ABOUT NORM

There are three types of NORM:

- **Cosmogenic** – NORM produced by cosmic rays interacting with the Earth's atmosphere; the most important examples are **^{3}H** (tritium), **^{7}Be**, and **^{14}C**.
- **Primordial** – Sufficiently long-lived NORM for some to have survived from before the formation of the Earth; there are 20 primordial NORM nuclides with the most important being **^{40}K**, **^{232}Th**, **^{235}U**, and **^{238}U**.
- **Daughters** – When ^{232}Th, ^{235}U and ^{238}U decay 42 different radioactive nuclides are formed (see below) with the most important being **^{222}Rn**, **^{226}Ra**, **^{228}Ra** and **^{228}Ac**.

When ^{232}Th, ^{235}U and ^{238}U decay a radioactive "daughter" nuclide is formed, which then decays into a radioactive "granddaughter" and so on until the last decay is to a stable isotope of lead; this sequence is a **decay chain**. Longer lived daughters accumulate in a material that is undisturbed for a long time.



Granite often contains small amounts of thorium and uranium – and all their decay chain daughters like radium.

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SOME NORM NUCLIDES OF SPECIAL INTEREST

Beryllium 7



^{7}Be is being continuously formed in the atmosphere by cosmic rays. Jet engines can accumulate enough ^{7}Be to set off radiological alarms when being cleaned.

Polonium 210



In the ^{238}U decay chain ^{210}Po is a distant daughter of ^{226}Ra. ^{210}Po gained notoriety in the 1960s as a radioactive trace component in cigarette smoke. Heavy use of phosphate fertilizers (which have trace amounts of ^{226}Ra) can triple the amount of ^{210}Po found in tobacco.

Radon 222



In the ^{238}U decay chain ^{222}Rn is the daughter of ^{226}Ra. ^{222}Rn is an inert gas that can accumulate in the air of confined spaces such as house basements and uranium mines. Long term exposure to high concentrations of radon can cause lung cancer.

Cesium 137

^{137}Cs is not NORM, but rather a long-lived fission product. Atmospheric testing of nuclear weapons and, to a greater extent, the Chernobyl reactor accident spread ^{137}Cs world-wide. It has entered into the soil, and from thence into plants and animals. Being chemically similar to potassium, it is often found in agricultural and wood products wherever the NORM nuclide ^{40}K is found.

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A Guide to Naturally Occurring Radioactive Materials (NORM)

Developed by the
DHS Secondary Reachback Program
March 2010

As defined by the International Atomic Energy Agency (IAEA), **Naturally Occurring Radioactive Materials (NORM)** include all natural radioactive materials where human activities have increased the potential for exposure in comparison with the unaltered natural situation. If processing has increased the concentrations of radionuclides in a material then it is **Technologically Enhanced NORM (TE-NORM)**.

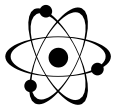


A truckload of clay-based kitty litter contains sufficient quantities of NORM to cause radiation portal alarms.

Joint Analysis Center (JAC)
24-hour Technical Assistance HOTLINE: 877-363-6522
Email : dndo.jac@hq.dhs.gov

COMMON NORM NUCLIDES

Uranium 238 and 235



^{235}U and ^{238}U are primordial nuclide found in low quantities in **rocks, minerals, and soil** – at an average of 2-4 parts per million. Uranium is 40 times more abundant than silver in the Earth's crust. Both nuclides form a chain of radioactive daughters when they decay that are comingled with the uranium in nature.

Radium 226 and 228



Natural radium is mostly ^{226}Ra, a daughter of ^{238}U, intermingled with trace quantities of ^{228}Ra, a daughter of ^{232}Th. Minute quantities of radium will be found in uranium and thorium deposits, and particularly in **uranium ore**.

Thorium 232



Like uranium, ^{232}Th is a primordial nuclide at the head of a chain of radioactive daughters. It is found in most **rocks and soils** – and is about as abundant as lead and 4 times more abundant than uranium.

Potassium 40



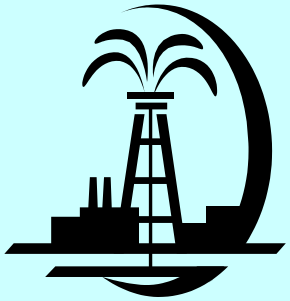
^{40}K is a radioactive primordial nuclide constituting a bit more than 0.01% of all potassium. Potassium is the seventh most abundant element on the Earth's crust, and is found in **seawater, soils, minerals, and in all living plant and animal life**. ^{40}K may be sufficiently concentrated in some food products and fertilizer to set off radiological alarms in bulk quantities.

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NORM IN INDUSTRY

Concerns about NORM arise in many types of industries, such as

- **Electricity generation**, e.g. coal-fired and geothermal plants
- **Oil and natural gas** production
- Drinking and waste **water treatment**
- Production and use of **fertilizers**
- **Mining, milling, and smelting**, e.g. aluminum, copper, gold, silver, titanium, uranium, and zircon
- **Construction**, e.g. soil movement and building materials



An Industrial Example: Oil Production

Step 1 – Ground water and oil mingle in under-ground deposits; water with a high chloride content has higher solubility, including for radium.

Step 2 – Saline, radium bearing water is brought to the surface with the oil.

Step 3 – Water is separated from oil in an apparatus consisting of pumps, pipes, casings, fittings, tanks, etc.

Step 4 – Changes in water temperature and pressure cause chemical changes which result in minerals being deposited as scale on various apparatus components; the scale is generally carbonate and sulfate minerals, including barite which readily traps radium.

Step 5 – Water disposal is by pumping into an injection well, or other means.

Step 6 – When the separation apparatus is repaired or decommissioned it can contain hazardous amounts of radium and radium decay products, and must be handled or transported in accordance with government regulations.

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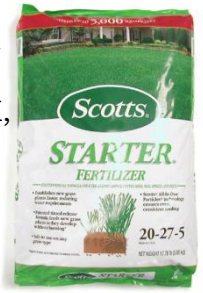
NORM IN COMMODITIES

NORM is present in many common commodities, and can cause radiation portal alarms when these are transported in bulk quantities. A few examples are below.



A single **banana** contains 450mg of potassium, 0.01% of which is the NORM ^{40}K.

Fertilizers with high phosphate and potassium content can contain a variety of NORM nuclides including ^{40}K, ^{238}U, ^{230}Th, ^{226}Ra, and ^{232}Th. Raw material processing affects daughter concentrations in the ^{238}U and ^{232}Th decay chains.





Many products sold in **home improvement** stores contain NORM such as cement, gravel, brick, wallboard, wood, tile, and granite counter tops.

Fresh US **mushrooms** may have measurable amounts of ^{40}K, ^{226}Ra, and ^{228}Ra.



TE-NORM Example

Coal contains tiny amounts of NORM, nearly all of which stays in the ash when the coal is burned. Ash is about 10% the weight of unburned coal, so the concentration of NORM in power plant waste is ten times that of the plant's coal fuel. For more information on TE-NORM see: http://www.epa.gov/rpdweb00/tenorm/index.html