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UTILIZATION OF AGING PROGRAM RESULTS IN PLANT INSPECTIONS

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ABSTRACT

Research conducted under the auspices of the U.S. Nuclear Regulatory Commission Nuclear Plant Aging Research (NPAR) Program has resulted in a large data base of component and system operating experience. This data base has been used to determine equipment aging susceptibility and the potential for equipment aging to impact plant safety and reliability. Methods of detecting and mitigating component and system aging have also been identified.

This paper discusses how the NPAR results could be used to focus inspection activities on age-sensitive components and systems and on the specific modes and mechanisms of age degradation. These activities range from the regular inspections conducted by resident inspectors to extensive special inspections such as the Safety System Functional Inspection typically conducted by a team of inspectors.

BACKGROUND

The NPAR Program's goals are to obtain an understanding of the aging degradation process in components, systems, and structures, and assess methods for detecting and mitigating aging[1]. This hardware-oriented engineering research program uses a two phase approach. The phase 1 studies assess the nuclear power plant operating experiences to identify and characterize aging modes, mechanisms, and effects, and identifies measurable functional parameters which could be used to detect aging degradation in the incipient stage. The phase 2 research is an in-depth engineering study and assessment of aging detection and mitigation methods based on the testing of naturally aged equipment, a review of current nuclear power plant maintenance practices, and a cost/benefit analysis for applying recommendations.

Associated with each NPAR study is the need to determine the role of inspection, maintenance, and monitoring in counteracting aging and service wear effects. The role of maintenance in managing aging is an important area where NRC emphasis has been applied. A review by the NRC of maintenance performed at several plants resulted in the conclusion that "Most utilities do not perform condition monitoring due to inadequate knowledge of degradation mechanisms and the relationship between measurable parameters and predicted functional capability."[2] The output from NPAR in this area could assist the inspector in determining the extent of licensee inadequacies where appropriate.

* Research has been carried out under the auspices of the U.S. Nuclear Regulatory Commission.

To achieve the objective of integrating NPAR information into the NRC Inspection Program, several tasks must be accomplished. These tasks are to determine which NPAR information is relevant to areas addressed by the inspector; how the Inspection Program presently addresses component and system performance monitoring; and the format in which the NPAR information can be presented so that the material can be readily accessed and updated.

As illustrated in Figure 1, the information flow path depicted includes the following:

1. Determine NRC Inspection Program requirements: The results of a review of the NRC Inspection Manual are presented, highlighting those areas in which typical NPAR research results could be applied.

2. Complete NPAR Program Results: This paper presents examples of NPAR Program results which should be available to the inspector. Several information areas are discussed.

3. Develop the guidelines: For extracting information from the NPAR reports, guidelines have been established which include background information, operating experience, recommended maintenance, testing, and inspection, and references. This is intended to be a summary of NPAR information pertinent to an inspection of a nuclear power plant.

4. Application of Guidelines: To determine the effectiveness of the guidelines established for obtaining information from the NPAR reports, a trial application of the methodology will be implemented for two components-motors and inverters.

5. Information Transfer: The potential information transfer mechanisms are presented, including relationships to inspection modules, team inspections, and special subject area inspections.

This paper presents the research findings developed from completion of the first three tasks.

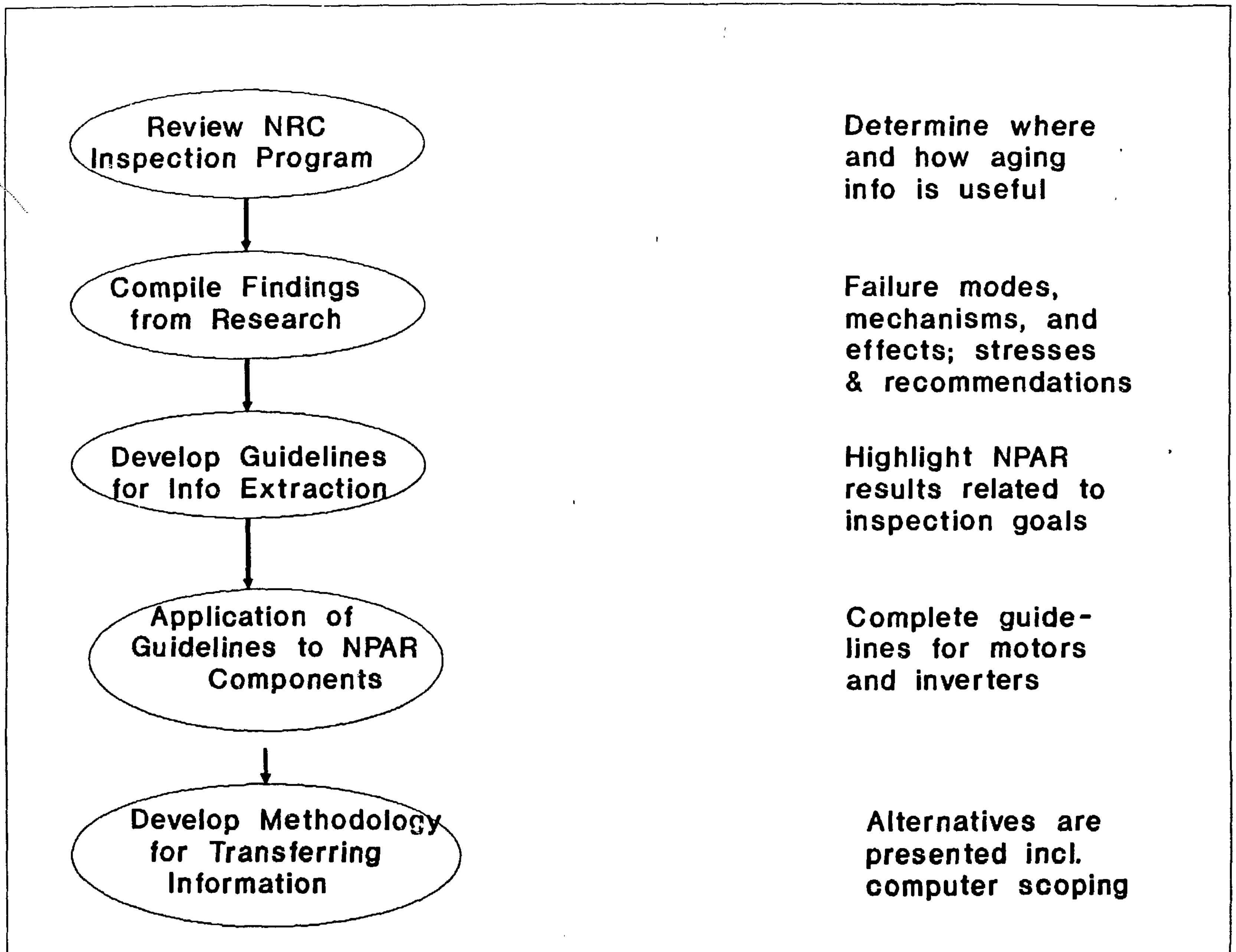

Figure 1 NPAR Information Integration Flow Chart

Inspection Guidance to Address Nuclear Power Plant Aging

The NRC Inspection Program derives its objectives from the fundamental NRC responsibility of ensuring that planned and existing licensed operation of a nuclear power plant can be and are being conducted without undue risk to the public. The Inspection Program objectives include the following[2]:

a. Identify conditions which may adversely affect public safety in order that appropriate corrective action can be taken

b. Determine the level of effectiveness of licensee performance.

c. Determine the status of compliance with NRC regulations and orders.

Through the use of inspection procedures, guidance is provided to inspectors in a variety of functional areas including Operations, Maintenance, Surveillance, and Modifications. Inspectors include Resident Inspectors, as well as other NRC personnel who may assist in specialized or team inspections.

Chapter 2515 of the NRC Inspection Manual was reviewed to determine areas of emphasis, and to ascertain where aging information could improve the inspection goals. It should be recognized that the utilities and the NRC require routine inspections with emphasis on monitoring, surveillance, detection, and preventive maintenance to assure that nuclear plants are operated safely. These provide potential indications of age related degradation.[4]

The NRC, through the regional offices, performs independent inspection of equipment and systems, as well as audits of each plant's inspection program and results. If necessary, augmented inspection teams are sent to a plant to resolve special issues and problems.

The NRC Inspection Program emphasis is on evaluating the performance of licensees by focusing on requirements and standards associated with administrative, managerial, engineering, and operational aspects of licensee activities. The Program recognizes that licensees may satisfy NRC requirements differently, and therefore expresses inspection guidance in the form of performance objectives and evaluation criteria.

NPAR Information Relevant to Inspections

The NPAR Program can provide information to the Inspection Program to help guide the regional inspection activities in areas relevant to aging, aging detection, and mitigation of aging degradation. This work can provide guidance to NRC inspectors on equipment which is aging sensitive by identifying specific modes and mechanisms of age-related failures.

The types of information generated by NPAR which were found to be relevant to inspection needs include the following:

- functional indicators - NPAR reports identify parameters which can be monitored or measured to detect aging degradation. The inspector can apply these results to enhance visual inspections (walkdowns) and to evaluate licensee programs for assuring equipment and system operability.

- failure modes, causes, effects - operating experience data evaluated in NPAR studies can alert the inspector to prevalent system and equipment failure mechanism. The potential for failure rate changes with plant age is an NPAR output of interest to the inspector in evaluating preventive maintenance resources.

- stresses which cause degradation - an inspector can benefit from knowing the environmental and operational stresses which cause aging degradation.

- maintenance recommendations - the inspector is required to evaluate aspects of a licensee's maintenance program for a number of different inspections, including special team inspections. Each NPAR report contains a review of current maintenance practices, a summary of vendor-recommended maintenance, and recommendations for preventive and corrective maintenance which can be used to detect and mitigate the effects of aging.

- inspection prioritization - based on the failure rate determined through a detailed operating experience review and a model developed through Probabilistic Risk Assessment (PRA) techniques, NPAR system reports present the relationship between age degradation and plant risk. These results can be applied in the Inspection Program for redirecting inspection resources as the plant ages.

To further summarize where this NPAR information may be used, a matrix (Table 1) has been developed. This table shows the primary information categories applicable to the inspection areas reviewed. It should be noted, however, that the inspection procedures give the inspector a great deal of latitude to perform his responsibilities. Therefore, for any given inspection or inspector, the level of detail required may differ depending upon the specific circumstances. It therefore is recommended that as much potentially useful information as possible be made available.

NPAR INFORMATION CATEGORIES

Inspection Type (Procedure)	Background Info.	Oper. Exper.	Maint. Recom.	References
1. Safety System Functional Inspection (SSFI)	X	X	X	X
2. Safety System Outage Modification Insp. (SSOMI)	X	X		
3. Operational Safety Verification (71707)	X(b)	X	X(a)	X
4. Engineered Safety Feature System Walkdown (71710)	X(b)	X(c)	X(d)	X
5. Maintenance Inspections (62700 series)			X(d)	X(e)
6. Surveillance Inspections (61700 series)	X(f)		X(d)	

(a) NPAR functional indicators
(b) Age susceptible components and stresses
(c) Dominant failure modes and mechanisms
(d) Evaluation of current maintenance practices
(e) Industry standards and guides for various components
(f) Stresses associated with testing

Table 1 Use of NPAR Results in Inspection

Continuing work in the risk area within NPAR will provide additional information to the inspector for selecting aspects of the system for inspection which are of greatest safety significance, and will therefore result in the largest benefit. The potential exists that, based on input from the NPAR Program, inspection priorities for systems and components would change over the life of the plant. This would be due to several reasons including:

1. The aging degradation rate of some systems are high. Therefore, the licensee must allocate additional resources as the system ages in order to maintain acceptable safety and availability. The resources would likely be in the areas of maintenance and testing. The Inspection Program should be capable of verifying that these resources are adequate.

2. For systems which do not experience significant aging degradation, the inspection priority may remain the same or decrease as the plant ages. Other priority selection techniques, such as PRA, would remain viable.

3. Within a system, components age differently and therefore, the impact of a component on system availability will change over the life of the plant. The selection of major components for inspection within the system could be altered based on input from NPAR.

Figure 2 illustrates conceptually how inspection priorities could change based on the influence of equipment aging.

Three types of systems are illustrated. The first is the Reactor Protection System (RPS) representing an important safety related system which may not exhibit substantial degradation due to aging. The inspection activities associated with this type of system are assumed to be of high priority early in plant life, and despite minimal aging degradation expected due to the nature of the equipment (electronics), would continue to demand a high priority on inspection resources throughout plant life. This influence is strictly due to the importance of the system on plant risk.

A second type of system operates in a standby mode, i.e., Low Pressure Coolant Injection (LPCI) in a BWR. Because of its safety significance and the importance of properly aligning the system to assure automatic operation as required, the inspection priority will initially be high. This is influenced by the need to evaluate the licensee's capabilities to safely operate the facility by reviewing the operating procedures, operator training, and surveillance testing associated with the system. On the other hand, as NRC confidence is gained in the licensee's abilities, and it can be shown that this standby system experiences minimal degradation due to aging, it is conceivable that inspection resources dedicated to this type of system could decrease over the plant's operating life.

The continuously operating system is the third type of system considered in Figure 3, i.e., the Component Cooling Water (CCW) System in a PWR. A significant aging rate has been modeled for this type of system due to the continuous mode of operation, particularly for active components such as pumps, valves, and instrumentation. Despite having a low inspection priority early in plant life due to redundancy and system simplicity, an increase in inspection priority could be justified based on the deleterious effects of aging on system reliability and availability. The ability of the NRC Inspection Program to verify that licensee maintenance effectively manages the effects of aging to offset potential plant risk increase is of paramount importance.

Figure 3 illustrates that within a system, component importance can change with plant life due to the effects of aging. From the NPAR phase 1 CCW work a model was developed which incorporated failure rates for pumps, valves, and the exchangers based on actual operating experience data[5]. When plotted over the 40 year life of the plant, it was observed that the importance of pump operation to CCW availability became dominant. This type of information could therefore assist the inspector in determining priorities for a system inspection.

CONCLUSIONS

It is concluded, based on the review of inspection procedures, that the NPAR data base can assist the inspector in focusing his activities on those components and systems most likely to affect plant safety as the plant ages. In addition, the NPAR data and research results can provide the inspector with criteria for determining the validity of findings and the completeness of licensee responses. Evaluating a licensee's administrative programs is another area where NPAR results can provide a reference, especially those reviews associated with operations, maintenance, and testing.

NPAR generated information which has a direct relationship with NRC Inspection Program requirements are:

- functional indicators
- failure modes, causes, and effects
- degradation causing stresses
- maintenance recommendations
- component and system risk impact as a function of time.

Examples of inspection procedures reviewed which could benefit from one or more of those NPAR results are:

- 71707, Operational Safety Verification
- 71710, Engineered Safety Feature System Walkdown
- 62700 series, Maintenance Program Inspections
- 61700 series, Surveillance Program Inspections
- Safety System Functional Inspection (SSFI)
- Safety System Outage Modification Inspection (SSOMI)

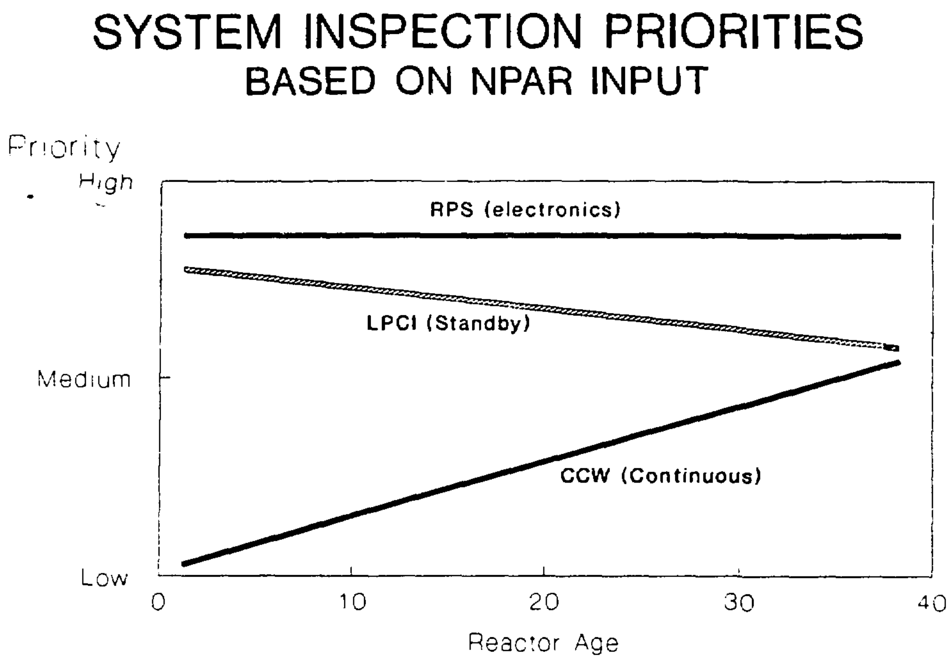

Figure 2 Potential Prioritization of System Inspections Based on NPAR Input

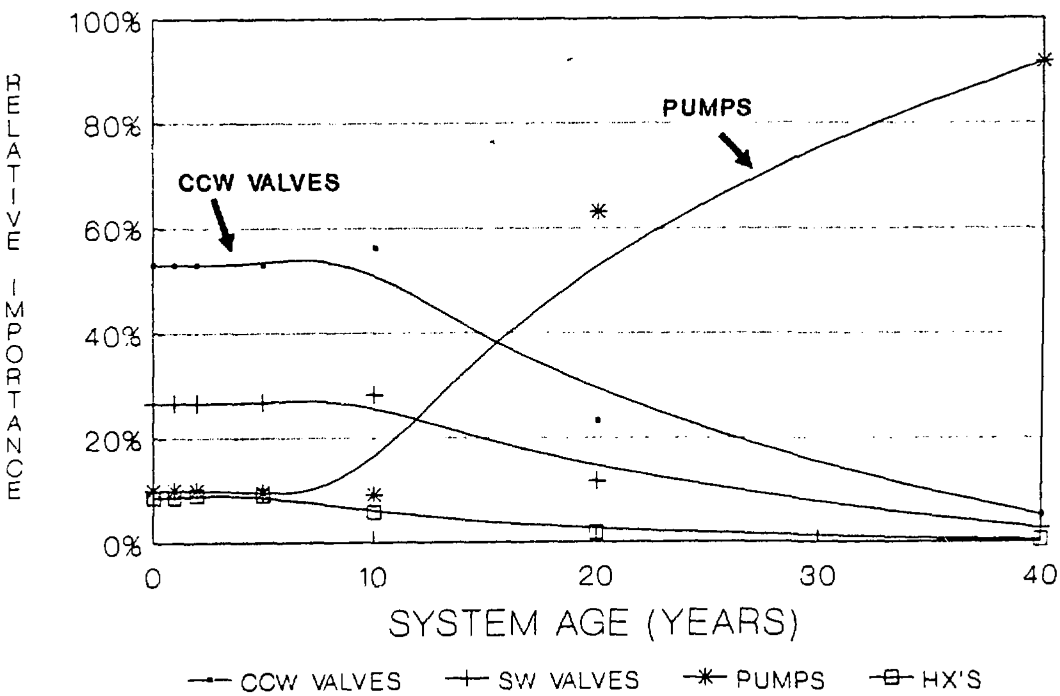

Figure 3 Inspection Importance of Components Within a System

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3. NRC Inspection Manual, "Policy and Guidance for Development of NRC Inspection Manual Programs" Chapter 0030, 10/13/87.

4. Prepared Testimony Submitted by Lando N. Zech, Jr. to the Subcommittee on Energy and Power of the US House of Representatives, 11/10/87.

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