Life Beyond 60 Workshop Summary Report

NRC/DOE Workshop
U.S. Nuclear Power Plant
Life Extension Research and Development
February 19-21, 2008
Bethesda, Maryland

Prepared by Energetics Incorporated
for the
U.S. Nuclear Regulatory Commission and the U.S. Department of Energy

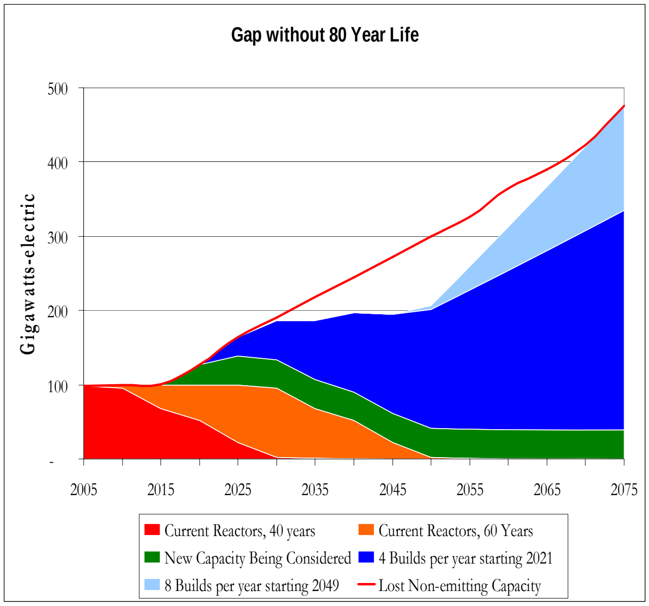
Executive Summary

The U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) jointly sponsored the *Life Beyond 60: NRC/DOE Workshop on U.S. Nuclear Power Plant Life Extension Research and Development* on February 19–21, 2008. This workshop was intended to facilitate discussion between the NRC, DOE, the domestic nuclear industry, the national laboratories, academia, international participants, and the public on potential research and development issues related to ensuring that, if the existing commercial light water reactor (LWR) licensees elect to pursue subsequent license renewal periods, continued long-term operations could be conducted safely. Panel and public discussions were held on relevant topics, such as the aging of systems structures and components (SSCs), materials degradation, diagnostics and prognostic technologies, and the future technical and research requirements of the nuclear industry to continue long-term operation.

Today, the 104 commercial nuclear reactors in the United States provide the largest share of domestic non-CO_2-emitting electricity, contributing over 70 percent of all such sources of energy. However, by 2030, with expected demand for energy growing to levels 40 to 50 percent higher than today, the existing operating nuclear plants will begin shutting down after reaching the end of their first license renewal period.

Recognizing the United State's energy security goals, economic growth projections, and emission reduction targets for future decades, it has been recently suggested that the present 20 percent nuclear power contribution to the nation's electrical generation remain viable while advanced nuclear technologies and renewal energy sources are being developed and deployed.

However, without establishing a firm scientific basis to understand the influences of plant aging mechanisms, it is possible that the significant non-CO_2-emmitting energy contributions from these plants could be retired from the domestic electricity supply over the next 20 years. These retirements, if allowed to occur, may serve to challenge U.S. energy security, potentially resulting in



Projected Nuclear Generation. The red line represents the total generating capacity of current and planned reactors, assuming extended operation to 80 years. The unshaded gap below the line represents lost capacity if the current reactor fleet is decommissioned increased greenhouse gas emissions and contributing to an imbalance between electric supply and demand.

From the nuclear regulatory perspective, if nuclear plant licensees choose to pursue long-term operations beyond their initial license renewal term (i.e., beyond 60 years), there are no current regulatory prohibitions. However, in keeping with the long established philosophies of ensuring public health and safety, these licensees would be required to demonstrate that such extended plant operations may continue to be conducted in a safe manner. As with present regulation, the licensee proposing such long term operations would be required to satisfy the requirements of Part 51 and 54 to Title 10 of the *Code of Federal Regulations* (10 CFR Part 51 and 54). Within these requirements, a licensee's responsibilities include addressing both the technical and managerial aspects of plant aging in addition to evaluating the potential environmental impact of extended plant operations.

To establish the framework from which to begin identifying potential knowledge gaps and research challenges, the *Life Beyond 60: NRC/DOE Workshop on U.S. Nuclear Power Plant Life Extension Research and Development* brought together stakeholders from the nuclear industry, research organizations, government, and the public. The workshop's goals focused on 1) identifying broadly defined research areas that address long-term challenges to plant operations, 2) developing prioritized research areas, 3) identifying cross-cutting topics of relevancy, and 4) establishing stakeholder roles and responsibilities. Additionally, the workshop was intended to provide a starting point for future discussions on specific aging-related research topics. It was anticipated that follow-on discussions will contribute to development of a detailed implementation roadmap proposing research activities that may provide a better understanding of aging and degradation behavior before extending reactor lifetimes beyond 60 years.

Scope of 10 CFR Part 54

1. Safety-related systems, structures, and components which are those relied upon to remain functional during and following design-basis events to ensure the following functions:
   - The integrity of the reactor coolant pressure boundary
   - The capability to shut down the reactor and maintain it in a safe shutdown condition
   - The capability to prevent or mitigate the consequences of accidents which could result in potential off-site exposures
2. All non-safety-related systems, structures, and components whose failure could prevent satisfactory accomplishment of any of the functions identified in this section.
3. All systems, structures, and components relied on in safety analyses or plant evaluations for fire protection, environmental qualification, pressurized thermal shock, anticipated transients without scram, and station blackout.

The scope of the workshop was limited to passive systems, structures, and components (SSCs) which are intended to perform their design functions during the operating lifetime of the plant and are not typically planned for replacement. While the primary workshop focus was on understanding materials and technologies for application within the defined regulatory scope identified in 10 CFR Part 54, much of the same attention was applied to secondary or non-safety related portions of the plant whose continued operational benefit is characterized principally in economic terms. Those plant components whose aging characteristics are clearly understood and managed, and are routinely overhauled or replaced as part of normal maintenance[1], were not considered within the workshop scope.

The workshop sessions summarized present and past industry license renewal perspectives and further confirmed the following potential research areas: SSC long-term reliability issues; aging-related materials degradation and characterization; and related diagnostics, sensors, and monitoring technology applications. Numerous research areas were identified that remain potential candidates for further examination. Appendix A contains the complete listing of workshop-identified potential research areas. Because of many commonalities across sessions, the identified potential research areas can be more succinctly characterized by the following three suggested groupings:

1) ***Research regarding SSCs Considered to be part of a 10 CFR Part 54 License Renewal Submittal.***

   Passive SSC-related research directly tied to operating nuclear plants through application of 10 CFR Part 54, as related within the scope identified above.

2) ***Research regarding SSCs Considered as part of an Economic Justification for Long-Term Operations.***

   Passive SSC-related research indirectly tied to application of 10 CFR Part 54 or directly affecting nuclear plant economic justifications, as related within the scope identified above.

3) ***Crosscutting Research.***

   Areas of research or development incorporating both of the previously identified groupings.

The first grouping of suggested research focuses on the fundamental mechanisms of long-term exposure to typical reactor environmental operating conditions of irradiation, high pressures and temperatures, and water chemistry as affecting materials that make up the reactor internal components, primary coolant system, containment structure, and other safety-related systems. This includes

[1] The NRC's Maintenance Rule, 10 CFR 50.65, provides requirements for monitoring the effectiveness of maintenance at nuclear power plants. The underlying objective is to help maintain plant safety by trending the performance and condition of structures, systems, and components (SSCs) within the scope of the rule in terms of reliability and availability to predict their future performance and condition and to assess the effectiveness of maintenance. Specifically, 10 CFR 50.65(a)(3) requires that licensees ensure that the objective of preventing failures of SSCs through maintenance, i.e., reliability, is appropriately balanced against the objective of maximizing availability (or minimizing unavailability) of SSCs due to monitoring or preventive maintenance.

the aging effects of safety-related concrete structures, piping, and cable insulation. A large body of knowledge exists in understanding the SSC and material behaviors during existing license and initial license renewal operational periods. Workshop discussions identified specific directed research pathways that may assist with expanding this understanding of nuclear environmental influences on plants as they age beyond 60 years.

The second suggested research grouping extends beyond the regulatory scope of 10 CFR Part 54 to address plant aging concerns that may influence the economic viability of long-term plant operations. This research area focuses on such areas as advanced digital instrumentation and control systems, new prognostic models, and improved inspection techniques and evaluation criteria. Aging factors also impact the continued reliability of electrical cables, buried piping, and concrete structures in systems that are beyond the regulatory scope of Part 54.

The crosscutting research grouping reflects the multidisciplinary nature of nuclear plant design and operations and includes topics such as developing improved non-destructive testing and evaluation, developing proactive prognostics for identifying degradation precursors, and employing advanced online monitoring systems. This category represents a potentially fruitful area of research in understanding mechanisms that influence aging and degradation.

The discussions of the Life Beyond 60 Workshop contributed to defining an initial framework of research objectives addressing aging related issues at nuclear power plants. These objectives, focusing on understanding the industry research needs to contribute to the safe sustainability of existing LWR operations, constitute a clear mission statement of future research activities.

The subsequent proposed steps from the workshop discussions include development of an integrated research plan addressing, as appropriate, collaborative activities between the Federal Government, utilities, vendors, universities, and the research community in addressing issues of aging and long term operation of existing nuclear power plants.

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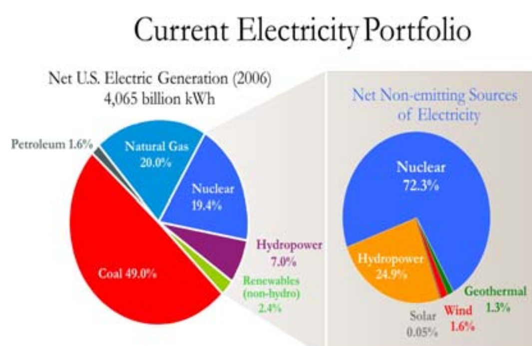
1.0 Introduction

The U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) jointly sponsored the *Life Beyond 60: NRC/DOE Workshop on U.S. Nuclear Power Plant Life Extension Research and Development* on February 19–21, 2008. This workshop was intended to facilitate discussion between the NRC, DOE, the domestic nuclear industry, the national laboratories, academia, international participants, and the public on potential research and development (R&D) issues related to ensuring that, if the existing commercial light water reactor (LWR) licensees elect to pursue subsequent license renewal periods, continued long-term operation could be conducted safely. Panel and public discussions were held on aging-related topics, such as systems structures and components (SSCs) aging, materials degradation, diagnostics and prognostic technologies, and the future technical and research requirements of the nuclear industry in continuing long-term operation.

Workshop discussions were based on current views of subject matter experts representing industry, government, academia, and the national laboratories (see Appendix B for a listing of participants). The specific focus of these discussions was to identify:

1) Research topics that address technology barriers and challenges that may contest continued safe long-term operations of existing LWRs
2) A set of prioritized research directions addressing stakeholder concerns and inputs from industry, research community, regulators, and the public
3) Crosscutting research topics that may impact continued, safe, long-term LWR operation
4) Suggestions addressing appropriate roles and responsibilities for industry, DOE, and NRC in a collaborative research agenda that could contribute to safe, sustainable, long-term LWR operation

Commercial nuclear power currently generates approximately 20 percent of the electricity consumed in the United States. As such, the 104 operating commercial LWR plants constitute the single largest domestic source of energy production that does not emit carbon dioxide (CO_2) or other greenhouse gases (GHG). Most of these plants commenced operation in the 1970s and 1980s with an initial licensed operating period of 40 years.



Historically, the Atomic Energy Act[2] established a 40-year initial operating license

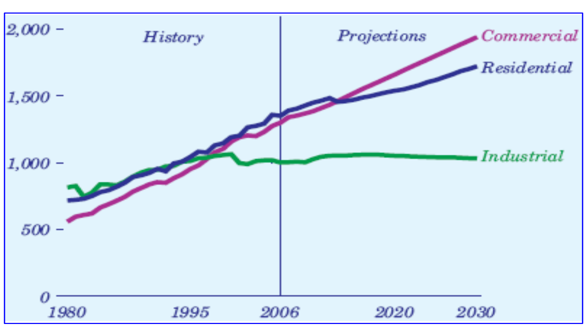
[2] See http://www.nrc.gov/about-nrc/governing-laws.html for details.

for nuclear plants. This time limit was developed from utility anti-trust concerns and not physically based design limitations from engineering analysis, components, or materials. Federal regulations governing license renewals (10 CFR Part 54) place no limit on the number of times a plant license renewal may be granted; however, additional license extension periods can be authorized in 20-year increments.

Virtually all current plant operators are expected to apply for an initial extra 20 years of operating life. Because of the high anticipated growth in domestic electrical demand,[3] coupled with expected sources of generation, there is a projected imbalance between expected generating capacity and requirements which will start as early as 2025. Without the additional knowledge base from which licensees can justify subsequent license renewal periods, more than 100 gigawatts of domestic electric generation, comprising nearly 20 percent of current domestic production, could shutdown between the years of 2030 to 2055.

Domestic Electricity Production [3]

Annual Sales by sector 1980-2030 (Billion Kilowatt-hrs)



[3] Energy Information Agency, U.S. Department of Energy; http://www.eia.doe.gov/oiaf/aeo/index.html

Currently, operating license renewal requirements for power reactors are based on two fundamental principles:

1) The regulatory process ensures that currently operating plants will continue to maintain adequate levels of safety during extended operation; and,
2) Each plant's licensing basis is required to be maintained during the renewal term in the same manner and to the same extent as during the original licensing term.

As part of the license renewal regulatory process, an LWR licensee applying for license renewal (i.e., the applicant) must identify all plant SCCs that are safety-related, or whose failure could affect safety-related functions, and that are relied on to demonstrate compliance with regulations. The applicant is then required to identify all SSCs within the scope of the rule that are "passive and long-lived." The applicant must demonstrate that the effects of aging will be managed in such a way that the intended functions of passive and long-lived SSCs will be maintained for the period of extended operation. Passive and long-lived SSCs include the reactor vessel, reactor coolant system piping, steam generators, pressurizer, pump casings, and valve bodies.

For some passive SSCs, no additional action may be required where it can be demonstrated that existing programs provide adequate aging management throughout the period of extended operation. However, if additional aging management activities are warranted for a system, structure or component, applicants have the flexibility to determine such appropriate actions. These activities could include, for example, justifying acceptable aging behavior or adding new monitoring programs or increasing inspections.

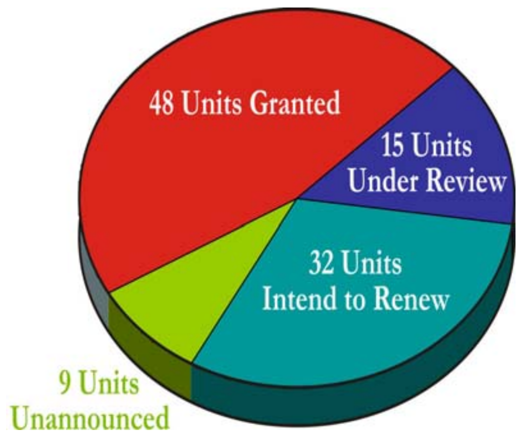
The detrimental aging effects in "active" components tend to be more readily detected and corrected by routine surveillance and maintenance. Such programs for active components are required throughout the license term. Therefore, active components are not typically part of the regulatory process associated with license renewal assessments. Active components include equipment such as motors, diesel generators, cooling fans, batteries, relays, and switches.

License renewal applicants are also required to identify, assess, and update time-limited aging analyses (TLAAs). During the design phase for a plant, assumptions concerning plant operating durations are incorporated into design calculations for plant systems, structures, and components. Under a renewed license, these calculations must be shown to be valid for the period of extended operation, or the affected systems, structures and components must be included in an appropriate aging management program.

Two primary concerns are central to the question of whether or not the current fleet of commercial power generation nuclear plants can safely and economically operate through extended periods of license renewals:

1) Ensuring public health and safety through application of continued knowledge and understanding of long-term plant component and material behaviors; and,

2) Maintaining the operating economic viability option through optimal use of maintenance programs, operating philosophies, and plant upgrades



Current License Extensions. Of the 104 operating plants, most are expected to seek license renewals to permit operation through 60 years of plant life.

Ensuring plant operational safety and protection of public health remains overriding to all other considerations of extended commercial plant lifetimes. Per current regulations, adequate levels of safety must be demonstrated for the subsequent license renewal periods. In conjunction with this precondition, plant operators are likely to consider other stakeholder risk factors outside 10 CFR Part 54 as associated with the extended operation of the existing LWR plants. As nuclear power plants operate beyond their original license period, and aging mechanisms become evident, the influence of these factors will likely increase. Each nuclear licensee will need to thoroughly assess these factors in order to make prudent business decisions regarding continued long-term plant operation. Consequently, the nuclear industry could utilize the results of research into the effects of aging so they can assess future utility actions based on appropriate, technically justified factors.

Much of the research identified through the workshop could be generically applicable regardless of plant design or vendor. Because of the scope and time commitment associated with resolving plant aging issues, it may be beneficial to the nuclear utility industry, NRC and DOE to collaborate in developing and implementing research in order to adequately investigate these issues.

The Life Beyond 60 Workshop's exploration of these issues provides a starting point for further discussion in the development of a comprehensive R&D strategy. The workshop agenda (Appendix C) was structured around four primary topical discussion sessions:

1) Historical license renewal efforts and anticipated industry needs for extended power operations
2) Long-term reliability of SSCs
3) Age-related materials degradation mechanisms and processes
4) New technologies, tools, and applications for diagnostics and monitoring

Workshop presentations and discussions identified numerous topics from which nuclear licensees are likely to benefit from further research. Because of the many commonalities across the workshop sessions, the research topics introduced and discussed were categorized in a manner related to the regulatory bases familiar to the nuclear utility industry:

1. ***Research regarding SSCs Considered to be Part of a 10 CFR Part 54 License Renewal Submittal.***
   Research and development on SSCs that are within the scope of Part 54, which focus on issues associated with the aging of those items considered as integral to a license renewal application. Examples of such issues include:

   - Irradiation effects on primary structures and components
   - Aging effects on safety-related concrete structures
   - Aging effects on safety-related cable insulation
   - Inspection capabilities for aging mechanisms

2. ***Research regarding SSCs Considered as Part of an Economic Justification for Long-Term Operations.***[4]
   Research and development on SSCs that are outside the scope of Part 54 and are not issues associated with the aging of those items considered as integral to a license renewal application. Such issues are likely to be considered as economic factors influencing long term operational decisions. A number of such areas may include:

[4] It should be noted that some of the activities falling within this classification may not be explicitly within the scope of 10 CFR Part 54, but may eventually require regulatory approval.

- Dry cooling technologies for waste heat management
- Implementation of digital sensors and control systems
- Development of improved NDE and prognostic technologies
- Aging effects on balance-of-plant piping, cables, and concrete structures

3. ***Crosscutting Research*.** This research topic integrates areas within both of the previous two categories and may or may not be within the Part 54 license renewal review scope. A number of such areas were identified as:

- Research Infrastructure
- Workforce
- Public Opinion / Policy
- Aging Analyses / Flaw Acceptability
- Component Failure Acceptance Criteria

Workshop participants identified and discussed challenges and technology gaps within each research area and suggested broad-based research pathways needed to address those gaps.

Following is a discussion of the research needs identified during the course of the workshop as well as participants' suggestions and the next steps that were proposed to be undertaken by key stakeholders.

2.0 Identified Research Needs

Areas addressed within this section focus on the related core questions of safety and economic feasibility. To evaluate the prospect of safe and economical long-term operation, it is critical to understand both the fundamental aging process mechanisms and the effects of prolonged exposure to typical reactor operating environmental conditions (e.g., temperature, pressure, water chemistry, and radiation). During the workshop, participants assessed key focus areas covering structural materials, plant structures, plant components, instrumentation, and diagnostics and identified the state of knowledge relevant to the current generation of nuclear plants. Following is a discussion of this knowledge, which may be expanded so it is applicable to extended periods of operation.

2.1 Research and Development for SSCs Within the 10 CFR Part 54 Scope

This research area focuses on those passive nuclear plant SSCs, and materials exposed to high temperatures, irradiation, and/or other environmental influences that affect the primary pressure boundary integrity, the capability to prevent or mitigate the consequences of accidents, or as relied upon in performance of related functions. Components within this category include the reactor vessel internals, primary coolant boundary piping, safety systems, containment structures, and the reactor pressure vessel. The constituents of this category are typically exposed to neutron and radiation fluencies, thus creating atomic-level degradation mechanisms that may be either unique or exacerbated by the conjunctive environmental influences of temperature, pressure, chemistry, or mechanical aging.

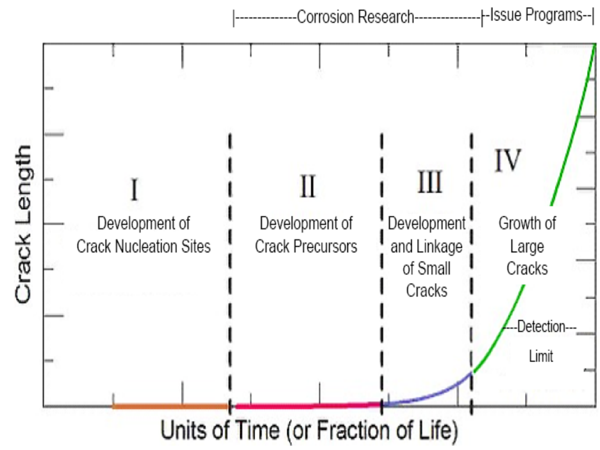
Industry has taken steps to identify and address a number of these issues based on a framework established in the Nuclear Energy Institute (NEI) document NEI 03-08, "Guideline for the Management of Materials Issues." This document laid the groundwork for industry's Materials Reliability Program (MRP), which seeks to identify materials used for the major passive SSCs and their potential degradation mechanisms. In 2004, the Electric Power Research Institute (EPRI) published their first Materials Degradation Matrix (MDM), which identified these potential mechanisms and provided the status of current research progress and needs. In addition, the NRC has developed the Proactive Management of Materials Degradation (PMMD) program to address the regulatory issues involved with materials aging, and the Generic Aging Lessons Learned (GALL) report covering aging issues associated with Part 54 reviews.

Workshop participants identified the following strategic issues that may require additional aging-related research:

- Environmental influences on material fracture resistance
- Environmental influences on material fatigue life
- Stress corrosion cracking (SCC) of nickel (Ni)-based alloys and stainless steels

- Irradiation-assisted stress corrosion cracking (IASCC) susceptibility and crack growth rates
- Void swelling

Typical profile of crack development.



Crack Growth Progression. Research goal is to identify and arrest crack growth at the earliest phase practical.

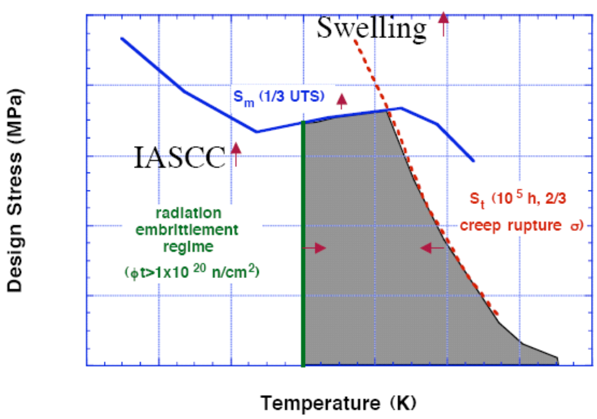
Research into these areas, as presently sponsored by both the industry and the NRC, is ongoing. Additional testing and experimentation could be beneficial in addressing industry and regulatory concerns associated with long-term plant operation. For example, it could be beneficial to expand research on environmentally-assisted stress cracking through the Cooperative IASCC Research Program[5], which is an international collaborative research effort that includes utilities, regulators, vendors, and research organizations. Currently, this program has created limited irradiated samples to develop a mechanistic understanding of how key parameters, such as neutron flux and temperature, affect IASCC initiation and growth. Planned future directions for this research include the limited testing of the irradiated alloys with final deliverables expected in 2009. However, expansion of this program could be expected to yield long-term applicable data on materials behavior as relevant to nuclear plant operations beyond 60 years.

Additionally, other organizations are attempting to obtain relevant data and build predictive models to improve the industry's understanding of SCC of stainless steels and nickel (Ni) alloys under both irradiated and unirradiated conditions. Research is being conducted on techniques characterizing surface films on Ni-based alloys and on stainless steels in an attempt to control corrosive behavior and better understand SCC mechanisms and behavior of components fabricated from these metals.

The long-term effects of radiation may also include studies of extended neutron embrittlement and swelling of carbon and stainless steels. These phenomena create metallic atomic-level structure changes which translate to macrostructural alterations in key materials properties. For example, over time, these environmental effects decrease a plant's allowable operational window in avoiding the negative impact of potential pressurized thermal shock occurrences. Such decreases limit operator actions in plant maneuverability and may cause both increased safety concerns and economic penalties during such transients.

[5] See the EPRI website for details at http://www.epriweb.com/public/RS_1002874.pdf

A better awareness of fundamental materials science at the molecular level allows informed assessments of material behavior, thus enabling enhanced prediction of the macro–effects of radiation damage on reactor vessel and reactor vessel internals metals. Some previously conducted research has simulated the effects of long-term exposure in an accelerated irradiation environment; nevertheless, these studies required a significant amount of experimental time to replicate the neutron exposure effects of extended nuclear plant operations. Therefore, it would be beneficial to consider development of testing samples in an environment similar to that of operating reactors. Such programs should be started as soon as possible.



Irradiation Effect on Operating Region
Although irradiation increases material strength (blue line moves up), it also causes embrittlement and creep, reducing the allowed operational area.

Potential Future Research and Development

While the ongoing research programs and initiatives address some of these areas, additional research could be beneficial to provide a firm technical foundation for long-term plant operation. There are three principal categories of research areas identified during the workshop that are of interest:

1) The development of an improved fundamental understanding of the degradation mechanisms that affect primary plant components, including repair or prevention methods that can be employed to combat the effects of plant aging

2) Characterization of specific aging mechanisms anticipated to contribute to higher nuclear plant risk, such as reactor vessel neutron embrittlement, validation of crack growth models, understanding late-failure modes, or validation of fundamental materials failure modeling

3) Investigations into advanced inspection techniques to enhance understanding between field measurements and degradation precursors and to facilitate development of prognostics in predicting material aging from basic precursors

Following is a list of potential investigative areas identified during the workshop to target future research:

Metals Degradation-Related Research and Development Topics:

- Investigation into complex aging fundamentals (e.g., late blooming phases, effects of microstructure)
- Thermal and irradiation embrittlement: synergistic effects on cast austenitic stainless steel and welds
- Assessment of the significance of void swelling and stress relaxation
- Impact of neutron flux on the SCC of stainless steels

- Prevention of "nucleation" in the SCC process
- Effects of irradiation on Ni alloys comprising reactor core support internals
- Primary water SCC management of Ni-alloy reactor internals
- Further Development of Water Chemical Control programs
- Fundamental metallurgical investigations into potential Alloy 690 degradation
- Assessments of long-term structural high cycle fatigue resulting from repeated thermal and mechanical stresses
- Fatigue, or progressive degradation, of SSCs caused by multiple occurring environmental effects
- Flow-assisted wear and high cycle fatigue of steam generator tubes and internals
- Investigation into the effects of reactor vessel annealing, a process by which the metal could be heated to a high temperature to improve its material properties
- Improved welding techniques and repair criteria
- Confirmation that repair processes, such as weld overlays and induction heating stress improvement, will be effective for the life of the plant
- "Combined effects" testing of reactor materials to identify potential interdependencies of multiple parameters

Other Degradation-Related Research and Development Topics:

- Concrete Structural Materials
  - Containment base mat degradation from groundwater leaching and corrosive actions
  - Reactor vessel concrete support degradation from radiation damage and thermal cycling
  - Containment shell degradation due to long-term environmental exposures
  - Containment and spent fuel pool liner anchoring age-related degradation
- Coatings and Paint Aging Degradation
- Aging and degradation of safety related cables

Inspection and Prognostic-Related Research and Development Topics:

- Development and demonstration of advanced inspection techniques, including use of lasers and advanced transducers
- Equipment accessibility for non-destructive examination (NDE)
- NDE/measurement matrix (analogous to materials degradation matrix)
- NDE capability: void swelling (identification and characterization)
- NDE capability for control rod guide tube support pins
- Demonstration of an integrated asset management program incorporating multi-scale models, on-line sensors/signal processing, and prognostic development

2.2 Research and Development for SSCs Considered as Part of an Economic Justification for Long-Term Operations.

The second category of research concepts developed by the workshop includes the passive SSC-related research influencing the economic justification for extended operations and is indirectly tied to the 10 CFR Part 54 scope. This area considers items that would not normally be included in a license renewal submittal, but rather are characterized as more of an economic risk contributor for long-term nuclear plant operations.

Existing research in this area by industry is ongoing. However, this current research is directed either toward understanding specific short-term behaviors or focused towards specific engineering solutions to identified problems. At present, there is limited long-term characterization efforts focused on understanding fundamental degradation mechanisms or developing prognostics to be used in prediction of degradation. Additionally, as with the metal-based research (see Primary Suggested Research), the combined influence of environmental factors such as heat, humidity and radiation is not well understood and requires structured investigation.

The workshop-identified research areas are:

Low- and Medium-Voltage Cable Aging

With time, cable degradation is highly likely to become a more significant issue as nuclear power plants age. At present, this problem is addressed on a case-by-case basis with cable replacement being the preferred solution. However, replacing individual cables can be problematic and costly, as they are often wound together in cable trays which are often filled to capacity and/or difficult to access. Wholesale cable replacement campaigns have been attempted at a few plants with varying degrees of success.

Future Research and Development

For low-voltage cables, the suggested research could be designed and conducted to ensure the integrity of contemporary inspection and testing techniques as applied to both aging and replacement cables. Research into the aging characteristics and management of zero halogen insulations and jackets is likely to be needed if these components are installed as replacements. Further study could also be conducted into the aging effects of very long-term wetting of low-voltage cable.

Research is also suggested for assessing the integrity of medium-voltage cables. Efforts could focus on the acceptance criteria for existing tests, in addition to development of examination techniques characterizing failure precursors. In addition, while long-term wetting is known to be a source of degradation of medium-voltage cables, development of an accurate aging model and environmental qualification could help to determine a better replacement schedule for these cables. Other research areas under consideration include development of prognostics to be used on non-shielded cables, use of nano-coatings, and improved NDE techniques.

Management of Buried Piping

Buried piping systems are used for fire suppression, radiation waste treatment, or component cooling. This piping may be either concrete or metal. For example, nuclear power plants require an external heat sink, such as a lake or river, in order to maximize thermal cycle efficiencies and provide an ultimate safety heat sink. Typically, the piping between these heat sinks and the plant secondary cooling loop is known as raw water piping. Degradation of raw water piping affects plant reliability, increases operation and maintenance costs, and potentially affects the plant's ability to remove excess heat in case of an accident (i.e., the service water system). Access to these pipes could be extremely limited—for example, in many cases, the piping runs under the turbine building.

Three areas of industry improvement and potential research related to buried piping were identified during the workshop: 1) condition assessment, 2) repair methodology, and 3) selection of replacement materials. Condition assessment addresses improved methodologies for determining the health of the existing piping and predictions of the remaining service life. Because buried piping will slowly degrade from exterior and interior pitting, as well as biofouling of the pipe internals, it is likely that significant repairs or replacements will be necessary during extended plant operations. At present, assessment and inspections of these pipes occur using either visual exams or with a guided wave technology. Both methods have disadvantages. Physical inspections are time consuming, require a large skilled labor resource, and expose the piping to potential damage during excavation and backfilling. In order to reduce the risk of damage, use of remote inspections, like guided wave technologies, may be an alternative to physical inspections. However, inspections using these technologies are currently limited to just a short piping distance from the access point.

Future Research and Development

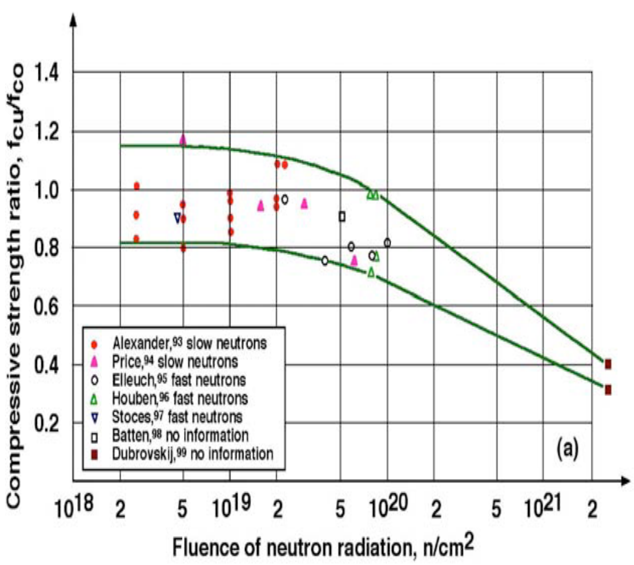
Research in this area could address the assessment of in-situ piping conditions, development of less labor-intensive repair methodologies, and development of new materials.

Research related to condition assessment strategies could focus on both developing better degradation models for buried piping and improving inspection techniques. Development of a robust degradation model may allow for better assessment planning and more accurate predictions for buried piping life-cycle management purposes. Improvements to global inspection methods and advancements in remote instrumented vehicles will provide plant operators with better assessment tools.

In addition, construction of material characterizations for alternate buried piping material characterizations may be required for extended nuclear plant operations. These characterizations may take the form of PVC piping to replace existing pipes or polymer-coated metal pipes to inhibit or retard corrosion. It is also possible that smart coatings could be employed that would give a visible indication when they begin to degrade.

Concrete Structures Outside 10 CFR Part 54 Scope

Concrete structures play a significant role in the composition of commercial nuclear power plants. Concrete is used in numerous applications from construction of containment buildings to radiation shielding, to creating equipment support structures. Overall, the performance of concrete at operating plants has been good, although there have been some instances of deterioration reported. In past assessments in this area, the NRC and industry have addressed these concerns from a regulatory perspective. An example of this type of review is NUREG/CR-6715; "Probability-Based Evaluation of Degraded Reinforced Concrete Components in Nuclear Power Plants," which provides pre-approved acceptance criteria for cracks with limits of flexural members and sheer walls. Similarly available is, NUREG 1801, "Generic Aging Lessons Learned (GALL) Report," which was developed as an industry reference tool providing guidance regarding applicable plant aging management programs. The GALL report is deemed suitable for referencing during the relicensing process. NUREG 1801 generically specifies aging management program features for which no further evaluation is necessary; however, it does not address criteria for determining acceptability of degradation if further evaluations find such occurrences. At present, there appears to be a need to further codify these experiences and research bases for underground concrete structures.



Concrete Strength Decreases with Neutron Flux. It is difficult to separate radiation from thermal effects because of differences in concrete composition and experimental method.

Future Research and Development

In examining other industrial applications of concrete, it appears that nuclear plant concrete has the capability to withstand the aging process quite well. However, to ensure that nuclear power plants may safely continue to operate past 60 years, it was recommended in the workshop that improved and more specific acceptance criteria be cultivated. To aid in the development of deterministic and/or probabilistic criteria, additional fundamental and applied studies are needed to enhance the understanding of the long-term effects of extended exposure of concrete to the unique environmental conditions found in nuclear plants. These studies would then be used in support of extended environmental qualification criteria for containment and other concrete structures. Additionally, these criteria could be coupled with the development of an integrated Operating Experience Database to help benchmark and monitor specific plant performance over time. It was noted that such an effort would be advanced by searching for well-established databases from other industries that rely heavily on concrete, such as bridge and building construction, and correlate their existing information to nuclear structures. Additionally, this effort could encompass development of accurate fundamental damage models and mitigation technology. Equally important to these areas is improvement to NDE techniques and targets for thick, heavily reinforced concrete.

Other Potential Research Areas

Several other research areas were discussed during the workshop that suggest further investigation and confirmatory research. One of these areas is the potential need for research addressing dry cooling technologies and water conservation methods to potentially minimize future environmental impacts. The availability of sufficient cooling water, and the corresponding environmental effect, is a growing concern both for plant life extension and new nuclear power plant construction. Additionally, as the existing nuclear plants undergo extended licensing actions, reviews of their impacts to the environment, including water and waste heat management, may become of an increasing importance.

A second topic, the use of protective coatings for all non-primary materials, such as exposed structural material and buried piping, was also discussed.

2.3 Crosscutting Suggested Research

The Common/Crosscutting category includes those research areas that include characteristics of both the first two research areas and which may or may not be within the 10 CFR Part 54 scope. Necessarily, the topics in this category are generally of a non-technical nature. Following is an overview of these research areas that were identified during the workshop:

Infrastructure and Policy

Research Infrastructure. A common theme that emerged during the workshop was the lack of cohesive domestic research infrastructure, particularly in considering use of test reactors and hot cell examination facilities. Reduced numbers of such facilities place restrictions on the materials research programs requiring irradiated samples. However, it was noted in the discussion on this topic that the Energy Act of 2005 had made the Advanced Test Reactor (ATR) at Idaho National Laboratory available for both DOE and academic researchers. Other discussion suggestions included looking for research opportunities at facilities outside the United States.

Workforce

Related to the research infrastructure concerns is a perceived shortfall in trained workers at all levels of the nuclear industry, including technicians, scientists, and engineers. Demands for this pool of workers are expected to increase as existing plants age and new plant construction begins. Additionally, workshop participants noted existing knowledge must be effectively transferred from the existing workforce to ensure continuity.

Public Opinion and Policy

Educating policymakers and nurturing public opinion remain essential for widespread acceptance of a nuclear renaissance. The industry may need to focus efforts on overcoming the public's perception that conservation and efficiency alone are sufficient to ensure our nation's energy independence. Further, the industry and DOE may cooperate in educational programs regarding existing nuclear plant's non-GHG-emitting energy technology as immediately available in achieving significant reductions in greenhouse gases.

Research Financial Resources

Industry organizations such as EPRI focus their research efforts primarily on near-term utility issues with corresponding budgets being insufficient to address the full scope of required research and development. Workshop participants noted that cooperative, coordinated research programs should be developed that effectively and efficiently leverage limited funds and infrastructure in order to address needed R&D, while minimizing needless duplication of efforts and maximizing international collaboration.

Data and Analysis

Plant Time Limited Aging Analyses

During initial plant design and subsequent license renewal applications, plant operators were required to perform Time Limited Aging Analyses (TLAAs), demonstrating that safety-related components would function properly throughout the license period. These TLAAs must continue to be verified in extended periods of operation, or the licensee must commit to an acceptable active aging management program. As plants age beyond 60 years, research results and improved understanding of aging mechanisms, as applied to TLAAs, may be expected.

Aging and Asset Management Database

Determining the effects of aging on a system or component is often hampered by a lack of historical data. Unless measurements were recorded throughout plant life, it is often difficult to ascertain the rate of degradation. Development of effective long-term asset management processes could identify an optimal condition to replace aging components—long before significant safety issues arise. As aging management programs are implemented, measurements should be collected so data are available in sufficient time for further evaluation and/or recalculation of TLAAs.

Component Failure Acceptance Criteria

Workshop participants noted that studies could focus on characterizing the effects of degradation on component or system performance in determining the acceptability of continued system operation. A systemic determination should be made as to what effect, if any, failure of a particular component could have on the system as a whole.

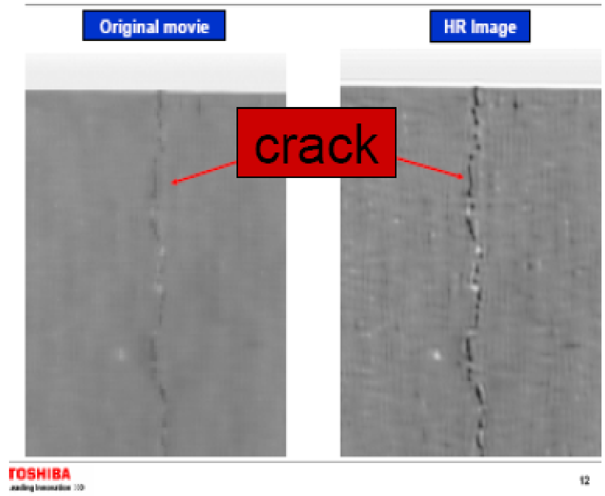
A similar idea of workshop participants is an alternate application of ASME Boiler and Pressure Vessel Code, Section 3, requiring the repair of a weld that is otherwise sound, but in which an innocuous flaw was found. Such corrective repairs have the potential to increase the overall risk of damage or degradation by creating unstable or failure-prone conditions. Work in this area corresponds with current EPRI research designed to create the technical bases that could allow such structurally innocuous flaws to remain in service, as long as they pose no significant hazard to the continued integrity of the weld. Developing technology to accurately detect and characterize such flaws could be a key step towards improvement in this area.

Testing and Evaluation

Material-related issues inherently include development of improved Non-Destructive Testing (NDT) methods, in searching for early indications of degradation. The NDT research focus is two-fold: 1) development of new techniques and 2) quantification and reduction of uncertainties in present NDT technologies.

Non-Destructive Evaluation (NDE) techniques are unique to each specific material. For example, in concrete examinations, new NDE methods, such as using filmless techniques, laser or radar, and ultrasound may be required to improve measurements. Or, future research and development on electrical cables may improve infrared technology and allow incorporation of nano-coatings. Radiography, microwave, and ultrasound are all candidate examination techniques for development. Finally, the increasing use of non-metallic pipe in some nuclear plant applications presents new NDE challenges, as its behavior remains unknown.

Further research may be needed to evaluate the effectiveness and reliability of current in-service inspection tools and to develop advanced methods, including the incorporation of risk-informed principles. Sensors and data processing algorithms may be needed to support on-line monitoring. Critical issues may include ensuring accessibility and inspectability of parts and components, validation or performance demonstrations, and continued safety.



Enhanced Signal Processing. Example of improved image from "super-pixel" signal processing

Emerging NDE tools include high-resolution eddy current, phased array and synthetic aperture ultrasonic testing, digital x-ray, advanced thermal imaging, remote and embedded radio-frequency sensors, and leak detectors using acoustic and ultrasonic technology. These tools share a number of common factors. Inspection techniques may result in enhanced spatial resolution, sensitivity, and accuracy. The large amounts of data generated could be reliably and efficiently processed and archived using automated analysis tools that employ modern signal processing methods. Numerical modeling and simulation techniques could improve understanding of complex problems, optimize probe designs, and reduce the need for expensive experimental studies. Improvements are also being developed for enhanced visual inspection techniques that focus on increasing the scanning speed and image resolution. One example is utilizing improved signal processing (e.g., "super-pixel"), which can dramatically improve image quality and allow faster scan rates.

Monitoring and Inspection

Prognostics

Monitoring and inspection programs pertain mostly to passive components; active components are managed through regular preventive maintenance programs. Condition-based maintenance (prognostics) attempts to predict the remaining useful life based on analysis of the precursor system or material conditions, stressors, and degradation phenomena. Prognostic methodologies model systems from either a physics-based or empirical method. Information developed from the system models could allow both operators and regulators to make better informed decisions regarding degradation. Additionally, prognostics could be applied to both active and passive components. In order to apply this technique, historical failure data may need to be collected and analyzed and empirical models developed. Prognostic development holds promise to supplement or even replace traditional inspection procedures.

Technical challenges associated with prognostics include determining how and what to measure; data interrogation, communication, and integration; development of predictive models; system integration and deployment; quantification of uncertainties; incorporation of smart components, self-diagnostic systems, and embedded micro-electromechanical systems; and distributed networks for data processing and control.

On-line Monitoring

Successful use of on-line monitoring of key passive components could provide early warning of impending failure and may be used to facilitate condition-based maintenance. Significant research is required to effectively implement on-line monitoring. A number of issues are likely to require resolution before commercial implementation. Concerns exist with sensor technology, including modalities, contact versus remote, distributed sensors, and continuous versus periodic sampling. Reliable algorithms are necessary, along with data transfer protocols and efficient methods to manage and archive data.

The following is a list of other potential crosscutting research areas identified during the workshop:

- Component failure-trending signatures and acceptance criteria
- Expanding the use of retired systems and equipment and “sentinel” samples for testing and data base generation purposes
- Characterization of acceptable base material and weld metal flaws with integration into applicable industry standards
- Transition to digital instrumentation and control systems
- Development of integrated risk-informed prioritization methods, considering safety and economic benefit.

3.0 Suggestions from Q&A Session

At the close of each session, public questions and comments were solicited from workshop attendees. Following is a highlight of these questions and areas of concern as well as some suggestions for addressing them.

Capturing Important Test Material Data

Greater industry effort should be taken to learn from decommissioned plants. It was noted that scientists may not have extracted parts for study and evaluation in the past due to the lack of a detailed history of the conditions to which the parts were exposed (e.g., chemistry or irradiation histories). Clearly, without understanding the environment to which the part was exposed, any study would lack proper scientific basis. Actions taken now can prevent some of these concerns.

- Identify detailed research goals so that specific parts can be harvested at the right time without delaying demolition
- Install additional test material into reactors that may be decommissioned early
- Maintain an accurate environmental history to which parts have been exposed
- Explore international interest in collaborative programs using industry harvested material, such as the St. Lucie pressurizer surge line, as well as reactor internals, for further developing an IASCC database
- Investigate defense-related facilities and international sources for test material and data

Other Topics from Workshop Participants

- There is a continuing need to break down institutional “stovepipes” between academia, national laboratories, DOE, and industry.
- While water chemistry is implicitly included in primary plant research areas, it should be noted that this is a highly important area for preventing degradation of all plant components exposed to water.
- While it appears that plants would not likely exceed the limits specified in the proposed pressurized thermal shock rule for even 80 years, research should be conducted into reactor vessel annealing to provide the possibility of further life extension.
- The oil industry has inspection techniques for pipes that could be applied to nuclear plants.
- Studies into the effects of seismic activity may be another area that requires research.

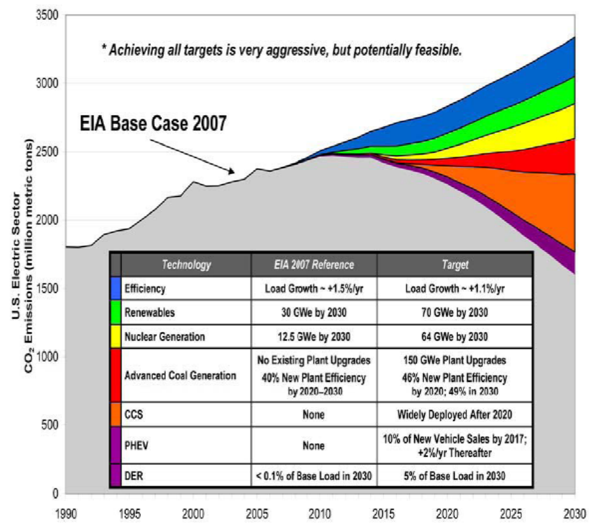
4.0 Next Steps

The *"Life Beyond 60"* workshop successfully promoted a diverse discussion on the long-term challenges faced by the existing nuclear plants. Additionally, the workshop provided a starting point for cooperation and collaboration among stakeholders on research and development needs to enhance the knowledge base achieving extended plant operations. As stakeholders, the nuclear industry, Department of Energy, and the Nuclear Regulatory Commission will all need to be involved with the process to ensure the development, acceptance, and effective implementation of all the proposed research pathways and specific research areas.

It is anticipated that follow-on discussions will assist with understanding the effects of aging on nuclear power plants. Each stakeholder has a distinct role in moving the license renewal process forward. The lead responsibility naturally falls on industry to drive the process and work with the Federal Government, academia, and National Laboratories to begin identifying the key areas likely to require research. The national laboratories, academia, and industry must all take part in conducting the necessary research, supported, as appropriate, by international collaborators. DOE should facilitate and coordinate these efforts and the NRC should continue to focus on confirmatory research required for the continued assurance of public health and safety. It is expected that any subsequent programmatic roadmaps will establish clear roles and responsibilities in each research area, including fiscal and oversight responsibilities.

Individual presentations from the workshop, as well as this workshop report, are available online in the NRC's ADAMS system, and on the website www.energetics.com/nrcdoefeb08/. Additionally, the workshop report is available on the DOE-NE website, www.ne.doe.gov.

Future Requirements: All options for generation



capacity, including life extension of power reactors, must be promoted - yet all options face challenges that must be overcome through R&D and Policy Initiatives

5.0 Summary and Conclusions

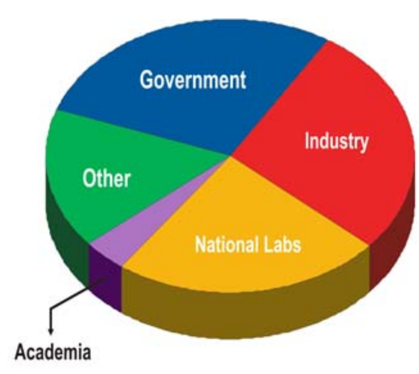
Originally, nuclear power plants were granted 40-year licenses based on non-technical antitrust concerns. Many plants have already been relicensed for an additional 20-year operating period, as allowed by current regulations, and most plants are expected to follow suit. There is no present regulatory restriction on the number of times a plant may be granted subsequent license extensions; however, each plant operator must continue to demonstrate that they maintain the plant's licensing basis and meet public interest requirements mandated by the NRC and other regulators. Workshop participants did not believe there is any compelling policy, regulatory, technical or industry issue precluding future extended plant operations. Ultimately, license renewal will be a business risk decision undertaken by the licensee.

The NRC/DOE Workshop on Plant Life Extension Research and Development was not designed to find solutions to all the challenges facing the nuclear industry over the next 30 years, nor was the goal to produce a final focused list of research topics. Rather, the workshop was intended to encourage early and proactive discussion of factors potentially affecting subsequent license renewal decisions and serve as a starting point for developing necessary research programs. This includes learning the lessons of previous extension efforts as well as lessons from other industries and foreign countries.

As the chart on this page illustrates, the workshop successfully attracted a broad and diverse group of participants, with industry, government, and the national laboratories about equally represented among the nearly 160 participants. Several international organizations were also represented.

Fundamental research to understand commercial nuclear plants aging beyond 60 years is crucial in determining an appropriate safe and economical operation basis. These research investigations should be accomplished cooperatively, leveraging limited resources to maximize the benefits gained. Furthermore, the workshop participants noted that this research must start soon so that accurate and complete information will be available for utilities in conducting decision analyses evaluating further license renewals and for the NRC in developing independent regulatory positions.

Finally, collaborative efforts should be focused and well coordinated to ensure research programs will produce timely information that contributes to the existing nuclear option and that this option remains a safe, secure, and environmentally friendly source of energy.



Workshop Participation. Breakdown of participants by type of organization.

Appendix A: List of Potential Research Areas

Research and Development for SSCs Within the 10 CFR Part 54 Scope

Degradation-related research areas

- Understanding thermal & irradiation embrittlement regarding synergistic effects on cast austenitic stainless steel and welds
- Developing improved welding techniques and repair criteria
- Assessing the impact of neutron flux on the Stress Corrosion Cracking of stainless steels
- Understanding and prevention of “nucleation” in Stress Corrosion Cracking process
- Understanding the long-term significance of high cycle fatigue
- Investigating primary water Stress Corrosion Cracking management of Ni-alloy reactor internals
- Developing materials-friendly Water Chemistry Control programs
- Investigating metal fatigue, or progressive weakness, caused by environmental effects
- Understanding the significance of void swelling & stress relaxation
- Assessing flow assisted wear & high cycle fatigue of secondary side materials
- Assessing the effects and significance of irradiation on Ni alloys that comprise many reactor internals

Inspection-related research areas

- Standardizing inspection and evaluation guidelines
- Development and demonstration of advanced inspection techniques, including the use of lasers and advanced transducers
- Development of an NDE/measurement matrix (analogous to materials degradation matrix)
- Development of enhanced NDE capabilities in detecting void swelling and inspections related to control rod guide tube support pins
- Demonstration of an integrated asset management program incorporating multi-scale models, sensors/signal processing, and prognostics

Other Research Areas

- Investigation into potential Alloy 690 weaknesses
- Investigation into the effects of reactor vessel annealing,
- Confirmation that repair processes, such as weld overlays and induction heating stress improvement, will be effective for life of the plant
- Understanding the combined effects testing of reactor materials to identify potential interdependencies
- Investigation into complex aging fundamentals (e.g., late blooming phases, effects of microstructure)
- Investigation into safety-related cable aging and degradation mechanisms

Appendix A: List of Potential Research Areas

Research and Development for SSCs Considered as Part of an Economic Justification for Long-Term Operations

Cable Aging

- Research addressing the effects of aging on newly developed zero halogen insulation
- Development of minimally invasive testing methods for medium voltage cables
- Standardization and refinement of acceptance criteria for non-destructive testing results
- Development of standardized testing for unshielded cables
- Reassess long term environmental qualification of cables
- Improve NDE techniques by incorporating infrared technology and NDE tools to examine nano-coatings

Buried Piping

- Development of fundamental degradation models for buried piping
- Development of broader global inspection methods (e.g., guided wave and acoustic emission)
- Development of improved remote instrumented vehicles
- Development and evaluation of in-situ repair and replacement options of buried piping
- Evaluation of new replacement and coating materials
- Development of improved methods of protecting buried components from groundwater

Concrete

- Development of fundamental irradiation and environmental damage models and degradation mitigation technologies
- Development of standardized degradation acceptance criteria
- Creation of a benchmarking database addressing degradation of concrete
- Assessing long-term effects of exposure to radiation, heat, and the environment
- Developing environmental qualification standards and baseline degradation models of containment structures
- Development and testing of improved NDE techniques and targets for thick, heavily reinforced concrete

Other Research Areas

- Assessment of dry cooling technologies for future applications at existing plants
- Development of robust coatings to protect structural materials, concrete, and piping (potential nanotechnology application)

Appendix A: List of Potential Research Areas

Crosscutting Research and Development

- Improvement to the basis for Time Limited Aging Analysis calculations
- Implementation of a materials and component aging database for information management (guarding against future obsolesce of formats)
- Development of component failure signatures and acceptance criteria; use of fundamental modeling techniques to create basic understanding of failure precursors
- Expansion of the use of retired systems and equipment and "sentinel" samples for testing purposes
- Characterization of acceptable flaws and integration into applicable standards
- Development of non-destructive testing and evaluation techniques
  - Improvement on existing probes and signal processing
  - Development of new testing methods
  - Development of techniques for new materials
- Creation and qualification of prognostic models and on-line monitoring systems
- Encouraging industry's transition to digital instrumentation and control systems as a way of increasing safety and reducing operational complexity
- Development of risk-informed prioritization methods, considering safety and economic benefit

Appendix B: List of Workshop Participants

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Appendix B: List of Workshop Participants

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Appendix C: Workshop Agenda

NRC/DOE Workshop on U.S. Nuclear Power Plant Life Extension Research and Development

Life Beyond 60

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Tuesday, February 19, 2008		
7:30 am – 8:30 am	**Registration Check-In and Continental Breakfast**	
8:30 am – 11:00 am	**Opening Plenary**	
	8:30 am	**Welcome Remarks and Purpose of Workshop** – Tom Miller, Deputy Director, Light Water Reactor Deployment, DOE Gene Carpenter, Group Lead, Aging Management Research, NRC
	8:45 am	**Comments on Subsequent License Renewal Terms** – Luis Reyes, Executive Director for Operations, NRC
	9:05 am	Dennis Spurgeon, Assistant Secretary for Nuclear Energy, DOE
	9:25 am	Joe Sheppard, President and CEO, South Texas Project
	9:45 am	**Nuclear Power Landscape and Outlook** – Lawrence J. Makovich, Vice President, Global Power, Cambridge Energy Research Associates
	10:05 am	**International Perspective on Plant Life Management (PLiM)** – Ki-Sig Kang, IAEA Plant Life Management Team Leader
10:25 am – 11:00 am	**Break**	
11:00 am	**Open Discussion Moderated by Miller & Carpenter**	
12:00 pm	**Regulatory Overview of License Renewal Process** *Samson Lee, Deputy Director, Division of License Renewal, NRC*	
12:30 am – 1:30 pm	**Lunch Break**	

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Tuesday, February 19, 2008 (cont.)		
1:30 am – 2:30 pm	**Session #1a: Industry Discussion on Historical License Renewal Efforts**	
	1:30 pm	**Session Introduction & Purpose** – Tom Miller, Deputy Director, Light Water Reactor Deployment, DOE
	1:35 pm	**Introduction of Session Panel Members** – Julie Keys, Senior Project Manager, Nuclear Energy Institute (NEI)
	1:40 pm	**The Road to License Renewal** – The Early Years Ted Marston, Principal, Marston Consulting
	2:00 pm	**Early License Renewal Challenges** – Doug Walters, Senior Director - Operations Support, NEI
	2:20 pm	**Eighty is the New Sixty** – Lessons from the Past Chuck Pierce, Manager, Nuclear Deployment, Southern Company
2:45 pm – 3:15 pm	**Break**	
3:15 pm – 6:00 pm	**Session #1b: Industry Perspective on Future Industry Needs for Continued Operation Beyond 60 Years**	
	3:15 pm	**Long-Term Operation of Nuclear Power Plants: Executive Interviews** – Ken Huffman, Technical Executive, Electric Power Research Institute (EPRI)
	3:30 pm	**License Renewal The Second Time** – Fred Polaski, License Renewal Manager, Exelon & Garry Young, Manager, License Renewal, Entergy Nuclear
	4:00 pm	**License Renewal Factors Outside of Part 54** – Jeff Gasser, Executive Vice President and Chief Nuclear Officer, Southern Nuclear Operating Company
	4:30 pm	**LWR R&D Strategic Plan** – Dan Keuter, Vice President - Planning & Innovation, Entergy Nuclear
	5:00 pm	Open Discussion Moderated by Miller & Keys
5:45 pm	Session #1 Wrap-up (Miller & Keys)	
6:00 pm	**Adjourn for the Day**	

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Wednesday, February 20, 2008		
8:00 am – 8:30 am	**Continental Breakfast**	
8:30 am – 12:30 pm	**Session #2: Long-Term Reliability of Systems, Structures, and Components**	
	8:00 am	**Session Introduction & Purpose** – Samson Lee, Deputy Director, Division of License Renewal, NRC
	8:05 am	**Introduction of Session Panel Members** – Ken Huffman, Technical Executive, EPRI
	8:15 am	**Vessel Internals The Functional Impact of Age-Related Degradation** – Randy Lott, Westinghouse
	8:30 am	**Concrete Structures** – Charlie Hofmayer, Group Leader, Engineering Mechanics and Infrastructure Group, Brookhaven National Laboratory
	8:45 am	**Aging Management of Cable and Buried Piping** – Gary Toman, Senior Project Manager, EPRI
	9:15 am	**Exelon Long Term Asset Management (LTAM) Process** – Andy Winter, Manager, Equipment Reliability, Exelon
	9:30 am	**License Renewal Perspective** – Mike Fallin, Principal Engineer, Constellation
	9:45 am	**Fort Calhoun Experience with Large Component Replacement** – Jeff Spilker, Supervisor Nuclear Projects, OPPD
10:00 am –10:30 am	**Break**	
10:30 am	Continue Session #2 – Open Discussion Moderated by Lee & Huffman	
12:15 pm	Session #2 Wrap-up (Lee & Huffman)	
12:30 am – 1:30 pm	**Lunch Break**	

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Wednesday, February 20, 2008 (cont.)		
1:30 am – 6:00 pm	**Session #3: Management of Age-Related Materials Degradation Issues**	
	1:30 pm	**Session Introduction & Purpose** – Jennifer Uhle, Director, Division of Engineering, NRC
	1:35 pm	**Introduction of Session Panel Members** – Jack Lance, Director, Engineering Technical Authority, Idaho National Laboratory (INL)
	1:45 pm	**Radiation Resiliency for 80 Year Cores** – Todd Allen, Professor, University of Wisconsin
	2:00 pm	**PWR Issues for LWR Life Extension** – Mike Burke, Westinghouse
	2:15 pm	**Primary System Corrosion** – Robin Dyle, Principal Engineer, Southern Nuclear
	2:30 pm	**Fatigue** – Steve Gosselin
	2:45 pm	**Material Degradation Matrix, Inconel Issues** – Mike Melton
	3:00 pm	**Concrete Materials and Structures** – Aging and Life Beyond 60 Years, Dan Naus, Distinguished Research Staff Member, Oak Ridge National Laboratory (ORNL)
	3:15 pm	**Coatings** – Jack Spanner/Neil Wilmshurst
3:30 pm – 4:00 pm	**Break**	
4:00 pm	Continue Session #3 – Open Discussion Moderated by Uhle & Lance	
5:45 pm	Session #3 Wrap-up (Uhle & Lance)	
6:00 pm	**Adjourn for the Day**	

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Thursday, February 21, 2008		
8:00 am – 8:30 am	**Continental Breakfast**	
8:00 am – 12:30 pm	**Session #4: Determination of New Technologies, Tools, and Applications for Diagnostics and Monitoring**	
	8:00 am	**Session Introduction & Purpose** – Michele Evans, Director, NRR:DCI
	8:05 am	**Introduction of Session Panel Members** – Leonard Bond, Laboratory Fellow, Pacific Northwest National Laboratory (PNNL)
	8:15 am	**From NDE to Prognostics: a Review** – Leonard Bond, Laboratory Fellow, PNNL
	8:30 am	**NDE Research Needs for Long Term Operation of LWRs** – Greg Selby, Senior Program Manager, EPRI
	8:45 am	**Current Inspection Practice for Reactor Internals and Future Needs** – John Lareau, Chief Engineer, WesDyne International, Inc.
	9:00 am	**Diagnostic Techniques to Be Developed for Aging Nuclear Power Plants** – Hash Hashemian, AMS Corp.
	9:15 am	**Research on Advanced ISI Technologies** – Sasan Bakhtiari, Argonne National Laboratory (ANL)
	9:30 am	**On-line Monitoring System Diagnostics** – Brandon Rasmussen, Consultant
	9:45 am	**Prognostic Method Requirements: Planning for the Future** – J. Wesley Hines, Professor, University of Tennessee
10:00 am – 10:30 am	**Break**	
10:30 am	Continue Session #4 – Open Discussion Moderated by Evans & Bond	
12:15 pm	Session #4 Wrap-up (Evans & Bond)	
12:30 am – 1:30 pm	**Lunch Break**	

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Thursday, February 21, 2008 (cont.)		
1:30 am – 3:00 pm	**Wrap-up Plenary**	
	1:30 pm	Session 1 Results (Keys & Miller)
	1:45 pm	Session 2 Results (Huffman & Lee)
	2:00 pm	Session 3 Results (Lance & Uhle)
	2:15 pm	Session 4 Results (Bonds & Evans)
	2:30 pm	Cross-Cutting/Other Issues (Miller & Carpenter)
	2:45 pm	Next Steps (Miller & Carpenter)
3:00 pm	**Adjourn for the Day**	