**Reducing the Cost and Complexity of Radiation Protection at Nuclear Facilities**

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Thirty-five years of safe operating experience at U.S. nuclear power plants have demonstrated an industry-wide commitment to the principles and practices of radiation protection for both workers and off-site populations. This commitment is demonstrated by well-maintained and operated facilities, negligible on-site and off-site radioactive emissions, ever-lower individual and collective worker radiation doses, and excellence in safety culture. The nuclear power industry is carefully regulated.

However, several factors greatly increase the cost and complexity of compliance to regulations that require submission to measures for protection against insignificant radiation levels under the false premise that “any amount of radiation exposure is harmful.” The public animosity and mindset against nuclear power stems largely from anxiety toward low-level radiation and fear of its consequences, despite a vast and comprehensive body of scientific literature on low-dose radiation effects.

This paper identifies *five common fallacies* and misconceptions related to the cost of implementing radiation protection practices at nuclear facilities. The grand challenge for regulators and industry leaders is to bring about meaningful changes to improve the cost-effectiveness of radiation protection regulations without increasing public perceptions that the industry has abrogated its commitment to safe practices and continuous improvement. The five common fallacies are:

1. Mathematical relationships predict proportionality between radiation dose and harmful effects at all dose levels
2. Scientists know and understand the absolute risk of radiation damage or cancer risk associated with very-low-dose radiation
3. Limits for radiation protection are meaningful (and beneficial) at fractions of the natural background level
4. Radiation safety increases proportionately with volume of regulations, costs of compliance, and penalties for minor infractions
5. Spending more and more money on radiation safety protects people better and prevents cancer incidence

Mathematical relationships. The relationships between radiation dose and biological effect are rarely linear or proportional at low dose. Thus, the linear, no-threshold dose-response hypothesis is invalid at low doses. An alternative may be the recognition of “safe levels” of absorbed dose below regulatory concern.

Risks at low dose. Radiation effects at low doses are so indistinguishable that even the most reliable scientific studies of radiation effects in mammalian cells, animals and man find need to convolute effects on system-elements and to extrapolate through unknown territory from known values down to zero dose for estimating the risks of low-dose radiation exposure.

Dose limits at or below the natural background. The public dose limit of 1 mSv per year (100 mrem) represents about 1/6th of an average person’s exposure to natural background radiation from all sources combined. When regulators apply a safety factor of 10 or more to this limit as a conservative and well-meaning measure to ensure compliance, they regulate at 1/60th or less of the natural background. This public dose limit greatly increases the cost of compliance without providing additional safety to the protected population.

Burden of regulatory requirements. Well-meaning but onerous volumes of regulation generally protect the regulator, but usually do little to improve safety in the workplace. However, the cost to promulgate regulations added to the cost of understanding and implementing increasing volumes of regulations will inevitably increase costs to ratepayers and taxpayers alike, and can sometimes reduce the effectiveness of the intended regulations with little or no improvement in radiation safety to the workers or the public.

Cancer reduction at less-than-background levels. Cancer due to natural non-radiogenic causes, such as diet, smoking, and hereditary factors is the second leading cause of death after heart disease. The lifetime risk of cancer averages about 35% among the general populations. Extensive efforts to reduce exposures to background radiation are calculated to prevent fractions of 1 percent of overall cancer risk, yet the costs of these efforts drive up the cost of facility design and construction, operation, and decommissioning and decontamination to extraordinary levels such that the benefit/cost ratios approach zero and become meaningless.

Examples where paradigm changes are needed:

Nuclear operations—Nuclear plant operators apply the “as low as reasonably achievable” (ALARA concept) at great cost. This practice evolves into “as low as achievable” and necessitates staffing to monitor and document very low-level radiation to comply with regulations. The ALARA practice taken to excessive lengths represents a common but wasteful practice in all parts of the nuclear fuel cycle.

Reactor design—Designers are faced with adding a multitude of barriers in the reactor island to provide protection against the release of radiation. Some of this is simply prudent design, but in many cases the additions are very costly (such as the core catcher) and would likely be unnecessary if a more realistic understanding were applied to the actual health effects of low-level radiation.

Nuclear accident response—Nuclear operations adhere to exceptionally rigid licensing requirements, including “end of spectrum” hypotheses. Yet experience shows that many planned emergency response actions are excessive or unnecessary for protecting human health—as recently demonstrated following the Fukushima accident.

Nuclear Waste Disposal—Incredibly rigid requirements for preventing near-zero radiation release to the biosphere for future millennia impose large and unreasonable costs, and potentially disqualify all disposal sites and options.

Nuclear professionals have so far been unsuccessful in preventing the five false premises to prevail. In the near future, the American Nuclear Society and the Health Physics Society will co-sponsor a topical scientific conference[[1]](#footnote-1) on radiation-response models and opportunities for paradigm change. This conference will include key decision-makers from the international community and will focus on the science underlying radiation protection standards and regulations, with the goal to improve their application and cost-effectiveness.

1. “Applicability of Radiation-Response Models to Low Dose Protection Standards,” September 23-26, 2018, Pasco, Washington. [↑](#footnote-ref-1)