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NORM AND UNCONVENTIONAL OIL & GAS PRODUCTION

Presented: May 12, 2014

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NORM and O&G Production

NORM – Naturally Occurring Radioactive Material

O&G Production – Oil and Gas Production, specifically fracking

Why are they "attached at the hip"?

NORM

3 Natural Decay Series found in all soil and rock:

- Uranium (U-238 parent + 13 radioactive progeny including Ra-226 and Rn-222)
- Actinium (U-235 parent + 11 radioactive progeny)
- Thorium (Th-232 parent + 10 radioactive progeny including Ra-228 and Rn-220)

NORM

- Secular Equilibrium – All progeny are in equilibrium with long-lived parent, i.e., all have the same activity concentration in nature.
- Radioactivity – all series contain alpha, beta and gamma emitters as well as a radon gas member.
- Progeny include U, Th, Ra, Rn, Pb, Bi and isotopes of other elements.

TENORM

TENORM – Technologically Enhanced NORM, NORM disturbed or altered from natural settings or present in a technologically enhanced state due to past or present human activities and practices, which may result in a relative increase in radionuclide concentrations, radiation exposures and risks to the public, and threat to the accessible environment above background radiation levels.

TENORM

TENORM

- Dis-equilibrium can occur when progeny of the decay series are selected/separated by their elemental properties.
- In addition to the geological weathering of rock and soil, isotope activity vary because of physical and chemical processes, both natural and man-made.

TENORM vs. NORM

- There is a great debate concerning if unconventional production byproducts are NORM or TENORM (they are TENORM).

- But it does not matter the title, the materials are still radioactive and should be evaluated and handled in accordance with their relative risk, not their title.

NORM and O&G Production

- Drilling, e.g. Marcellus Shale (MS) drilling is a man-made activity causing dis-equilibrium and resulting TENORM activity.

- The hydraulic fracturing associated with MS drilling results in process/flowback water containing varying concentrations of total dissolved solids (TDS).

NORM and O&G Production

- The TDS in the water is comprised of the elements in column IIA of the Periodic Table, grouped because of their like chemical properties, including Mg, Ca, Sr, Ba and Ra.
- Naturally occurring Ra (radium) includes the radioactive isotopes Ra-226 and Ra-228.

NORM and O&G Production

Although not very mobile at standard temperature (T) and pressure (P) and a neutral pH, Ra is more mobile than other NORM isotopes at the T, P and pH of process water, resulting in Ra-226 and Ra-228 in process water.

NORM and O&G Production

- The dissolved solids including Ra-226 and Ra-228 precipitate in the form of carbonates and sulfates.
- Sludge and scale associated with drilling equipment become impacted with Ra-226 and Ra-228.
- Radium decays to radon gas, the only non-particulate member of the natural decay series.

NORM and O&G Production

- Recently radon gas has been detected in methane and off gassing.
- The relatively "long lived" radon progeny of Pb-210 (22 yr half-life) and Po-210 (140 day half-life) are appearing in dis-equilibrium.
- Horizontal drill cuttings are rich in natural uranium, the entire decay series, including radium, radon and all the progeny.

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NORM and O&G Production

In summary:

- Gas - NORM appears in methane/off gassing (radon).
- Solids - NORM appears in horizontal drill cuttings (entire uranium decay series including radium and radon).
- Solids – NORM appears as scale on the surface of equipment and pipes (radium)

NORM and O&G Production

In summary:

- Liquids - NORM appears in process and flowback water (radium)
- When water is treated the sludge, filter cakes, filters, etc. concentrate the radium in the water treated in a solid form

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NORM in Regulatory Space

- The Nuclear Regulatory Agency (NRC) does not regulate/license NORM, leaving the Environmental Protection Agency (EPA), Occupational Safety and Health Administration (OSHA) and state governments to regulate.
- There is a NRC rad material license requirement for source material (> 0.05% by weight uranium/thorium). The requirement does not apply to radium.

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NORM in Regulatory Space

- Where as NRC regulations for ionizing radiation (10CFR20), address **licensed** radioactive material (RAM), OSHA regulations for ionizing radiation (29CFR1910) address **employer** radioactive material.
- Some of the regulations of 10CFR20 are mirrored in OHSA 29CFR1910 and some of the more recently revised regulations are not.

NORM in Regulatory Space

- Traditional drilling states such as Texas and Louisiana have formal NORM/TENORM regulations.
- Most MS states, including PA, OH, WV and NY do NOT have formal TENORM regulations.
- States without formal regulations generally default to Conference of Radiation Control Program Directors (CRCPD) recommendations and other standards/guidance.

NORM in Regulatory Space

- Recently (August 31, 2009) the American National Standards Institute (ANSI) approved and published a standard addressing NORM/TENORM titled Control and Release of TENORM (ANSI/HPS N13.53-2009).
- This standard specifies dose limits and release criteria for the management of material, products, and waste containing TENORM.

NORM in Regulatory Space

Potentially Applicable or Relevant and Appropriate Requirements (ARARs)

Air (gas):

- The EPA Radon Gas Standard is 4 pCi/L.
- The NRC/OSHA Air Effluent for radon with progeny removed is 10 pCi/L, with progeny present is 0.1 pCi/L.

NORM in Regulatory Space

Potentially ARARs

Water:

- The EPA Drinking Water Standard for radium is 5 pCi/L total radium above background.
- The EPA Maximum Contaminant Level for radon in drinking water is 300 pCi/L
- The NRC/OSHA Water Effluent Concentration for radium is 60 pCi/L.

NORM in Regulatory Space

Potentially ARARs

Solids:

- EPA Surface Soil Standard for radium is 5 pCi/g and for Subsurface Soil (below 15 cm) is 15 pCi/g (40CFR192).
- States range from no activity to 50 pCi/g of NORM (radium) in solids as "exempt".
- ANSI N13.53 – radium is exempt < 3 pCi/g

NORM in Regulatory Space

Potentially ARARs

Posting:

- NRC and OSHA both require posting areas or rooms with > 1 uCi of total radium with: "CAUTION RADIOACTIVE MATERIALS" and the tri-foil radiation symbol.
- The NRC refers to licensed radioactive material where OSHA does not.

NORM in Regulatory Space

Potentially ARARs

Exposure:

- Most regulations and guidance documents agree on the annual exposure limit to the general public – 100 mrem/year
- Since workings on O&G production sites are not trained and qualified as radiation workers, the general public exposure limit is applicable (versus the occupational limit).

NORM in Regulatory Space

Potentially ARARs

Exposure:

- The 100 mrem/year exposure limit is for Total Effective Dose Equivalent (TEDE) i.e. the sum of both external and internal exposure.
- In regards to NORM on O&G sites external exposure is "gamma shine" and internal exposure is inhalation of radium particulates.

NORM in Regulatory Space

Potentially ARARs

Transportation and Disposal:

- Department of Transportation (DOT) regulations (49CFR173) are always applicable - > 270 pCi/g radium is usually UN2910, Radioactive Material and shall be labeled as such.
- Disposal – various waste acceptance criteria (WAC) may be applicable.

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Regulatory Compliance

- Compliance with specific NORM regulations may be straight forward in states with formal NORM regulations.
- In states without formal NORM regulations any of the ARARs may be applicable.
- DOT regulations are always applicable.
- Public exposure limit is always applicable.

Regulatory Compliance

- Dependent on the activity concentrations of Ra-226, Ra-228 and progeny including radon gas, in process water, cuttings, sludge and scale, the following should be evaluated:
  - Public and occupational exposure
  - Waste water byproduct disposal
  - Effluent discharge of water
  - Scale impacted pipes and equipment

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Regulatory Compliance

- Total activity (needed for compliance with posting requirements and risk assessments) is the product of volume and concentration.
- MS fracking produces both high volumes of water and relatively high radium activity concentration in water.
- Resulting activity is orders of magnitude higher than conventional production.

Conclusions

- Characterization data through sample and analyses is needed to assess exposure and compliance.