

Adequate protection at the DOE's nuclear facilities

By *Kamiar Jamali*

In an effort to define the term “adequate protection” as it applies to Department of Energy nuclear facilities (reactors and nonreactor facilities) within a more practical framework than what has been used to date, the DOE can look at the concept from the perspective of the Nuclear Regulatory Commission, and base that definition on NRC precedents. The discussion of adequate protection in this article builds on the criteria that were promulgated by former Deputy Secretary of Energy Daniel Poneman in an enclosure to a July 19, 2012, letter to Defense Nuclear Facilities Safety Board (DNFSB) Chairman Peter Winokur [1], and later supplemented by a memorandum issued to the Department of Energy's Central Technical Authorities on September 17, 2012 [2]. In the memorandum, Poneman states that adequate protection is defined as those measures that permit a facility to operate safely for its workers and the surrounding community. A subpart of this definition relates to the protection of the public, which, I propose, can be expressed as a standard that can be used in specific applications more readily than the general provisions given in Poneman's letter. The proposed definition is based on a primary qualitative criterion, complemented and informed by a secondary quantitative criterion when warranted.

Kamiar Jamali (<horizon2012@msn.com>) was a Senior Technical Advisor at the National Nuclear Security Administration (within the Department of Energy) before retiring at the end of March 2015.

The DOE can build upon the framework that has already been set out to establish a practical definition of “adequate protection.”

This approach is inspired by precedents set by the Nuclear Regulatory Commission for both its conceptual framework and the two-part criteria for the proposed definition, while complying with existing DOE requirements and expectations.

The dual construct of qualitative and quantitative criteria for the definition of adequate protection is fully consistent with the existing DOE Policy 420.1, *Department of Energy Nuclear Safety Policy* [3], which duplicates the NRC's Safety Goal Policy that was originally promulgated in 1986 [4].

The NRC's approach

It is especially instructive to examine the concept of adequate protection from the NRC's perspective, because of the historical maturity of that perspective, which is almost entirely based on the evolution of the safety assurance policies and requirements for nuclear power plants. Nonreactor nuclear facilities, primarily owing to their much smaller radionuclide inventories and lack of decay heat as an inherent source of energy for the dispersal of radionuclides, have always constituted somewhat of an afterthought with respect to their applicable nuclear safety policies and requirements. Nonreactor facilities need only a relative downward adjustment of requirements (a graded approach), as compared to their nuclear reactor counterparts.

Adequate protection at the NRC is a subjective but mandatory standard. As discussed later, there is a presumption of meeting adequate protection through compliance with applicable requirements [4]. But even this simple statement cannot be used in isolation or be fully understood without a discussion of what it means to be in compliance with applicable requirements. The discussions on compliance with nuclear safety requirements are provided under the “Compliance” subhead.

At the NRC

The Atomic Energy Act (AEA), the NRC, and the courts that have been involved in cases brought against the NRC have never provided a concrete or unambiguous definition of adequate protection, and they have intentionally left its definition to the NRC's discretion on a case-by-case basis. The AEA merely charges the commission with the responsibility to provide reasonable assurance of adequate protection.

As noted in Reference 4 and implied by Reference 5 in paragraph (a)(4)(i), compliance with requirements is presumed to ensure adequate protection at a minimum. The AEA allows the NRC to impose requirements that are deemed to go beyond adequate protection—sometimes referred to as safety enhancements—but imposing a safety enhancement requires the performance

of a backfit analysis in accordance with 10 CFR 50.109 (for reactors), and other CFRs, such as Parts 70, 72, and 76 (for nonreactor facilities). In contrast, backfit analysis, which in practice establishes some limits on the NRC's authority, will not be performed for cases that are deemed essential to providing adequate protection or for defining or re-defining it, based on the sole discretion of the commission. When backfit analysis is performed, the consideration of costs and benefits forms a key part of the process. It must be shown that the proposed regulatory action provides a substantial increase in the protection of the public and is justifiable in terms of direct and indirect costs.

In Reference 4, Commissioner William Ostendorff cites the following principles, which provide guidance on adequate protection based on the congressional language in the AEA and the relevant court cases:

- The NRC's authority under the adequate protection mandate is extremely broad.
- The NRC has significant discretion in deciding whether the adequate protection standard has been met.
- Matters related to adequate protection must be related to radiological hazards.
- The NRC's determination on adequate protection can be made on a case-by-case basis.
- Adequate protection does not mean "zero risk" (Case law, *Nader v. Ray*, 363 F. Supp. at 954).

Also, Ostendorff notes, "Many, if not all, of the issues that come before the commission boil down to how much risk we [the commission] are willing to accept. The main factor that I find critical to decision-making related to adequate protection is the consideration of risk." With regard to this quote from Ostendorff, setting quantitative criteria has not been deemed practical by the courts or the NRC, even though the commission decides how much risk is acceptable based in part on quantitative probabilistic risk assessment (PRA) results. The reason is that the presence of uncertainties precludes total reliance on PRA results. In addition, in the case of commercial nuclear power plants, there are a few plants that may not have large margins to the Quantitative Health Objectives (QHO), which are identical to the DOE's Quantitative Safety Objectives (QSO), as defined in Reference 3, based on the results of their plant-specific PRAs and comparisons of results to the surrogate QHOs of core damage frequency, with a proposed threshold of 10^{-4} per plant-year, and large early release frequency, with a proposed threshold of 10^{-5} per plant-year. The NRC augments PRA results with contextual evaluations—for example, consideration of the totality of circumstances, adverse impacts, regulatory stability, application of common sense, engagement with stakeholders, binding requirements versus other solutions, and following commission precedents.

The presumption of adequate protection through meeting deterministic requirements—such as those documented through the final safety analysis reports, technical specifications, and similar and/or lower-tier requirements documents that ensure compliance with all safety management program requirements—has been borne out by the results of the commercial nuclear power plant PRAs. These PRA results also formed the basis for the development of the NRC's Safety Goal Policy Statement [6], which in hindsight—that is, with the concurrent but evolving state of the nuclear safety requirements for commercial nuclear power plants—confirmed a very low level of risk to the public for all operating commercial nuclear power plants. (Risk to the public would be lower than 0.1 percent of the *combined* effects of *all* other sources for acute fatalities and latent cancer fatalities to which the public living in the vicinity of a nuclear power plant would be subject; the risk to the general public would be far lower.) The newer designs are shown to present even lower risks, by orders of magnitude, than the operating nuclear power plant designs.

The historical context and the evolution of the NRC's nuclear safety requirements from purely deterministic methods to the gradual influence of risk-based methods on the creation of risk-informed regulations/requirements is critical in understanding the NRC's reluctance to formally endorse a quantitative component to the definition of adequate protection through a rulemaking process or other actions. This fact, however, did not prevent the NRC from implicitly endorsing such a definition within the confines of a Regulatory Guidance document, namely the benchmark of risk-informed regulation framework, RG 1.174, *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis*, Revision 1 [7]. The definition of adequate protection is somewhat ambiguously furnished in RG 1.174 for the following reasons:

- The existing nuclear power plant licenses were granted based on deterministic nuclear safety requirements with the presumption that reasonable assurance of adequate protection was qualitatively confirmed.
- While PRAs for every existing plant and all future designs have shown that the NRC's QHOs are generally met by varying margins for all nuclear power plants—a fact that (a) was not known prior to the development of plant-specific PRAs for each and every nuclear power plant, and (b) may not

hold true for all plants at all times—the presence of uncertainties in all PRA results compels the commission to reserve the right to define adequate protection with other qualitative criteria at its sole discretion and on a case-by-case basis.

DOE reactors, and nonreactor facilities in particular, generally contain far smaller inventories of radionuclides with accident frequencies comparable to commercial nuclear power plants. Therefore, they are expected to meet the QSOs with even larger margins than nuclear power plants.

Consequently, the DOE can justifiably depart from full consistency with the NRC's

The presumption of adequate protection through meeting deterministic requirements has been borne out by the results of the commercial nuclear power plant PRAs.

precedent in defining adequate protection for its nuclear facilities, while taking full advantage of RG 1.174. The relevant paragraphs from RG 1.174 are reproduced below, along with proposed considerations for appropriate application by the DOE:

- The NRC has the statutory authority to require licensee action above and beyond existing regulations and may request an analysis of the change in risk related to the requested LB [licensing basis] change to demonstrate that the level of protection necessary to avoid undue risk to public health and safety (i.e., "adequate protection") would be maintained upon approval of the requested LB change.

- *Proposed consideration:* Risk results can be directly linked with the concept of adequate protection.

- PRA and associated analyses (e.g., sensitivity studies, uncertainty analyses, and importance measures) should be used in regulatory matters, where practical within the bounds of the state-of-the-art, to reduce unnecessary conservatism associated with current regulatory requirements, regulatory guides, license commitments, and staff practices. Where appropriate, PRA should be used to support the proposal for additional regulatory requirements in accordance with 10 CFR 50.109 (Backfit Rule).

- *Proposed consideration:* Deterministic requirements can lead to unnecessary conservatisms that may not merit application when considering risk/benefit.

- The commission's safety goals for nuclear power plants and subsidiary numerical objectives are to be used with appropri-

ate consideration of uncertainties in making regulatory judgments on the need for proposing and backfitting new generic requirements on nuclear power plant licensees.

• *Proposed consideration:* In its approval of the policy statement, the commission articulated its expectation that implementation of the policy statement will improve the regulatory process in three areas: (1) foremost, through safety decision-making enhanced by the use of PRA insights, (2) through more efficient use of agency resources, and (3) through a reduction in unnecessary burdens on licensees.

■ Consideration of the commission's Safety Goal Policy Statement [6] is an important element in regulatory decision-making. Consequently, this regulatory guide provides acceptance guidelines consistent with this policy statement. *In theory, one could construct a more generous regulatory framework for consideration of those risk-informed changes that may have the effect of increasing risk to the public.* (Emphasis added.) Such a framework would include, of course, assurance of continued adequate protection (that level of protection of the public health and safety that must be reasonably assured regardless of economic

and large early release frequency at 10^{-5} /yr that substitute for latent cancer and acute fatality safety objectives with some margin as shown from the results of numerous nuclear power plant PRAs.]

• *Proposed consideration:* The last sentence, in conjunction with the earlier quoted paragraphs and the italicized sentence, is suggestive of a staff-endorsed semi-quantitative construct for adequate protection: Once the existence of sufficient margin and defense-in-depth are established to guard against uncertainties, there is reasonable assurance that adequate protection is achieved by meeting the NRC's QHOs, which, as noted earlier, are the same as the DOE's QSOs.

Under the AEA, the DOE (as one of the successor agencies to the Atomic Energy Commission) also has broad authority in the determination of adequate protection, both in general and on a case-by-case basis.

A standard for the DOE

Selected portions of the letter from former Deputy Secretary of Energy Poneman to DNFSB Chairman Winokur on adequate protection of the public are reproduced below [1]:

1. "Adequate protection" is defined as those measures that permit a facility to operate safely for its workers and the surrounding community. The DOE relies on engineered safety systems and controls derived from safety basis requirements and operational and safety management programs to provide reasonable assurance that our facilities are operated safely.

2. As the phrase itself indicates, adequate protection is not an absolute criterion, but reflects the condition achieved when *all necessary measures* are being taken in a manner that is consistent with *applicable requirements* and the regulatory process. (Emphasis added.)

3. The DOE nuclear safety policy 420.1 describes measures that the DOE has established to provide reasonable assurance that adequate protection is achieved. The principal measure is the system of nuclear safety requirements that are designed to satisfy the department's safety objectives, thus providing adequate protection when met.

4. The DOE uses an expansive set of nuclear safety-related requirements at both the departmental level (e.g., high-level policies such as Integrated Safety Management) and facility-specific levels (e.g., nuclear facility safety analysis requirements and standards) to provide adequate protection. At the facility level, various means and combinations

of controls follow the philosophy of defense-in-depth to ensure there is no reliance on a single control in order to achieve adequate protection.

5. Additional DOE measures to provide adequate protection include:

- Implementation of Integrated Safety Management.
- Use of a safety management system and approach.
- Use of appropriate quantitative and probabilistic risk assessments.
- Establishment of quantitative safety objectives (adapted from the NRC).

Adequate protection of the public is a subjective but mandatory standard that both the DOE and the NRC are charged to uphold through the phrase "ensuring reasonable assurance of adequate protection" within the AEA.

I propose that the DOE build upon the adequate protection framework constructed in Poneman's letter and formally adopt in its directives a practical definition that is based in large part on NRC precedents and with appropriate DOE-related adjustments as discussed below. The proposed definition of adequate protection is arguably identical to the above five points. This definition would be added to the existing nuclear safety policy to clarify that policy, not replace it.

The proposed definition for adequate protection of the public in nonemergency situations would be referred to as the Adequate Protection Standard, defined below. It should be noted that the entry point for defining adequate protection for the DOE is the same as for the NRC, namely, that no radiological incident/accident has occurred. In the aftermath of a nuclear accident, DOE actions will be under the purview of the emergency response requirements, which are usually developed in a consistent manner to their Environmental Protection Agency/NRC/other-agency counterparts to ensure adequate protection in the context of an emergency response.

Expressed as a standard that can be used in specific applications, the proposed definition of adequate protection of the public is based on a primary qualitative criterion, complemented and informed by a secondary quantitative criterion when warranted, as follows:

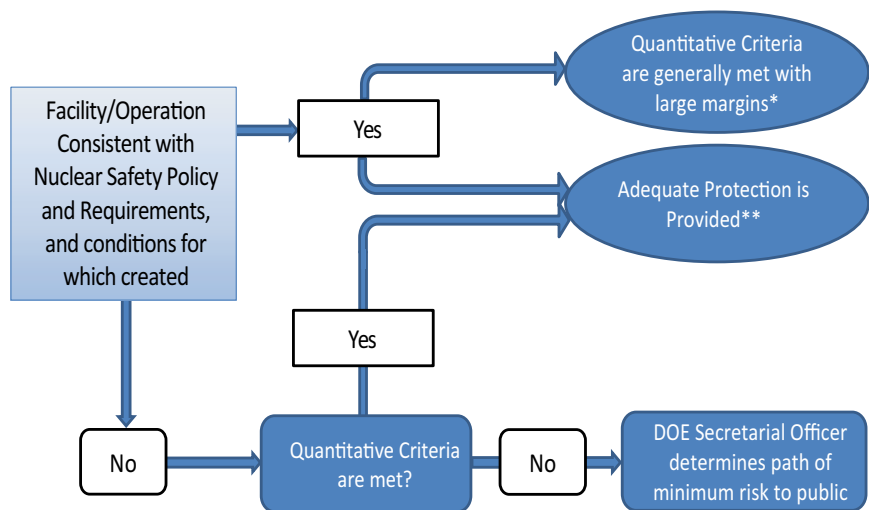
Qualitative Criterion—Compliance with applicable DOE nuclear safety requirements. The DOE may develop or modify nuclear safety requirements without regard for resource or mission impacts of implementation.

Quantitative Criterion—The DOE's Quantitative Safety Objectives, described in DOE Policy 420.1, are used to inform decisions regarding adequate protection of the public and compliance with nuclear safety requirements in situations that the DOE deems as necessary.

Under the AEA, the DOE has broad authority in the determination of adequate protection, both in general and on a case-by-case basis.

cost). But it could also include a provision for the possible elimination of all measures not needed for adequate protection, which either do not effect a substantial reduction in overall risk or result in continuing costs that are not justified by the safety benefits. Instead, in this regulatory guide, the NRC has chosen a more restrictive policy that would permit only small increases in risk and only when it is reasonably assured, among other things, that sufficient defense-in-depth and sufficient margins are maintained. This policy is adopted because of uncertainties and to account for the fact that safety issues continue to emerge regarding design, construction, and operational matters notwithstanding the maturity of the nuclear power industry. These factors suggest that nuclear power reactors should operate routinely only at a prudent margin above adequate protection. The safety goal subsidiary objectives are used as an example of such a prudent margin. [Author's note: Safety goal subsidiary objectives refer to the core damage frequency at 10^{-4} /yr

Adequate Protection of the Public at DOE Nuclear Facilities



*Meeting Quantitative Criteria can be tested as needed. Quantitative Criteria can also confirm presumption of Adequate Protection through meeting requirements. DOE nuclear safety requirements generally ensure levels of protection beyond Adequate Protection.

** DOE Secretarial Officer may choose to prioritize approach to meet requirements or grant exemption.

Pictorial representation of adequate protection of the public at DOE nuclear facilities

The first criterion recognizes that requirements and determinations as to whether they are met are subject to gradation (formally referred to as the “graded approach” in a number of DOE directives) and constant change. They are dynamic because the department is continuously making revisions to existing requirements or developing new requirements that are subjectively deemed necessary for the assurance of adequate protection. Furthermore, because compliance with requirements is generally determined based on degrees of applicability, relevance, and numerous other factors, and the circumstances in which a given set of requirements is applied is not always the same as those envisioned when they were created, the first criterion is not sufficient for the determination of adequate protection in all circumstances. Therefore, the first criterion should be complemented and informed by the quantitative criterion when the DOE determines that its use is warranted.

The first criterion is a compact restatement of the qualitative concepts discussed in Poneman’s letter. It should be noted that in practice and when determined by the DOE, only QSOs on latent cancer fatalities need to be assessed, as DOE nuclear facilities do not have the kinds and the magnitudes of radiological source terms that can present any potential of acute fatalities. The accompanying figure depicts the dual-criterion adequate protection standard.

■ If a facility or an operation (e.g., transportation or nuclear explosive operations) meets all of its applicable requirements,

there is a presumption of meeting adequate protection of the public. The DOE may choose to inform this presumption by performing a properly scoped PRA or other quantitative risk assessment to show that the quantitative criterion is met.

■ If a facility or operation does not fully meet nuclear safety requirements, if there are issues with respect to the margins by which some requirements are met or application of defense-in-depth, or if the circumstances could differ from those for which the requirements were written, the

DOE may choose to invoke the quantitative criterion to inform its decisions about what (if any) actions should be taken and the needed time frame for completing the identified actions.

- If the risk analysis demonstrates that the quantitative criterion is met with some margin, adequate protection is met. (Characterization of the needed margin and application of defense-in-depth are application-dependent and at the discretion of the responsible DOE officials.)

—Since the DOE generally seeks to implement design or operational improvements to ensure that adequate protection

is met with large margins, the responsible DOE secretarial officer may still commission studies to prioritize options for improving the safety profile of the facility or operation.

■ If neither criterion is met, the responsible DOE officials will expeditiously determine the options and associated actions that minimize the risk to the public in both the short and long terms. These actions can range from immediate design or operational changes, including the shutdown of operations, to those normally associated with emergency response planning, such as evacuation.

Regarding emergency response plans, it should be noted that the current values necessitating specific actions for post-accident public doses in the Protective Action Guidelines are two to three orders of magnitude larger than the DOE’s QSOs. This means that the quantitative criterion of the proposed adequate protection standard would be triggered far earlier than the guidelines, even in post-accident conditions.

Again, if a DOE nuclear facility is found to be operating outside of the boundaries of the Adequate Protection Standard (or without sufficient margin to the boundaries at the DOE’s sole discretion), the responsible federal officials will direct the timely performance of analyses to determine the appropriate course of protective actions. No action, including emergency response, can be taken immediately without significant potential consequences as discussed in References 8–10, so some analysis is always required in situations when immediate actions can be avoided. As recognized in these references, moving the public to areas of lower radiological risk, even in the aftermath of a nuclear accident, is not always the lowest-risk option. The DOE is

The DOE is committed to perform analyses, at a commensurate level of detail, and implement actions to ensure that risk to the population is minimal and that protection is adequate at all times.

committed to perform analyses, at a commensurate level of detail, and implement actions to ensure that risk to the population is minimal and that protection is adequate at all times.

Continued

Compliance

Meeting or complying with the DOE's or the NRC's nuclear safety requirements is not a condition that can be specified as being met with definitive declarations at all times, nor does being in compliance necessarily ensure the desired end state. Although nuclear safety requirements are developed with the intention of providing adequate protection, and meeting those requirements offers a presumption of providing adequate protection, the presumption is not a guarantee, as it is impossible to foresee every situation in which a requirement might be applied.

Further, implementation of nuclear safety requirements is inherently always "graded." Not all requirements are always fully applicable for a given nuclear facility, and many of them constitute high- or programmatic-level controls, as opposed to being objective and specific. A specific implementation of a requirement, while technically complying with the requirement, may fall short of meeting the intended outcome of the requirement.

Objective and specific requirements, such as inventory limits for nuclear materials in a specific facility, can usually be evaluated as either "met" or "not met" in a simplistic fashion, but broad, programmatic requirements—such as integrated safety management, radiation protection,

and training—can be much more subjective to evaluate. The requirements documents often allow (or require) grading of the programs in a manner commensurate with the hazards. These documents typically include numerous "shall," "must," "will," "may," or "can" statements to allow this grading.

Safety program requirements can be so broad and encompassing that the individual discrepancies within a program would not usually be considered as constituting a failure to meet the overall programmatic requirement. Individual discrepancies must be evaluated in terms of the significance and frequency of occurrence to inform a judgment as to whether the overall program is still effectively meeting its intent.

Being in compliance with a safety management program can also mean that parts of its provisions are either met through equivalency and/or exemptions granted by the cognizant approval authorities. One method for meeting a requirement is to (a) obtain approval from the authority with jurisdiction to grant an exemption from meeting it, or (b) find alternative methods for meeting the requirement.

References

1. Department of Energy, "Path Forward on Adequate Protection," enclosure to letter from Deputy Secretary of Energy Daniel B. Poneman to Peter S.

Winokur, July 19, 2012.

2. Memorandum for the Central Technical Authorities from Deputy Secretary of Energy Daniel B. Poneman, Adequate Protection, Sept. 17, 2012.

3. DOE Policy 420.1, Department of Energy Nuclear Safety Policy, Feb. 8, 2011.

4. "Adequate Protection in Commission Decision-Making," Remarks of Commissioner William C. Ostendorff at Nuclear Energy Institute Lawyers Committee Meeting, Mar. 7, 2011.

5. 10 CFR 50.109, *Backfitting*, 53 FR 20610, June 6, 1988, as amended in 54 FR 15398, Apr. 18, 1989; 72 FR 49504, Aug. 28, 2007.

6. U.S. NRC, *Federal Register*, 51 FR 30028, *Safety Goals for the Operations of Nuclear Power Plants*, Aug. 21, 1986.

7. U.S. NRC, Regulatory Guide 1.174, *An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis*, Revision 1, Nov. 2002.

8. *Protective Action Guides and Planning Guidance for Radiological Incidents*, U.S. Environmental Protection Agency, Draft for Interim Use and Public Comment, July 2012.

9. *Manual of Protective Action Guides and Protective Actions for Nuclear Incidents*, Office of Radiation Programs, U.S. Environmental Protection Agency, May 1992.

10. "Loss of life after evacuation: lessons learned from the Fukushima accident," <[www.lancet.com/journals/lancet/article/PIIS0140-6736\(12\)60384-5/fulltext](http://www.lancet.com/journals/lancet/article/PIIS0140-6736(12)60384-5/fulltext)> *The Lancet*, Vol. 379, Issue 9819, pp. 889–891, Mar. 10, 2012.

