The interpretation of radiation measurements may have as much to do with attitudes and perceptions of radiation risks as it does about technology. The very same measurement may have a wide variety of meanings to different people. For example, a technician at a nuclear plant saw a small blip on the readout of a whole body scan of a worker and announced, “Wow, we have a hot one here!” While the blip was technically interesting, although of no health significance, the worker heard the result as a matter of life and death. Litigation followed which cost the nuclear plant over $1.5 million for defense. Many times concerned persons have concluded that if radiation is measurable, it must be bad. Interpretation of the measurements becomes a matter of responding to fears of radiation. One person defending their conservative decision said, “Why take chances?” While this may seem prudent as a matter of the “precautionary principle – better to be safe than sorry,” such decisions could not be technically defended in terms of potential risks from radiation. Much more information is needed for interpreting radiation measurements for determining health risks.

I propose that there are two key factors governing interpretation of radiation measurements: 1) measurements have no meaning until interpreted and 2) measurements only have meaning in terms of how they are interpreted. Thus, recorded or reported radiation measurements have no inherent meaning by themselves, they are just numbers. Radiation safety specialists have the advantage for interpreting radiation measurements based on knowledge of comparative readings from background and other sources. Most people without this specialized knowledge do not know that we live in a sea of radiation which surrounds us all the time. Furthermore, a screaming Geiger counter may sound alarming but radiation risks depend on many other factors, such as the type of radiation, the proximity of people, and the duration of exposures. A Geiger counter reading is only one piece of information which specialists would use for assessing potential risks.
Misunderstandings Abound
The interpretation of radiation measurements may have as much to do with attitudes and perceptions of radiation risks as it does about technology. The very same measurement may have a wide variety of meanings to different people. For example, a technician at a nuclear plant saw a small blip on the readout of a whole body scan of a worker and announced, “Wow, we have a hot one here!” While the blip was technically interesting, although of no health significance, the worker heard the result as a matter of life and death. Litigation followed which cost the nuclear plant over $1.5 million for defense. A worker at an industrial facility observed the RSO taking readings with a Geiger counter and saw the meter go off scale. That was enough information for this worker to start an uproar that eventually involved several hundred other workers, the union, and management. An industrial hygienist seeing Geiger counter readings above background on a granite countertop told the homeowner that she would not have the granite in her house. A worker at a food production facility heard a GM meter in use for surveying the installation of a new x-ray machine for product quality control. He raised concerns and when the company manager heard there was radiation in his facility, he told the x-ray company to remove their machine. This resulted in the loss of a $4 million sale for 20 x-ray machines.

What is the Common Factor in these Anecdotes?
In each case the concerned persons concluded that if radiation is measureable, it must be bad. Interpretations of the measurements became a matter of responding to fears of radiation. One person defending their conservative decision said, “Why take chances?” While this may be seen as a prudent matter of the “precautionary principle – better to be safe than sorry,” none of these decisions could be technically defended in terms of potential risks from radiation.

Two axioms on measurements,
I propose that there are two key factors governing interpretation of radiation measurements:
1) measurements have no meaning until interpreted and
2) measurements only have meaning in terms of how they are interpreted.
Thus, recorded or reported radiation measurements have no inherent meaning by themselves, they are just numbers. Radiation safety specialists have the advantage for interpreting radiation measurements based on knowledge of comparative readings from background and other sources. Most people without this specialized knowledge do not know that we live in a sea of radiation which surrounds us all the time. Furthermore, a screaming Geiger counter may sound alarming but radiation risks depend on many other factors, such as the type of radiation, the proximity of people, and the duration of exposures. A Geiger counter reading is only one piece of information which specialists would use for assessing potential risks. Next month we will look at how uncertainties may affect our interpretation of radiation measurements.
The Psychology of Radiation Measurements

Ray Johnson, MS, PSE, PE, FHPS, CHP
Director, Radiation Safety Counseling Institute

Presentation at the Health Physics Society Midyear Meeting
Charleston, SC   February 8, 2011

Good and defensible radiation measurements require several steps: 1) deciding what to measure (contamination or exposure), 2) choosing the proper instrument for the intended measurement, and 3) using the instrument properly. Assuming you have accomplished these three steps appropriately (there are countless pitfalls in these steps), you now have measurements to interpret. Several questions now arise: 1) what do the numbers mean, 2) are the measurements defensible, and 3) how much would you be willing to commit for resources on the basis of these measurements? This is where the psychology of radiation measurements could become very significant. Interpretation of radiation measurements may have as much to do with attitudes and perceptions of radiation risks as it does about technology.

The very same measurement may have a wide variety of meanings to different people. For example, a technician at a nuclear plant saw a small blip on the readout of a whole body scan of a worker and announced, “Wow, we have a hot one here!” While the blip was technically interesting, although of no health significance, the worker heard the result as a matter of life and death. Litigation followed. A worker at an industrial facility observed the RSO taking readings with a Geiger counter and saw the meter go off scale. That was enough information for this worker to start an uproar that eventually involved several hundred other workers, the union, and management. An industrial hygienist seeing Geiger counter readings above background on a granite countertop told the homeowner that she would not have the granite in her house. A fireman observing Geiger readings of twice background, called for cordonning off and evacuating several blocks of a city during a business day.

A common aspect of each of these scenarios is the assumption that if radiation is measureable, it must be bad. Interpretations of measurements become a matter of responding to fears of radiation. One person defending their conservative decision said, “Why take chances?” There are two axioms on measurements, 1) measurements have no meaning until interpreted and 2) measurements only have meaning in terms of how they are interpreted”
Interpretation of Radiation Measurements

Steps for Defensible Measurements
- 1. Deciding what to measure?
  - Exposure or contamination?
- 2. Choosing the proper instrument
- 3. Verifying instrument performance
- 4. Using the instrument properly
  - According to calibration?
- If you have been careful with above steps,
  - There are still countless pitfalls
  - You now have measurements to interpret

Two Axioms on Measurements
1) “Measurement results have no meaning until interpreted for a particular purpose”
   They are just numbers
2) “Measurements only have a meaning in terms of how they are interpreted”
The meaning is whatever people believe

Psychology of Radiation Measurements
- Interpretation may have as much to do with attitudes and perceptions as it does with technology
- Same measurements may have different meanings for others
- Examples:
  - Technician at nuclear plant, “We got a hot one here!”
  - Industrial worker saw GM meter go off scale
  - Granite counter tops
  - Firemen observing twice background
  - Screaming GM meter

Common Aspect of Scenarios
- If it’s measurable, it must be bad!
- Interpretation of measurements is often a matter of responding to fears
- One person’s answer for defending conservative decision, “Why take chances?”
- Common mindset
  Measurement = “Deadly Radiation”
- Risks of NOT taking action
  - Fears, criticism, responsibilities
  - Making a mistake
Interpretation of Radiation Measurements

Questions for Interpretation?
- What do the numbers mean?
- Are the measurements defensible?
- What decision do you want to make?
- How much resources are you willing to commit on the basis of these measurements?
- What is the risk of making a mistake?
  - What if you act or do not act?
  - How will you be held accountable?
  - Possible litigation?
  - Upset workers? Union? Management?

Making Good Decisions
- How to avoid decisions that may not be warranted by the data, false positives
  - Be skeptical, ask lots of questions, false positives
- Repeat measurements for confirmation, with other people and other instruments ideally
- Typical when finding actionable levels
  - Most want to take immediate action
- No one wants to be criticized
  - For not taking action

Dealing with Uncertainty
- Most people do not want to deal with uncertainty, they want absolute values
- They typically do not ask questions to evaluate the data or to determine if the data are defensible
- Tendency is to assume all data are of high quality and suitable for making decisions
  - When the number is written down, it becomes reliable

Defending Results
- Ask lots of questions
- How do you know if the data are any good?
- Right instrument, working properly, used properly, calibration, energy dependence, geometry?
- Report results with estimates of all sources of uncertainty,
  - Be careful of significant figures
- Always repeat for confirmation,
  - Before reporting or making expensive decisions

Summary
- Common assumptions
  - If it’s measurable - it must be bad
  - Written data are always good
  - Must take immediate action
- Common to make decisions (cry wolf)
  - Without verifying the measurement
- Stay calm
- As minimum – repeat at least once
  - For confirmation, with other instruments and people, if possible

Summary
- What do the numbers mean?
- Measurements only have meaning in terms of interpretation
- Data interpretation may be driven by fears
  - Of radiation
  - Of consequences, health risks, liabilities
  - Making a mistake
- Is your interpretation defensible?
- What are you willing to commit?
Interpretation of Radiation Measurements

Questions?

Ray.johnson@moellerinc.com
Raymond H. Johnson,  MS, PSE, PE, FHPS, CHP
Director, Radiation Safety Counseling Institute 301-370-8573

- BS - Civil Engineering, University of Vermont (1961)
- MS - Sanitary Engineering, Massachusetts Institute of Technology (MIT) (1963)
- PSE - Professional Sanitary Engineer Degree, MIT and Harvard University (1963)
- PE – Licensed Professional Engineer, Vermont (1965 – present)
- CHP – Certified Health Physicist, American Board of Health Physics (1983–present)
- FHPS - Fellow of the Health Physics Society and Past President (2000)
- President, American Academy of Health Physics (2013)
- Commissioned Stephen Minister – Counselor, United Methodist Church (2003–present)

Experience

2010 – pres. Director , Radiation Safety Counseling Institute. Workshops, training, and counseling for individuals, companies, universities, or government agencies with concerns or questions about radiation and x-ray safety. Specialist in helping people understand radiation, what is safe, risk communication, worker counseling, psychology of radiation safety, and dealing with fears of radiation and nuclear terrorism for homeland security.

2007 – pres. VP, Training Programs and consultant to Dade Moeller Radiation Safety Academy, training and consulting in x-ray and radiation safety, safety program audits, radiation instruments, and regulatory requirements.

1984 - 2007 Director, Radiation Safety Academy. Providing x-ray and radiation safety training, audits, and consulting to industry (nuclear gauges and x-ray), universities, research facilities, and professional organizations.

1988 - 2006 Manager and Contractor to National Institutes of Health (NIH) for radiation safety audits of 3,500 research laboratories and 2,500 instrument calibrations a year, along with environmental monitoring, hot lab and analytic lab operations, and inspections of three accelerators and over 100 x-ray machines.

1990 - 2005 President of Key Technology, Inc. a manufacturer and primary laboratory for radon analysis with over 1,500,000 measurements since 1985. Primary instructor at Rutgers University for radon, radon measurements, radiation risks, radiation instruments, and radon risk communication courses (1990-1998).

1986 - 1988 Laboratory Director, RSO, Inc. Directed analytical programs and Quality Assurance for samples from NIH, Aberdeen Proving Ground, radiopharmaceutical companies, and the nuclear industry.


Health Physics and Professional Activities


Publications