

From 40 to 60 to 80 Years – What is Next for License Renewal in the USA?

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Abstract. License renewal in the United States enables extension of nuclear power plant operating licenses for an additional 20 years of safe plant operation. This program has been successful, with 90 percent (84 out of 92 units) of operating United States (U.S.) reactors holding renewed licenses for operation beyond the original license period of 40 years. This total includes 78 units with licenses to operate to 60 years, and an additional 6 units that have received licenses for continued safe operation to 80 years, “subsequent license renewal” in the U.S. A status of license renewal and subsequent license renewal in the U.S. is provided, along with a description of several initiatives aimed at enhancing the license renewal process.

1. Background

In accordance with Section 103c of the Atomic Energy Act (AEA) of 1954, as amended, nuclear power plants in the United States are licensed to operate for a term not exceeding 40 years, and licenses may be renewed. This original 40-year license term for reactor licenses was based on economic and antitrust considerations – not on limitations of nuclear technology.

The U.S. Nuclear Regulatory Commission (NRC’s) regulations related to renewal of operating licenses for nuclear power plants are provided in Part 54 of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 54, “Requirements for Renewal of Operating Licenses for Nuclear Power Plants” [1]. 10 CFR 54.31(b) specifies that licenses may be renewed for a specified period not to exceed 20 years, with the renewed license term not to exceed 40 years, just like the original license. In addition, 10 CFR 54.31(d) states that a renewed license may be subsequently renewed in accordance with all applicable requirements, with no explicit limit to the number of “subsequent” renewals for each license.

2. Assuring Plant Safety in the First 40 Years of Operation

From a regulatory perspective, plant safety is assured throughout the first 40 years of plant operation by an interrelated combination of regulations and guidance, licensing processes, oversight activities and consideration of operating experience, which provide for adequate protection of public health and safety at every point during the plant’s life. The role of operating experience is a key element because it provides valuable information to adjust the NRC’s oversight activities and, when necessary, to change regulations or requirements.

The management of aging-related degradation issues begins during the plant design and construction phases, and is accomplished through a variety of means, within the context of the NRC’s existing regulatory processes. Aging management is primarily accomplished through implementation of the NRC’s regulations in 10 CFR Part 50 [2]. In particular, the Maintenance Rule of 10 CFR 50.65, the Quality Assurance Program of Appendix B to 10 CFR Part 50, and the requirements of 10 CFR 50.55a, Codes and standards, provide the basic framework that assures adequate aging management for both active and passive components and structures.

The Maintenance Rule focuses on monitoring and testing activities to ensure that systems, structures and components (SSCs) are capable of performing their intended functions. The Quality Assurance Program requirements ensure that licensee programs meet quality standards and incorporate effective corrective actions on operating experience gained from their inspection and testing. 10 CFR 50.55a focuses on implementation of consensus industry standards, for inspection and testing as well as analysis of results to inform future inspections. Other provisions to 10 CFR Part 50 also provide aging management, such as the environmental qualification of electrical equipment (10 CFR 50.49) and the reactor vessel materials surveillance program requirements (Appendix H to 10 CFR Part 50).

There are other elements of the NRC's regulatory process that provide reasonable assurance of safe plant operation. These elements include:

- Resident inspectors who are located on-site at each plant.
- Frequent inspections out of the NRC's regional offices to assess performance at each site, include such topics as plant security, emergency planning, radiation protection, environmental monitoring, and inservice inspection and testing.
- A daily assessment of plant events, both domestic and international.
- Safety issue resolutions for both generic issues and plant-specific issues.

In particular for materials aging and degradation issues that are important to safety, resolution of these issues can occur through a variety of approaches, including rule changes, generic communications, issuance of orders, and voluntary plant actions.

3. Assuring Plant Safety from 40 to 60 Years - License Renewal Review and Guidance

Activities to ensure plant safety in the operating period from 40 to 60 years follow the same processes and framework identified previously for the first 40 years, with the exception that additional aging management is implemented for operation beyond 40 years. The requirements to identify and implement the additional aging management are established through development of a specific regulation for license renewal, 10 CFR Part 54 [1]. The NRC licensing process ensures the implementation of both generic and plant-specific aging management programs (AMPs) that incorporate insights from operating experience to ensure components continue to perform their intended functions. The NRC's inspection programs verify licensee implementation of the AMPs.

The scope of license renewal includes (1) safety-related SSCs; (2) all nonsafety-related SSCs whose failure could adversely impact functionality of safety-related SSCs; and (3) all SSCs relied on in certain safety analyses or plant evaluations for specific NRC regulations. After in-scope SSCs have been identified, those structures and components (SCs) that are long-lived and passive, such as the reactor pressure vessel, steam generators, piping, seismic Category I structures, electrical cables and connections, among others, are subject to aging management review (AMR). The AMR is the process by which the license renewal applicant identifies aging effects that could adversely affect the ability of SSCs from performing their intended functions and develops activities (e.g., AMPs) to manage those aging effects. SCs that are not subject to AMR are those that are active, such that their failure will be identified during surveillance and testing in accordance with the Maintenance Rule or replaced on a fixed schedule.

The fundamental premise of the License Renewal Rule, provided at 10 CFR Part 54, is that the current licensing basis (CLB) for plants is adequate to ensure the safety of operating plants, with the possible exception of the effects of aging of long-lived, passive SSCs. In this case the CLB includes the NRC requirements applicable to a specific plant; a licensee's

written commitments for ensuring compliance with and operation within the applicable NRC requirements and the plant-specific design basis; orders; license conditions; exemptions; technical specifications; the plant-specific design-basis information documented in the most recent final safety analysis report, and the licensee's commitments remaining in effect that were made in docketed licensing correspondence such as responses to NRC bulletins, generic letters, and enforcement actions, as well as licensee commitments documented in NRC safety evaluations or licensee event reports.

A basic aspect of the License Renewal Rule is a licensee's integrated plant assessment that demonstrates that the SCs requiring AMR have been identified and the effects of aging on their functionality will be managed in order to maintain the CLB such that there is an acceptable level of safety during the period of extended operation from 40 to 60 years. License renewal also involves applicant consideration of time-limited aging analyses (TLAAs), which are those licensee calculations and analyses in the CLB for the SSCs within the scope of license renewal. Each application must also include a supplement to the environmental report that complies with the requirements of Subpart A of 10 CFR Part 51 [3].

The NRC has developed several documents to aid in effective and efficient evaluation of license renewal applications (LRAs). The Generic Aging Lessons Learned (GALL) Report (NUREG-1801) [4] provides generic evaluations of materials and environments to identify applicable aging effects and aging mechanisms, along with acceptable aging management approaches (e.g., AMPs). Use of the GALL Report by applicants and NRC staff facilitates NRC review of LRAs and provides for a stable review process, subject to findings such as emergent technical issues.

The "Standard Review Plan for Review of License Renewal Applications for Nuclear Power Plants," or SRP-LR (NUREG-1800) [5], provides guidance to the NRC staff reviewers in performing safety reviews of applications to renew nuclear power plant licenses in accordance with 10 CFR Part 54. The SRP-LR was developed to assure quality and uniformity of staff reviews and to present a well-defined technical basis from which to evaluate a licensee's application. Availability of the SRP-LR aids in the transparency of NRC staff reviews of LRAs such that applicants can understand the types and detail of information needed by the staff in its reviews. The SRP-LR incorporates by reference the GALL Report.

Both the SRP-LR and the GALL Report were initially issued in 2001 and the last revision, Revision 2, was issued in 2011. Subsequent changes to both the SRP-LR and the GALL Report have been implemented through the License Renewal Interim Staff Guidance (LR-ISG) process, wherein incremental changes are made to these documents. A total of 10 LR-ISGs have been issued for Revision 2 of these documents, as listed on the NRC website [6].

It should be noted that further full revisions of the SRP-LR and the GALL Report, e.g., Revision 3, will not be issued because of the limited number of plants that would use these reports.

A more detailed description of the license renewal process is provided in TECDOC-1736 [7].

4. Assuring Plant Safety from 60 to 80 Years – Subsequent License Renewal

With the maturity of license renewal, utilities have expressed an interest in renewing their licenses for an additional 20 years beyond their first renewed license. This is called "subsequent license renewal," or SLR, consistent with the terminology of 10 CFR 54.31(d). The Commission has stated that the license renewal rule has provided an effective basis for ensuring safe operation during the license renewal period and will continue to be an effective

basis for SLR. Thus, the process for SLR is the same as that for license renewal. Consistent with the license renewal rule, the focus of SLR is on the adequacy of additional aging management activities to ensure safe plant operation during the subsequent period of extended operation.

To support SLR, the NRC has developed guidance documents analogous to those for license renewal, although they specifically address operating conditions to 80 years. The “Generic Aging Lessons Learned for Subsequent License Renewal (GALL-SLR) Report” (NUREG-2191) [8] provides acceptable methods to manage aging effects for 80 years of plant operation. The “Standard Review Plan for Review of Subsequent License Renewal Applications for Nuclear Power Plants” (SRP-SLR) (NUREG-2192) [9] provides guidance to NRC staff reviewers to perform safety reviews of SLR applications.

To develop the SLR guidance documents, the NRC created internal expert panels to review and disposition information from the following sources: the 2014 “Expanded Materials Degradation Assessment” [10]; AMP effectiveness audits [11]; international and national operating experience databases; and comments from stakeholders that were collected during public meetings and a public comment period. These panels started with the Revision 2 versions of the GALL Report and the SRP-LR that were developed for license renewal. The panels then reviewed and deliberated on the information provided by the sources identified above. Draft SLR guidance documents (the GALL-SLR Report and the SRP-SLR) were then made available for public comment. Subsequently, the staff held public meetings to provide interested stakeholders information on the disposition of the expert panels and to solicit stakeholder comments. The SRP-SLR and GALL-SLR Report were issued as final documents in July 2017.

More information on the development of GALL-SLR and SRP-SLR is provided in [12].

5. Status of License Renewal and Subsequent License Renewal

As of the end of September 2022, licenses have been renewed for operation to 60 years for a total of 94 nuclear power plant units in the U.S., although ten of those units have since shut down permanently (one unit of these ten ceased operation before reaching 40 years of operation). Of the 92 units that are currently in operation, 78 units have renewed licenses to operate for 60 years. Of eight units operating under their original 40-year licenses, four units have indicated that they will apply for license renewal by early 2024.

Subsequent license renewal has also been very active. Six units have been approved for operation to 80 years, although four of these licenses have had the expiration date of their subsequent renewed licenses reset to 60 years due to Commission orders related to the environmental review for those units. The Commission’s direction will hold until the NRC staff completes its re-evaluation of generic environmental issues for subsequent license renewal. In addition, reviews of subsequent license renewal applications have been completed for another four units and are on-going for five units. Applications for five units are expected in 2023.

6. Recent Topics Considered

License Renewal for 40 Years

One of the plants planning a license renewal application in 2023 was considering concurrent applications that would request license renewal (to extend plant operation to 60 years) and subsequent license renewal (to extend plant operation to 80 years). Following a public meeting with this plant [13], the NRC staff began an activity to assess the feasibility of

extending the time period for license renewal from the current 20 year maximum to a maximum period of 40 years and to identify options for implementing this change.

As described in the closure memorandum for this activity [14], the staff formed a multi-disciplinary working group to identify options to address topics that would be impacted by implementation of license renewal, in the areas of legal/regulatory issues, the environmental review, the safety review, and inspection/oversight aspects. At a public meeting on this topic [15], an industry representative stated that no plant had expressed interest in this topic and the industry neither supported nor opposed the activity. The public comments were generally not supportive, citing concerns with the need to benchmark AMPs for the proposed 40-year license extension period, extension of the 2013 Generic Environmental Impact Statement for License Renewal to cover a 40-year license renewal period, inadequacies in reactor pressure vessel material surveillance and embrittlement predictions, limitations that would occur on public engagement, and inadequate local outreach for environmental meetings.

The NRC staff recommended that this activity be discontinued [14] and that consideration be given to an evaluation of possible changes to oversight and inspection activities related to license renewal and subsequent license renewal.

Technical Issues for Plant Operation to 100 Years

As a companion topic to the prior item, the NRC considered whether it should begin to consider the technical issues and development of guidance documents related to plant operation to 100 years, based on the potential for an applicant with a 60-year license applying for an additional 40-year renewal term. At a public meeting that included a variety of industry, academic and nongovernmental organizations [16], an industry representative stated that no plant had expressed interest in this topic but expressed prudence in continuing relevant research on aging to extend the current level of knowledge, given the lead time needed to implement and complete research activities. The public comments were generally not supportive of operation up to 100 years, including concerns over reactor pressure vessel surveillance specimens, the age of foundations for plants that had delays during construction (such that the time for the foundation in its environment greatly exceed the plant's operating time), and parts of the plant that cannot be inspected.

The memorandum recommending closure of this activity [14] recommended an evaluation to identify on-going research activities (related to concrete, cables, reactor vessel internals and reactor pressure vessels) that could be extended to greater exposure levels (e.g., higher fluence levels) to address the potential for reactor operations up to 100 years in a cost-effective manner, and a periodic query of the industry to determine licensee interest and timing to pursue operation to 100 years, so that the staff can identify the need and timeframe to initiate development of guidance documents which would support 100 years of plant operation.

7. On-going Activities

Using Risk Information in License Renewal

The license renewal rule [1] is deterministic in that *all* systems structure and components that meet the scoping criteria of 10 CFR 54.4 are included, and *all* such SCs are subject to AMR. The standards for approval of a renewed license include a finding of reasonable assurance regarding managing the effects of aging on the functionality of the SCs are subject to AMR. There is no explicit provision in the rule for incorporation of risk information or other means to prioritize or diminish the significance of the structures or components in the AMR.

The NRC's Statements of Considerations for the 1991 [17] and 1995 [18] Part 54 rulemakings have provided various messages on the use of probabilistic risk assessment (PRA) in license renewal, including:

- . . . probabilistic assessments can be a useful adjunct to deterministic methods to help draw attention to specific vulnerabilities and to help guard against significant oversights in the screening process. In view of the PRA limitations discussed, probabilistic assessment alone is not an acceptable basis for the exclusion of SSCs to be evaluated as part of an IPA. It may be useful to identify additional SSCs to be evaluated as part of the IPA.
- Probabilistic arguments may assist in developing an approach for aging management adequacy. However, probabilistic arguments alone will not be an acceptable basis for concluding that, for those structures and components subject to an aging management review, the effects of aging will be adequately managed in the period of extended operation.
- . . . within the construct of the final rule, PRA techniques are of very limited use for license renewal scoping.

In January 2022, the Nuclear Energy Institute (NEI) submitted proposed revisions to two AMPs based on risk insights [19]. The NRC is reviewing this submittal as an adjunct to the guidance document revision activity described below. In addition, NEI has indicated that it will submit a "Technical Report on Risk Insights for Aging Management (RIAM)," by the end of 2022 and will then seek to expand the framework in this document to multiple AMPs.

As part of a more general consideration on use of risk information in license renewal, the NRC held a public meeting on August 4, 2022 [20]. No additional areas for inclusion of risk information were identified by the meeting participants beyond the NEI risk-informed AMP activities described above.

Subsequent to the public meeting, the Idaho National Laboratory issued a report [21] which contemplates an alternative approach to identify SSCs subject to AMR. The NRC is evaluating possible uses of this report in license renewal.

Development of Revision to Subsequent License Renewal Guidance Documents

The NRC has historically issued revisions of its license renewal guidance documents on an approximate 5-year basis, when sufficient additional operating experience, application review experience, increase in state of knowledge and revisions to supporting industry and NRC documents have accrued to warrant revisions. With the issuance of GALL-SLR and SRP-SLR in 2017, the NRC previously began interim modifications to the documents through the issuance of Subsequent License Renewal Interim Staff Guidance (SLR ISG) in four areas [11]. The NRC has recently begun an activity for a revision of GALL-SLR and SRP-SLR. This activity is described in more detail in [12].

8. Conclusions

The NRC's License Renewal Program has successfully evaluated and renewed 100 licenses for the fleet of nuclear power plants in the United States, including 94 for renewal for operation to 60 years and 6 for renewal for operation to 80 years. These reviews have focused on ensuring that licensees have adequate aging management in place to ensure safe plant operation during the period of extended operation to 60 years or the subsequent period of extended operation of 80 years.

Near-term activities will consider appropriate ways to use risk information in AMPs and potentially other aspects of license renewal and will develop revisions to the subsequent license renewal guidance documents.

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