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Submitter Information

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General Comment

Please find attached a comment on the scope of risk function, requesting that it should be limited to containment. Also, the comment suggests that all design elements not related directly to containment be designed to commercial standards.

Attachments

comment1

Comment on safety function risk scope

NRC–2019–0062

The comment

To be transformative and result in commercial deployment of a wide variety of advanced reactor technologies, the Nuclear Energy Innovation and Modernization Act (NEIMA) regulation should require safety function on the critical elements of safety as enumerated below and remaining elements should be designed to commercial standards.[1]

1. maximum power during production (licensed power level),
2. prompt criticality,
3. reactor shutdown, and
4. fission product release.

Focusing resources on these four critical elements would lead to a high level of confidence in protection efficacy against fission product release by assuming the core inventory is present in containment at an elevated thermodynamic state commensurate with the energy contained by the process. A short summary statement for design of safety function Systems, Structures, or Components (SSCs) requirements that applies to both "normal process" releases and as well as unexpected releases would be:

> "*SSCs containment of radioactive release above the maximum allowed must achieve a high level of protection efficacy.*"

On the concern

Failing to sharply focus the scope of regulatory prescription and oversight, investor uncertainties associated with licensing schedule and costs will help lead to continued decline of energy production by nuclear power in the commercial marketplace. The risk-informed and performance-based regulation framework asked for in NEIMA should reduce regulatory review scope as well as reduce risk of radioactive release.

[1] `https://www.congress.gov/bill/115th-congress/senate-bill/512`. Accessed 7 December 2020.

Summary of Background

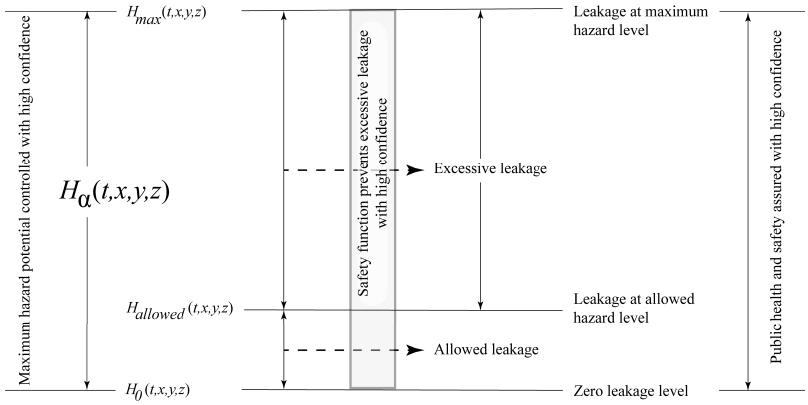

Figure 1: A notional representation of SSCs that perform safety function as the ones that ensure the maximum hazard level, $H_\alpha(t,x,y,z)$, to the public is controlled and that radiation release is at or below the allowed level. Satisfying this criteria assures adequate protection of the health and safety of the public.

Consider Figure 1 where the primary hazard present in fission reactors is the radiological inventory "source" created by the fission process. The central idea in this figure is the source, that may be relocated in different areas and configurations, is released from the process, regardless of the advanced reactor type, and must be contained. A small amount may be allowed during normal operation, the leakage allowed at hazard level $H_{allowed}(t,x,y,z)$; leakage level that would be harmless and ALARA. For all hazard levels up to the total source inventory, $H_{max}(t,x,y,z)$, the leakage should not exceed the leakage allowed at $H_{allowed}(t,x,y,z)$. Any leakage at levels exceeding the leakage allowed at $H_{allowed}(t,x,y,z)$ are excessive and should be prevented with high confidence under regulation.[2] The central idea of the figure is what informs this comment.

The risk-informed NEIMA objective should direct the Nuclear Regulatory Commission (the Commission) and the industry attention to what is important for protecting the public. A secondary risk-informed objective would help make advanced reactors commercially viable by effort reduction on both the regulator and industry sides. Advanced reactor safety would be enhanced by properly applying a risk-informed regulatory framework that focuses attention on the most important safety function, that of containment.

The basis for considering safety functions on protection for maximum hazard potential is summarized as follows.

1. Prompt criticality has the potential to produce an extreme hazard; SSCs that prevent prompt criticality should be considered as safety function SSCs.

[2]Of course, the total (integrated) amount of radioactive material released would produce a time-dependent dose rate according to the allowed leakage input and the decay chains of the isotopes released.

2. The SSCs that keep the reactor at, or below, the licensed power level ensure the hazard potential is bounded by the process stored energy plus the energy released from radioactive decay; SSCs that prevent power from exceeding the licensed power level should be considered as safety function SSCs.

3. The SSCs that reach and maintain reactor shutdown ensure the thermodynamic state can be known over time; SSCs that prevent the fissile material from returning to power should be considered as safety function SSCs.[3]

The safety function design requirement should be on SSCs that prevent fission product leakage above the allowed level. All other equipment should be treated as commercial-grade. In this concept, design of safety function assumes the fission product inventory is always outside of the process and therefore moves the safety function focus from process side protection, classically referred to as the "reactor coolant system," to the efficacy of containment. Therefore, this concept in risk-informed and transformative regulation is to assume that the hazard is present at all times; it can not be be avoided but release outside the plant can be managed.

In this regulatory framework public protection is assured by preventing radioactive material release; performance-based regulation would then be used to make any enhancements to commercial standards. Therefore, plants could be brought online more quickly but also most importantly, safely. This regulatory framework would allow investors to get return on their investment in a reasonable time frame as well as allow for any safety improvements or necessary enforcement of safety function and/or commercial standards that may be identified (performance-based) during operation. This concept of a risk-informed and performance-based recognizes that risk management has two elements, ex ante protections as well as control of risk going forward.

[3]The amount of energy present would be the stored energy in the process plus the energy released from fission product decay less any energy removed over time. Of course it is important to keep in mind that some materials may chemically react when exposed to high temperature corium.

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Reviewer background & statement on motivation

My experience extends to most nuclear power settings, US Navy nuclear operator (submarine service), fuel manufacture, national laboratory tests (LOFT program), and experience as Shift Technical Advisor, Unit Reactor Engineer, Probabilistic Risk Analyst at a large commercial PWR power station, and in academia, teaching undergraduate and graduate nuclear engineering courses and nuclear engineering research in university settings. Experience in nuclear power has led me to believe that careful regulation of nuclear power technology is absolutely essential, and that the the Commission, as it is has been designed to regulate following the Atomic Energy Act of 1954 (AEA), is certainly the most effective United States regulatory authority. Over my career, from 1972 to the present, it can be said that commercial deployment of nuclear technology has stagnated despite efforts by those who see the need to revive it if no other reason than to retain minimal domestic expertise in the technology in case energy needs now supplied by carbon-based sources can not be offset by any other non-carbon-based technologies.

This comment is motivated by my observation that obtaining a license to build and operate a nuclear facility takes many years and, despite industry efforts to reduce costs and expedite build schedules, investors simply are not willing to lay out large capital sums over many years with no return. It is clear that carbon-based energy can be provided more rapidly and at much higher rates of return than nuclear power. Also is clear that, despite lack of supporting evidence, domestic nuclear power is perceived to pose highly consequential accident risk where carbon-based sources, again despite evidence to the contrary, pose little or no risk to the health and safety of the public. But the NEIMA asks the Commission to develop a "risk-informed" and "performance-based" regulatory framework. It seems Congress expects this approach holds out hope for greater commercialization of advanced reactors and, in my opinion it can, if the application of risk management to design and operation results in swift approval of license applications. This comment is to encourage substantial reduction of the scope of regulatory oversight consider just two tiers; safety function only on those SSCs that would prevent radioactive material release and all other SSCs would be built to commercial standards.