Interpretation of Radiation Measurements*

Health Physics Society Midyear Meeting
Baton Rouge, LA February 12, 2014

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

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 measureable, 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.

- Presented at a plenary session at the Midyear Meeting of the Health Physics Society, Baton Rouge, LA on February 12, 2014

No. 16 – Radiation Safety Psychology
Interpretation of Radiation Measurements –Part 1

Health Physics Society Newsletter – August 2013

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

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 cordoning 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

Health Physics Society Midyear Meeting

Baton Rouge, LA
February 12, 2014

Ray Johnson, MS, PSE, PE, FHPS, CHP
Consultant
Dade Moeller Training Academy
Ray.johnson@moellerinc.com

Outline for this Presentation

- Steps for defensible measurements
- Interpretation may be more about attitudes and risk perceptions, than about technology
- Two axioms on interpreting measurements
- A few anecdotes about interpretations
- Interpretation as a response to fears
- Caution leads to "precautionary principle"
- Dealing with uncertainty
- Many factors can cause measurements to be misleading

Dade Moeller Training Academy 2

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

Dade Moeller Training Academy 3

Two Axioms on Measurements

1) "Measurement results have no meaning until interpreted for a particular purpose"

They are just numbers

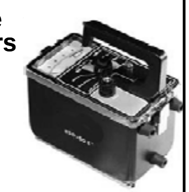
2) "Measurements only have a meaning in terms of how they are interpreted"

The meaning is whatever people believe

Dade Moeller Training Academy 4

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



Dade Moeller Training Academy 5

Common Aspect of Scenarios

- If its measureable, 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

Dade Moeller Training Academy 6

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 ?

Dade Moeller Training Academy 7

Making Good Decisions

- How to avoid decisions that may not be warranted by the data, false positives
  - Be skeptical, ask lots of questions before decisions
- 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

Dade Moeller Training Academy 8

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

Dade Moeller Training Academy 9

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

Dade Moeller Training Academy 10

Summary

- Common assumptions
  - If its 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

Dade Moeller Training Academy 11

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 ?

Dade Moeller Training Academy 12

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)
- PhD Studies, Radio and Nuclear Chemistry, Rensselaer Polytechnic Institute (1966–1972)
- Greater Washington Institute for Transactional Analysis - Counseling (1977–1980)
- CHP – Certified Health Physicist, American Board of Health Physics (1983–present)
- Johns Hopkins Fellow, Organizational Systems (1984–1985)
- 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.
1970 - 1985	Chief, Radiation Surveillance Branch, EPA, Office of Radiation Programs. Directed studies of radiation exposures from all sources of radiation in the US, coordinated 7 Federal agencies for nuclear fallout events, QA officer 8 years. Head of US delegations to I.A.E.A and N.E.A. on radioactive waste disposal. ANSI N-13 delegate (1975-1985). Retired as PHS Commissioned Officer (0-6) in 1985 with 29 years of service.
1963 - 1970	U.S.P.H.S. Directed development of radiation monitoring techniques at DOE National Labs, nuclear plants, and shipyards in the US and Chalk River Nuclear Laboratory in Canada.

Health Physics and Professional Activities

Health Physics Society (HPS) plenary member 1966; President-elect, President, Past President (1998-2001), Fellow (2000), Treasurer (1995-1998); Secretary (1992-1995); Executive Cmte. (1992-2001), Chair, Finance Cmte. (1996-1998); Head of U.S. delegation to IRPA X (2000). RSO Section Founder and Secretary/Treasurer (1997-2000); Co-founder and President, Radon Section (1995-1996). Co-Chair Local Arrangements Cmte. Annual Meeting in DC (1991); Public Info. Cmte. (1985-1988); Summer School Co-Chair (2004); Chair, President's Emeritus, Cmte (2006); Chair, Awards Cmte. (2002); Chair, History Cmte. (2005-2012); Historian (2012-Pres.) Continuing Education Cmte. (2005-2012). Academic Dean for HPS Professional Development School on Radiation Risk Communication (2010). PEP, CEL and AAHP Instructor; Journal Reviewer; Treasurer, AAHP (2008 – 2011). AAHP President (2013). Baltimore-Washington Chapter: President (1990-1991) and Honorary Life Member; Newsletter Editor (1983-2005); Public Info. Chair (1983-1991), Science Teacher Workshop Leader (1995 – Pres.). New England Chapter HPS, Newsletter Editor, Board of Directors, Education Chair (1968-1972). President, American Association of Radon Scientists and Technologists (1995-1998) and Honorary Life Member, Charter Member; Board of Directors; Newsletter Editor (1990-1993). Founder and first President, National Radon Safety Board (NRSB) (1997-1999). Member of American Industrial Hygiene Association (1997-Pres.) (Secretary, Vice Chair, Chair, Ionizing Radiation Committee, 2009-2012), Conference of Radiation Control Program Directors (1997-Pres.), Studied H.P. communication styles and presented Myers-Briggs seminars to over 3500 H.P.s since 1984. Over 35 professional society awards. Licensed Professional Engineer since 1965. Certified Health Physicist since 1983.

Publications

Authored over 500 book chapters, articles, professional papers, training manuals, technical reports, and presentations on radiation safety. Author of monthly column, "Insights in Communication" HPS Newsletter 1984 – 1989, 1994 -2001, and 2012- 2013..

Contact at: 301-990-6006, ray.johnson@moellerinc.com; 301-370-8573, www.radiationcounseling.org