Putting Radiation Risks from NORM Into Perspective

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Topics for Discussion

• Typical radiation levels at oil and gas facilities
• Radiological Health Risk – perception vs. reality
• LNT and ALARA
• What it all means for our health and safety programs (78a.58(d))
External Exposure

- PADEP looked at various types of facilities; found very little potential for external doses exceeding the 100 mrem/yr public limit
- Marcellus Shale
- Drill cuttings typically <20 uR/h
- Sludges up to 150 uR/h
- Equipment surfaces in processing facilities typically 5 – 100 uR/h, but occasionally several thousand uR/h
Internal Exposure

• Could be an issue at natural gas processing facilities due to presence of Pb-210 and Po-210 on surfaces; can be as high as several thousand pCi/g

• Why? Because natural gas typically contains 10 – 1,000 pCi/L radon-222 gas

• Minimal contribution to lung dose from increase in airborne radon
Potential Internal Exposure (continued)

• From TENORM in:
  – Produced water; up to 2,000 pCi/L total Ra
  – Scales; up to several thousand pCi/g total Ra
  – Sludges; up to several hundred pCi/g total Ra

• Risk of ingesting or inhaling NORM is easily controlled via personal hygiene and common sense:
  – Use protective clothing, respirators as appropriate
  – No eating, drinking, etc.
  – Keep NORM contamination wet
  – Implement good housekeeping to prevent spread of NORM contamination
Radiological Health Risk (Cutting Right To The Chase)

• Perception
  – All radiation is lethal
  – Being irradiated is not normal and is something to be feared
  – Powerful carcinogen

• Reality
  – No sound evidence of carcinogenicity at low doses
  – Abundance of studies showing threshold and/or hormesis
LNT – What It Is

• Method of estimating cancer risk from radiation
  – High doses - Risk increases linearly
  – Low doses – extrapolated, large errors

• Key, troubling aspects:
  – No threshold
  – Any dose increases risk
  – Teaches us to be afraid of low doses
Why LNT Is Senseless

• All cells respond to stimuli, so LNT can be rejected based on basic biology.
• Why would we extrapolate low dose effects from high dose effects?

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<thead>
<tr>
<th>To determine the effect of</th>
<th>Extrapolate from the effect of</th>
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<tbody>
<tr>
<td>1 sleeping pill</td>
<td>Taking 100 sleeping pills</td>
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<tr>
<td>1 cm of rain in a day</td>
<td>100 cm of rain in a day</td>
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<tr>
<td>Applying warm water bottle to an aching joint</td>
<td>Applying boiling water to an aching joint</td>
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<tr>
<td>Applying cold pack to injured area to reduce pain</td>
<td>Applying liquid nitrogen to injured area</td>
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<td>Hugging a baby</td>
<td>A bear hugging the baby</td>
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<td>A gentle massage</td>
<td>Being pushed by an elephant</td>
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<tr>
<td>Drinking a cup of water</td>
<td>Drinking buckets of water</td>
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<tr>
<td>Jumping from a step</td>
<td>Jumping from top of building</td>
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These types of extrapolations don't make sense.
Flawed Logic Behind LNT

- Low dose $\rightarrow$ small amt DNA damage $\rightarrow$ may result in mutations $\rightarrow$ more cancer cells $\rightarrow$ higher cancer incidence
Flawed Logic Behind LNT

- Do more mutations equate to more cancer?

• % patients with cancerous mutations relatively unchanged (age 45-99) but cancer mortality rate increases drastically with age. Some factor other than mutations is causing these cancers.

[Graph: Presence of Cancerous Mutations vs. Age]

[Graph: Cancer Mortality Rate in Japan (Males)]
LNT – Why It’s Wrong

• What does the evidence look like?
  • Using BEIR VII
  • Taiwan apartments
  • Nuclear shipyard worker study
  • British radiologists (1955 – 1979)
  • Evacuated residents near
    – Mayak Nuclear Weapons
    – Facility

• Radiation exposure reduced cancer incidence
LNT – Why It’s Wrong

• Repeated low dose therapy to cancer patients
• Repeated low-dose radiation treatments to cancer patients did not increase but reduced cancers, contradicting the LNT model
LNT – Why It’s Wrong

Leukemia Incidence in Hiroshima Survivors

- LNT Model
- Data from UNSCEAR

Bone Sarcomas in Radium dial painters

- Data from (Evans, 1974)

Mortality Rate/100,000

- Predicted from current theories on radiation risk
- U.S. average cancer mortality rate

Background Dose (mSv/y)

No increase in cancers
LNT – Why It’s Wrong

Cancer Deaths in Evacuated Village Residents near Mayak Nuclear Weapons Facility

Data from (Kostyuchenko, 1994)

Nuclear Shipyard Worker Study

Data from (Sponsler, 2005)

Non-Hodgkin’s Lymphoma Radiation Therapy Patients

Improved survival with additional low-dose radiation treatments to whole body or half-body

Standard Treatment to Tumor only

Percentage of Patients Who Survived

Data from (Sakamoto, 2004)
LNT – Why It’s Wrong

Cancers in irradiated Taiwan Apartment Residents

- Reduced Cancers
- 50 mSv

Data from (Hwang, 2006)

Second Cancers Following Radiation Therapy

- Data from Tubiana, 2011

Breast cancers in Canadian TB Patients who underwent fluoroscopic examinations

- No increase in Cancers

Data from (Miller, 1989)
The Historical Basis of LNT and ALARA

- BEAR I Report, 1956 published by the National Academy of Science
  - Genetic harm is proportional to dose
  - There is no such figure other than zero (for the amount of radiation that is genetically harmless)
  - Our society should hold additional radiation exposure as low as it possibly can
Statements in letters between Committee members in 1957

“I, myself, have a hard time keeping a straight face when there is talk about genetic deaths and the tremendous dangers of irradiation. I know that a number of very prominent geneticists, and people whose opinions you value highly, agree with me.”

“Let us be honest with ourselves—we are both interested in genetics research, and for the sake of it, we are willing to stretch a point when necessary”, and

“Now, the business of genetic effects of atomic energy has produced a public scare, and a consequent interest in and recognition of importance of genetics. This is to the good, since it will make some people read up on genetics who would not have done so otherwise, and it may lead to the powers-that-be giving money for genetic research which they would not give otherwise.”

Calabrese, 2014; Seltzer, 2007
According to the USEPA

- Since the early 1990s, EPA has been parroting that Radon
  - Is the second leading cause of lung cancer
  - Causes 21,000 lung cancer deaths per year
  - This is “real?” It’s simply an extrapolation of lung cancer in uranium miners (very high doses) to lower doses based on LNT.
Radon & Lung Cancer in Ramsar, Iran

- Radon levels in some dwellings are up to 3700 Bq/m3 (over 100 pCi/L).
- The people and their ancestors exposed to abnormally high radiation levels over many generations.
- Study showed that the highest lung cancer mortality rate was in Galesh Mahaleeh, where the radon levels were normal.
- On the other hand, the lowest lung cancer mortality rate was in Ramak, where the highest concentrations of radon in the dwellings were found.

Does it get any worse than Po-210

• Toxic alpha emitter
• Used to kill former KGB spy

• Mortality Among Mound Workers Exposed to Polonium-210 and Other Sources of Radiation, 1944-1979; Boice et al, Radiation Research 181, 208-228 (2014)
• 7,270 workers, long-term mortality study
Key Findings

• Mean doses
  – External radiation – 26.1 mSv
  – External and internal lung dose – 100.1 mSv

• 3,681 deaths vs. 4,074 expected (SMR 0.90; 95% CI 0.88-0.93)

• Among 4,977 radiation workers
  – All cancers, 968 cases vs. 1083 expected, SMR 0.89; 95% CI 0.84-0.95
  – Lung cancer, SMR 0.85, 95% CI 0.74-0.98
Chernobyl

- 28 emergency workers died from radiation.
- 15 children died of thyroid cancer, of 8,000 afflicted.
Chernobyl

• Surviving Chernobyl emergency workers have fewer cancers.

• Dr. Zbigniew Jaworowski, MD PhD DSc, former Chairman of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) stated:

“What is really surprising, however, is that data collected by UNSCEAR and the Forum show 15% to 30% fewer cancer deaths among the Chernobyl emergency workers and about 5% lower solid cancer incidence among the people in the Bryansk district (the most contaminated in Russia) in comparison with the general population. In most irradiated group of these people (mean dose of 40 mSv) the deficit of cancer incidence was 17%.”
What Does It Mean To My H&S Program?

• O&G workers die and are injured from hazards encountered OTJ; none will die from the very low risk from TENORM radiation

• 78a.58(d) requires operators processing fluids onsite to develop radiation protection plans that cover radioactive materials produced by treatment processes
  – Monitoring procedures
  – Radiation safety training
  – Notification, record-keeping and reporting requirements
Questions?

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