1. Introduction

As part of the AMR results presented in Tables 3.x.2-y of recently completed license renewal applications, comparisons to the generic AMR results of NUREG-1801 were performed and documented in the last three columns of the tables. The comparisons of the plant to NUREG-1801 AMR results have been hampered by the differences in the format and content of the results presentations. The number of individual items of the plant AMR results that had a direct match to the NUREG-1801 AMR results was low, particularly for the non-class 1 mechanical systems.

This document proposes changes to NUREG-1801 in the format and content of the AMR results tables presented in Volume 2. The objective of the proposed changes is to increase the number of direct matches between the AMR results of future plant license renewal applications and NUREG-1801 which should reduce the NRC review time required for the applications.

2. Overview of Changes

Several changes are proposed to achieve the objective. The changes proposed vary for different chapters of the NUREG, depending on the suitability of the current tables for comparisons. The types of changes proposed for the NUREG-1801, Volume 2 tables, are described below.

ESF, Auxiliary, and Steam and Power Conversion Systems, Chapters V, VII and VIII

Comparisons of the non-class 1 mechanical system AMR results are the most difficult. These systems include the majority of the components evaluated and the broadest range of material and environment combinations. The corresponding NUREG tables address many (but by no means all) components but contain relatively few material and environment combinations for those components. Proposed changes to the non-class 1 mechanical systems tables include:

- Restructuring the NUREG tables to maximize the use of the AMR results currently presented in the tables (see Section 3).
- Adding material, environment, aging effect and program (MEAP) combinations established by precedents from earlier applications (see Section 4).

The proposed changes to the Volume 2 tables for ESF systems, auxiliary systems and steam and power conversion systems are presented in Attachments 2, 3 and 4 respectively.

Reactor Vessel, Internals, and Reactor Coolant System, Chapter IV

The NUREG tables for reactor vessels and internals include significantly more detail than the non-class 1 tables. The tables for the reactor coolant system and steam generators are less detailed than the vessel and internals tables but are still more suitable for comparisons than the non-class 1 system tables. Proposed changes to the NUREG Chapter IV tables include:

- Simplifying the materials and environments descriptions in the vessel and internals tables (see Sections 3.3 and 3.4)
- Restructuring the reactor coolant system and steam generator tables to maximize the use of the AMR results currently presented in the tables (see Section 3).
- Adding MEAP combinations established by precedents to all Chapter IV tables(see Section 4).

The proposed changes to the Volume 2 tables for the reactor vessel, internals and reactor coolant system are presented in Attachment 1.

Containment Structures, and Structures and Component Supports, Chapters II and III

The comparison of structural AMR results has been much better than the mechanical comparisons, primarily because the focus of the structural reviews is more on commodities than on specific components. Although the structural tables in NUREG-1801 can be awkward to use, with criteria for different materials and environments combined in the aging management programs column, the tables generally permit comparisons: however, the NUREG should address a broader range of materials. Proposed changes to the NUREG Chapters II and III tables include:

- Adding MEAP combinations established by precedents (see Section 4).

The table of MEAP combinations to be added to the Volume 2 tables for the containment structures, and structures and component supports, are presented in Attachment 5.

Electrical Components, Chapter VI

Like structures, the electrical reviews are primarily commodity based and comparisons of AMR results are generally acceptable. Additional materials should also be added to the NUREG electrical tables. Proposed changes to the NUREG Chapter VI tables include:

- Adding MEAP combinations established by precedents (see Section 4).

The table of MEAP combinations to be added to the Volume 2 tables for the electrical systems are presented in Attachment 6.

3. Restructuring of NUREG-1801 AMR Results

Throughout this document, the term “aging management review results,” “AMR results” or simply “results,” refers to a line from a NUREG-1801 table or license renewal application table identifying a component, material, environment, aging effect and aging management program. The line of information represents the conclusion that, for a given combination of component, material and environment, the identified aging effect can occur, and that the effect can be managed by the identified aging management program(s).

For the NUREG-1801 AMR results of the mechanical systems, other than the reactor vessel and internals, various materials, a range of environmental conditions, and an aging effect with a variety of aging mechanisms are typically listed in their respective columns for a given component. In some cases (e.g., heat exchangers), multiple materials exposed to multiple environments and an aging effect with a variety of mechanisms are listed for a single component with a single applicable aging management program.

This type of descriptive detail makes sense for the presentation of AMR results for generic PWRs and BWRs, since it demonstrates that typical plant equipment, major materials and representative environments were considered. However, it does not lend itself to a direct comparison with the AMR results of a specific plant. Plant AMR results are generally presented for component types with a single material exposed to a single environment. Making a match with the NUREG-1801 results (assuming the aging effects and programs match) frequently requires assumptions and interpretations of the NUREG-1801 results.

Many of these problems could be eliminated by restructuring the NUREG-1801 AMR results. The restructuring would align the results more closely with those presented in the standard license renewal application format.

3.1 Proposed Restructuring

The restructuring of the NUREG-1801 mechanical systems tables is not intended to alter the generic AMR results. The intent is to clarify those results and extend their applicability to a broader range of equipment to permit better comparisons to the results found in a typical plant AMR. Some new technical criteria, such as temperature thresholds for aging effects in common use by the industry, are added to further clarify applicability of the results. The bases for these new criteria are provided as part of the documentation for the proposed changes.

The restructuring documentation for the proposed changes is in Attachments 1, 2, 3 and 4, for the RCS, ESF, auxiliary, and steam and power conversion systems respectively. Each of these attachments includes the following four subsections:

Subsection 1) Table Changes

In the Table Changes section, each row of the NUREG-1801 system tables has been rewritten into one or more rows with changes to the components, materials, environment and aging effects to simplify and standardize their presentation. In the modified tables, the shaded rows are from the existing NUREG-1801 table; the un-shaded row(s) beneath each shaded row is a standardized presentation that maintains the essential information of the AMR result. The changes to the components, materials, environment and aging effects are described in more detail in Sections 3.2 through 3.5 below. Where the proposed change may include a new technical criterion, a hyperlink (in blue text once per system) leads to the bases for the criterion in the second subsection. Additional explanation or commentary on the interpretation of a given line of the tables is provided as a comment in the Word document.

In the first column of the un-shaded rows is a link to the corresponding row of the fourth subsection. See the discussion on Combined Restructured Tables for an explanation of this link.

As described in Section 2, the reactor vessel and internals tables in the RCS tables have not received the full restructuring. Changes to the materials and environments have been made. In a few cases, where the result is consistent with other RCS systems, changes to the components have been made and a link to the Combined Restructured Tables is provided in the first column.

Subsection 2) Bases Information for Table Changes

This subsection provides supporting information for the changes in the first (Table Changes) subsection. This subsection is identical in Attachments 1, 2, 3 and 4. The content of this subsection is described further in Sections 3.3, 3.4 and 3.5.

Subsection 3) Tables Restructured by Systems

The third subsection shows the restructured tables as they could appear in the revised NUREG. These tables were generated by copying the entire Table Changes subsection, deleting the original shaded rows, sorting the rewritten rows within each system table, and eliminating the duplicate rows. The resulting rows represent all the unique AMR results presented in the original NUREG for the respective system.

Since this subsection is proposed to be incorporated into the revised NUREG, the table of additional MEAP combinations, described further in Section 4, is also included in this subsection.

Subsection 4) Combined Restructured Tables

The forth subsection is a combination of the rewritten results of all the restructured tables within the system group. As with the system tables, the rows were sorted and duplicate rows were eliminated. The first column of this table contains the line number used for the links from the other subsections. The second column contains the item number(s) from the row(s) of the original NUREG tables in which the corresponding rewritten row is used.

This subsection was used as a tool to help provide consistency between similar AMR results from different systems. By combining and sorting the rows, minor differences in the presentation of results, that did not affect the conclusions of the result, were identified and eliminated. For some common results, such as those associated with fatigue, this section was used to compile a list of all similarly affected materials, so the same complete list could be used wherever the result occurred. This subsection also provides a useful list of all rows that would be affected if a change needs to be made to a rewritten row. Once the table changes have been accepted, this subsection may be deleted.

3.2 Generalize Component Descriptions

NUREG-1801 identifies aging management review results for many system components. Some components are identified in general terms while others are very specifically described. While the NUREG AMR results for a system identify a cross-section of typical components, many of the components that must be included for the corresponding system in the AMR results of a plant LRA are not addressed in the NUREG. To extend the NUREG-1801 AMR results to a broader range of plant components, the component descriptions have been generalized as much as possible while still retaining enough information to support the conclusions of the AMR results. Determining how much information is required for a component column entry, requires a subjective evaluation of the entire AMR result.

The occurrence of an aging effect in plant equipment (resulting from one or more aging mechanisms) is dependent on a variety of characteristics of the equipment and its environment. These characteristics include the material of equipment construction, the equipment configuration with respect to its environment and adjacent equipment, the chemistry of the environment, the temperature of the equipment and environment, the relative motion between the equipment and the environment or adjacent equipment, and the history of those conditions that are time dependent (operating conditions). Ideally, for the presentation of AMR results, the combined information in the component, material and environment columns of a line identifies the various characteristics that can lead to the identified aging mechanism. Realistically, some of the characteristics are implied. For example, the high flow rates leading to flow accelerated corrosion are implied by identifying the component as a main steam line.

The interdependence of the component, material and environment information requires that all three aspects of the AMR result be considered and restated together. The goal in restating the component, material and environment of each AMR result was to maintain enough combined information to permit an individual with a reasonable background in plant systems and material aging effects to understand the conclusions of the AMR result (similar to the background requirement for understanding the current NUREG AMR results).

The level of information detail (and thus, the level of specificity of the component description) required to support a result, depends on the complexity of the characteristics required to produce an aging effect. For example, on the simple end of the spectrum, carbon steel in treated water is subject to loss of material by the three relevant aging mechanisms of general, pitting and crevice

corrosion. General and pitting corrosion apply to the component surface regardless of configuration, and because of the ubiquitous nature of crevices in plant mechanical equipment, essentially all components are assumed to have them. Nothing more than the material and the environment is required to support the aging effect. Consequently, the component description can be completely general.

By contrast, some AMR results apply only to a specific component. For example, the steam generator feedwater impingement plate and support of a recirculating steam generator is subject to the relatively rare aging effect of erosion. This AMR result is most easily defined by reference to the specific component configuration so no generalization is warranted.

Between these two extremes, the example of main steam lines subject to flow accelerated corrosion demonstrates how the component description can be generalized without losing the essential characteristic necessary to support the AMR result. By describing the component as "general piping and components with high local flow rates," the AMR result remains consistent with the original NUREG result, and can be made applicable to all components subject to high local flow rates.

In summary, the justification, or bases, for generalizing the component descriptions is that the restated description, together with the restated material and environment maintain (and in many cases improve) the level of information needed to support the conclusions of the AMR results. The restated component descriptions, materials and environments were derived by a subjective evaluation that can best be validated by an independent (NRC) review.

3.3 Consolidate Materials

Materials are listed in various ways in NUREG-1801. In most cases, general material types (e.g., stainless steel, carbon steel, nickel alloy) are used, while in others (e.g., reactor vessels and some vendor internals), specific types of steel are identified. For some results, multiple general material types are listed together.

As discussed in the preceding section on component descriptions, the material column entry was restated such that the combined information of the component, material and environment columns supported the conclusions of the AMR results. The restatement of materials information was based on the following considerations.

General material types should be used instead of specific types, unless the specific material has a unique aging effect or requires the use of a different aging management program. The replacement of specific types with general types was done extensively for the reactor vessel and internals tables (not otherwise part of the restructuring process as discussed in Section 2), for a few results in the remaining RCS tables, and for the cranes table in auxiliary systems.

Attachments 1, 2, 3 and 4, which document the restructured tables, include a list of general material types that encompass most materials used at typical plants. The list does not include all the unique materials (e.g., ferritic stainless steel) that could appear in a license renewal application. The list provides a brief description of the materials included in the general material type. Where the basis for the grouping is not self explanatory, additional explanation and references are provided. The general material types which replaced specific material types were selected from this list.

The general material types were determined on the basis of a common susceptibility to aging effects and mechanisms, shared with the specific material types replaced. For example, the

specific material types listed in the first row of the reactor vessel table, A1, are SA302-Gr B, SA533-Gr B and SA336. Respectively, these materials are manganese-molybdenum alloy steel, carbon steel, and chromium-molybdenum alloy steel. The carbon steel and both the alloy steels are characterized as carbon steel because they are susceptible to general, pitting and crevice corrosion in a wetted (reactor coolant) environment, a common aging susceptibility for carbon steel found throughout the NUREG. Within the NUREG, references to these specific material types refer to other aging susceptibilities consistent with carbon steel (e.g., loss of material due to boric acid corrosion, fatigue, neutron embrittlement and wear). Therefore, these specific material types are considered carbon steel, and the description of carbon steel in the materials list in the attachments mentions alloy steels as a part of the general material type.

Additionally, each specific material type was confirmed to be a part of the general material type (as defined in the materials list) that replaced it. Common material specification references were used for this confirmation (e.g., References 5 and 6 of the bases information sections of Attachments 1 through 4).

The general material types encompass a larger set of specific material types than those identified in the NUREG results. This expanded applicability of the NUREG results is acceptable because the AMR results would apply equally to these different material types. The components addressed in these AMR results have complex design requirements that place limitations on the specifications for the materials of construction. Consequently, the different material types would have properties similar to those of the material types in the NUREG results, and the susceptibility to aging effects for the different material types would not be significantly different from the material types in the NUREG results. Thus, the identified aging effects would be equally applicable to the different material types, and the aging management programs, which are not sensitive to minor quantitative changes in rates of material aging susceptibility, would adequately manage the aging effects for the different material types.

Composite materials (e.g., carbon steel clad with stainless steel) should not be included in the list unless the aging effect, such as fatigue, would apply to the composite material. Otherwise, each material of a composite should be evaluated separately with its respective environment. For example, a carbon steel tank with stainless cladding containing borated water should be evaluated as stainless steel in borated water, and carbon steel in air. The restatement of some NUREG AMR results that included carbon (or low alloy) steel clad with stainless, addressed only the stainless portion since the environment and the aging management program were not applicable to the carbon steel portion. In these cases, the AMR results for exterior carbon steel surfaces (located elsewhere in the tables) address the balance of the component material.

Multiple materials may be listed in a single entry provided the aging effect, including the aging mechanisms, and program are the same for all materials. Many NUREG AMR results with multiple listed materials, were divided into two or more rows to clarify which aging effects, aging mechanisms and aging management programs applied to which materials.

3.4 Use Consistent Environments

The environments listed in NUREG-1801 describe those typically found in the systems being reviewed. The level of detail of the environments varies widely from system to system. Multiple environments are given for some AMR results.

As discussed in the section on component descriptions, the environment column entry was restated such that the combined information of the component, material and environment columns supported the conclusions of the AMR results. The environments were revised to identify the

pertinent aspects of the environment that influence the aging effects applicable to the material. The restated environments identify the general chemical content (e.g., treated borated water) and if necessary, a temperature range that determines the applicability of aging effects.

Only one environment is used in each restated result. Where multiple environments need to be addressed, separate results lines were provided.

Attachments 1, 2, 3 and 4, which document the restructured tables, include a table of environments that characterize most plant system and structure environments. The table includes a brief description of the environments.

3.5 Simplify Aging Effects

NUREG-1801 lists aging effects along with one or more aging mechanisms. The aging mechanisms, while useful to describe the considerations used in the generic aging management review, are generally not useful when comparing the plant AMR results to the NUREG-1801 results. Although aging mechanisms are considered during the plant AMR, the results are reported in terms of aging effects. The suitability of an aging management program is determined primarily on its ability to detect or prevent the overall aging effect rather than the individual aging mechanism.

An aging mechanism should be used to qualify an aging effect only where the particular mechanism affects the selection of the aging management program for a given component. For example, loss of material may be managed by a water chemistry program, while loss of material due to flow accelerated corrosion requires a separate program. Aging mechanisms in the proposed changes have been reduced to those necessary to support the choice of aging management program.

Attachments 1, 2, 3 and 4, which document the restructured tables, include a table of aging effect terms different from those previously used in NUREG-1801. The table includes a brief description of the new aging effect terms.

4. Additional MEAP Combinations

In addition to the restructuring of the mechanical systems tables, all of the NUREG-1801 tables would benefit from the addition of MEAP combinations that are common to most applications, including those that have already been reviewed. Of particular interest are those with different materials or environments than those currently in NUREG-1801. The AMR process requires plants to evaluate such combinations whether they are included in NUREG-1801 or not. Inclusion in the restructured tables would increase the number of matches between the plant and NUREG-1801 AMR results and shorten the review time. The additional MEAP combinations applicable to a system or structure group are included in a table in the corresponding attachment. Other MEAP combinations may be submitted later to supplement these preliminary lists.

5. Further Considerations

The proposed restructuring and additional MEAP combinations will increase the number of direct matches between the AMR results of future plant license renewal applications and NUREG-1801. It is important to remember however, that, even with these changes, NUREG-1801 remains a generic presentation of aging management review results. It by no means addresses all the possible combinations of component, material, environment and aging effect that must be considered in an actual plant aging management review. Nor does the presentation of an AMR

result in NUREG-1801 assure that it is completely applicable in all circumstances. The applicant must be aware of the generic nature of NUREG-1801 and its limitations. The applicant has the responsibility to perform a complete and accurate aging management review and to identify differences with NUREG-1801 where appropriate. This observation may warrant a note in the introduction to NUREG-1801.