Integrated Regulatory Review Service Mission to the United States

WHITE PAPER: U.S. APPROACH TO ENHANCING SAFETY

Overview

The U.S. Nuclear Regulatory Commission (NRC) assures the safety of nuclear power plants through a system of legal requirements, comprehensive operating experience evaluations, and extensive on-site inspections. The NRC's statutory mandate is to assure adequate protection of public health and safety. What constitutes adequate protection can change over time as operating experience, technological understanding, significant events, and inspection findings are assessed. The NRC updates its requirements to reflect these assessments to satisfy the adequate protection mandate, which in turn enhances nuclear power plant safety. In addition, the Institute for Nuclear Power Operations (INPO), an industry sponsored oversight organization that has a Memorandum of Agreement with the NRC, provides an impetus for nuclear utilities to steadily improve performance in pursuit of excellence in operations. Furthermore, the license renewal program provides assurance that aging management programs are established to assure the safety of long-term operations. The result, as evidenced by industry trends and the Accident Sequence Precursor Program, is an enhancement of nuclear power plant safety on a continual basis.

Statutory Authority and "Adequate Protection"

The Atomic Energy Act (the Act) of 1954, as amended (Ref. 1), is the fundamental U.S. law on the civilian use of nuclear materials. The Act requires that civilian uses of nuclear materials and facilities be licensed, and it empowers the U.S. Nuclear Regulatory Commission (NRC) to establish by rule or order, and to enforce, such standards to govern these uses as "the Commission may deem necessary or desirable in order to protect health and safety and minimize danger to life or property." Commission action under the Act must conform to the Act's procedural requirements, which provide an opportunity for hearings and Federal judicial review in many instances.

Specifically, Section 182 of the Act states the following:

> "In connection with applications for licenses to operate production or utilization facilities, the applicant shall state such technical specifications, including information of the amount, kind, and source of special nuclear material required, the place of the use, the specific characteristics of the facility, and such other information as the Commission may, by rule or regulation, deem necessary in order to enable it to find that the utilization or production of special nuclear material will be in accord with the common defense and security and will provide adequate protection to the health and safety of the public.

The determination of what constitutes "adequate protection" under the Act, absent specific guidance from Congress, is just such a situation where the Commission should be permitted discretion to make case-by-case judgments based on its technical expertise and on all the relevant information.[1]

"There does not exist a generally applicable definition of "adequate protection" which would guard against every possible misuse of the phrase. Congress established "adequate protection" as the standard the Commission is to apply in licensing a plant, and gave the Commission authority to issue rules and regulations necessary for protection of public health and safety, but Congress did not define "adequate protection", nor did it command the Commission to define it. In the absence of a useful and generally applicable definition of "adequate protection", the Commission can still make sound judgments about what "adequate protection" requires, by relying upon expert engineering and scientific judgment, acting in the light of all relevant and material information."[2] In practice, the NRC affords adequate protection through the use of Regulations, Regulatory Guides, Standard Review Plans, Branch Technical Positions, living licensing and design bases and other similar tools. Over time, safety is enhanced as adequate protection requirements are adjusted to reflect operating experience.

NRC Safety Philosophy

To fully understand the NRC's approach to safety, it is necessary to first examine the mission of the NRC. The mission of the NRC, as stated in NUREG-1614, Volume 4 "Strategic Plan: Fiscal Years 2008-2013," issued February 2008 (Ref 2), is "to license and regulate the Nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment." The NRC has developed and promulgated regulations and guidance for licensees so that the agency can efficiently carry out its mission.

The NRC's regulatory process has five main components: (1) developing regulations and guidance for our applicants and licensees, (2) licensing or certifying applicants to use nuclear materials or operate nuclear facilities or decommissioning that permits license termination, (3) overseeing licensee operations and facilities to ensure that licensees comply with safety requirements, (4) evaluating operational experience at licensed facilities or involving licensed activities, and (5) conducting research, holding hearings to address the concerns of parties affected by agency decisions, and obtaining independent reviews to support the agency's regulatory decisions.

The key components of the regulatory program are:

1. Operating Experience
    a. Event Assessment - daily review and long term trend analysis of accidents and other reportable incidents to determine the appropriate regulatory response
    b. Generic Issues - identifying and resolving safety issues that affect more than one licensed facility

2. Regulations and Guidance
    a. Rulemaking - developing and amending regulations that licensees must meet to obtain or retain a license or certificate to use nuclear materials or operate a nuclear facility

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1 U.S. Court of Appeals for the District of Columbia Circuit, *Union of Concerned Scientists vs.U.S. Nuclear Regulatory Commission and the United States of America*, No. 88-1561, 1989

2 Nuclear Regulatory Commission, "10 CFR Part 50, Revision of Backfitting Process for Power Reactors", *Federal Register* Vol. 53, No. 108. June 6, 1988, p20606

b. Guidance Development - developing and revising guidance documents, such as regulatory guides, standard review plans, and NRC's Inspection Manual (Ref 3) to aid licensees in meeting safety requirements
c. Standards Development - working with industry standards organizations to develop consensus standards associated with systems, equipment, or materials used by the nuclear industry so that these standards may be referenced in NRC regulations or guidance

3. Support for Decisions
    a. Research Activities - experiments, technical studies, and analyses to help the NRC make realistic decisions, assess the safety-significance of potential technical issues, and prepare the agency for the future by evaluating potential safety issues involving new designs and technologies
    b. Risk Assessment - use of risk analysis methods and performance insight to support decision making throughout the regulatory process
    c. Performance Assessment (for waste disposal and decommissioning) - evaluating potential releases of radioactivity into the environment, and assessing the resultant radiological doses to demonstrate whether a disposal facility has met its performance objectives
    d. Advisory Activities - review and assessment of regulatory proposals by independent advisory bodies reporting to or chartered by the Commission
    e. CRGR Reviews - review and assessment of proposed generic backfits by the Committee To Review Generic Requirements (CRGR), an independent advisory committee chartered by the NRC's Executive Director for Operations
    f. Adjudication - listening to concerns of parties affected by licensing or enforcement actions in a legal setting

4. Licensing, Decommissioning and Certification
    a. Licensing – authorizing an applicant to use or transport nuclear materials or to operate a nuclear facility
    b. Decommissioning - removing a nuclear facility safely from service and reducing residual radioactivity to a level that permits termination of license
    c. Certification - authorizing an applicant to manufacture spent fuel casks, transportation packages for nuclear materials, and sealed sources and devices and authorizing an applicant to operate a gaseous diffusion plant

5. Oversight
    a. Inspection - verifying that a licensee's activities are properly conducted to ensure safe operations in accordance with NRC's regulations
    b. Enforcement - issuing sanctions to licensees who violate NRC regulations
    c. Assessment of Performance (for operating facilities) - reviewing inspection findings, together with objective performance indicators, to assess the performance of nuclear facilities and determine appropriate agency action, up to and including Orders
    d. Allegations- responding to reports of wrongdoing by NRC licensees, applicants for licenses, or licensee contractors or vendors
    e. Investigations - investigating wrongdoing by NRC licensees

Operating Experience

The U.S. approach starts with operational experience (OpE). The NRC monitors nuclear power plant design and operations on a continual basis. As new OpE is identified and evaluated, the NRC adjusts its inspections and requirements to address the new information. OpE is reviewed on a continual basis, including daily screening of events, resident inspector input, regional assessments, daily OpE communications, semi-annual Technical Review Group reviews, and through the Reactor Oversight Process of plants and the industry as a whole.

Each licensee must send information to the NRC about certain "reportable events" that occur at their facility or during their use of nuclear materials. At NRC Headquarters technical experts review the reported events by applying plant-specific risk insights and operating experience to identify significant weaknesses in plant design, operation, or equipment. When problem areas are identified, the NRC coordinates the appropriate level of inspections with the regional offices to reach a satisfactory resolution. In certain cases, these reported events are addressed through generic communications to the industry and other interested or potentially affected parties and are made available to the public through the Web. (http://www.nrc.gov/reading-rm/doc-collections/gen-comm/index.html)

The NRC initiated the Industry Trends Program to monitor trends in indicators of industry performance as a means to confirm that the safety of operating power plants is being maintained. If any long-term indicators show a statistically significant adverse safety trend, the NRC evaluates them and takes appropriate regulatory action using its existing processes for resolving generic issues and issuing generic communications. The NRC formally reviews these indicators as part of the Agency Action Review Meeting each year, and reports any statistically significant adverse trends to Congress in the NRC's Performance and Accountability Report. The NRC also uses the Accident Sequence Precursor (ASP) Program to systematically evaluate nuclear power plant operating experience to identify, document, and rank the operating events most likely to lead to inadequate core cooling and severe core damage. Some examples of how safety was enhanced (the “adequate protection” bar was raised) by rulemakings or changes to guidance documents include the Station Blackout Rule (53 FR 23203, June 21, 1988), security enhancements (74 FR 13925, March 27, 2009) and the Anticipated Transient Without Scram requirements (NUREG-1000).

Advances in technology and an enhanced understanding of physical phenomena also can result in adjustments to regulatory requirements to assure adequate protection. For instance, steam generator tube cracking mechanisms and improved non-destructive examination techniques led to new Technical Specifications for steam generator inspections. The result has been improved steam generator performance, which has enhanced safety. Other examples are the current issue regarding the sump strainers of pressurized water reactors (Generic Safety Issue 191) and changes to boiling water reactors as a result of better understanding the thermal hydraulic effects blowdown.

Resident Inspectors and Regional Inspections

Resident (onsite) inspectors carry out the core of the NRC inspection program for nuclear power plants; at least two inspectors are assigned to each site. These inspectors continually monitor day-to-day operations, design modifications, maintenance activities, response to unusual/emergency situations, and all other aspects of the licensee’s activities that affect the safe operation of the reactor. Staff from the regional offices support and augment the resident inspectors.

Also, inspectors conduct a continual review of the design of nuclear power plants (Ref 3). This includes monitoring licensee obligations required under 10 CFR Part 50 Appendix B (Ref 4), engineering inspections (e.g. Component Design Basis Inspection), baseline inspections (e.g. Cornerstone-based inspections, verification of performance indicators, Corrective Action Program (CAP)), and Problem Identification & Resolution inspections (another look at CAP). This provides a level of assurance that plant design is not inappropriately changing over time.

The Operating Experience Smart Sample (OpESS) program is designed to provide the NRC inspection staff with a detailed synopsis of selected operating experience that the agency considers to have generic safety implication. The OpESS is designed as an additional tool for used by agency staff in preparing for ROP baseline inspections. The information and trends identified from OpESS inspections may further indicate that a specific issue warrants additional agency action.

In addition, inspection specialists from the regional offices periodically review plant security, emergency planning, radiation protection, environmental monitoring, periodic testing of plant equipment and systems, fire protection, construction activities, and other more specialized areas. During the course of a year, NRC specialists may conduct 10 to 25 routine inspections at each nuclear power plant, depending on the activities at the plants and problems that may occur. Team inspections regularly review fire protection, plant design, and corrective actions. Special team inspections may focus on a specific plant activity, such as maintenance or security, or a team may be sent to the plant examine a specific operating problem or accident. On average, the NRC spends about 6,000 hours of inspection per site over the course of a year.

Many inspection findings raise issues of adequate protection. Plant-specific issues are addressed directly with licensees. Generic issues are processed through established programs. Regulatory changes are implemented to address these issues. These changes are promulgated by the use of Bulletins (e.g. BL-03-01 - Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors; BL-02-01 - Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity), Generic Letters (e.g. GL200801 - Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems; GL200701 - Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients), and Information Notices (e.g. IN2010-12 - Containment Liner Corrosion; IN2010-07 - Inadvertent Control Rod Withdrawal Event While Shutdown). In these instances adequate protection issues were raised and addressed resulting in enhanced nuclear power plant safety.

Institute of Nuclear Power Operations

Following the event at Three Mile Island, The U.S. nuclear electric utility industry established the Institute of Nuclear Power Operations (INPO) in 1979 to promote the highest levels of safety and reliability – to promote excellence – in the operation of its nuclear electric generating stations. INPO is a non-governmental corporation that operates on a not-for-profit basis and does not issue capital stock. Under the U.S. tax law, the company is classified as a charitable organization that “relieves the burden of government”

In forming INPO, the nuclear utility industry took an unusual step. The industry placed itseld in the role of overseeing INPO activities, while at the same time endowing INPO with ample authority to bring pressure for change on individual members and the industry as a whole. That feature makes INPO unique. The industry clearly established and accepted a form of self-

regulation through peer review by helping to develop and then committing to meet INPO's performance objectives and criteria. The industry's recognition that all nuclear utilities are affected by the action of any one utility motivated its commitment to and support of INPO. Each individual member is solely responsible for the safe operation of its nuclear electric generating plant(s). The NRC has statutory responsibility for overseeing the licensees and verifying that each licensee operates its facility in compliance with federal regulations to assure public health and safety. INPO's role, encouraging the pursuit of excellence in the operation of commercial nuclear electric generating plants, is complementary but separate and distinct from the role of the NRC.

INPO accomplishes its mission through activities centered on three cornerstones – Evaluation Programs; Training and Accreditation Programs; and Analysis and Information Programs.

Examples of Evaluation Programs include:

Plant Evaluations
- Operations
- Maintenance
- Engineering

Corporate Evaluations
- Direction and standards for station operation, including the organizational alignment, communications, and accountability for strategic direction, business/operational plans, and performance standards
- Performance of corporate functions such as human resources, industrial relations, fuel management, supply chain management and other areas, as applicable to the nuclear organization

Other Review Visits
- Areas include critical materials issues that affect the structural integrity of the reactor coolant system and reactor vessel internals of both boiling water reactors and pressurized water reactors.
- Components or systems that are significant contributors to unplanned plant transients and force loss rate, including main generator and transformer, switchyard and electrical grid components.
- In 2006, 54 reviews visits were conducted

Examples of Training and Accreditation Programs include:
- Training and Qualification Guidelines
- Courses and Seminars
- Accreditation of nuclear power plant training programs

Examples of Analysis and Information Exchange Programs include:
- Events Analysis Program
- Nuclear Network System
- Equipment Performance Data

The nuclear industry's commitment to go beyond compliance with regulations and continually strive for excellence, with INPO's support, has resulted in substantial performance improvements over the last 30 years. For example, in the early 1980s the typical nuclear plant

had a capacity factor of 63%, experienced six automatic scrams per year, had high collective radiation dose, and experienced numerous industrial safety accidents among its staff. Today, median industry capacity factor is above 92 percent, most plants have zero automatic scrams per year, and collective radiation dose and industrial accident rates are both lower by a factor of 7 when compared to the 1980s. Thus, enhanced adequate protection requirements and industry efforts to promote excellence; work in concert to enhance nuclear power plant safety.

License Renewal

The Atomic Energy Act and NRC regulations limit commercial power reactor licenses to an initial 40 years, but also permit such licenses to be renewed. This original 40-year term for reactor licenses was based on economic and antitrust considerations -- not on the limitations of nuclear technology.

The license renewal process and application requirements for commercial power reactors are based on two key principles:

1. The regulatory process, continued into the period of extended operation, is adequate to ensure that the current licensing basis of all currently operating plants provides adequate protection, with the possible exception of the detrimental effects of aging on certain systems, structures, and components, and possibly a few other issues related to safety only during the period of extended operation.

2. Each plant's current licensing basis is required to be maintained during the renewal term.

Two parts of Title 10 of the *Code of Federal Regulations* (10 CFR) contain the license renewal regulations, 10 CFR Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants,” deals with the safety aspects, and 10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions,” addresses the environmental aspects of license renewal. These two parts establish a regulatory process that is simple, stable, and predictable. The focus of 10 CFR Part 54 is on managing the adverse effects of aging rather than on identifying of all aging mechanisms. The rule ensures that important systems, structures, and components will continue to perform their intended function in the period of extended operation. In addition, the integrated plant assessment process focuses on passive, long-lived structures, systems, and components. Each plant that receives a renewed license must implement aging management programs beyond the established programs required by the Maintenance Rule (10 CFR Part 50.65). This enhances nuclear power plant safety in the renewed period.

The NRC responsibilities under the National Environmental Policy Act appear in 10 CFR Part 51. During a license renewal review the NRC must investigate whether there are environmental issues related to the extension of the reactor’s operating license. The “Long-Term Operation White Paper,” issued July 2010 (Ref. 6), and NUREG/BR-0291, “Reactor License Renewal – Preparing for Tomorrow’s Safety Today,” issued August 2008 (Ref. 5) present a more thorough explanation of the license renewal process.

License renewal reviews include an evaluation of technical information that includes current licensing basis changes; time limited aging analyses of systems, structures and components, and a supplement to the Final Safety Analysis Report describing the programs and activities for managing the effects of aging. The reviews also include technical specification changes or additions necessary to manage the effects of aging during the period of extended operation.

Examples of license conditions imposed during the license renewal process include Fire Protection Program enhancements, Buried Piping and Tanks Inspection Program enhancements, and Fire Water System Program procedures enhancements.

Summary

The NRC's primary function is to regulate the safe use of radioactive materials for civilian purposes and to ensure adequate protection of public health and safety and the environment. As discussed above, the NRC maintains vigilance over safety performance through licensing reviews, inspections, and expanded oversight (when needed). The NRC continually seeks to identify and resolve potential safety issues. As issues are resolved, new thresholds for adequate protection are established and safety is enhanced.

The success of the NRC's programs is evident in the performance of the U.S. nuclear fleet. For example, in the last 10 years, the average exposure rates at plants have dropped from about 120 millirem per year to about 100 millirem per year. Also, the number of safety system failures per plant has dropped from about 1.8 failures per plant to about 0.8 failures per plant.[3]

[3] U.S. Nuclear Regulatory Commission, NUREG-1350, Vol. 21 "Information Digest 2009-2010, August 2009