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BWR NSSS DESIGN BASIS DOCUMENTATION

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ABSTRACT

In 1985 an incident at Toledo Edison's Davis Besse plant caused the U.S. Nuclear Regulatory Commission (NRC) to re-evaluate the technical information that the utilities had readily available to support the design of their plants. The Design Basis programs, currently on going in most U.S. utilities, have been the nuclear industry's response to the needs identified by this re-evaluation. In order to understand the Design Basis programs which have been implemented by the U.S. nuclear utilities, it is necessary to understand the problem as it was perceived by the nuclear industry (the utilities, the original NSSS designers and the regulators) after the Davis-Besse incident, the subsequent programs undertaken by the industry under the leadership of INPO and NUMARC, the NRC's actions, and the overall evolution of the industry's vision in relation to this problem.

This paper presents the history of the design basis efforts from the first recognition of the problem by the NRC after the Davis-Besse incident, describes the actions taken by the NRC, INPO, NUMARC, the U.S. utilities and the NSSS designers, and brings the problem statement up-to-date in relation to the vision presently held by the U.S. nuclear industry. It then presents a technical discussion to develop a detailed definition of design basis information to support the problem statement. The information originally supplied by the NSSS designers during the plant design and construction is discussed as well as its relationship to the previously defined design basis information. This section of the paper concludes by defining the additional information needed by nuclear utilities to satisfy the requirements developed from the problem statement.

Having developed a definition of the additional information (i.e., information not originally supplied during design and construction) required to solve the design basis problem as it is presently perceived by the U.S. nuclear industry, the paper then discusses design basis programs that GE has participated in and describes the different options and approaches that have been used by various utilities in their design basis programs. Some of these variations deal with the scope and depth of coverage of the information, while others are related to the process (how the work is done). Both of these topics can have a significant effect on the program cost. Some insight into these effects is provided.

The final section of the paper presents a set of lessons learned and a recommendation for an optimum approach to a design basis information program. The lessons learned reflect the knowledge that GE has gained by participating in design basis programs with nineteen domestic and international BWR owner/operators. The optimum approach described in this paper is GE's attempt to define a set of information and a work process for a utility/GE NSSS Design Basis Information program that will maximize the cost effectiveness of the program for the utility.

INTRODUCTION

The Davis Besse incident in 1985 resulted in the development of an awareness that the owner/operators of US. nuclear plants needed additional information relating to the NSSS design if they were going to take ownership of the plant design. The following sections of this paper will explain in detail what the situation was, what the industry has done about it, and will provide some recommendations relating to design basis programs.

INDUSTRY RECOGNITION OF UTILITY DESIGN BASIS INFORMATION NEEDS

The Davis Besse incident occurred in 1985 at Toledo Edison's Davis Besse Plant. The plant lost both feedwater and auxiliary feedwater systems while the plant was operating at over 90% power.

The plant operating staff did an excellent job and managed to shut the plant down without damage to the steam generators. When the NRC investigated the incident, there were several findings, two of which provided significant concern to the NRC. The first finding was that both systems had been modified over the operating life of the plant such that they no longer met their original design bases. The second finding was that the periodic surveillance testing of the systems did not disclose that they no longer met their design basis.

As a result of these two findings, the NRC created two new inspection programs (Safety System functional Inspections [SSFIs] and Safety System Outage Modification Inspections [SSOMIs]) which were designed to determine whether there were similar problems at other nuclear plants. The results of these inspections in 1986 and 1987 confirmed the NRC's concerns. They found that design basis information to support the as-configured system design and proposed plant modifications was often not available. As a result of this lack of design basis information, the NRC found, in some instances, plant modifications being made that potentially jeopardized the ability of safety systems to perform their intended safety function due to the lack of a full understanding of the original system design requirements by utility personnel.

These findings reinforced the original NRC opinion that the nuclear plant owner/operator needed more information. These results also alerted the rest of the industry to the problem. The utilities began to review their design documentation to evaluate what information they had and the organization and retrievability of it. These reviews led to conversations with the original plant design organizations (NSSS and BOP) in an attempt to define what information the utilities really needed. The following section of this paper presents a discussion of what really constitutes design basis information.

INDUSTRY VISION OF DESIGN BASIS INFORMATION

Any design process develops a hierarchy of requirements. The overall plant requirements become implemented by doing engineering work to develop system requirements, which in turn are implemented by doing engineering work which results in component requirements, etc. Each set of engineering work is usually documented in design output documents (engineering drawings, specifications, or design reports).

In the NSSS design area the NSSS vendors turned over to the utilities most of the design documentation they created at the system level. However since the design work usually involved proprietary methods or technical knowledge, very little of the design inputs or design work itself was transferred to the utility. Thus, the utilities received the product of the work but not the work itself or the requirements/assumptions on which the work was based. This set of information the inputs to the design and the design work has come to be recognized as the "Basis for the Design", more commonly called the "design basis".

One of the points that should be understood is that, while most of the design basis for the NSSS design was retained by the NSSS designers, the situation in the BOP design area was different. Since the BOP design usually did not involve proprietary methods or technical knowledge, much of the basis for the BOP design was provided to the utilities along with the design output documents. Thus, the design basis programs for BOP design are often very different from those related to the NSSS design.

INDUSTRY AND REGULATORY EFFORTS

Since the utility Design Basis Information (DBI) programs first began in 1986, a number of industry and regulatory programs and actions have been implemented to define, quantify or expedite these DBI programs. The following paragraphs describe the major actions/programs.

INPO/SPAC Design Basis Committee

The first industry effort related to Design Basis Information was initiated and sponsored by INPO in January 1988. INPO's Supplier Participant Advisory Committee (SPAC) is made up of the major nuclear designers, both NSSS and BOP, and major equipment suppliers. These organizations are all members of INPO and the committee (SAPC) comprised of their representatives acts as an advisor to INPO on technical issues. In the case of design basis information, INPO approached the SPAC and asked whether it could form a working group to look at the design basis problem and provide some recommendations to the utilities. A subcommittee formed under SPAC produced a set of program recommendations and a topical outline for a system design basis document. These recommendations were eventually folded into an INPO report on design basis which was eventually merged into the NUMARC guidance document.

NUMARC Design Basis Issues Working Group

Following the INPO/SPAC effort in 1988, INPO did a survey of its member utilities to determine what DBI actions they had taken. INPO intended to combine this information with the INPO/SPAC guidance and issue it as an INPO report on design basis. However, before this report was formally issued NUMARC formed a working group to look at the design basis problem. This group which began work in 1989 eventually decided to issue a guidance document and incorporate the INPO work into it. The NUMARC document, Design Basis Program Guidelines, was issued in October 1990.

NRC Design Basis Actions

Beginning with the concerns caused by the Davis-Besse incident in 1985, which were confirmed by the results of the Safety System Functional and the Safety System Outage Modification Inspections, the NRC has displayed an increasing concern that the utilities do not have documented, readily retrievable design bases in their possession. After enunciating their concerns in several industry meetings, in 1989 the NRC decided to initiate a design documentation study that resulted in the publication of NUREG-1397, An Assessment of Design Control Practices and Design Reconstitution Programs in the Nuclear Power Industry. This NUREG was published in February 1991.

In August 1992, the NRC issued a policy statement on the "Availability and Adequacy of Design Basis Information at Nuclear Power Plants." This policy statement emphasized that maintaining current and accessible design documentation (including design bases) is important to ensure that:

- Plant physical and functional characteristics are maintained and are consistent with the design bases as required by NRC regulations.
- Plant systems, structures and components can perform their intended functions.
- The plant is operated in a manner consistent with its design bases.

All of this continuing effort over a period of several years emphasizes the importance that the utilities and the NRC place on this industry concern.

GE SUPPORT OF CUSTOMER DESIGN BASIS PROGRAMS

GE has done Design Basis Document (DBD) work for 19 utilities to date. Several of these programs are still in progress. GE's practice with these programs has been to provide an information scope and format dictated by the customer. The result has been a wide variation in the scope and format of the information presented. Some typical variations are as follows:

- Organize the information the customer already has. (This results primarily in a plant configuration and requirements document with little basis content).
- Provide a design basis document on the system level (primarily requirements and their associated bases) through commercial operation.

- Provide a design basis document that covers both system and component requirements/basis through commercial operation.

- Provide one of the two proceeding options (B or C) for the as-built configuration of the plant.

- In addition to the standard information, identify margins in system and component performance parameters.

- Also summarize utilities' licensing commitments and cross reference the DBD to identify information relating to them.

- In addition to providing a design basis document, review the plant FSAR and TECH SPECS for agreement with the DBD and resolve discrepancies.

- Search customers record systems and identify and index all records related to the system even if they are not relevant to the DBD.

As can be seen from the preceding listing of scope/information options, there is a wide variance in DBD content from utility to utility. There is also a lot of plant configuration information included in these documents that does not significantly contribute to the resolution of the original concern, which was to provide insight or support for the plant design documentation such that the utility understood the design intent and how the design was originally created.

OPTIMUM APPROACH

As can be seen from the foregoing material, there are many considerations to be weighed when starting a DBD program. This final section of this paper is GE's attempt to incorporate our "lessons learned" into an optimum program.

The first consideration is to decide what utility problem or problems the information in the DBD is intended to solve. GE believes that the utilities need a set of supporting information for the plant/system design documentation that was originally provided. This supporting information would summarize the original design inputs and design work to provide insight into the original design intent and the major design decisions. This view is consistent with the NRC's vision. If this vision is accepted, the DBD program and content become relatively focused and could be summarized as follows:

DBD Program

1. A writers' guide should be developed that concentrates on the design inputs and the design work that were germane to the functional requirements and design features. This is the point in the process where the utility needs to determine what additional information (plant configuration, licensing, etc.) they want in their DBD's.

2. A DBD that concentrates on the design requirements and the supporting basis will not require a lot of utility documentation (i.e. drawings, specs). Most of the relevant reference material will be in the original designers' records. The utility should plan to provide copies of any utility documentation that may be needed by the DBD preparers.

3. In order to update the DBD so that it is correct for the plant "as built" design, the modification that have been made since plant turn over need to be evaluated to assure that they have not inadvertently degraded the design capability of the system, structure, or component, and that the basis has not been deliberately changed by redesign activity. This activity can be handled as part of the original basis program or as a subsequent activity.

4. The various utility users should be involved in the original planning so that they understand what is driving the program and what kind of problems it is designed to solve.

5. One or two systems should be picked as pilot systems and DBDs completed for them to "test run" the writers guide and the process.

6. The process for the NSSS, BOP and Topical DBD will be different. Don't try to do them the same way.

7. Once the writers' guide is completed, a kickoff meeting should be held at the start of each DBD. This kickoff meeting should include both the utility and the NSSS designers technical personnel who will be involved in preparing the DBD and should result in mutual understanding of:

   - Writers guide requirements
   - Format and depth of coverage
   - System boundaries and interfaces
   - System modes of operation to be covered
   - List of components to be covered
   - Technical and Administrative contacts
   - How project in-process reviews will be handled
   - Progress Reporting
   - Schedules and milestones

8. During the preparation of the pilot DBD's, at least one meeting should be scheduled between the two technical groups (utility/NSSS) to review progress and completed draft material.

9. After the draft is complete, one utility review and comment wresolution cycle should be sufficient. When comments are resolved the document can be issued.

NSSS DBD CONTENTS

The following material provides an overview of the technical content of a DBD which is focused on the objective of providing a summary of the design inputs and the design work to support the design.

System Description

This material provides a brief description of the system and its functions. It will describe all the functional modes of operation and place them in perspective in relation to the overall NSSS design.

Safety Classification

The DBD should discuss the overall safety classification of each mode of system operation as well as providing the rationale for classification of the major system components.

System Boundaries/Interfaces

This set of material should define the electrical and mechanical boundaries and will also provide a detailed description of the functional inputs/outputs at those boundaries.

Design Inputs/Assumptions

The design inputs and designer's assumptions should be covered separately since they become the givens the design is based on.

Design Requirements/Features and Their Associated Bases

The design requirements and features covered in this section represent the output of the design work. These are the requirements or system features that the designer develops as a result of his design work and the bases for them are summaries of the design work. This set of material, along with the design inputs, provides a summary of the design activity and is the most valuable information in the DBD.

References

Much of the material in a DBD will be based on test programs, analysis, calculations, etc. The DBD should provide a crisp summary and a coherent overview. Where more detail is necessary, relevant portions of engineering documents will be provided as reference material. The DBD contents will be referenced to this additional material which will be listed in the reference section. Copies of this reference material should be provided along with the DBD.

DESIGN BASIS INFORMATION PROGRAM COST/BENEFIT

The major cost benefits attributable to a design basis program with the NSSS designer are the internal efficiencies in the utility organization which result from the acquisition of the basis. This basis typically provides/explains the input design criteria and the engineering work which resulted in a requirement or design feature. Having this information readily retrievable in the utility engineering office, will result in significant efficiencies in various engineering tasks.

There are four major categories of engineering work that having the NSSS design basis will simplify:

1. Determination of the safety classification of systems/major components
2. Completion of Safety Evaluations (50.59s) for Proposal Modifications
3. Evaluation of Plant Operational Problems
4. Evaluation of Plant Operational Practices

It is GE's opinion that the possession of a readily retrievable set of design bases for the NSSS would result in typical savings of at least 30% in the engineering hours normally expended in these tasks by a utility.

CONCLUSION

The foregoing material has been presented in an attempt to provide some insight into what the design basis concern is, what design basis information is, and what types of programs would optimize the utilities cost/benefit from a DBD program. As experience increases, we expect to see the development of a strong set of owners in the utility for this information with the consequent significant increase in the utilities technical capability.