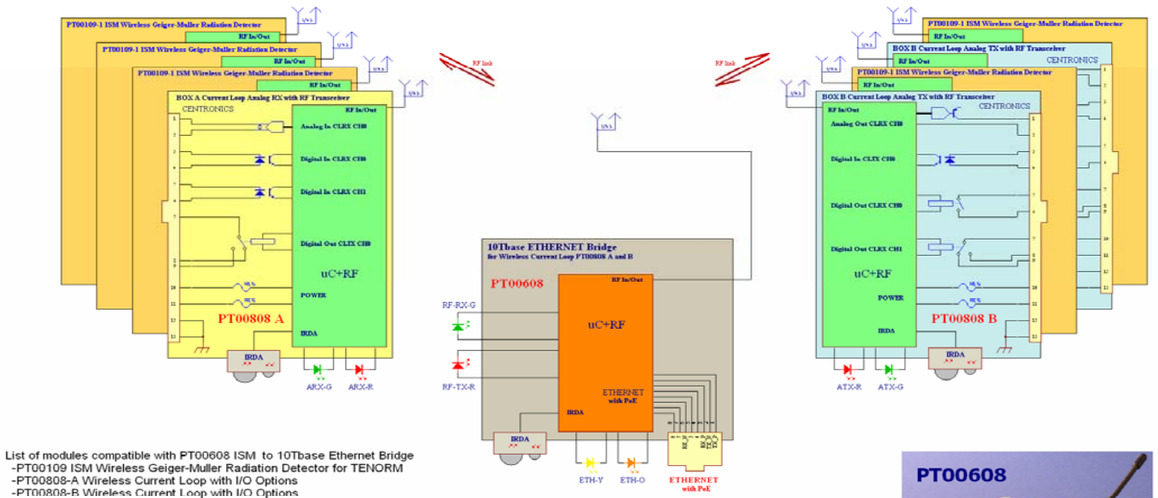
TENORM ISM Detectors Network

PT00109-1 in “point-to-multipoint” network using PT00608 ISM to 10Tbase Ethernet Bridge



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Our solution for TENORM monitoring

PT01109-3 Submersible Geiger-Muller Radiation Detector

http://www.pelczar.com.pl/PT01109-3-Submersible-Geiger-Muller-Radiation-Detector.pdf

The PT01109-3 is a seawater submersible sensor, which integrates the temperature and depth gauges with Geiger-Muller detector.
It has been designed for surveying ocean euphotic depth up to 150m for artificially produced radionuclides as well as Naturally Occurring Radioactive Materials (NORM).

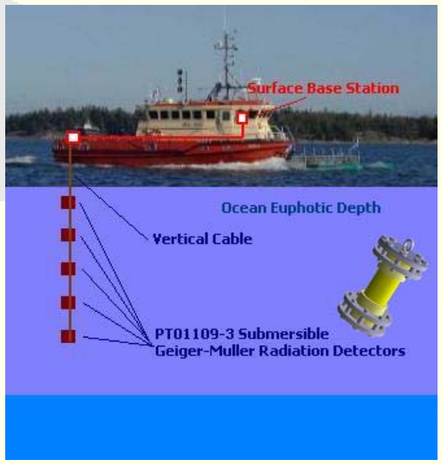
The instrument can be used by industrial fisher to help them measure the seawater radioactive contamination on multiple depths before fishing attempt.
The result of the measurement should help to optimize decision about selecting the fishing region and desisted fishing in case of contamination of the seawater.

*The instrument can be also used to **monitor radionuclides level** on sea waterways, roadsteads and seaside facilities.*

The instrument is sensitive to gamma radiation with energy levels from 50keV to 1.25MeV and measure low level radiation emission sources and can be permanently immersed in seawater.

Typically, the PT01109-3 sensors are hanging on immersed vertical cable (each sensor in a different depths), and automatically perform readings of seawater temperature, radiation in counts per minute [cpm] and the sensor depth. Each sensor reading is transmitted to the surface base station located in vessel cockpit by wire connection.

Block Diagram of PT01109-3 Submersible Geiger-Muller Radiation Detectors System



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PT10109 coverage of Non-TENORM Radionuclides

- **Artificially Produced Radionuclides**
  - Be-7
  - Na-22
  - Na-24
  - P-32
  - Sc-46
  - Cr-51
  - Mn-54
  - Mn-56
  - Co-58
  - Co-60
  - Fe-59
  - Zn-65
  - Zr-95
  - Nb-95
  - Ru-103
  - Ru-106
  - Cs-134
  - Cs-137
  - Ba-140
  - Ce-141
  - Ce-144
  - Np-239

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