Beyond Score-Keeping for the Regulator: Reasons to Perform Personnel Monitoring[1]

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Abstract – Most radiation safety programs monitor employees for exposures to radiation and radioactive materials. Sometimes monitoring is extended to visitors, members of the public, students, minors, and declared pregnant women, as well as off-site public. Ultimately, most programs do this because it is required by a regulation or rule invoked by a license or contract. Beyond the "score-keeping" needs of regulatory compliance, there are at least seven other valid reasons for performing personnel monitoring, many of which fall into the category of "no news is good news," or more aptly, "null news, as long as you can prove it, is good news." Personnel monitoring results are used to 1) measure performance for contractual compliance and demonstration that exposures and doses are kept as low as reasonably achievable (ALARA); 2) diagnose the need for and design safety or protection measures; 3) measure dose for worker surveillance programs and epidemiology; 4) document conditions for prevention of litigation or for evidence in litigation; 5) provide factual support for labor-management relations and public relations; 6) counsel workers; and 7) enhance workers' peace of mind. Modern management methods stress measuring and assessing quality and performance, and, although fraught with problems, quantitative assessments of individual and collective dose have been incorporated into performance measures of radiation safety and ALARA programs. While it is unethical to use a worker as a "canary in a coal mine," analysis of worker intakes, ontakes, and doses helps diagnose radiation protection problems, and facilitates the design of protection measures. Dose measurements and assessments, and in particular, assessments of annual (not committed) doses to tissues, are needed for worker health surveillance and occupational epidemiology studies. Records of dose assessments and the measurements and methods on which such doses are based are critical for support of litigation, and good measurements may prevent litigation in some cases. Assessments of dose to workers, the public, and the environment are useful for documenting management commitment to workplace safety as part of management-labor relations, as well as for demonstrating to the public that an operation involving radiation is safe. Assessments of dose are useful in counseling workers (for example, declared pregnant women) about personal health. Providing there is a policy for dealing with false positive results, in the majority of cases, assessment of dose and communication of the results to individual workers enhances their peace of mind by minimizing worry, displacing uncertainty with knowledge, and providing reassuring evidence that the workplace is safe. On the basis of the arguments presented above, I advocate 1) more personnel monitoring (external dosimetry, bioassay, and exposure monitoring) rather than less, and 2) better communication of dose assessment results.

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1 Introduction

Workers and members of the public may be exposed to hazardous conditions and agents in the course of working and living (Figure 1). The universe of all agents includes hazardous and non-hazardous agents. Hazardous agents include *conditions* such as cold, heat, vibration, lack of oxygen, vacuum, pressure, and electricity. Two other broad categories of hazardous agents are *energy fields* and *substances*. Energy fields include ionizing and nonionizing radiation. Substances include radioactive substances. In contrast to toxic chemicals, radioactive substances have the unusual property of producing an energy field, (a property shared by magnets and electrets, hot or cold items, and items with enough mass to be gravitationally significant), that allows one to make precise quantitative measurements using simple physical devices.

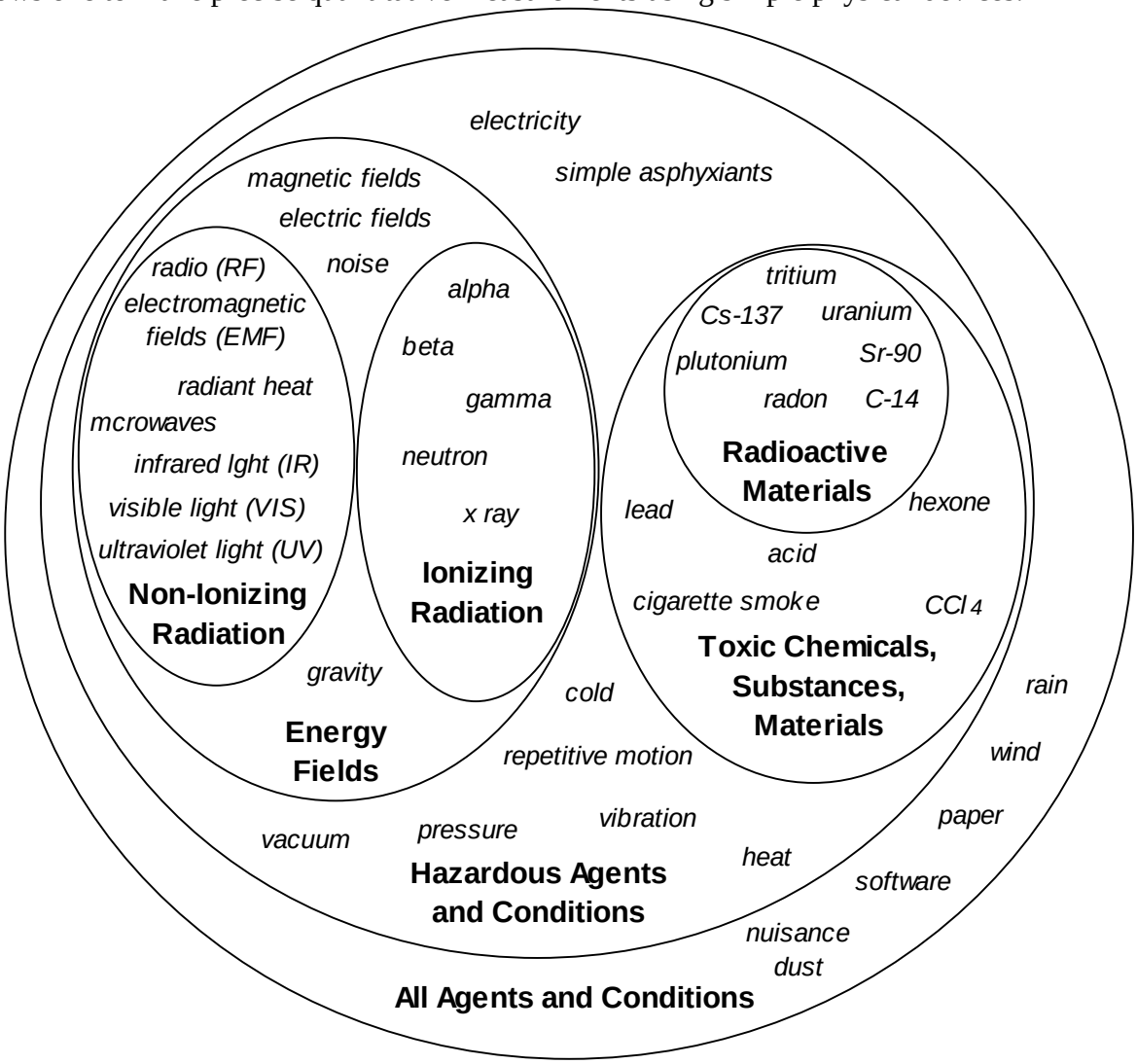

Figure 1. The universe of agents and conditions, including hazardous agents and conditions, to which workers and members of the public may be exposed.

One can *monitor* places and persons. Since photographic emulsion was one of the earliest

detection devices for radiation, it was natural to use film as a personnel monitor for radiation as an energy field originating outside of the body. Later, other monitoring devices, including electrometers, ionization chambers, and a variety of other detectors came into use. Monitoring personnel for exposure to radiation sources outside of the body (external irradiation) is true dosimetry, in that measurements of dose are being made and usually there is little inference needed to assess the dose to the person wearing the monitoring device.

Radioactive materials taken into the body pose a different problem. Monitoring for *exposure* to radioactive substances is simpler than inferring the quantity of the substances themselves in the human body. Exposure monitoring is generally done by sampling air, either at a fixed location in the workplace or in the worker's breathing zone. *Bioassay* is the general name given to inferential measurements of radioactive substances in the human body or in bioeffluents (e.g., excretions such as urine and feces, secretions such as breast milk or sputum, breath) or tissue samples (blood, hair, fingernails, material debrided from a wound, etc.). *Direct bioassay* is the measurement of a radioactive substance in the body by detecting the energy field (radiation) it emits. *Indirect bioassay* is the measurement of a radioactive substance in bioeffluents. Even when retained or excreted quantities of radioactivity are well known, inferring dose

Most radiation safety programs monitor some, but usually not all, employees for exposures to radiation and radioactive materials. Sometimes monitoring extends to visitors, members of the public, students, minors, and declared pregnant women, as well as off-site public and environmental sites.

2 "Score-Keeping" for the Regulator

Historically, individuals were monitored because it was in the best interests of researchers and weapons producers to have a healthy staff. Gradually, monitoring requirements and action levels were codified. Throughout the careers of currently practicing health physicists, radiation safety programs have monitored most individuals because monitoring was required by a regulation or rule invoked by a license or contract. Radiation protection regulations in the USA such as the U.S. Nuclear Regulatory Commission's (NRC's) "Standards for Protection Against Radiation" and the U.S. Department of Energy's (DOE's) "Occupational Radiation Protection" require monitoring of individuals to demonstrate compliance with dose limits. Monitoring must be done for persons likely to exceed 100 mrem (NRC) and 500 mrem (DOE) of total effective dose equivalent in one year (U.S.Department of Energy (DOE) 1993; U.S.Nuclear Regulatory Commission (NRC) 1993).

Serious consequences of exceeding a dose limit or appearing to exceed a dose limit include: criminal prosecution, civil penalties, loss of revenues due to work stoppage, and bad publicity for a radiation protection program and the organization it supports. Consequently, the results of dose measurements and assessments are treated as exact numbers with no margin of error when compared with exact limits. Keeping track of dose assessments is similar to keeping score in a high-stakes game where the outcomes are either punishment or absence of punishment.

Since the adverse outcomes for failure to obey regulations (and failure to keep doses to

individuals below limits), which are fairly certain, severe, and immediate, must be balanced within the corporate budget, radiation protection programs often do little more than is required by law. In fact, one DOE document urges minimizing the number of dosimeters provided to workers: "To minimize the number of personnel in the dosimetry program, the issuance of dosimeters is discouraged to other than personnel entering Radiation Areas, High Radiation Areas or Radiological Buffer Areas where there is a potential for external exposure. Although issuing dosimeters to personnel who are not occupationally exposed to radiation can appear as a conservative practice, it creates the impression that the wearers are occupationally exposed to radiation" (U.S.Department of Energy (DOE) 1994) (Article 511.4).

3 Going Beyond Score-keeping to Good Practices

Beyond the "score-keeping" needs of regulatory compliance, and despite the existence of short-term budget constraints, there are at least seven other valid reasons for performing personnel monitoring, many of which fall into the category of "no news is good news," or more aptly, "null news, as long as you can prove it, is good news." Rather than "creating the impression that the wearers are occupationally exposed to radiation," providing personnel monitoring to workers who are not likely to be exposed but who work in an institution where others are exposed can convey many positive messages and provide many long term benefits beyond short term avoidance of adverse outcomes. Personnel monitoring results can be used to 1) measure performance for contractual compliance and demonstration of ALARA; 2) diagnose the need for and design safety or protection measures; 3) measure dose for worker surveillance programs and epidemiology; 4) document conditions for prevention of litigation or for evidence in litigation; 5) provide factual support for labor-management relations and public relations; 6) counsel workers; and 7) enhance workers' peace of mind.

3.1 Measure performance for contractual compliance and demonstration of ALARA

Regulations and contracts require employers to limit doses to values less than prescribed values, and to provide monitoring to demonstrate compliance with the limits. Beyond mere dose limitation, other aspects of the performance of a radiation protection program are scrutinized by contracting agencies. Modern management methods stress *measuring* and *assessing* quality and performance. Although fraught with problems (Strom et al. 1998), quantitative assessments of individual and collective dose have been incorporated into performance measures of radiation safety and ALARA programs. In principle, for a constant workload under constant conditions, a reduction in collective dose represents an improvement in radiation protection. While this use of personnel monitoring results is not free of problems, quantitative measures of the success of radiation protection programs should include some use of measurements of exposures and doses to people.

3.2 Design and diagnose the need for safety or protection measures

While it is unethical to use a worker as a "canary in a coal mine," analysis of worker intakes, ontakes, and doses helps diagnose radiation protection problems, and facilitates the design of protection measures. Unexpectedly high results or unusual trends of results from dosimeters,

bioassay results, or air monitors could indicate a loss of control of radiation, or lack of effectiveness of overall radiation protection program. Furthermore, high results could help determine whether or not medical treatment or monitoring might be needed in the aftermath of an accident. Continued absence of exposure in a population indicates continued control.

3.3 Measure dose for worker surveillance programs and epidemiology

Dose measurements and assessments, and in particular, assessments of annual (not committed) doses to tissues, are needed for worker health surveillance and occupational epidemiology studies. Surveillance is intended to detect health problems as early as possible. Results of personnel monitoring that show a lack of exposure are important for directing attention elsewhere. In a world in which there is controversy about the putative effects of low doses of radiation, only by measuring low doses can we help settle the question for future generations.

3.4 Document conditions for evidence in litigation or for litigation avoidance

Records of dose assessments and the measurements and methods on which such doses are based are critical for support of litigation. Awareness of the existence of a radiation protection program that stresses good measurements may persuade potential plaintiffs to drop or forgo litigation. The outcome of radiation lawsuits usually hinges on plausible determinations of dose and the uncertainties in those determinations (Jose 1986; McGarry III 1996; Robinson 1996). Having quality measurement data available is crucial to achieving a fair outcome in legal cases.

3.5 Provide factual support for labor-management relations and public relations

Assessments of dose to workers, the public, and the environment are useful for documenting management commitment to workplace safety as part of management-labor relations, as well as for demonstrating to the public that an operation involving radiation is safe. In situations where there is a lack of trust between the workforce and management, results of a program of systematic measurements of dose, bioassay activity, or exposure (or the lack thereof) can reinforce the belief that radiation protection is adequate. Similarly, in situations where there is a lack of trust between the public and an institution, measurements of dose, bioassay activity, or exposure (or the lack thereof) can foster the belief that radiation protection is adequate. Greater partnership between labor and management are part of current workplace trends for the federal government and its contractors (Clinton 1993), and are incorporated in DOE's Enhanced Work Planning. Increased productivity is expected to result from less adversarial labor-management relationships and greater trust.

3.6 Counsel workers

Assessments of dose are useful in counseling workers about personal health. I have personally used personnel monitoring results to place a dose in perspective for women who were pregnant or intending to become pregnant, and for men who were considering starting a family. I have also counseled workers who were considering quitting their jobs due to real or perceived exposures. I have counseled parents of young or infant children when a parent had received an nuclear

medicine diagnostic procedure, in particular when a mother was nursing a child. In the latter cases, measurements would have made the situation far easier, and the counsel more trustworthy to the parent.

3.7 Enhance workers' peace of mind

In the majority of cases, assessment of dose and communication of the results to individual workers enhances their peace of mind by minimizing worry, displacing uncertainty with knowledge, and providing reassuring evidence that the workplace is safe.

I have personally seen workers come out of containment, remove their personal protective equipment, and urgently read their pocket ion chambers to see how much dose they had picked up; I have seen the expressions of relief when they realized that they were not "cooked." I have dealt with workers whose quality of life was devastated by a perceived dose they believed they had received. In one case, I worked with a woman who could not sleep, who lost weight, and who could experience no joy until a long-delayed bioassay result became available to reassure her that her intake of ^{45}Ca had been relatively minor. I have talked to workers who felt"safer" (in the old days of more ample budgets) when they contributed bioassay specimens, because they felt they were being better cared for. I, too, have been personally relieved when a blunder of mine in testing shielding resulted in an exposure that, when the dosimetry results became available, proved to be minor. Educated workers *do* care about their doses, and are naturally alarmed about not having the information available.

A down side of the peace-of-mind issue is the problem of false positives. False positive results are essentially "false alarms," and are just as frightening to people as real alarms until their cause or nature is determined. A clear policy for dealing with false positive results must be in place and must be the subject of effective training of the workforce. False positive results can occur during continuous air monitoring due to radon progeny or when sampling for short-lived alpha emitters such as ^{238}Pu (Scott et al. 1997). Similarly, false positive results can carry a significant consequence when a routine bioassay program is used for materials like class Y plutonium (U.S.Department of Energy (DOE) 1996). When a result just above the decision level is detected, the advice "don't panic" should be taken by all parties involved (health physicists, workers, managers, and regulators).

4 Conclusions

Good practices in health physics include not only staying within limits, but also proving we're doing our job, getting better at doing our job, supporting scientific research on health effects of radiation, protecting potential lawsuit defendants (our employers), making the workplace less contentious, caring for individual workers, and reducing fear of potential radiation injury by measuring dose or exposure to replace supposition with knowledge. All of these goals are supported by personnel monitoring results above and beyond those necessary for mere score-keeping for the regulator.

On the basis of the arguments presented above, I advocate 1) more personnel monitoring (external

dosimetry, bioassay, and exposure monitoring) rather than less, and 2) better communication of dose assessment results.

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