POLICY ISSUE
(Notation Vote)

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SECY-90-377

For: The Commissioners

From: James M. Taylor
Executive Director for Operations

Subject: REQUIREMENTS FOR DESIGN CERTIFICATION UNDER 10 CFR PART 52

Purpose: To provide recommendations to the Commission regarding (1) the level of detail required for an essentially complete nuclear power plant design in an application and available for audit for design certification, and for a combined license under 10 CFR Part 52; (2) related issues such as staff review and issue finality; (3) the applicability of the industry's proposed two-tier approach to design certification; and (4) flexibility to incorporate necessary changes and technological advances while preserving standardization.

Background: On July 11, 1990, in response to several staff requirements memoranda (SRM), the staff issued for Commission consideration SECY 90-241, "Level of Detail Required for Design Certification." The SECY paper described four options regarding the level of detail to be required of an applicant for design certification. On July 18, 1990, the staff discussed SECY 90-241 with the Commission. As a result of this meeting, the Commission issued an SRM of August 22, 1990, requesting additional information and staff recommendations. The staff made SECY 90-241 available to the public, and a request for comments was published in the Federal Register. On August 9, 1990, the staff gave a presentation to the Advisory Committee on Reactor Safeguards (ACRS) concerning the level of detail required for design certification. In this paper, the staff responds to the requests in the SRM of August 22, 1990, and presents recommendations for implementing the provisions of 10 CFR Part 52.

NOTE: PAPER BEING MADE PUBLICLY AVAILABLE 11/9/90

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<u>Discussion</u>: In response to the SRM of August 22, 1990, the staff has met with the Nuclear Management Resources Council (NUMARC), nuclear steam supply system (NSSS) vendors, architectural and engineering firms, and the U. S. Department of Energy (DOE), as well as several utilities having plants that have experienced some form of standardization such as the Standard Nuclear Unit Power Plant System (SNUPPS) plants and the Palo Verde Nuclear Generating Station, Units 1, 2, and 3. The staff examined the design process in detail to determine the degree of design completion necessary for the staff to make its safety judgment (which will include safety benefits of standardization) while recognizing the limits of what is feasible and practical under the provisions of 10 CFR Part 52. This analysis is presented in Appendix A. Attachment F of Appendix A discusses the ramifications of requiring that the General Electric (GE) Advanced Boiling Water Reactor (ABWR) design be developed and certified to the level of design detail recommended herein.

From the SRM of August 22, 1990, the staff identified seven items that required discussion, each of which is presented herein.

I. Structures, systems, and components for which a level of detail equivalent to Levels 1 or 2 is not feasible or practical to achieve

II. Structures, systems, and components for which Level 1 detail is not necessary to achieve standardization

III. An approach that provides controlled flexibility while preserving standardization for the life of the facility

IV. Advantages and disadvantages of the two-tier approach and the applicability of the "ASARA" (as standard as reasonably achievable) concept

V. Analysis of public comments

VI. Description of the "standardization portion" of the review

VII. Evaluation of the standardization experience

I. STRUCTURES, SYSTEMS, AND COMPONENTS FOR WHICH A LEVEL OF DETAIL EQUIVALENT TO LEVELS 1 OR 2 IS NOT FEASIBLE OR PRACTICAL TO ACHIEVE

SECY 90-241 provided the following definitions for the degrees of standardization that can be achieved by requiring each of the four levels of design detail:

- Level 1 design detail - identical physical, functional, and performance characteristics for structures, systems, and components
- Level 2 design detail - physically similar with identical functional and performance characteristics for all structures, systems, and components affecting safety
- Level 3 design detail - identical functional and performance characteristics for all structures, systems, and components affecting safety
- Level 4 design detail - identical functional characteristics for selected safety-related and risk-significant structures, systems, and components

To determine where it is not feasible or practical to achieve Levels 1 and 2, the staff examined the design process for plants licensed under 10 CFR Part 50 and those designs currently being developed for certification under 10 CFR Part 52. The design process can be divided into four stages of development that loosely relate to the levels of detail described in SECY 90-241: (1) conceptual design complete - Level 4, (2) preliminary design complete - Level 3, (3) detailed design complete - Level 2, and (4) final design in process - greater than Level 2. As discussed in more detail in Appendix A, the staff used this information to determine the amount of design detail that could be developed by the applicant at the design certification stage for four distinct groups of systems: nuclear island, balance of nuclear island, turbine island, and site-specific systems.

To develop Level 1 design detail, the applicant must have either custom-built components or vendor nameplate data within its current capabilities. The NSSS vendor could develop a level of design detail that is close to Level 1 for the reactor vessel and certain other major components. While in very few cases design detail close to that of Level 1 can be developed, the staff believes that design detail greater than Level 2 can be achieved for several of the nuclear island systems. In addition, the staff believes the vendors could develop a design detail of Level 2 for those structures, systems, and components for the turbine island and the balance of systems in the nuclear island, except those that are site dependent.

More specifically, it is the staff's opinion that it is both practical and feasible for an applicant for design certification to develop the following levels of design detail.

Table 1 - Design Detail That Is Feasible and Practical

Greater than Level 2 (final design in process) - Nuclear Island

*Reactor (Rx) vessel	*Major NSSS-supplied components
Primary coolant system	Containment structure
Reactivity control system	Feedwater (FW) Class 2 piping
Rx protection system	Mainsteam (MS) Class 2 piping
Engineered safety features actuation system	

Level 2 (detailed design complete) - Balance of Nuclear Island

Containment spray	Chemical volume and control
Residual heat removal	Component cooling water (CCW)
Fire protection	Radioactive waste
MS (including MSIVs)	Emergency core cooling systems
Containment heat removal	Essential instrument air
Control room habitability	Spent fuel pool cooling
Diesel generator auxiliary systems	Anticipated transient without scram mitigation system
Heating, ventilation, and air-conditioning (HVAC) for the Rx and Auxiliary buildings	

Level 2 (detailed design complete) - Turbine Island

MS	Auxiliary steam
Condensate and feedwater	Turbine building (TB) cooling water
Heater drain	TB lube oil
TB HVAC	
Plant compressed air	

Level 4 (conceptual design and design interfaces complete) - Site-Specific Systems, Structures, and Components

Ultimate heat sink	Essential service water (ESW)
Circulating water	Screen wash
Traveling screens	Non-ESW
Intake structure HVAC	

* Design for these items can be developed to a level that is nearly Level 1.

In the design process, it is necessary to develop the design of some systems further to allow the design of other systems to progress. Based on this need and the ability of an applicant to develop the design, it is both feasible and practical for the design to progress as defined in the above Table 1 and in Attachment B to Appendix A. Therefore, it is possible for an applicant to complete the overall design to a level of detail that equals or exceeds Level 2, except for site-specific features. The staff believes that an applicant can achieve a high degree of design finality (approximately 85 percent) by expending approximately 50 percent of engineering hours at design certification. Such an effort would complete nearly all the engineering necessary to prepare procurement specifications. While it is technically possible to develop the design further, the additional design finality and standardization would be small when compared with the additional engineering hours expended (refer to Attachment D of Appendix A). This relationship between design finality and engineering hours is discussed more fully in Appendix A.

II. STRUCTURES, SYSTEMS, AND COMPONENTS FOR WHICH LEVEL 1 DETAIL IS NOT NECESSARY IN ORDER TO ACHIEVE STANDARDIZATION

A discussion of this item should begin with a definition of "standardization." In SECY 90-241, the staff discussed degrees of standardization ranging from physical (dimensional) to functional. As discussed in Section I, to realize identical physical, functional, and performance characteristics, an applicant must have a level of design detail such as that described as Level 1 in SECY 90-241, which requires either custom-built components or vendor nameplate data. The staff believes that the degree of standardization should be realized by requiring an applicant to reach levels of design maturity for design certification that vary between systems according to safety significance and the degree to which the design incorporates new, innovative design concepts. The staff will not require vendor nameplate data since, in most cases, such data is impractical to develop and may limit component suppliers. As discussed in Section III and Appendix A, this vendor nameplate data (achieved in the final phase of design development) is not necessary for the staff to make its safety judgment.

III. AN APPROACH THAT PROVIDES CONTROLLED FLEXIBILITY WHILE PRESERVING STANDARDIZATION FOR THE LIFE OF THE FACILITY

The staff proposes using an approach that combines regulatory processes with some dependence on economic forces to achieve and preserve standardization. As discussed in Appendix A, the design process consists of four phases: (1) conceptual, (2) preliminary, (3) detailed, and (4) final. The staff proposes the use of a graded approach to determining the level of detail the applicant must develop. A regulatory guide will be developed by the staff to define the level of detail to which the design must progress on a system-by-system basis. The applicant will be required to develop the design (1) through the conceptual phase for almost all structures, systems, and components; (2) through the detailed phase for selected structures, systems, and components in the balance of nuclear island and turbine island; and (3) for some structures, systems, and components in the nuclear island, information normally developed during the final phase should be available. The level of detail to be developed will not exceed that normally contained in procurement specifications and construction and installation specifications. Examples of the design products that could be developed are defined in more detail in Appendix A and Attachments B and C.

The design detail to be developed by an applicant for design certification can be considered in three bodies of information: (1) that submitted in the application and certified by rulemaking (Tier 1); (2) that submitted in an application and not certified (Tier 2); and (3) that available for NRC audit. An application (Tiers 1 and 2) will contain a depth of design detail similar to that of a final safety analysis report (FSAR) at the operating license (OL) stage for a recently licensed plant (1985-90), minus site-specific and as-built information. The level of detail to be developed and available for audit will be based on what is necessary for the staff to judge that the criteria set forth in Tiers 1 and 2 are satisfactorily implemented into the design. The staff proposes that a regulatory guide be developed to define for an applicant, the level of detail to be included in Tier 1, Tier 2, and the level to be available for audit.

Tier 1

Tier 1 will include information developed during the conceptual phase, such as design criteria and bases and certain information developed during the preliminary and detailed design phases, such as the following:

- System and key component descriptions
- Functional and performance requirements for plant systems
- Simplified electrical single-line diagrams
- Simplified piping and instrumentation drawings (P&IDs)
- General arrangement drawings
- Inspection, test, analysis, and acceptance criteria (ITAAC)

Typical design products that provide the information to be included in Tier 1 are further defined in Attachments B and C to Appendix A. In developing the Tier 1 requirements, the staff sought to standardize design details to the maximum extent practical, considering the procurement and design reconciliation process. Tier 1 information will be certified by the rulemaking process and will not be changed without previous NRC approval (through an amendment rulemaking, an exemption pursuant to 10 CFR 52.63, or a waiver pursuant to 10 CFR 2.758) for the life of a facility referencing a design certification. An amendment to a certified design will affect all licensees referencing the certified design. Any combined license (COL) applicant or licensee may apply for an exemption affecting that one license only. Further, a contested COL proceeding could result in a rule waiver affecting that COL. 10 CFR 52.63 requires that in its review of proposed changes to Tier 1, the NRC examine the effect on standardization and the resulting safety benefits from the change. The staff will use existing guidelines, including NUREG-CR3568 ("A Handbook for Value-Impact Assessment") and NUREG-BR0058 ("Regulatory Analysis Guidelines of the US Nuclear Regulatory Commission," Revision 1) for analyzing the safety benefits.

Tier 2

Tier 2 will include information demonstrating how Tier 1 criteria are implemented in the design and will be of sufficient detail for the staff to make its safety determination as to the adequacy of the design as described in Tier 1. 10 CFR Part 52 does not address changes to uncertified information in the application for design certification (Tier 2) between design certification and COL issuance. Because Tier 2 forms a basis for the staff's safety determination, the staff believes that Tier 2 should not undergo any changes before COL without previous NRC approval. Therefore, the staff proposes that the design certification itself require that any changes to Tier 2 information before the issuance of a COL be processed in a similar manner as Tier 1 changes (through an amendment rulemaking, an exemption, or a rule waiver pursuant to 10 CFR 2.758). 10 CFR Part 52 is not clear concerning changes to Tier 2 material during construction of a facility (after COL). 10 CFR 52.63(b)(2) invokes 10 CFR 50.59 for making changes to the uncertified portion of the application by a licensee only. Because Section 50.59 applies only to a licensee authorized to operate (see 10 CFR 52.83 and 10 CFR 50.59), 10 CFR Part 52 is best read to say that Tier 2 may be changed pursuant to 10 CFR 50.59 only after operation is permitted in accordance with 10 CFR 52.103. It is widely recognized throughout the industry that a certain amount of flexibility will be needed to finalize the design and construct the facility. To provide this flexibility, the staff proposes that a change process paralleling that of 10 CFR 50.59 be incorporated into the COL for making changes to Tier 2 information between COL issuance and operation. Changes to Tier 2 information after COL may be subject to hearing before operation if, as discussed in Section 52.103, acceptance criteria have not been met. Market forces such as the cost of redesign and the possibility for adjudication are major disincentives for changing Tier 2 design information and will help to preserve standardization. Although strong at the time of certification, the force associated with the cost of redesign will diminish over the life of the certification as technology advances.

Available for Audit

Under the staff proposal, the applicant will develop and retain a third body of information for NRC audit. As stated in 10 CFR 52.47(a)(2), that information normally contained in certain procurement specifications and construction and installation specifications will be developed and available for audit if such information is necessary for the NRC to make its safety determination. To ensure that Tier 1 and Tier 2 criteria have been properly translated into design products, the staff proposes allowing applicants for design certification and COL to develop and finalize the design in a graded approach and have this material available for audit. This body of information shall be available at the applicant's offices for staff audit. A regulatory guide will be developed to specify the information expected to be developed. Typical design products (to be developed and available for audit) that provide information such as that normally contained in procurement specifications and construction and installation specifications will be further defined in the proposed regulatory guide using insights from Attachments B and C of Appendix A. If during the audit, the staff finds a part of this material necessary to make its safety determination (about the adequacy of the design information in Tier 1), this part will be docketed in the application. No restrictions apply to changing this third body of information as long as the changes do not violate the provisions of the application and design certification (Tiers 1 and 2). Although there are no regulatory constraints on modifying this information, the high cost of redesign will deter changes and will encourage the maintenance of standardization. As discussed above, this disincentive to change will diminish with time. However, the more stringent controls over Tiers 1 and 2 will preserve a substantial degree of standardization.

It is important to note that the current SRP requires more detail for some structures, systems, and components (based on their importance to safety) in order for the staff to complete its safety review. For example, the current SRP requires more detail for nuclear island systems than for balance of plant systems. In its review of Tiers 1 and 2, the staff will not depart from this concept of safety significance. Consistent with this concept, the graded approach for the design detail available for audit will result in more design detail for some structures, systems, and components than others.

Attachment F of Appendix A provides an analysis of the ABWR design documentation status with respect to the staff proposal. The staff concludes that the ABWR design will require a substantial amount of additional design work by the applicant in order to reach the level of design completion recommended by the staff.

IV. ADVANTAGES AND DISADVANTAGES OF THE TWO-TIER APPROACH AND THE APPLICABILITY OF THE "ASARA" CONCEPT

The two-tier approach is largely a manner of formatting in which the information contained in an application for design certification is divided into two parts: (1) design information to be certified and subject to regulatory standardization constraints and (2) design information in the application that is not certified but which describes what is considered resolved (unless it is changed) and the basis for resolution regarding Tier 1 safety issues. Changes made to Tier 2 between COL and operation will be made using a proposed change process similar to 10 CFR 50.59 and after operation using the 10 CFR 50.59 process. For this reason, the two-tier apporach offers the following advantages.

- Simplifies the design process and reduces the associated costs. This approach provides a mechanism for accommodating changes as fit-up problems arise. Thus, engineers need not anticipate and accommodate extra margins in designing every minute detail of the plant before certification. Without this flexibility, more engineering time and money will be necessary to cover every design detail that may be affected by a change regardless of its significance to safety or importance to standardization.

- Simplifies the construction process and reduces the associated costs. The flexibility inherent in the two-tier approach will allow for necessary fit-up changes during construction, resulting in an easier construction and installation process.

- Provides a more efficient way to compensate for unavailable equipment. If a component or piece of equipment (not specified in Tier 1) is no longer available, the ability to change Tier 2 information will be a more efficient way of incorporating replacement equipment into the design than requiring an exemption according to 10 CFR 52.63.

- Enables a COL holder and licensee to incorporate technological improvements. The change mechanisms governing changes to Tier 2 will provide more efficient means to take advantage of technological improvements that may be developed during the life of the certification or facility than by requiring an exemption under 10 CFR 52.63.

- Allows greater owner input to the procurement process. The two-tier approach will provide a more efficient process for a licensee to incorporate its preferences into the procurement process for any equipment not certified in Tier 1. This may be especially important if the standard plant is to be built on the site of an existing plant of different design. If components similar to the existing unit are procured, the utility could share maintenance equipment and personnel, replacements parts, and parts storage space between the units.

Allowing the Tier 2 design information to be changed by a COL holder or licensee results in the following disadvantages.

- Possible loss of standardization. By not certifying all design information and allowing changes to the uncertified material (Tier 2), the degree of standardization achieved among plants referencing a single design certification may not be constant.

- Greater chance for hearing before operation. As changes are made to the design, the possibility for challenges increases.

- Less cost accountability. Certification provides stability in design and cost. By not certifying all design information and allowing changes to the uncertified material, this approach will reduce the utility's ability to predict and then control the cost of construction and field engineering.

The staff has considered an ASARA concept, as requested, and believes that plants built referencing a design that was developed and constructed in accordance with 10 CFR Part 52 and the proposed regulatory guide described in this paper will be as standard as reasonably achievable. However, it is difficult to put a numerical value on the benefits of ASARA in a manner similar to ALARA (as low as reasonably achievable). For example, while ALARA was defined as a cost per man-rem threshold, it is not clear how one would quantify standardization for ASARA in order to develop the denominator of the ratio. The graded approach to determining the level of detail to be developed by an applicant will result in a design that is ASARA. Departure from standardization will be controlled by certifying as much of the design as practical (considering necessary flexibility during construction) and controlling the changes to Tiers 1 and 2 as described in Section III in this paper.

V. ANALYSIS OF PUBLIC COMMENTS

The Commission published in the Federal Register a request for comment on SECY 90-241, "Level of Detail Required for Design Certification Under Part 52." The Commission received responses from NUMARC, Westinghouse, General Electric, Americans for Nuclear Energy, DOE, the Illinois Department of Nuclear Safety, and the California Public Service Commission. The following is a summary of the most significant comments and the staff's position regarding each.

Level of Detail

Public Comment

NUMARC, Westinghouse, Americans for Nuclear Energy, and DOE believe that the design detail required for design certification should only be that necessary for the staff to make its safety determination. Indeed, DOE maintains that "standardization should not be a function of the NRC, but should be provided for by DOE and the industry to assure economic viability and financial certainty as well as the overall benefits of standardizing various aspects of a well-developed technology."

In addition, Westinghouse believes that it "is premature to attempt to establish the details of standardization," and suggests that the first plant built constitutes the "baseline" design. Standardization can then be achieved by rigorously controlling the changes between the baseline design and subsequent plants built to that design.

Staff Response

The staff believes that standardization, if properly managed, can provide increased safety and economic benefits to a facility constructed in accordance with a certified design. The "Supplemental Information" (54 FR 15372; April 18, 1989) states, "the Commission has long sought nuclear power plant standardization and the enhanced safety and licensing reform which standardization could make possible." As discussed in Section III and Appendix A of this paper, the staff proposes a graded approach to developing the level of detail based on safety significance considering the degree of standardization (including its inherent safety benefits) that is feasible and practical to achieve.

10 CFR Part 52 does not provide for the suggested controls on changes to subsequent plants relative to the baseline plant. After the first plant is built, the entire design could become part of a new design certification (Tier 1). By referencing the new design certification in the COL for subsequent plants, 10 CFR 52.63 would control deviations from the first plant. However, this approach may make construction difficult by involving the use of change processes governing modifications to Tier 1 (10 CFR 52.63 and 2.758); and the new design certification would be subject to any new NRC requirements developed since the "first" certification.

<u>NUMARC's Two-Tier Approach</u>

Public Comment

NUMARC proposes that the Commission adopt its two-tier approach to design certification with a provision to allow flexibility for changing Tier 2 information. In NUMARC's proposal, Tier 1 would contain an independent description of the design and design bases, and inspection, test, analysis, and acceptance criteria (ITAAC). The NUMARC proposal would most closely resemble Chapter 1.2 of the standard safety analysis report (SSAR) amplified to a level of detail equal to the staff's safety evaluation report (SER). Tier 2 would contain the remainder of the SSAR, including validation attributes, the equivalent of ITAAC, for the non-certified portion of the design.

Staff Response

10 CFR Part 52 provides for three categories of design material: (1) certified information in the application, (2) uncertified information in the application, and (3) uncertified information that is completed and available for audit. The staff agrees that the two-tier approach is not inconsistent with 10 CFR Part 52. Section III and Appendix A further discuss the typical information that the staff proposes to be in each of the tiers.

Providing Flexibility and Controlling Standardization

Public Comment

NUMARC stresses that flexibility is necessary to accommodate practical problems arising from procurement, as-built considerations, start-up issues, obsolescence, and advances in technology. NUMARC agrees that changes to Tier 1 can be accommodated by an amendment rulemaking or an exemption pursuant to 10 CFR 52.63. To change Tier 2, NUMARC believes that the holder of a COL should use a process parallel to that of 10 CFR 50.59. NUMARC encourages the staff to investigate the use of a process similar to 10 CFR 50.59 to facilitate changes to Tier 2 design information between design certification and COL issuance. However, NUMARC itself is not investigating this option. NUMARC also believes that additional NRC controls are not necessary to maintain standardization because factors such as construction schedules and the need to reduce operation and maintenance costs will result in the adoption of standardization practices. However, NUMARC stated that it "is committed to developing methodologies and guidelines to assure that the benefits of standardization are not eroded during the life of the certification or the life of the plant."

Staff Response

Section III discussed the staff position on flexibility and the preservation of standardization. The staff is not proposing to invest the resources necessary to investigate the use of a process similar to that described in 10 CFR 50.59 to change Tier 2 material before COL without the need clearly expressed.

Issue Finality

Public Comment

NUMARC believes that the staff should treat as resolved all material in both tiers including the determination of what should be properly placed in each tier. NUMARC agrees with SECY 90-241 that any changes to Tier 2 information after a COL is issued may be subject to adjudication. However, NUMARC does not agree that additional design developed after design certification may be subject to adjudication. NUMARC believes that material available for audit should also be treated as resolved.

Staff Response

As stated in SECY 90-241, the information contained in the application (both Tiers 1 and 2), reviewed and approved by the staff in the design certification process is resolved as long as it is not changed. If additional design material is determined to be needed to make the COL safety findings, it may be subject to hearings. However, since all safety issues presented in the certified design should have been resolved in the certification rulemaking, the additional design subject to hearing should be confined to changes in Tier 2 and site-specific matters. The staff does not agree that design material available for audit by the NRC, but not made publicly available, is resolved unless it has been reviewed and documented in the staff's SER supporting the design certification, subject to a safety finding, and is a part of the rulemaking proceeding.

VI. DESCRIPTION OF THE "STANDARDIZATION PORTION" OF THE REVIEW

The staff is not proposing to perform a separate review to ensure standardization, and 10 CFR Part 52 does not contemplate such a review. A design in accordance with the proposed regulatory guide or equivalent will be a prerequisite for design certification. As discussed in Section III, the application for design certification will contain a depth of design detail similar to that of an FSAR at the OL stage for a recently licensed plant (1985-1990) without site-specific and as-built information. This detail will include design bases and criteria, system descriptions, performance requirements and other information in sufficient detail for the staff to make its safety determination. This information will be subject to the normal licensing review process as directed by the SRP. In the 10 CFR Part 50 process, the staff relies on an inspection of a physically constructed facility to provide assurance that licensing commitments and regulations have been met. In lieu of a constructed facility, the proposed regulatory guide will request the applicant to develop and make available for NRC audit information such as that normally contained in certain procurement specifications and construction and installation specifications if it is necessary for the staff to make its safety determination. Similarly, a higher degree of design detail for site-specific structures, systems, and components is needed at the time that a COL application is submitted. This additional design detail will enable the staff to reach a final conclusion on the adequacy of the design and the design process by providing reasonable assurance that the design criteria and commitments in Tiers 1 and 2 will be properly implemented. The staff audit of this design detail will most likely involve integrated design inspections or independent design verifications. Information obtained during the staff's question-and-answer process or audit that forms the basis for a safety decision, will be formally docketed. Examples of what the staff expects to be completed and available for audit appear in the tables in Appendix A.

VII. EVALUATION OF THE STANDARDIZATION EXPERIENCE

The NRC staff has examined two levels of standardization achieved in the population of U.S. nuclear plants: "product line" standardization, described in SECY 90-241, and duplicate plant standardization (SNUPPS, Byron and Braidwood, Palo Verde). The staff found that the standardization benefits achieved by the duplicate plant approach were far greater than those achieved by the product-line approach.

The product-line approach was developed by reactor vendors who obtained NRC approvals for a portion of a nuclear plant design, usually the nuclear steam supply system only. The approvals, called Preliminary Design Approval (PDA) or Final Design Approval (FDA) were then made part of a package of design services sold by the reactor vendor to a utility. The utility applied to the NRC for a construction permit and operating license under 10 CFR Part 50, referencing the preapproved design on a site selected by the utility. The staff conducted reviews at the construction permit (CP) and operating license (OL) stages during final plant design and construction, in the usual sequence of a custom plant schedule. With this method, a relatively low level of total plant standardization was achieved between two or more plants owned by different utilities and referencing the same PDA or FDA. Current applications for design certification are similar, in a sense, to earlier applications for PDAs and FDAs (such as RESAR, GESSAR, BSAR) which were product line standards. They are applications for design approvals which will be sold to utilities to attain financing for finishing a "first plant" project.

Plant owners used a second form of plant standardization to copy an existing complete plant design. This action was done either by the same utility on the same site (Arizona Public Service - Palo Verde), or by one or more different utilities on different sites (Union Electric Co. and Kansas Gas and Electric - Callaway and Wolf Creek). This second approach is fundamentally different in that the detailed and final design of the entire plant was completed and the plant was constructed at one site, with construction only slightly ahead of a duplicate, essentially identical, plant using the same design and construction drawings and specifications, at the second and succeeding sites. However, the NRC's safety review of the first plant was substantially identical to that for any other custom plant application of the period (mid 1970s). The NRC performed reviews in accordance with 10 CFR Part 50. However, our safety review of the typical second plant required about one-half of the NRC resources required for the review of the typical first plant, and the staff asked the applicant only one-half as many questions to complete its review. Because several plants were constructed at the same time, the utilities achieved standardization at the component level among the plants because of standard procurement actions and by referencing large blocks of material from one FSAR into another (the practical effect of using a certified design). After the first plant was licensed, owners of subsequent plants gained the benefit, in their own licensing hearings, of reference to material that had been litigated in previous hearings. The level of detail carried from one project to the next was comparable to Level 1, yielding a high degree of physical identity; but the NRC did not require that level to be provided in the application. The level of detail reviewed was, as previously stated, that which was associated with a custom OL review of that era.

Under 10 CFR Part 50, the utility owner conducted the entire project from initial planning to operation. From project inception, two or more utility owners shared the costs of design, procurement, and regulatory interaction to obtain a construction permit and later, an operating license. The owner (or consortium of owners) had the incentive to complete the design. However, a reactor vender and architect/engineer, working together to obtain design certification under 10 CFR Part 52, may not have the same incentive.

Utilities can receive benefits from the duplication of plants in the following ways:

- o Multiple procurement actions reduce cost to each utility involved and enhance physical identity among components.

- o Construction cost and schedule are reduced at subsequent plants.

- o Resource sharing during design and construction results in a more thoroughly engineered design at less cost to each participating utility.

- o Construction deviations are resolved on the first plant, reducing the cost, increasing construction efficiency, and developing better as-built design for greater safety during operation.

- Plant operation can be enhanced because experience is shared on training, maintenance, operating events analysis, outage planning, procedures, and the management of replacement components.

- The large quantity of operating data, obtained earlier because of the number of plants using similar or identical design and components, provides earlier signs of incipient problems or precursors to more serious events.

In examining the standardization experience of the SNUPPS plants and Palo Verde Units 1, 2, and 3, the staff identified two initiatives that utilities could adopt to enhance those benefits. Adopting these approaches would not require changes to 10 CFR Part 52, and either or both would help gain the full benefits of standardization. The initiatives are as follows:

- Prospective plant owners intending to use a particular design certificate would do so independently of one another, but within a short time (e.g., five years). By constructing several plants in a short period of time, licensees will face little pressure to change their designs to incorporate advances in technology. This would enable the plants to be similar enough that the owners are encouraged to work together to design and implement standardized changes in later years to accommodate advances in technology, unavailability of components, or safety issues.

- Prospective plant owners or groups of owners would voluntarily arrange to submit applications that declare their intention to build at least two plants with essentially identical functional design, physical configuration, and equipment selection. The plants' construction schedules should provide a lead plant but should ensure construction of all plants over a schedule close enough to allow standard procruement actions, and standard resolutions of engineering issues, regulatory issues, or construction deficiencies, in the manner of the SNUPPS experience. This activity to duplicate plants would also ensure that the utilities gain the advantages of standardization during the subsequent operation of the several plants.

Conclusions: The staff has determined that a regulatory guide (or guides) should be developed to incorporate the following as NRC policy for implementing the requirements of 10 CFR 52.

1. <u>Scope</u>

   In accordance with 10 CFR 52.47, the applicant will submit in an application for design certification "an essentially complete nuclear power plant design." The regulatory guide will define "essentially complete" in terms of scope of design and will describe the systems, structures, and components to be included in the application.

2. <u>ITAAC</u>

   The regulatory guide will provide guidance on the formulation of an ITAAC program pursuant to 10 CFR 52.47(a)(1)(vi).

3. <u>Level of Detail</u>

   The level of detail described herein will be expected from an applicant for design certification.

   a. Pursuant to 10 CFR 52.47, an applicant for design certification will have developed a design sufficient to enable the staff to reach a final conclusion on all safety matters, permit the preparation of acceptance criteria and inspection requirements by the staff, and permit the preparation of procurement specifications and construction and installation specifications by the applicant. The graded approach described in this paper will be used to determine design detail to be developed by an applicant. The level of detail will vary from system to system based on safety (including the additional safety benefits from standardization) and will recognize the limits set by what is feasible and practical. Appendix A tables will provide input in developing this guidance.

   b. The applicant will submit in the application a depth of detail similar to that in an FSAR at the operating license (OL) stage for a recently licensed plant (1985-1990) except for site-specific and as-built information.

   c. The applicant will develop and retain for staff audit additional design information such as that normally contained in certain procurement specifications and construction and installation specifications. This information translates the design criteria set forth in the application into design products. If a portion of this additional information forms the basis for a safety determination by the staff (regarding the adequacy of Tier 1), it will be docketed.

4. Flexibility and Issue Finality

The information developed by an applicant for design certification shall be considered to be in one of three categories: (1) design information submitted in the application and certified by rulemaking; (2) design information submitted as part of the application and not certified; and (3) design information available for NRC audit at the applicant's office(s). These categories provide the applicant with varying degrees of flexibility and regulatory stability.

a. Design material submitted in an application and certified through rulemaking (Tier 1) will include information completed during the conceptual phase of the design, such as design criteria and bases, and certain information developed during the preliminary and detailed design phases, as detailed in the proposed regulatory guide. Tier 1 can be changed by a rulemaking to amend the certification, an exemption pursuant to 10 CFR 52.63, or a rule waiver pursuant to 10 CFR 2.758. Changes resulting from a rulemaking become binding on all licensees referencing the certified design. Applicants for COL, COL holders, or licensees referencing a design certification may submit exemption requests pursuant to 10 CFR 52.63 or waivers pursuant to 10 CFR 2.758 for changes to Tier 1. Such exemptions or waivers would not change the requirements of the certification for other licensees.

b. The remaining design information in the application and not certified (Tier 2) will include information demonstrating how Tier 1 criteria are implemented and will be of sufficient detail for the staff to perform its safety review of the adequacy of Tier 1. The design certification will include a provision whereby Tier 2 information cannot be changed except through an amendment rulemaking by the holder of the design certification, or by an exemption to the rule or a waiver from the rule certifying the design by a COL applicant after the NRC issues a design certification. The COL will be conditioned such that the COL holder may make changes to Tier 2 design information pursuant to provisions paralleling that of 10 CFR 50.59 until such time as 10 CFR 50.59 becomes effective. The findings and conclusions of the staff's safety evaluation report (SER) that supports the certification rulemaking and COL will identify those matters resolved in accordance with 10 CFR 52.63. Changes to Tier 2 design information may be subject to hearing before the NRC grants permission to operate depending on whether compliance with acceptance criteria is implicated by the change.

c. Information developed and available for NRC audit may be changed provided the change does not violate the provisions of the application and certification. The staff will perform audits of this design material to ensure that the design products meet the commitments of the design certification and supporting design details (Tiers 1 and 2). If such information forms the basis for the staff's formal safety determination about the adequacy of Tier 1, it will be docketed as part of the application. The finding and conclusions of the staff's SER that support the design certification or COL will identify those matters resolved.

Coordination: The Office of General Counsel has reviewed this paper and has no legal objection.

Recommendations:

1. The staff recommends that the Commission agree with the general approach presented in the above conclusions of this paper for implementing the requirements of 10 CFR 52.

2. The staff also recommends that the Commission authorize the staff to develop and issue a regulatory guide (or guides) in accordance with the above conclusions that describes for applicants the contents of an application for design certification and COL, the design products expected to be developed and available for audit, and the process for making changes to the design. In addition, this regulatory guide (or guides) will provide guidance on the formulation of an ITAAC program.

James M. Taylor
Executive Director
for Operations

Commissioners' comments or consent should be provided directly to the Office of the Secretary by COB Friday, December 21, 1990.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Wednesday, December 5, 1990, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional time for analytical review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

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Appendix A

DESIGN COMPLETION

ANALYSIS OF FEASIBILITY

AND

RELATIONSHIP TO 10 CFR PART 52 CERTIFICATION

Prepared by the Division of Reactor Inspection and Safeguards

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TABLE OF CONTENTS

PREFACE

This appendix provides information on the design process now followed under 10 CFR Part 50 and that projected to be followed under 10 CFR Part 52. The key differences between these processes are pointed out, and the complexity of the design process is illustrated by a specific example.

The staff evaluated the feasibility of reaching various levels of design completion by an inductive process. That is, the staff (1) examined design products at various stages of the design process in detail for each major technical discipline and (2) determined the feasibility of completing specific items, given the constraints of the 10 CFR Part 52 design and licensing process, the flexibility for competitive procurement, the ability to accommodate evolving technology, and the capabilities of current design process technology. The staff also estimated the engineering resources required to reach the proposed completion level. This appendix also addresses selected standardization and review process issues.

The staff performed the evaluation of the feasibility of design completion using an evolutionary design such as the General Electric Company advanced boiling water reactor (GE ABWR) as the model. For a design and construction approach that uses prefabricated modules such as the Westinghouse AP-600, the levels of design completion evaluated for the evolutionary design and perhaps higher levels, would be feasible. Although the following discussion does not contain an explicit evaluation of the modular design, many of the concepts presented in this paper would be applicable.

DISCUSSION

Definitions

In SECY 90-241, the staff defined the Level 1 design detail as not only achieving functional and performance standardization for all but site-specific structures, systems and components, but also achieving standardization of the dimensional and physical configuration. This design detail required at the time of design certification requires a knowledge of the equipment dimensional information which would be typically listed on vendor-supplied outline drawings. For example, Level 1 design detail would be achieved if, at the time of design certification, the designer knew the exact location of all piping connections for any given component; the range, accuracy, and response time of instruments; the exact routing of all piping, electrical raceways, and conduit; instrument tubing; component weights and the locations of their centers of gravity; the exact electrical loads; equipment foundations and support details; and a myriad of other details. This information is only available from a vendor when a specific component is selected and purchased, or if procurement specifications more detailed and specific than are in current practice are used to ensure that the geometries and capabilities of components are within specified margins. In the latter case, many vendors would need to custom build components to fit the detailed specifications. This may inhibit the competitive procurement process and could increase costs because fewer vendors may be willing to fabricate custom components. Level 1 design detail would produce duplicate plants that are identical, except for construction tolerances, in all respects except for site-specific aspects.

In SECY 90-241, the staff defined Level 2 design detail as achieving functional and performance standardization for structures, systems, and components affecting safety and the standardization of the dimensional and physical configuration within a defined envelope. For example, Level 2 design detail would be achieved for a pump if, at the time of design certification, the designer knew the pump type (e.g., centrifugal or positive displacement), the pump flow, the shape of the pump head curve (e.g., continuously decreasing), the approximate shutoff head and net positive suction head (NPSH) requirements, the approximate motor horsepower and amperes, the pump style (e.g., close-coupled with end suction and top discharge or vertical in-line), and the size and approximate locations of the pump nozzles. Level 2 design detail would contain sufficient information to prepare component procurement specifications. The applicant would develop these procurement specifications from reviewing commercially available component data. Therefore, the designer would have assurance that equipment meeting the procurement specification could be supplied from several vendors. This differs from Level 1 in that the designer for Level 1 would be required to either select a specific vendor's component or to develop procurement specifications to a level of detail that would require the fabrication of custom components. Level 2 design detail would not produce duplicate plants down to the component level. However, even to a knowledgeable observer, the plant systems would be identical in function and performance and physically similar with a small variance because of vendor-specific information or construction tolerances.

The level of design detail necessary at the time of design certification (e.g., Level 1 or Level 2) has major financial implications for the design certification applicant. In addition, although economic incentives will restrain departure from standardized designs, the information that is incorporated either directly or by reference in the rule certifying the design will be the primary means of ensuring standardization. Over the past two months, the staff has conducted a study to identify (1) the appropriate level of detail at design certification and (2) the information that should be in Tier 1 of a design certification rule. The study determined (1) the engineering products that are technically feasible to complete at the time of design certification, without site- and vendor-specific information; (2) whether the completion of this level of effort enhances standardization or the staff's ability to make a safety judgement; and (3) what portion of this information should be embodied in a rule certifying the design. The results of this study are discussed herein and presented in tabular and graphical form in Attachments A through F.

10 CFR Part 50 and Part 52 Design Processes

To present the information gathered from this survey, the staff prepared Attachment A, which depicts the design process for plants licensed under 10 CFR Parts 50 and 52. The primary difference in the design process between the Part 50 and the Part 52 plants is the effect of the construction schedule on the design. In the 10 CFR Part 50 process, several factors influenced the development of the design detail. Nuclear steam supply system (NSSS) vendors and architect/engineer firms (A/Es) developed the design to a point where a customer utility could be reasonably assured that a product would perform as specified for an estimated cost. The design was developed to the extent where component manufacturers could provide equipment that would meet the design requirements. Finally, throughout the design process, the designers made choices primarily based on the critical path needs related to the design and construction of the facility. This resulted in less than optimum designs. For example, if the electrical installation contractor was first onsite following the completion of the structures, that contractor could install the pull-boxes, cable tray, and conduit in the space intended for piping, necessitating rerouting and redesign of the pipe or the electrical raceways. In addition, if large components were installed out of sequence, this sometimes limited the accessibility to space allocated for other components, and resulted in a redesign or relocation of components and piping to avoid removing or disassembling the installed equipment. In most cases, construction was well under way before actual vendor information was available or the piping design was finalized. In the 10 CFR Part 50 process, major components were often ordered and fabricated before the design was finalized. Often, this resulted in the expenditure of a large number of engineering hours trying to accommodate purchased components in already fabricated systems and structures. In other words, the plants licensed under 10 CFR Part 50 were designed through an iterative process, in which the design was continually changing during construction as vendor and field information became available. Because of the effort to expedite construction and begin operating the plants in the shortest possible time, the plants required numerous field changes and redesigns. In some cases, such as the SNUPPS project, a high degree of design finality before construction and the use of a detailed plant model, that was updated on a daily basis, overcame many of these problems and significantly reduced the number of design changes initiated in the field.

Overall, the 10 CFR Part 50 process was very inefficient and resulted in some rather unusual or unique configurations. However, the design process for a plant licensed under 10 CFR Part 52 should be much more orderly and controlled because construction would not commence until a substantial portion of the engineering is completed. The staff believes that this feature will enhance the safety of standardized plants as the new design process will significantly reduce the number of design compromises forced by completed construction.

Design Products

While the 10 CFR Part 52 design process should be more efficient than the Part 50 process, it is still very complex. To illustrate this complexity, the staff prepared Attachment B which shows in tabular form the design products available at four different phases in the design process: conceptual design, preliminary design, detailed design, and final design. Attachment B shows the engineering products for each of the five major engineering disciplines: civil, electrical power, instrumentation and control, mechanical systems, and engineering mechanics (e.g., analysis and design of piping, ducts, and supports).

Design Maturity at Design Certification and at the Issuance of the COL

Attachment B also provides examples of (1) which engineering products the staff believes can be completed at the time of design certification without ordering specific components if there was no consideration given to initial engineering costs (i.e., maximum technically achievable) and (2) the engineering products the staff recommends be completed at the time of design certification. These design products are not necessarily part of the application or certification. Attachment B also defines the type of information (Tier 1 information) that should be both reflected in the application and certified in the design certification rule that establishes the standardized design.

The level of design completion depicted for design certification will comprise the engineering efforts needed to reach a high level of design finality. Additional products not developed at this point would enable the applicant to implement the design at a very detailed level. Additional products would generally require vendor-specific component information.

Attachment B also shows the level of design completion recommended at the time of the issuance of the combined operating license (COL) for site-specific systems. The staff recommends that, prior to issuing the COL, those systems and structures that are heavily influenced by site-specific considerations (e.g., the essential service water system, the circulating water system and the intake structure) be completed to a level of detail equivalent to that available at the time of design certification for the balance of nuclear island (i.e., the nuclear island excluding the more detailed primary system components) and the turbine island (refer to Attachment C). This level of detail will also ensure that construction does not commence until a substantial portion of the engineering associated with site-specific structures, systems, and components is completed.

Attachment C lists systems and structures in groups according to the degree of design finality or maturity at the time of design certification and COL. In Attachment C, specific systems are listed that define the scope of each of the following general system groupings. This scope and the associated groupings also apply to Attachment B. Attachments B and C should be used together.

Within the nuclear island group, the reactor vessel and the reactor protection system (RPS) should both have certain engineering products typically developed during the final design phase completed at the time of design certification. Subsequent changes would have a minimal effect on standardization. The degree of standardization would provide dimensionally equivalent components, that is, approaching Level 1 design detail, for the reactor vessel or any of the other major components in the primary system that are designed and possibly manufactured by the NSSS vendor. For the RPS, the design may be finalized to the degree that logic diagrams, data network descriptions, and schematic diagrams have been developed; functional component types (such as square root extractors), and their performance requirements have been identified; and certain components may have been selected. However, design products such as interconnection wiring diagrams cannot be developed until all the components are selected. The variability between the design of the RPS completed at the time of design certification and the design completed when the components are physically installed will have little effect on standardization. However, the design is not complete to the detail of the reactor vessel because of the need for vendor information. Therefore, the RPS would be closer to a Level 2 system as defined in SECY 90-241. However, both systems have highly mature designs, although these designs may not have the same level of detail.

Design Finality in Relation to Engineering Effort

Several figures in Attachment D express the degree of design finality as a function of the engineering hours expended. The degree of design finality is difficult to quantify. However, Figure D-2 shows that approximately one-half of the engineering hours expended in design during design and construction of a nuclear power plant are expended in the final design and field engineering phase. These engineering hours result from the procurement process and the need to reconcile the vendor-supplied data and vendor exceptions to the purchase specifications and as-built conditions. As illustrated in Figure D-4, at the time of design certification, the engineering for all but site-related structures, systems, and components should be complete to a sufficient degree such that nearly all components have been identified, all necessary information for equipment procurement specifications has been prepared, and performance requirements have been specified for each component. At this point, the procurement documents could be prepared with little effort because little or no additional detailed engineering would be required. For example, the additional engineering beyond design certification is necessary to produce final piping isometric drawings; to design and analyze supports for small bore piping; to design equipment anchorages; to perform the final seismic analysis of piping, ducts, and cable trays; and to perform the reconciliation tasks identified in Attachment A-3. These reconciliations and the final engineering tasks require significant quantities of personnel resources because of the detail necessary to finalize the design and to produce final construction and manufacturing drawings. However, this effort does not substantially change the plant configuration and does not have a real effect on functional or general physical standardization.

Graded Approach to Level of Detail

The staff expects that the level of detail for NSSS vendor design products (e.g. reactor coolant system and reactor protection system) will typically provide information such as (1) precise design and dimensional information for the primary coolant system, containment, and the reactivity control system, and (2) a software specification for the reactor protection system that has been reconciled against a prototype where necessary to validate innovative design concepts. Attachment B provides examples of the level of detail to be developed for the nuclear island for each discipline in terms of design products completed at the time of design certification. This level is greater than Level 2 but is less than Level 1. Requiring a high degree of design finality for the nuclear island allows greater specificity in Tier 1. This approach ensures a high degree of standardization of the nuclear island and will produce many of the safety benefits inherent in standardization.

Certain aspects of the plant are required to be in an advanced state of design completion for the purposes of the staff safety review. These relate principally to primary system and associated protection systems grouped in Attachment C under "nuclear island." For these systems, the level of detail recommended for the supporting design products may not be significantly greater than that level which is required for the safety review in the 10 CFR Part 50 review process.

For innovative portions of the design, the staff also recommends a high degree of design completion as reflected in Attachment B. For example, innovative instrumentation system designs employed in evolutionary or advanced reactor designs may include distributed microprocessors, fiber optics, multiplexers, and local area networks. Analog designs have had a comparatively long application history in nuclear plants, and the design approach to analog systems is generally uniform throughout the industry. Thus, for analog systems, the industry has a mature design practice and the performance results obtained by applying analog systems are predictable without necessarily requiring that the design be complete to the final details. By contrast, the nuclear industry has not achieved uniform level of practice in its approach to digital hardware and software systems design. Such a uniform level would provide adequate assurance that the original configuration is acceptable based only on detailed design products such as specifications. For this reason, the applicant for design certification should complete more of the final design configuration for innovative systems and should have the associated design products available for audit. The staff recommends that these design products for innovative systems also include representative software and hardware system prototype performance data. Prototyping has been used as an element of design verification programs for innovative reference plant designs such as the RESAR-414 Integrated Protection System previously evaluated by the staff.

Attachment F provides an analysis of the status of the ABWR documentation with respect to the graded approach to level of detail.

Next in the hierarchy of safety-significant systems, structures, and components, are those relied on to mitigate the consequences of a postulated accident, their support systems, and related structures. These systems are defined in Attachment C as forming the "balance of the nuclear island." As indicated in Attachment B, the staff recommends that these systems, structures, and components meet the criteria for Level 2 design completion. To develop Level 2 design detail, the following conditions must be true: (1) the detailed phase of engineering is completed (approximately 50 percent of the engineering hours are expended) and (2) engineering has progressed to the point where the applicant could prepare almost all of the procurement specifications. At this level of design completion, the primary tasks remaining to be accomplished in the final phase of engineering are the actual preparation of procurement documents, the procurement of equipment, and the finalization of design details based on actual specified vendor data. The staff also recommends that the level of detail necessary for the turbine island at the time of design certification equal the level required for the balance of the nuclear island. This uniform level of detail has the added safety benefit of standardizing the systems whose malfunctions could challenge the safety systems or make recovery from an off-normal condition more difficult.

For 10 CFR Part 52 design certification, a level of detail not greater than Level 2 is recommended for the systems, structures, and components grouped under the balance of nuclear island and turbine island (refer to Attachment C). A somewhat higher degree of detail is recommended for systems grouped in the nuclear island. During the 10 CFR Part 50 licensing process, however, the level of detail required by the staff decreased across the hierarchical spectrum of systems beginning with the systems contained in the nuclear island and continuing to the balance of nuclear island and turbine island systems. The 10 CFR Part 50 licensing process allowed for a greater variance in design detail between safety and non-safety related systems than does the 10 CFR Part 52 process. The level of detail recommended for design certification pursuant to 10 CFR Part 52 is slightly higher for the systems grouped under the nuclear island than previously required of equivalent systems for a nuclear power plant licensed under 10 CFR Part 50. In contrast, the level of detail recommended for systems grouped in the balance of the nuclear island or the turbine island is substantially higher for a 10 CFR Part 52 design certification than was required for the equivalent systems of a power plant licensed under 10 CFR Part 50. The largest difference between the two licensing processes involves the variance in the level of detail for the systems grouped in the turbine island.

Because the NRC has no actual constructed facility on which to base a licensing decision, both test and acceptance criteria (ITAACs) and a high level of design completion for most aspects would be needed, even without standardization considerations, to provide the staff with the necessary confidence that these systems, structures, and components will fully implement the criteria specified in the application and will perform their intended functions.

The applicant cannot know details of the site-specific elements of a nuclear plant at the time of design certification because a site has not been selected. Therefore, at the time of design certification, the completion of a conceptual design for site-specific elements would be appropriate as specified in 10 CFR 52.47(a)(1)(vii) and Section 52.47(a)(1)(ix).

Design Inspections and Audits

Although the development of an inspection and audit program must await a decision on the level of detail to be required, it may be appropriate to perform audits or inspections of the supporting design information at three points during the 10 CFR Part 52 process to verify that Tier 1 and Tier 2 commitments have been properly implemented. Audits could be performed in conjunction with and to support the staff's review of an application for design certification or a combined operating license. Inspections could be performed after the issuance of the combined operating license. The staff could perform audits at the following times: (1) before design certification to review elements of the plant design addressed in the standard safety analysis report (SSAR) and (2) after design certification but before issuance of the combined operating license to review site-specific design aspects. Inspections could be performed after the combined operating license issuance but before fuel load to examine reconciliation of vendor and as-built data and to review other engineering products from the final design phase. These inspections and audits could resemble the integrated design inspections (IDIs) that the staff performed during the 10 CFR Part 50 licensing process. They would verify that the applicant has appropriately incorporated the Tier 1 and Tier 2 design commitments into the supporting design information and would provide additional assurance that the systems, structures, and components will perform their intended safety functions. The inspections and audits could use the vertical slice methodology to review one or two systems and associated structures in detail to assess design adequacy and implementation of regulatory commitments. This effort would also assess the design process by reviewing the interdisciplinary technical interactions necessary in the development of the supporting design documentation.

The amount of staff resources required to carry out the design inspections and audits is dependent upon the number of separate inspections found to be necessary. When the Commission approves the approach proposed in this paper the staff will further develop the inspection and audit approach.

Alternatively, the applicant for a design certification or COL could be required to perform a technical review of the design products through approaches similar to those used during the 10 CFR Part 50 licensing process. The applicant could perform the technical review using an approach similar to the independent design verification program (IDVP) where a third party (from outside the applicant's organization) implements the review or through an engineering assurance program (EAP) where technically qualified personnel (from other projects within the applicant's organization but not associated with the plant under review) perform the review by conducting detailed technical audits throughout the design process. The staff would perform oversight inspections or audits to ensure proper implementation of these review efforts. The applicant's performance of either an IDVP or EAP would require fewer staff resources than would be necessary for the IDI-type approach and would result in more comprehensive reviews because of a larger expenditure of resources by the applicant. Regardless of whether the IDI or IDVP/EAP approach is used, the design inspections and audits necessary to review the 10 CFR Part 52 process would require more NRC inspection resources than the 10 CFR Part 50 process.

SELECTED ISSUES

Feasibility of Achieving Level 1 or Level 2 Design Detail

As stated in SECY 90-241, Level 1 "will provide identical physical, functional, and performance characteristics of all structures, systems and components except for site specific characteristics." Standardization at Level 1 of design detail requires a knowledge of detailed engineering information, supplied by the vendor, about the systems and components installed in the plant, or very detailed procurement specifications to which the vendors would build custom components. Therefore, without detailed specifications, it is extremely difficult to approach Level 1 detail, except for the containment building and for major components that form the primary coolant system. Such components are designed and possibly fabricated by the NSSS vendor. The design of the containment can be developed to a higher degree of detail than other Seismic Category I structures, primarily because the physical data for the major equipment are known.

To finalize a design at Level 1 detail, an applicant must receive specific data or develop detailed purchase specifications on all components purchased from vendors. The specifications must be written so tightly that only one physical configuration is possible. This would either limit the component to one vendor or require custom components to be fabricated. Such a limitation is not considered practical because it would inhibit the competitive procurement process and would increase the component costs because the first-of-a-kind costs associated with custom built components would likely need to be absorbed by the first components.

Attachment A-2 depicts the many interfaces that must be considered in the design process for any component. In this illustration, a pump was selected to demonstrate the design interface considerations and the cascading effect that relatively minor changes to components have on the design. For example, the weight of the component must be known to develop the rebar details in the pedestal. The pump support configuration, amplified response spectra, and center of gravity must be known to develop the anchor bolt details. The nozzle locations must be known to finalize the routing of the interconnecting piping. When the piping is routed, the nozzle loads must be verified against vendor-specified allowables. A change in the pressure drop across a control valve or the addition of a control valve or flow-measuring orifice will change the system flow, the motor horsepower, the electrical load, and possibly the electrical protective relay setting and the power cable size, and will increase the load on the diesel generator, which will change the fuel consumption requirements and possibly the size of the day tank or the fuel oil storage tank. The effect of any single change is small, but the innumerable, small, and individually insignificant changes may become collectively significant. Therefore, the total design cannot be frozen at Level 1 unless the equipment is selected and nameplate data is available, or unless unusually detailed procurement specifications are prepared.

While a level of detail approaching Level 1 can only be achieved in very few cases, the staff believes that a level of detail equivalent to Level 2 as described in SECY 90-241 can be attained for structures, systems, and components except for those that are heavily influenced by site-specific data. Typical site-dependent systems, structures, and components have been identified in Attachment C. For the systems, structures and components grouped in the balance of nuclear island and the turbine island (refer to Attachment C), the staff believes that a maximum of Level 2 design completion could be achieved at the time of design certification.

Standardization

There are many degrees of standardization, ranging from functional standardization to dimensional standardization. Level 1 detail is required to achieve dimensional, functional, and performance standardization of structures, systems and components. This level of detail would ensure duplicate plants and would require vendor and equipment nameplate data or very detailed procurement specifications. Such detail could only be realized if a utility or group of utilities contracted to build several nuclear units and purchased components simultaneously with a single purchase specification, such as was done for SNUPPS. However, even the SNUPPS plants have minor differences such as the number and location of embedded plates. Experience has shown that standardization is a changing process that may require several iterations to optimize the design and resolve problems that naturally arise during any large, complex task with many inter- and intra-organizational interfaces.

The staff's concept of standardization would require bringing the design to a level of design maturity at the time of design certification such that the design products identified in Attachment B (preliminary) are completed and available fo audit, if indicated. This level of maturity and the inclusion of certain key design attributes in Tier 1 as listed in Attachment B would ensure the following degree of standardization for the nuclear, balance of nuclear, and turbine islands within normally accepted construction tolerances:

1. Identical design bases and design criteria
2. Identical simplified piping and instrumentation diagrams (P&IDs)
3. Identical basic Class 1E ac/dc electrical single-line diagrams (typically for systems operating at 4kV and lower, these diagram the configuration of busses, bus ties, and load centers)
4. Identical general arrangement drawings
5. Identical locations of equipment within a defined envelope [1 2]

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1 Inside the containment, these details would be more precisely known.

2 "Within a defined envelope" as used in this document is intended to connote that although exact dimensions may not be available at the time of design certification, due to lack of actual vendor specific information, it is possible for an applicant for design certification or a combined operating license to define a physical envelope based on available vendor catalog information and previous experience.

6. Identical routing of piping 6 inches and greater in diameter within a defined envelope with preliminary stress analyses performed [1,2]
7. Identical routing of all high-energy piping 2-1/2 inches and greater in diameter within a defined envelope with preliminary piping analyses performed [1,2]
8. Identical routing of HVAC ducts within a defined envelope [1,2]
9. Identical routing of cable tray systems within a defined envelope [1,2]
10. Identical equipment performance requirements (e.g., pump capacity, pump head, type of pump, and general pump configuration)
11. Identical structures (except for minor variations dictated by equipment such as localized rebar patterns)
12. Identical functional and performance requirements for plant systems (except for minor variations due to nameplate data)
13. Identical pipe routing and supports for all ASME Section III, Class 1N piping greater than 1 inch in diameter within a defined envelope[1,2]
14. Identical man-machine functional interfaces in the control room;
15. Identical data network descriptions (architecture) and
16. Identical programmatic documents (e.g., software verification and validation plan, seismic qualification plan, and setpoint tolerance methodology)

This degree of standardization could be achieved with the graded approach recommended by the staff requiring the design of the nuclear island, balance of the nuclear island and the turbine island to be completed to a design detail of, at most, slightly greater than Level 2 and the inclusion of information developed in certain key design products (see Attachment B) in the design certification; that is, in Tier 1.

The NRC could issue formal guidance to applicants to effectively communicate the Commission's decisions on the level of design detail. A regulatory guide could be issued based on the information contained in Attachments B and C. Although the guide would likely be in a table format similar to the Attachments, the staff would not expect the design control system of each applicant to be the same or to use the exact nomenclature of Attachment B. Therefore, the staff would need to use judgement during its audit of these documents for adequate technical implementation and completeness. Guidance for staff inspectors would need to be developed to address this aspect and also to define expectations for the technical content of documents not yet finalized. Refinement of the nomenclature, and perhaps some standardization of the industry's design process, would be expected during the public comment process on the regulatory guide.

<u>Flexibility</u>

To accommodate changes over the life of the design certification, licensees will require flexibility to adapt to changing availability of vendor products. Vendors generally do not freeze the characteristics of their hardware. Vendors change components as the product is updated to enhance reliability, lower fabrication costs, and address operating problems. Vendor model changes could result in the discontinuation of certain product lines or could drastically change the component characteristics. After 15 years, an identical replacement would probably not be available for many plant components. A licensee will require the flexibility to accommodate the changing commercial marketplace by incorporating updated component models into the plant systems.

Flexibility is also necessary to accommodate minor construction deviations. The past 10 CFR Part 50 construction practices have demonstrated that fabrication and construction deviations will occur. While these can be controlled somewhat through rigid specifications and a significant amount of initial engineering, experience has shown that these deviations cannot be eliminated because of the complexity of the plant systems. The licensees may have to accommodate such things as re-routing instrument tubing because of unforeseen field interferences. This will result in revising the supporting engineering products listed in Attachment B during construction. The staff concludes that it is important to allow for controlled changes to accommodate evolving technology, changes in the commercial marketplace, and construction deviations, while preserving functional, performance and general dimensional standardization.

Staff Review Related to Standardization

The staff anticipates no direct review effort related solely to standardization. The following describes the staff safety review efforts.

Because the level of information submitted in an application for design certification is equivalent to current final safety analysis reports (FSARs), the standard review plan (SRP) should not require drastic revision to accommodate the review of a standardized evolutionary plant. However, in selected review areas the introduction of rapidly evolving technology, such as instrumentation and controls, will necessitate additional SRP review guidance. In addition, the staff can augment the SRP by requiring the reviewer to address whether the proposed design properly accounts for past operating experience.

10 CFR Part 52 requires the development of information normally contained in certain procurement specifications and construction and installation specifications to be available for NRC audit if necessary for the staff to make its safety determination. This information would be developed to the level of detail shown in Attachments B and C. For the scope of the design certified, the staff expects to perform design audits similar to the integrated design inspections. The staff would perform these audits before design certification to verify the proper translation of the Tier 1 and 2 information into the detailed design products. Alternatively, applicants could conduct IDVPs or engineering assurance programs with staff oversight as was done for recently licensed facilities. This detailed design audit is not within the scope of the ITAAC that will be implemented upon issuance of the COL. The design audit augments the ITAAC in that it occurs within the design certification process. The design audits confirm that the SSAR information has been appropriately translated into the working level design products.

This supporting design information will enable the applicant to achieve a high level of design finality. Because of the volume and complexity of this information, it is not feasible to require the submission of this supporting design information as part of the certification application. However, the development of these detailed design products will be an economic incentive to minimize design changes that would detract from standardization. Attachment E illustrates the relative magnitudes of various classes of information.

ATTACHMENT A - DESIGN PROCESS

10 CFR Part 50 Design Process

Under the 10 CFR Part 50 licensing regime, the power plant design process is a complex group of interactions between numerous design disciplines. Attachment A-1, Figures A-1-1 and A-1-2, provide a simplified representation of this process. The earliest phases of the project involve the identification of the basic utility requirements for unit size, approximate location, and desired completion date. The utility selects an architect/engineer (AE) firm to perform the primary design functions for non-NSSS areas. The utility obtains expert assistance to evaluate candidate sites with respect to seismological and hydrological considerations. The utility then selects the prime site. This defines important design parameters such as cooling water volume and temperature.

The design process includes the following: (1) the definition of general design requirements, (2) the development of a concept and a general configuration that meets the general functional requirements, and (3) the development of all necessary design details to support the implementation through the fabrication and construction of the plant. The design process is iterative as numerous design products are generated, reviewed, revised, released for use, and superseded as the design is improved. These iterations are necessary to resolve conflicting design aspects, to reconcile new information generated within the design process, and to address vendor information.

While the demarcation between the design phases is not always distinct, the design process includes four generally accepted phases: conceptual, preliminary, detailed, and final. While selecting the site, the utility begins the conceptual design phase. The conceptual phase involves the development of basic design criteria, preliminary calculations, and functional requirements for structures, systems, and components. System-level design products at this stage include flow diagrams, general plant arrangements, principal single-line diagrams, and lists of major equipment. While these documents are developed in a preliminary state, they undergo numerous revisions during the design process to optimize the design and to incorporate vendor information. These revisions result in refined design products. The inquiry specifications are prepared for the NSSS and turbine generator packages. Once the major decisions are made, the utility completes the conceptual design.

In the preliminary design phase, there is increased definition of the engineering analyses and design products. The utility's design agent refines and develops system design products, such as piping and instrument diagrams (P&IDs), system descriptions, equipment arrangements, electrical load lists, logic diagrams and electrical single-line diagrams. In this phase, the design groups from different disciplines typically compete for available space to locate components and to route piping, cable tray, and conduit systems. This discipline-by-discipline effort does not always address overall plant integration and design optimization. Space is allocated on a first-come first-served basis. This process has created unique or unusual configurations. In parallel with the preliminary phase, the utility prepares and dockets a preliminary safety analysis report (PSAR) to support issuance of a construction permit. To support the earliest needs of the onsite construction activities, the structural design approaches completion before the designs for other disciplines.

In the detailed design phase, the utility's design agent and vendors continue to prepare drawings and specifications to construct the plant, procure material, and fabricate equipment. The engineering products include piping isometrics, and associated stress analyses, raceway layouts and cable routing, structural drawings, and instrument loop diagrams. The utility continues to develop the final safety analysis report (FSAR) in parallel with the site construction activities and vendor fabrication activities.

During the detailed design phase, the utility reviews vendor design information as it becomes available to ensure that previous design assumptions remain valid. Attachment A-2 shows the numerous discipline interactions and design considerations that are necessary in developing the performance, procurement, and installation specifications for a pump. These interactions and considerations illustrate the cascading changes that can result from differences between specified vendor data and design assumptions and vendor exceptions to inquiry specifications. For example, if the pump shutoff head is higher than specified, the piping class may need to be changed to accommodate the higher pressure. The piping analyses would need to be redone to account for the thicker walled piping. Because the thicker walled piping is less flexible, the location of postulated piping breaks may change, necessitating a revision to the hazards analyses performed to verify safe shutdown following a high-energy line break. The new break locations, as determined by the hazards analyses, may require relocation of instrument transmitters, instrument tubing, or other components that could affect safe shutdown or could create new jet impingement loads on other piping that would then have to be reevaluated. The cascading effect of seemingly minor changes can result in the expenditure of many engineering hours to complete the reconciliation and determine their acceptability. Vendor data can usually be enveloped by using engineering judgement based on previous experience. However, this is not always possible. Even if the vendor data is within the specified range, it is still necessary to reconcile all the affected documents to ensure consistency. Therefore, engineering hours will need to be expended even though the plant configuration is not affected.

The final design reconciliations occur when the design agent assesses the vendor information and as-built information with respect to the engineering analyses. For example, final stress calculations are performed for the piping systems, and test results are compared with engineering acceptance criteria. Attachment A-3 presents a list of design reconciliations, which are discussed in detail in the following paragraphs.

Reconciliations are performed at several points during the design process. Attachment A-3 lists specific design products that are reconciled with respect to either vendor or as-built data. The vendor reconciliation incorporates the following information:

- Vendor specifications
- Equipment ratings
- Mountings
- Electrical termination data

- Dimensional and physical data
- Detailed design features
- Make and model numbers
- Vendor test certifications
- Pump performance curves
- Nozzle locations
- Valve weights
- Heat transfer rates

The vendor information affects the assumptions and results of a wide variety of design products. Confirmatory analyses are needed to verify that the conclusions of the original design are not affected by the specific vendor data.

For a limited set of mechanical components (reactor coolant system components), the applicant could feasibly complete the design work based upon the premise that the applicant will directly manufacture the components or will obtain firm commitments for future deliveries from the vendor through an appropriate competitive bidding process.

While enveloping calculations can be performed without specific vendor data, the applicant can only finalize the design upon receipt of the as-procured component data. For example, flow balance calculations are affected by pump performance curves, seismic analyses are affected by equipment weights and centers of gravity, transient analyses are dependent upon motor acceleration curves, and breaker coordination studies are dependent on the time-current characteristic curves of circuit breakers. The designer must update drawings to reflect vendor-specific wiring details and must update single-line drawings to reflect equipment nameplate data.

Design reconciliation will also be required to accommodate as-built field data that falls within construction tolerances, receipt inspection data for vendor equipment characteristics, and revisions resulting from design changes to resolve field interferences. Items such as small bore piping, electrical conduit, and instrument tubing typically have been field run using detailed installation criteria with a subsequent seismic analyses of the as-built configuration.

For a 10 CFR Part 52 plant, the degree of design finality will be relatively high at the beginning of construction. However, the design agent will still need to expend a substantial engineering effort to perform these reconciliations based on variations in vendor equipment and as-built plant conditions.

The most significant aspect of the 10 CFR Part 50 process is the flexibility that is allowed for different design disciplines to proceed at various speeds. Theoretically, this flexibility can allow for earlier building construction and earlier procurement and installation of components. However, in practice this flexibility has resulted in large expenditures of engineering resources to repetitively reconcile the many interdependent design constraints and design products. During the design process for a plant licensed under 10 CFR Part 50, the construction may begin with as little as 20 percent of the engineering completed. In this situation, engineering is driven by the needs and demands of the construction schedule. In some cases, this process has resulted in much of the facility being built before the design is finalized. In addition, piping that is less than six inches in diameter is generally designed and installed towards the end of plant construction. Thus, space and embed steel reserved for piping has commonly been used by the electrical installation contractor to mount pull-boxes, conduit, and cable trays. Changes resulting from the advanced completion of certain aspects of design and construction can cause the expenditure of substantial engineering resources in discipline iterations in completing the design for a facility licensed pursuant to 10 CFR Part 50. Such changes can result in less than optimum designs.

In a fast track project, the utility's design agent allocates engineering resources and develops engineering products in a prioritized manner as needed by construction and vendor activities. As was shown at two recent near-term operating licenses (NTOLs), (St. Lucie 2 and Limerick 2), utilities can help complete successful construction schedules by performing a significant amount of the engineering before initiating construction activities. In both of these cases, the utility had a duplicate plant available to augment the initial design efforts.

10 CFR Part 52 Considerations

The projected 10 CFR Part 52 design process is shown in Attachment A-1, Figures A-1-3 and A-1-4. The major difference from the 10 CFR Part 50 process is that construction will likely not commence until the design is 70- to 80-percent complete as measured by the expenditure of engineering hours. Although only about 50 percent of the engineering hours will have been expended at the time of design certification, engineering activities can progress significantly during the COL review. In addition to performing site-specific design activities, the applicant can procure components for the previously certified portion of the design before issuance of the COL and can complete many of the reconciliations of vendor data before starting construction. Therefore, engineering will not be bound to the demands of the construction schedule. This will result in an integrated plant design that achieves a substantial degree of design optimization.

As illustrated in Attachment D, the 10 CFR Part 52 design process will enable the design to approach finality by the time of design certification, because approximately 50 percent of the engineering hours will have been expended to produce the level of detail sufficient to allow the staff to complete the review and audits necessary to make its safety determination. Although many design and as-built reconciliations will consume the remainder of the engineering-hours necessary to complete the final design, this will not significantly affect the physical degree of standardization. Plants built referencing the same certified design will have an identical general arrangement and will have functionally identical equipment with similar performance characteristics, perhaps supplied by different vendors.

An examination of the diversity in plant design that occurred under the 10 CFR Part 50 process will help in understanding why 10 CFR Part 52 will enable the applicants to achieve standardization. The plants constructed under

10 CFR Part 50 varied greatly between one another because they were produced from among 4 NSSS vendors, at least 6 A/E firms, and 54 licensees. In addition, these plants were designed and constructed during a period of evolving regulatory requirements. Even within the same A/E, the designs varied considerably between projects because they were produced at different engineering office locations and by engineering personnel with different design preferences. Therefore, as would be expected, present operating facilities, with few exceptions, are different from one another. However, for design certification under 10 CFR Part 52, the NSSS vendor becomes the 10 CFR Part 50 applicant and works with a single A/E firm to produce the design that is certified. Additionally, the utilities will not be able to influence the design outcome to the degree they did under Part 50 because they have acted only as advisors in the development of the evolutionary and advanced reactor designs. In the 10 CFR Part 52 process, the utilities will not typically become involved individually until after design certification. The certification of key design attributes in Tier 1 increases the economic advantages of referencing a certified design without making subsequent changes. In addition, the degree of design finality recommended by the staff at the time of design certification will ensure that the next generation of plants will not have the wide variation of design and construction attributes of the current generation and will gain the safety benefits that result from standardization.

ATTACHMENT A-1

PART 50 AND PART 52

DESIGN AND LICENSING PROCESSES

FIGURE A-1-1 PART 50 DESIGN PROCESS

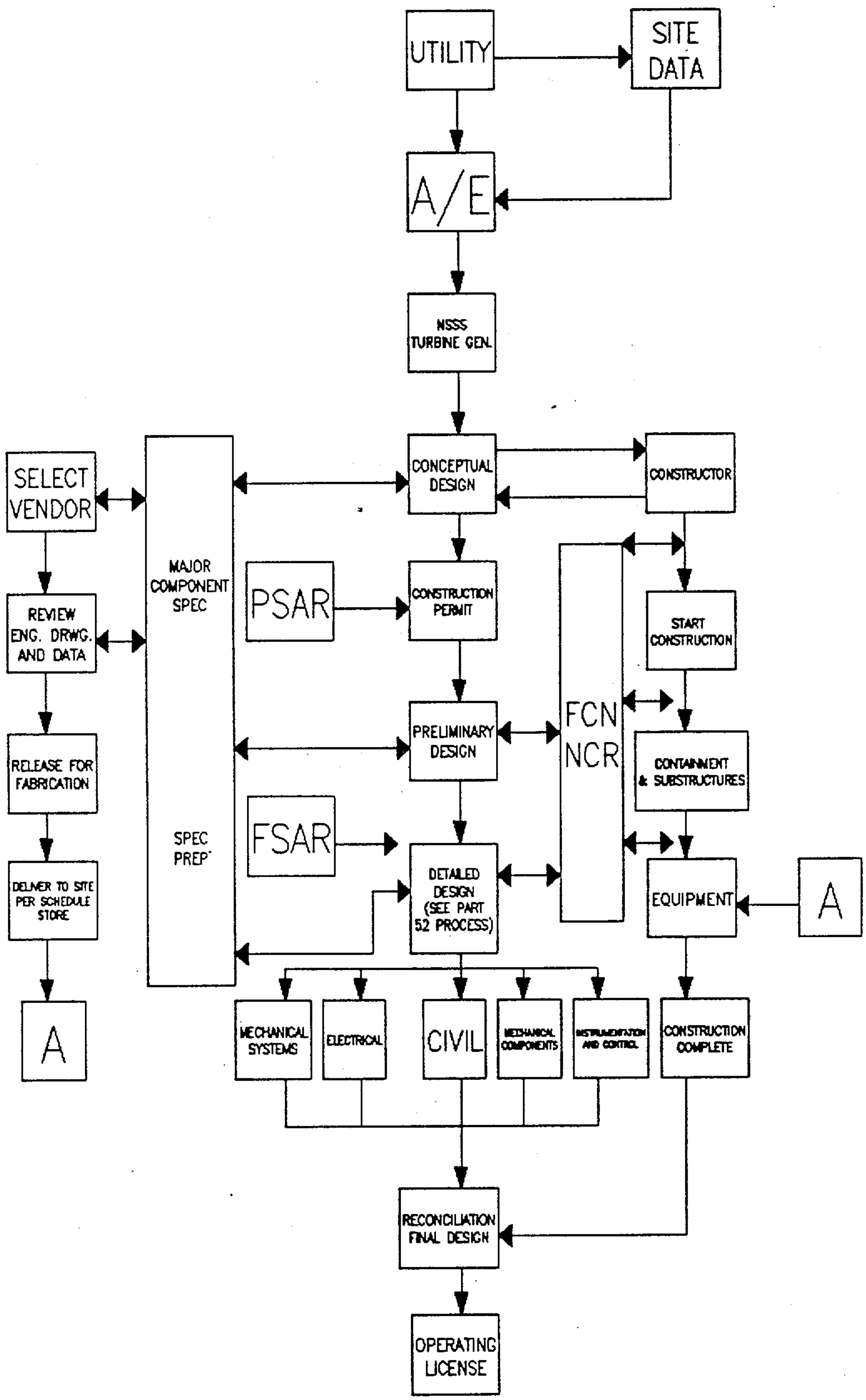


FIGURE A-1-2 PART 50 LICENSING PROCESS

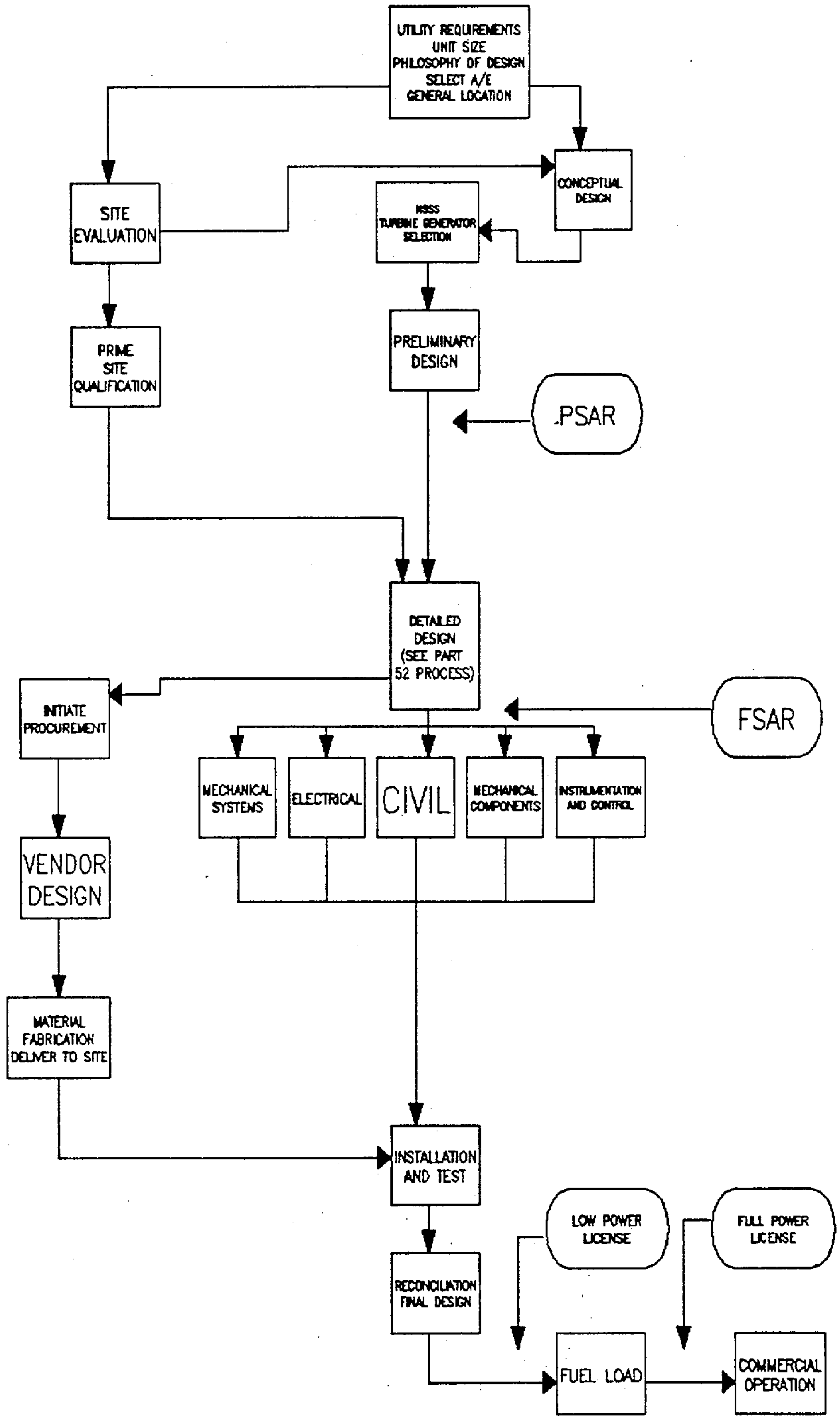


FIGURE A-1-3 PART 52 LICENSING PROCESS

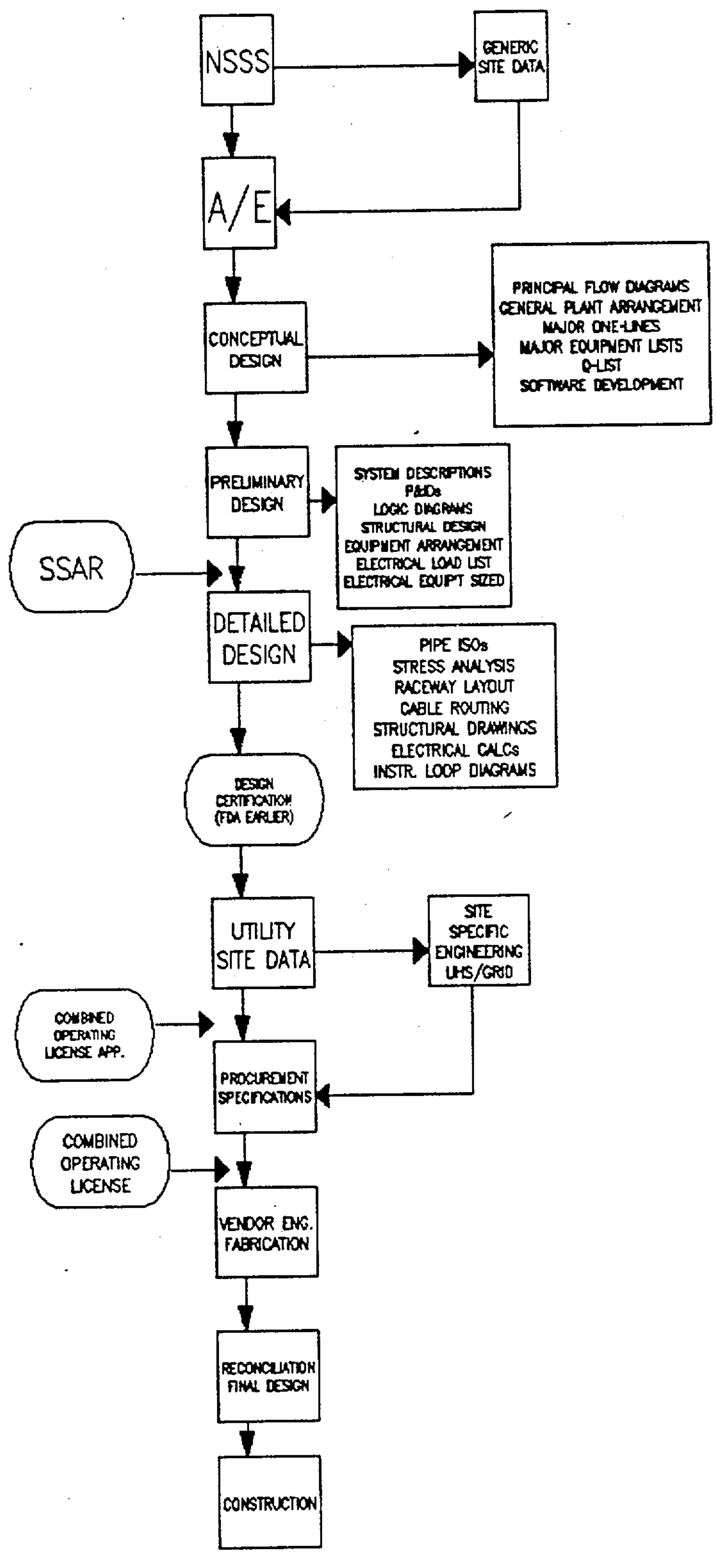
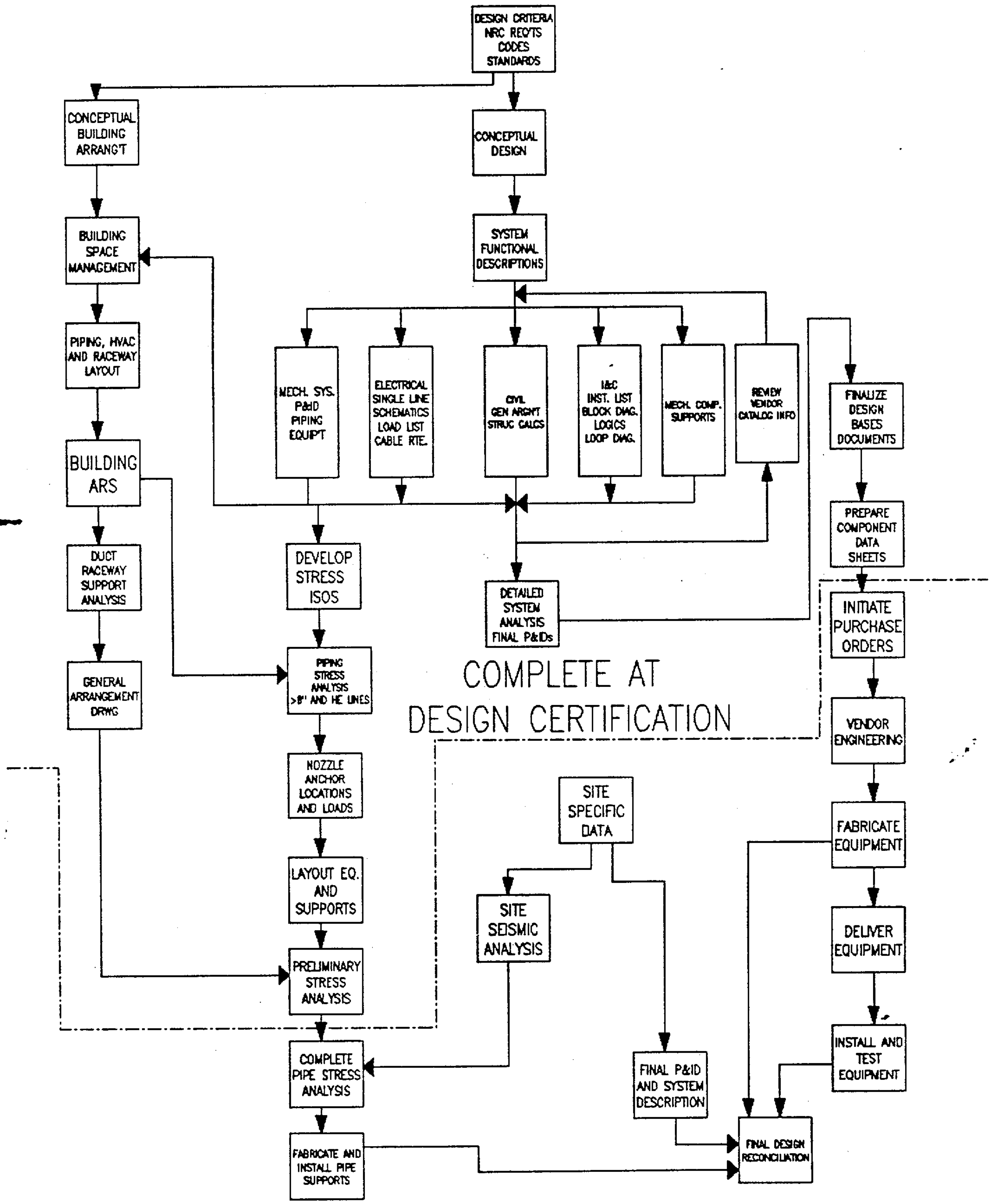
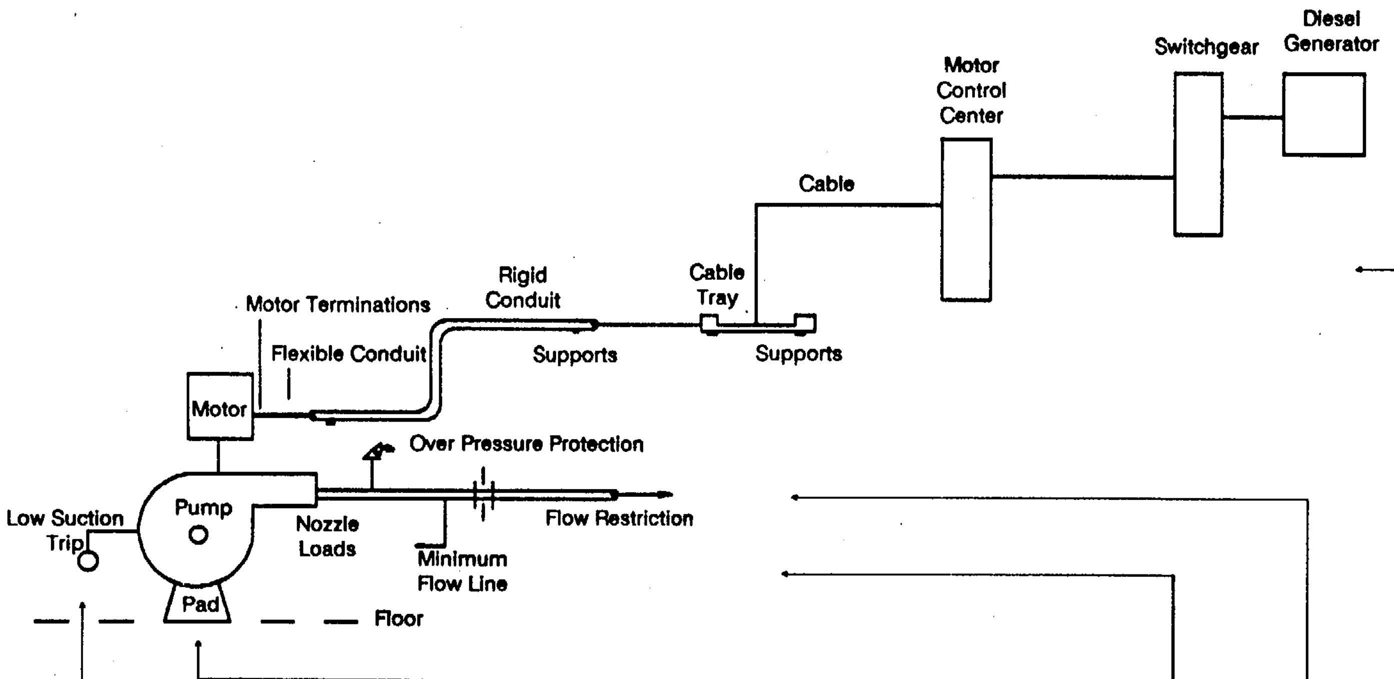


FIGURE A-1-4 PART 52 DESIGN PROCESS





ELECTRICAL:
- One-Line Diagrams
- Relay and Metering Diagrams
- Diesel Generator Loading and Sequencing
- Electrical Separation and Independence
- Load List
- Equipment List
- Equipment Specifications
- Environmental Qualification
- Room Heat Loads
- Breaker Coordination
- Protection Relays
- Degraded Voltage Analysis
- Short Circuit Current
- Voltage Drop
- Feeder Cable Sizing
- Cable and Raceway Schedule
- Cable Bill of Materials
- Electrical Schematics
- Cable Block Diagrams
- Termination Sheets
- Cable Pull Calculations
- Cable Tray Arrangement Drawings
- Conduit Layout Drawings
- Grounding Drawings

INSTRUMENT and CONTROL:
- Logic Diagrams
- Instrument Loop Diagrams
- Instrument List
- Instruments and Alarms (Flow,Vibration,Pressure,Temperature)
- Data Sheets
- Instrument Specifications
- Instrument Location Drawings
- Panel and Display Details
- Instrument Schematics
- Tubing Routing Drawings
- Multiplexer Input/Output List
- Instrument Tap Locations
- Instrument Setpoint Calculations
- Setpoint List

STRUCTURAL:
- Plant Arrangement Drawings
- Pad Design
- Mounting
- Floor Loads
- Seismic Analysis
- Seismic Qualification Requirements
- Embedments
- Floor Space
- Airplane Crash Analysis
- Barge Impact Analysis

MECHANICAL SYSTEMS:
- Piping and Instrument Diagrams
- Process Flow Diagrams (Pressure, Flow, Temperature)
- Operating Modes
- Horsepower
- Acceleration
- Differential Head
- Accident Analysis
- Dimensions
- Transients
- Weight
- Pump Specification
- Physical Separation

HAZARDS ANALYSIS:
- Missiles
- Appendix R Analysis
- Flooding
- Pipe Whip
- Fluid Jet Impingement
- Seismic Interactions
- Radiation Shielding
- Environments

ENGINEERING MECHANICS:
- Piping Loads
- Stress Analysis
- Pipe Support
- Seismic Analysis
- Jet Impingement Shields
- Seismic II/I Review
- Cold Spring
- Building Settlement
- Pipe Break Locations

Design Products and Activities for a Typical Pump

LIST OF RECONCILIATIONS

INSTRUMENTATION AND CONTROL

VENDOR DATA

Design Specifications
Instrument List
Instrument Data Sheets
Instrument Loop Diagrams
Schematic Connection Diagrams
Instrument Installation Details
Instrument Tubing Routing
Panel Arrangement Drawings and Display Formats
Internal Rack Arrangement Drawings
Failure Mode and Effects Analysis
Reliability and Availability Analysis
Environmental Qualification Analysis
Electromagnetic Compatibility Analysis
Human Factor Analysis
Setpoint Tolerance Calculations

AS-BUILT DATA

Instrument Data Sheets
Instrument Loop Diagrams
Schematic Connection Diagrams
Instrument Installation Details
Instrument Tubing Routing
Panel Arrangement Drawings and Display Formats
Internal Rack Arrangemet Drawings
Failure Mode and Effects Analysis
Reliability and Availability Analysis
Environmental Qualification Analysis
Electromagnetic Compatibility Analysis
Human Factors Analysis
Setpoint List
Instrument Calibration Calculations

MECHANICAL SYSTEMS

VENDOR DATA

Calculations
- Pressure Drop
- Flow Distribution
- Heat Transfer
- Waterhammer
- Transient and Off-normal Conditions
- Environmental Envelope
- Subcompartment Pressurization

Hazards Analysis

Failure Modes and Effects Analysis

AS-BUILT DATA

Hazards Analyses
- Appendix R
- Jet Impingement
- Compartment Flooding
- Internal Missiles

Piping and Instrumentation Diagrams

Flow Diagrams

CIVIL

VENDOR DATA

Adequacy of Supporting Structures
Adequacy of Seismic Analysis of Buildings

AS-BUILT DATA

Structural as-builts
Seismic Analyses of Buildings
Foundation Design
Protection Structure Adequacy with Respect to Equipment Location

ENGINEERING MECHANICS

VENDOR DATA

Pump, Tanks, Heat Exchangers, Pressure Vessels
- Nozzle Locations
- Nozzle Allowables
- Seismic Qualifications
- Structural Loadings

Valves
- Size
- Weight
- Operator Size and Location
- Center of Gravity

Strainers, flow restrictors
- Size
- Weight
- Center of Gravity

Pipe Supports
- Manufacturer

AS-BUILT DATA

Pumps, Tanks, Heat Exchangers, Pressure Vessels
- Location and Orientation

Valves
- Location
- Orientation

Strainers, Flow restrictors
- Location
- Orientation

Pipe Supports
- Location
- Orientation
- Stiffness
- Configuration

ELECTRICAL

VENDOR DATA

Single line drawings
Electrical Load Lists
Equipment Sizing Calculations
Heat Load Calculations
Short Circuit Analysis
Electrical Equipment List
Equipment Installation Drawings
Termination Sheets
Interconnection Drawings
Electrical Installation Specifications
Schematic Diagrams
Circuit Breaker Coordination and Protection Relay Settings
Diesel Generator Steady State and Transient Loading Analysis
Raceway and Suppport Drawings
Bus Voltage Calculations
Diesel Generator Load Sequencer Analysis
Load Sequence Scheme
Battery Sizing Calculations

AS–BUILT DATA

Electrical Load List
Single Line Drawings
Equipment Sizing Calculations
Voltage Drop Calculations
Electrical Equipment List
Panel and Control Board Physical
Wiring Drawings (Vendor Furnished)
Load Flow Calculations
Bus Voltage Calculations Degraded
Voltage Analysis Raceway and
Support Details Seismic Analyses of
Raceways Cable Tray Arrangement
Drawings Conduit Layout Drawings
Fire Stop and Fire Barrier Details
Grounding Drawings Schematic
Drawings

ATTACHMENT B - LEVEL OF DESIGN COMPLETION

This Attachment presents tables that list, by technical discipline, the level of completion and scope of those design products that are initiated during the various phases of the design process (i.e., conceptual, preliminary, detailed, or final). The staff considers this Attachment to be a preliminary document. Although not a complete list of design products, this Attachment contains sufficient detail to demonstrate by example, the level of design completion recommended. To aid in this demonstration, this Attachment specifies the types of design products required to be completed at the time of design certification and presents the type of information that the staff expects to be included in the design certification rule.

The following example using page B-1-1 illustrates the way to read these tables. Page B-1-1 contains the design products developed by the civil engineering discipline for the nuclear island as defined in Attachment C. For the civil engineering discipline, the nuclear island design includes primarily the containment building. The heading specifies the level of design detail as greater than level 2, indicating a staff requirement for a mature design at the time of design certification.

For example, the information contained on page B-1-1 indicates (1) that the major equipment locations within the containment are initially specified during the preliminary design phase but at the time of design certification the locations are completely defined, (2) that this information is of the maximum specificity that can be technically achieved at design certification, and (3) that this information should be reflected in the rule certifying the design as Tier 1 (i.e., only changeable pursuant to 10 CFR 52.63). Although design products may be listed under a heading such as "detailed" or "preliminary," this arrangement only indicates the design phase in which the product is initiated. This information does not indicate the state of completion of the design product. Therefore, an "X" in the "Completed at Design Certification" column indicates that information in the design product is finalized at the time of design certification (except for minor variations that can result from specified vendor data and as-built data) and is not conceptual or preliminary as the headings might lead a casual reader to infer.

In developing this Attachment, the staff found several instances in which the completion of a design product was technically achievable but did not require the product to be completed at design certification. In those cases, such as the entry for equipment and pipe support locations on Page B-2, the staff felt that completing this portion of the design would not be necessary for the staff to make a safety judgement.

In several instances in this Attachment, a design product not indicated as Tier 1 was required for completion at design certification. In these cases, such as the conceptual sizing of major electrical equipment shown on page B-1-5, the staff determined that the influence of vendor-specified and/or site data, obtained after the design certification, made it impractical to include this in Tier 1 of the design certification rule.

The tables herein are organized by design discipline and by system group.

The disciplines are as follows:

- Civil
- Electrical power
- Instrumentation and control
- Mechanical systems
- Engineering mechanics (pressure vessel and piping design)

The system groupings are as follows:

- Nuclear island (primary system and containment)
- Balance of nuclear island
- Turbine island
- Site-specific systems, structures, and components

For each discipline and system group, design products are listed for four phases of the design process:

- Conceptual - general functional, performance, and configuration requirements

- Preliminary - more detailed design information requirements (and preliminary supporting analyses)

- Detailed - specific definition of design configuration within the scope of the certified design (and refined analyses). This definition includes installation standards, test plans, ITAAC, technical specifications, interface requirements for non-certified portions of the design, procurement requirements, and detailed layouts.

- Final - design configuration completed in sufficient detail to develop construction and manufacturing drawings that can be used for fabrication and start-up activities (reconciliations of vendor specified data, and detailed test procedures for start-up)

This Attachment provides the staff's judgments on the technical feasibility of completing a design product and the degree of design completion that the staff recommends should be required at the time of design certification for the plant scope certified, and at the issuance of a combined operating licensing for site-specific aspects of the power plant design. This information is arranged under the following headings:

- "Complete at design certification" - The design product is part of the set of information the staff concludes should be complete at the time of design certification to provide an added degree of confidence that the applicant has properly implemented the requirements contained in Tier 1 and Tier 2.

- "Maximum technically achievable" - The staff judges that it is technically feasible to produce the design product. For the balance of nuclear island and turbine island, the design product is usually limited by the lack of vendor-specific and as-built information. For much of the primary coolant system and for other systems supplied by the NSSS vendor (e.g., reactor protection system), the staff believes that it may be feasible to reflect vendor-specific, but not as-built information.

- "Tier 1" - the information contained in these design products should be incorporated in the rule certifying the design and is changeable by an amendment rulemaking, an exemption pursuant to 10 CFR 52.63, or by rule waiver pursuant to 10 CFR 2.758. Tier 2 information would be that contained in the standard safety analysis report (SSAR) as required by the scope of the standard review plan and standard format and contents document but not specified as Tier 1. All of the completed design products provide supporting information that demonstrates (1) the appropriate implementation of the Tier 1 and Tier 2 SSAR commitments, and (2) allows NRC reviewers to audit the design documents as they would at the FSAR stage of review in the 10 CFR Part 50 process.

- "Additional Design Completed at COL Issuance" - This heading applies to site-specific systems, structures, and components. 10 CFR Part 52 does not explicitly require that the site-specific systems be brought to the same level of completion as those systems required for the certified design. However, the staff believes that such a requirement will provide the requisite assurance of safety. This will provide NRC reviewers with access to supporting information comparable to that which would be available in the 10 CFR Part 50 process.

The staff analyzed the feasibility of completing the design process. From this analysis, the staff determined that the graded approach will yield a level of detail not to exceed that shown below for system groupings:

- Nuclear island (primary system/containment) - final design in process (greater than Level 2)

- Balance of nuclear island and turbine island - detailed design complete (Level 2)

- Site-specific systems, structures, and components - conceptual design and design interfaces complete (Level 4)

Refer to Attachment C for the specific systems in each of these groups.

FINAL DESIGN IN PROCESS
(Greater than Level 2)
CIVIL – DESIGN PRODUCTS AT EACH DESIGN PHASE
NUCLEAR ISLAND – PRIMARY COOLANT SYSTEM / CONTAINMENT

CIVIL (NUCLEAR ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Building locations	X	X	X	
Building sizes	X	X	X	
Design bases, codes, and standards	X	X	X	
PRELIMINARY PHASE				
Concrete Enclosures, e.g., steam generator, pressurizer	X	X	X	
Building layouts	X	X	X	
Sizes of structural elements	X	X	X	
Major equipment locations	X	X	X	
Containment liner design	X	X	X	
Seismic analysis of buildings (Bounding)	X	X	X	
Floor response spectra (Bounding)	X	X	X	
Reactor vessel & primary component supports	X	X	X	
DETAILED PHASE				
Rebar arrangements (typical, floors & walls)	X	X	X	
Penetration design for pipe, electrical	X	X	X	
Hatch design for personnel and equipment	X	X	X	
Equipment and pipe support locations	X	X		
Locations of cable tray, conduit, HVAC supports	X	X		
FINAL PHASE				
Rebar arrangements (Localized)				Vicinity of equipment and pipe supports
Equipment pads and anchorage locations		X		
Reconcile seismic analyses of buildings				
Reconcile structural designs				

PRELIMINARY

DETAILED DESIGN COMPLETE
(Level 2)
CIVIL – DESIGN PRODUCTS AT EACH DESIGN PHASE
BALANCE OF NUCLEAR ISLAND

CIVIL (BALANCE OF NUCLEAR ISLAND)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
CONCEPTUAL PHASE				
Building locations	X	X	X	
Building sizes	X	X	X	
Design bases, codes, and standards	X	X	X	
PRELIMINARY PHASE				
Building layouts	X	X	X	
Sizes of structural elements	X	X	X	
Major equipment locations	X	X	X	
Seismic analysis of buildings (Bounding)	X	X	X	
Floor response spectra (Bounding)	X	X	X	
Turbine Missile Shield	X	X	X	If required by hazards analysis
DETAILED PHASE				
Rebar arrangements (typical, floors & walls)	X	X	X	
Equipment and pipe support locations		X		
Locations of cable tray, conduit, HVAC supports		X		
FINAL PHASE				
Rebar arrangements (Localized)				Vicinity of equipment & pipe supports
Equipment pads and anchorage locations		X		
Reconcile seismic analyses of buildings				
Reconcile structural designs				

DETAILED DESIGN COMPLETE
(Level 2)
CIVIL – DESIGN PRODUCTS AT EACH DESIGN PHASE
TURBINE ISLAND

CIVIL (TURBINE ISLAND)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
CONCEPTUAL PHASE				
Building locations	X	X	X	
Building sizes	X	X	X	
Design bases, codes, and standards	X	X	X	
PRELIMINARY PHASE				
Building layouts	X	X	X	
Sizes of structural elements	X	X	X	
Major equipment locations	X	X	X	
Seismic analysis of buildings (Bounding)	X	X	X	Collapse of turbine building (II/I)
DETAILED PHASE				
Rebar arrangements (Turbine Pedestal & Typicals)	X	X	X	
Equipment and pipe support locations		X		
Locations of cable tray, conduit, HVAC supports		X		
FINAL PHASE				
Rebar arrangements (Localized)				
Equipment pads and anchorage locations		X		
Reconcile seismic analyses of buildings				
Reconcile structural designs				

CONCEPTUAL & DESIGN COMPLETE
(Level 4)
CIVIL – DESIGN PRODUCTS AT EACH DESIGN PHASE
SITE SPECIFIC SYSTEMS, STRUCTURES AND COMPONENTS

CIVIL (SITE SPECIFIC) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Building locations				X	
Building sizes				X	
Design bases, codes, and standards	X	X	X		
PRELIMINARY PHASE					
Building layouts				X	
Sizes of structural elements				X	
Major equipment locations				X	
Seismic analysis of buildings (Bounding)				X	
Floor response spectra (Bounding)				X	
DETAILED PHASE					
Rebar arrangements (Typical, Floors & Walls)				X	
Equipment and pipe support locations				X	
Locations of cable tray, conduit, HVAC supports				X	
FINAL PHASE					
Rebar arrangement (Localized)					
Equipment pads and anchorage locations					
Reconcile seismic analyses of buildings					
Reconcile structural designs					

ELECTRICAL POWER SYSTEMS – DESIGN PRODUCTS AT EACH DESIGN PHASE
NUCLEAR ISLAND – PRIMARY COOLANT SYSTEM* / BALANCE OF NUCLEAR ISLAND / TURBINE ISLAND

ELECTRICAL DESIGN (NI/BONI/TI) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Electrical design basis and detailed design criteria document (codes & standards, electrical control philosophy, voltage tolerance, cable derating, voltage drop, separation criteria and separation groups, etc.)	X	X	X	
Major electrical equipment list	X	X	X	
List of safety related electrical equipment	X	X		
Major electrical equipment general location	X	X	X	
Cable tray arrangement (general layout)	X	X	X	Undimensioned layout to obtain basic routing
Identification of required calculations and analyses	X	X		
Single line electrical power distribution drawing – (basic) medium voltage AC switchgear and diesel generators	X	X	X	Includes UAT and RAT transformers, buses, bus ties and loads
Single line electrical power distribution drawing – (basic) low voltage AC 600V or 480V switchgear	X	X	X	Includes load center transformer, bus ties, buses, and loads
Single line electrical power distribution drawing – (basic) 125V DC batteries and main distribution bus	X	X	X	Includes batteries, battery charger, bus ties and distribution loads
Conceptual sizing calculations for major electrical equipment	X	X		

* Electrical power systems for the Nuclear Island – Primary Coolant System are included under Balance of Nuclear Island (i.e., Level 2). Greater than Level 2 detail is not considered feasible because of the dependence on vendor specific information for components not normally supplied by the NSSS vendor.

ELECTRICAL DESIGN (NI/BONI/TI) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Electrical equipment functional and performance specifications (major)	X	X	X	
Electrical distribution system design description (general)	X	X	X	
Identification of NSSS functional interfaces	X	X	X	
Calculations and analyses:				
- equipment sizing (battery, battery charger, switchgear, diesel generator, transformers, load centers, etc.)	X	X		
- short circuit current for switchgear	X	X		
- feeder cable sizing, ampacity, cable derating and cable selection	X	X		
- Voltage calculation at main buses	X	X		
- Transformer impedances	X	X		
- Switchgear rating	X	X		
- Heat loads for cable and major electrical equipment	X	X		
- Voltage drop (AC) and maximum allowable cable length	X	X		
- Enveloping voltage drop (DC) and maximum allowable cable length	X	X		
- Voltage drop at MCC starters	X	X		
- Control circuit voltage drop	X	X		
- MCC starter sizing and overload sizing	X	X		
- Circuit breaker coordination	X	X		
- Emergency diesel generator steady state loading and sequencing	X	X		
- Fuse requirements and selection	X	X		
- Appendix R analysis	X	X		
Logic diagrams (electrical equipment functional control scheme)	X	X	X	

ELECTRICAL DESIGN (NI/BONI/TI)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Electrical schematics (elementary diagrams or control wiring diagrams)	X	X		Includes power source, fuses, equipment rating, wire number, etc.
Block diagrams (cable from–to)	X	X		Includes cable size and cable numbers
Electrical load list	X	X		
Electrical equipment list	X	X		
Electrical equipment location and layout	X	X		
Electrical penetration list	X	X		
Electrical bus transfer scheme and load shedding	X	X		
Electrical penetration protection scheme	X	X		
Cable list (bill of materials)	X	X		
Circuit breaker equipment rating	X	X		
Interlock scheme for low voltage conditions	X	X		
Cable and raceway schedule	X	X		
Cable routing in raceways	X	X		
Ground detection scheme	X	X		
Low voltage single line drawings:				
– 480V AC single line drawings	X	X		
– 208V AC power distribution drawings	X	X		
– 120V AC power distribution drawings		X		Non-Class 1E

ELECTRICAL DESIGN (NI/BONI/TI)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
- 120V AC vital instrument power distribution drawings	X	X		
- 125V DC distribution drawings	X	X		
Relay and metering drawings	X	X		
Cable tray arrangement drawings	X	X		
Conduit layout drawings	X	X		Undimensioned layout to obtain basic path, wall sleeves & embedded conduit
DETAILED PHASE				
Typical electrical installation details	X	X		
Calculations and analyses:				
- Degraded voltage analyses	X	X		
- Load flow analyses	X	X		
- Emergency diesel generator transient loading	X	X		
- Protective relay settings				Dependent on vendor data
- Motor reduced voltage starting and acceleration time	X	X		
Alarm relay setting list		X		Dependent on vendor data
Reference documents:				
- Cable and raceway description and routing tabulation	X	X		
- Electrical load list	X	X		
- Electrical device list		X		Dependent on vendor data
- Protective relay setting list		X		Dependent on vendor data
- Block diagrams	X	X		
- Relay and metering drawings	X	X		

PRELIMINARY

ELECTRICAL DESIGN (NI/BONI/TI)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Single line power distribution drawings				
– Medium voltage AC switchgear	X	X		
– Low voltage AC switchgear	X	X		
– 125V DC battery and main bus	X	X		
– 480V AC motor control centers	X	X		
– 208V DC distribution system	X	X		
– 120V AC distribution system	X	X		Non-Class 1E
– 120V AC vital instrument distribution system	X	X		
– 125V DC distribution system	X	X		
FINAL PHASE				
Electrical equipment functional and performance specifications		X		
Construction drawings:				Dependent on vendor data
– Cable tray arrangement drawings				
– Conduit layout drawings				
– Cable tray support drawings and details				
– Conduit support drawings and details				
– Conduit schedule and junction/pull box schedule				
– Conduit isometric drawings				Final design dimensioned
– Penetration termination drawings or list				Dependent on vendor data
– Schematic (elementary or control wiring diagram)				Dependent on vendor data
– Interconnection wiring drawings (or termination cards)				Dependent on vendor data
– Cable pull cards				
– Grounding drawings				
– Fire stops and barriers				

ELECTRICAL DESIGN (NI/BONI/TI)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Electrical installation details (grounding details, cable termination details, flex conduit installation, equipment mounting details, conduit sizes, ground cable sizes, sealing materials, torque requirements, min. cable bend radius, pull box sizing, cable tie points, conduit bend radius, strain relief connectors, etc.)		X		Vendor equipment specific

PRELIMINARY

CONCEPTUAL DESIGN COMPLETE
(Level 4)
ELECTRICAL POWER SYSTEMS – DESIGN PRODUCTS AT EACH DESIGN PHASE
SITE SPECIFIC SYSTEMS, STRUCTURES AND COMPONENTS

ELECTRICAL DESIGN (SITE SPECIFIC) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Electrical design basis and detailed design criteria document (codes & standards, electrical control philosophy, voltage tolerance, cable derating, voltage drop, separation criteria and separation groups, etc.)	X	X	X		
Major electrical equipment list	X	X			
List of safety related electrical equipment	X	X			
Major electrical equipment general location				X	
Cable tray arrangement (general layout)				X	Within specified tolerances
Identification of required calculations and analyses	X	X			
Single line electrical power distribution drawing – (basic) high and medium voltage AC switchgear				X	Includes switchyard and offsite power supplies
Single line electrical power distribution drawing – (basic) low-voltage AC 600V or 480V switchgear				X	Includes load center transformer, bus ties, buses, and loads
Single line electrical power distribution drawing – (basic) 125V DC batteries and main distribution bus				X	Includes bus ties and distribution loads
Conceptual sizing calculations for major electrical equipment				X	
Cable routing to remote buildings containing safety-related equipment, e.g., intake structure				X	
Plant security system				X	

ELECTRICAL DESIGN (SITE SPECIFIC) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Electrical equipment (major) performance specifications				X	
Electrical distribution system design description				X	
Identification of NSSS interfaces				X	
Calculations and analyses:					
– grid stability analysis (voltage variation)				X	
– equipment sizing (switchgear, transformers, load centers, etc.)				X	
– short circuit current for switchgear				X	
– feeder cable sizing, ampacity, cable derating and cable selection				X	
– Voltage calculation at main buses				X	
– Transformer impedances				X	
– Switchgear rating				X	
– Heat loads for cable and major electrical equipment				X	
– Voltage drop (AC) and maximum allowable cable length				X	
– Enveloping voltage drop (DC) and maximum allowable cable length				X	
– Voltage drop at MCC starters				X	
– Control circuit voltage drop				X	
– MCC starter sizing and overload sizing				X	
– Circuit breaker coordination				X	
– Fuse requirements and selection				X	
– Appendix R analysis				X	
Logic diagrams (electrical equipment functional control scheme)				X	

ELECTRICAL DESIGN (SITE SPECIFIC)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Electrical schematics (elementary diagrams or control wiring diagrams)				X	Includes power source, fuses, equipment rating, wire number, etc.
Block diagrams (cable from–to)				X	Includes cable size and cable numbers
Electrical load list				X	
Electrical equipment list				X	
Electrical equipment location and layout				X	
Electrical bus transfer scheme and load shedding				X	
Cable list (bill of materials)				X	
Circuit breaker selection				X	
Interlock scheme for low voltage conditions				X	
Cable and raceway schedule				X	
Cable routing in raceways				X	
Ground detection scheme				X	
Low voltage single line drawings:					
– 480V AC single line drawings				X	
– 208V AC power distribution drawings				X	
– 120V AC power distribution drawings					Non-Class 1E

PRELIMINARY

ELECTRICAL DESIGN (SITE SPECIFIC)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
– 120V AC vital instrument power distribution drawings				X	
– 125V DC distribution drawings				X	
Relay and metering drawings				X	
Cable tray arrangement drawings				X	
Conduit layout drawings				X	Undimensioned layout to obtain basic path, wall sleeves & embedded conduit
DETAILED PHASE					
Electrical installation details				X	
Calculations and analyses:					
– Degraded voltage analyses				X	
– Load flow analyses				X	
– Emergency diesel generator transient loading				X	
– Protective relay settings					Dependent on vendor data
– Motor reduced voltages starting and acceleration time				X	
Alarm relay setting list				X	
Cathodic protection				X	
Reference documents:					
– Cable and raceway description and routing tabulation				X	
– Electrical load list				X	
– Electrical device list					Dependent on vendor data
– Protective relay setting list					Dependent on vendor data
– Block diagrams				X	
– Relay and metering drawings				X	

ELECTRICAL DESIGN (SITE SPECIFIC)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Single line power distribution drawings					
– Medium voltage AC switchgear				X	
– Low voltage AC switchgear				X	
– 125V DC battery and main bus				X	
– 480V AC motor control centers				X	
– 208V DC distribution system				X	
– 120V AC distribution system					Non-Class 1E
– 120V AC vital instrument distribution system				X	
– 125V DC distribution system				X	
Lightning protection				X	
FINAL PHASE					
Electrical equipment functional and performance specifications				X	
Construction drawings:					Dependent on vendor data
– Cable tray arrangement drawings					
– Conduit layout drawings					
– Cable tray support drawings and details					
– Conduit support drawings and details					
– Conduit schedule and junction/pull box schedule					
– Conduit isometric drawings					Final design dimensioned
– Penetration termination drawings or list					Dependent on vendor data
– Schematic (elementary or control wiring diagram)					Dependent on vendor data
– Interconnection wiring drawings (or termination cards)					Dependent on vendor data
– Cable pull cards					
– Grounding drawings					
– Fire stops and barriers					

ELECTRICAL DESIGN (SITE SPECIFIC)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Electrical installation details (grounding details, cable termination details, flex conduit installation, equipment mounting details, conduit sizes, ground cable sizes, sealing materials, torque requirements, min. cable bend radius, pull box sizing, cable tie points, conduit bend radius, strain relief connectors, etc.)				X	

PRELIMINARY

FINAL DESIGN IN PROCESS
(Greater than Level 2)
INSTRUMENTATION & CONTROL (I&C) – DESIGN PRODUCTS AT EACH DESIGN PHASE
NUCLEAR ISLAND – PRIMARY COOLANT SYSTEM / CONTAINMENT

PRELIMINARY

I&C (NUCLEAR ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Identification of applicable higher-level codes, standards, and regulatory requirements (e.g. IEEE Std. 279 for the reactor protection system, Reg. Guide 1.75 for channel separation and independence).	X	X	X	
Verification and validation (V&V) plan.	X	X	X	
Software development plan.	X	X	X	
Principal plant control & protection functional requirements (e.g. identification of load follow requirements and protective functions).	X	X	X	
Principal plant control & protection performance requirements (e.g. DNB limits).	X	X	X	
Higher-level control & protection system block diagrams (e.g. pressurizer pressure control strategy, protection system I/O).	X	X	X	
List of major equipment and its safety classification (e.g. remote multiplexers, reactor trip switchgear).	X	X	X	
Verification and validation reports.	X	X		For design products completed during conceptual phase.

I&C (NUCLEAR ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
System requirements specifications (e.g. reactor protection system, radiation monitoring system, remote multiplexing system); many of the design products that follow could be provided in this type of document.	X	X	X	
Identification of applicable lower-level standards (e.g. IEEE Std 802.4 for local area networks, ANSI/IEEE Std C62.41 for surge protection, ISA S75.01 for sizing control valves).	X	X	X	
Qualitative system architecture and configuration diagrams (e.g. block diagrams, data flow diagrams, network diagrams).	X	X	X	
Quantitative data flow diagrams.	X	X		
Definition and scope of vulnerability/susceptability requirements and methodology (e.g. EQ, hazards, electromagnetic interference, surge withstand capability, electrostatic discharge).	X	X	X	
Detailed safety/Q-class assignments.	X	X		
Detailed separation, independence and isolation criteria (e.g. criteria for application of isolation devices, acceptable distances/barriers).	X	X	X	
Diversity (defense-in-depth) methodology.	X	X	X	
Diversity (defense-in-depth) requirements and supporting analysis (e.g. analysis of parameter diversity; NUREG-0493 analysis; system segmentation; assignment of diverse hardware, software, or operating systems).	X	X		

I&C (NUCLEAR ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Typical instrument block diagrams and control logic diagrams for measurement of process variables.	X	X	X	
Functional requirements for specific process instruments and final control elements (instrument block diagrams and control logic diagrams.	X	X		
Performance requirements for specific process instruments and final control elements (range, preferred failure modes, transient response, accuracy/repeatibility, reliability/ availability goals, testability).	X	X		
Protective bypass indication criteria.	X	X	X	
Setpoint tolerance methodology.	X	X	X	
Selection of instrument type (e.g. magnetic flowmeter vs. orifice differential pressure meter vs. vortex shedding flowmeter).	X	X		
Software design requirements (functional requirements, performance requirements, interface requirements, design requirements and development standards).	X	X		
Data network requirements (e.g., protocol, error detection and correction.	X	X		
Man/machine interface requirements/philosophy	X	X	X	
Preliminary instrument list.	X	X		
Test requirements (e.g. requirement for surge withstand test, time domain reflectometry test).	X	X		
Failure mode and effects analyses (FMEAs).	X	X		
Preliminary reliability analyses.	X	X		
Preliminary human factors analyses.	X	X		
Trade-off analyses (e.g. evaluation of alternative logic architectures).	X	X		
Verification and validation reports.	X	X		For design products completed during the preliminary phase.

I&C (NUCLEAR ISLAND) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Equipment specification (field instruments and final control elements).	X	X		
Data sheets (e.g. ISA RP20 specification sheets).*	X	X		
Instrument loop diagrams (show hardware elements in loop without specific terminal numbers and make/model numbers).	X	X		
Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic circuits).*	X	X		
Instrument location drawings.	X	X		
Instrument installation standards/details.*	X	X		
Panel arrangement/layout drawings; display formats; task analysis.*	X	X		
Man/machine interface prototype.	X	X		
Rack arrangement/layout drawings.*	X	X		
Detailed instrument list.*	X	X		
Preliminary setpoint list.*	X	X		
Software design specifications (includes algorithms, control logic, data structures, input/output formats, interface descriptions, etc.).	X	X		
Software design analyses (resource utilization, timing, etc.).*	X	X		
Data network specification (e.g., topology, nodes, recovery specification)	X	X		
Reactor protection system, engineered safety features actuation system, reactor control system and man/machine interface system, hardware and software system prototype.	X	X		As necessary for innovative concepts
Factory and site acceptance test (FAT & SAT) plans/specifications.	X	X		
Instrument tubing routing.	X	X		
Verification and validation reports.	X	X		For design products completed during the detailed phase.

* Exclusive of vendor data

I&C (NUCLEAR ISLAND) FINAL PHASE

I&C (NUCLEAR ISLAND) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Reactor protection system, reactor control system, engineered safety features actuation system and man/machine interface system. – design specifications – schematic drawings – software	X	X		Reconciled to prototype test results, as applicable, for innovative concepts.
Equipment specifications (field instruments and final control elements).**				
Data sheets (e.g. ISA RP20 specification sheets).**				
Instrument loop diagrams (show hardware elements in loop with specific terminal numbers and make/model numbers).**				
Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic).**				
Instrument location drawings.				
Instrument installation standards.**				
Instrument tubing routing.				
Panel arrangement/layout drawings/display descriptions vendor prints).**				
Rack arrangement/layout drawings (vendor prints).**				
Primary element sizing calculation.				
Control valve sizing calculations.				
Final instrument list.**				
Final setpoint list.**				
Setpoint tolerance calculations.**				
Verification and validation reports.**				For design products completed during the
Factory and site acceptance test (FAT & SAT) reports.				
Final software code.				
Confirmatory analyses/tests (e.g. EQ, reliability/availability, electromagnetic compatability, calibration, scaling).**				
Detailed site acceptance test procedures.				

** Incorporates vendor data

DETAILED DESIGN COMPLETE
(Level 2)
INSTRUMENTATION & CONTROL (I&C) – DESIGN PRODUCTS AT EACH DESIGN PHASE
BALANCE OF NUCLEAR ISLAND AND TURBINE ISLAND

I&C (BALANCE OF NUCLEAR ISLAND/TURBINE ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Identification of applicable higher–level codes, standards, and regulatory requirements (e.g. IEEE Std. 279 for the reactor protection system, Reg. Guide 1.75 for channel separation and independence).	X	X	X	
Verification and validation (V&V) plan.	X	X	X	
Software development plan.	X	X	X	
Principal plant control system functional requirements (e.g. load follow requirements.	X	X	X	
Principal plant control system performance requirements (e.g. load rejection capability).	X	X	X	
Higher–level control & protection system block diagrams (e.g. control strategy, control system I/O).	X	X	X	
List of major equipment and its safety classification.	X	X	X	
Verification and validation reports.	X	X		For design products completed during the final phase.
PRELIMINARY PHASE				
System requirements specifications (e.g. radiation monitoring system, remote multiplexing system); many of the design products that follow could be provided in this type of document.	X	X	X	
Identification of applicable lower–level standards (e.g. IEEE Std 802.4 for local area networks, ANSI/IEEE Std C62.41 for surge protection, ISA S75.01 for sizing control valves).	X	X	X	
Qualitative system architecture and configuration diagrams (e.g. block diagrams, data flow diagrams, network diagrams).	X	X	X	

I&C (BALANCE OF NUCLEAR ISLAND/TURBINE ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Quantitative data flow diagrams.	X	X		
Definition and scope of vulnerability/susceptability requirements and methodology (e.g. EQ, hazards, electromagnetic interference, surge withstand capability, electrostatic discharge).	X	X	X	
Detailed safety/Q–class assignments.	X	X		
Detailed separation, independence and isolation criteria (e.g. criteria for application of isolation devices, acceptable distances/barriers).	X	X	X	
Diversity (defense–in–depth) methodology.	X	X	X	
Diversity (defense–in–depth) requirements and supporting analysis (e.g. analysis of parameter diversity; NUREG–0493 analysis; system segmentation; assignment of diverse hardware, software, or operating systems).	X	X		
Typical instrument block diagrams and control logic diagrams for measurement of process variables.	X	X	X	
Functional requirements for specific process instruments and final control elements (instrument block diagrams and control logic diagrams).	X	X		
Performance requirements for specific process instruments and final control elements (range, preferred failure modes, transient response, accuracy/repeatibility, reliability/availability goals, testability).	X	X		
Protective bypass indication criteria.	X	X	X	
Setpoint tolerance methodology.	X	X	X	
Selection of instrument type (e.g. magnetic flowmeter vs. orifice differential pressure meter vs. vortex shedding flowmeter).	X	X		
Software design requirements (functional requirements, performance requirements, interface requirements, design requirements and development standards).	X	X		
Data network requirements (e.g. protocol, error detection and correction).	X	X		

I&C (BALANCE OF NUCLEAR ISLAND/TURBINE ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Man/machine interface requirements/philosophy.	X	X	X	
Preliminary instrument list.	X	X		
Test requirements (e.g. requirement for surge withstand test, time domain reflectometry test).	X	X		
Failure mode and effects analyses (FMEAs).	X	X		
Preliminary reliability analyses.	X	X		
Preliminary human factors analyses.	X	X		
Trade-off analyses (e.g. evaluation of alternative logic architectures).	X	X		
Verification and validation reports.	X	X		For design products completed during the preliminary phase.
DETAILED PHASE				
Equipment specification (field instruments and final control elements).	X	X		
Data sheets (e.g. ISA RP20 specification sheets).*	X	X		
Instrument loop diagrams (show hardware elements in loop without specific terminal numbers and make/model numbers).	X	X		
Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic circuits).*	X	X		
Instrument location drawings.	X	X		
Instrument installation standards/details.*	X	X		
Panel arrangement/layout drawings; display formats, task analysis.*	X	X		
Man/machine interface prototype.	X	X		
Rack arrangement/layout drawings.*	X	X		

PRELIMINARY

* Exclusive of vendor data

I&C (BALANCE OF NUCLEAR ISLAND/TURBINE ISLAND) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Detailed instrument list.*	X	X		
Preliminary setpoint list.*	X	X		
Software design specifications (includes algorithms, control logic, data structures, input/output formats, interface descriptions, etc.).	X	X		
Software design analyses (resource utilization, timing, etc.).*	X	X		
Data network specification (e.g. topology, nodes, recovery specification).	X	X		
Factory and site acceptance test (FAT & SAT) plans/specifications.	X	X		
Instrument tubing routing.	X	X		
Verification and validation reports.	X	X		For design products completed during the detailed phase.

PRELIMINARY

FINAL PHASE

Equipment specifications (field instruments and final control elements).**

Data sheets (e.g. ISA RP20 specification sheets).**

Instrument loop diagrams (show hardware elements in loop with specific terminal numbers and make/model numbers).**

Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic).**

Instrument location drawings.

Instrument installation standards.**

Instrument tubing routing.

* Exclusive of vendor data
** Incorporates vendor data

I&C (BALANCE OF NUCLEAR ISLAND/TURBINE ISLAND) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Panel arrangement/layout drawings/display descriptions (vendor prints).**				
Rack arrangement/layout drawings (vendor prints).**				
Primary element sizing calculation.				
Control valve sizing calculations.				
Final instrument list.**				
Final setpoint list.**				
Setpoint tolerance calculations.**				
Verification and validation reports.**				For design products completed during the final phase.
Factory and site acceptance test (FAT & SAT) reports.				
Final software code.				
Confirmatory analyses/tests (e.g. EQ, reliability/availability, electromagnetic compatability, calibration, scaling).**				
Detailed site acceptance test procedures.				

** Incorporates vendor data

CONCEPTUAL DESIGN COMPLETE
(Level 4)
INSTRUMENTATION & CONTROL (I&C) – DESIGN PRODUCTS AT EACH DESIGN PHASE
SITE SPECIFIC SYSTEMS, STRUCTURES AND COMPONENTS

I&C (SITE SPECIFIC) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Identification of applicable higher–level codes, standards, and regulatory requirements (e.g., NUREG–0654).	X	X	X		
Verification and validation (V&V) plan.	X	X	X		
Software development plan.	X	X	X		
Principal functional requirements.	X	X	X		
Principal performance requirements.	X	X	X		
Higher–level system block diagrams.	X	X			
List of major equipment and its safety classification.	X	X			
Verification and validation reports.	X	X			For design products completed during the conceptual phase.
PRELIMINARY PHASE					
System Requirements Specifications (e.g. plant security systems); many of the design products that follow could be provided in this type of document.	X	X	X		
Identification of applicable lower–level standards (e.g. IEEE Std 802.4 for local area networks, ANSI/IEEE Std C62.41 for surge protection, ISA S75.01 for sizing control valves).	X	X	X		
Qualitative system architecture and configuration diagrams (e.g., block diagrams, data flow diagrams, network diagrams).	X	X	X		
Definition and scope of vulnerability/susceptability requirements and methodology (e.g. EQ, hazards, electromagnetic interference, surge withstand capability, electrostatic discharge).	X	X	X		

I&C (SITE SPECIFIC) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier 1	Additional Design Comp. at COL Issuance	Remarks
Detailed safety/Q–class assignments.				X	
Detailed separation, independence and isolation criteria (e.g. criteria for application of isolation devices, acceptable distances/barriers).	X	X	X		
Diversity (defense–in–depth) methodology	X	X	X		
Diversity (defense–in–depth) requirements and supporting analysis (e.g. analysis of parameter diversity; NUREG–0493 analysis; system segmentation; assignment of diverse hardware, software, or operating systems).	X	X			
Typical instrument block diagrams and control logic for measurement of process variables.	X	X	X		
Functional requirements for specific process instruments and final control elements (instrument block diagrams and control logic diagrams).				X	
Performance requirements for specific process instruments and final control elements (range, preferred failure modes, transient response, accuracy/repeatibility, reliability/ availability goals, testability).				X	
Bypass indication criteria.	X	X	X		
Setpoint tolerance methodology.	X	X	X		
Selection of instrument type (e.g. magnetic flowmeter vs. orifice differential pressure meter vs. vortex shedding flowmeter).				X	
Software design requirements (functional requirements, performance requirements, interface requirements, design requirements and development standards).				X	
Data network requirements (e.g. protocol, error detection and correction)	X	X			
Man/machine interface requirements/philosophy.	X	X	X		

I&C (SITE SPECIFIC) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Preliminary instrument list.	X	X			
Test requirements (e.g. requirement for surge withstand test, time domain reflectometry test).	X	X			
Failure mode and effects analyses (FMEAs).				X	
Preliminary reliability analyses.				X	
Preliminary human factors analyses.	X	X			
Trade–off analyses (e.g. evaluation of alternative logic architectures).	X	X			
Verification and validation reports.	X	X			For design products completed during the preliminary design phase
DETAILED PHASE					
Equipment specification (field instruments and final control elements).				X	
Data sheets (e.g., ISA RP20 specification sheets).*				X	
Instrument loop diagrams (show hardware elements in loop without specific terminal numbers and make/model numbers).				X	
Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic circuits).*				X	
Instrument location drawings.				X	
Instrument installation standards/details.*				X	
Panel arrangement/layout drawings; display formats; task analysis.*				X	
Rack arrangement/layout drawings.*				X	
Detailed instrument list.*				X	
Preliminary setpoint list.*				X	

* Exclusive of vendor data

I&C (SITE SPECIFIC) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Software design specifications (includes algorithms, control logic, data structures, input/output formats, interface descriptions, etc.).				X	
Software design analyses (resource utilization, timing, etc.).*				X	
Data network specification (e.g., topology, nodes, recovery specification)				X	
Factory and site acceptance test (FAT & SAT) plans/specifications.				X	
Instrument tubing routing.				X	
Verification and validation reports.				X	For design products completed during the detailed design phase.
FINAL PHASE					
Equipment specifications (field instruments and final control elements).**					
Data sheets (e.g. ISA RP20 specification sheets).**					
Instrument loop diagrams (show hardware elements in loop with specific terminal numbers and make/model numbers).**					
Schematic diagrams for circuits not in electrical discipline (e.g. control board interposing electronic logic, steam dump logic).**					
Instrument location drawings.					
Instrument installation standards.**					
Instrument tubing routing.					
Panel arrangement/layout drawings/display descriptions (vendor prints).**					
Rack arrangement/layout drawings (vendor prints).**					

* Exclusive of vendor data
** Incorporates vendor data

I&C (SITE SPECIFIC) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Primary element sizing calculation.					
Control valve sizing calculations.					
Final instrument list.**					
Final setpoint list.**					
Setpoint tolerance calculations.**					
Verification and validation reports.					For design products completed during the final design phase.
Factory and site acceptance test (FAT & SAT) reports.					
Final software code.					
Confirmatory analyses/tests (e.g. EQ, reliability/availability, electromagnetic compatability, calibration, scaling).**					
Detailed site acceptance test procedures.					

PRELIMINARY

** Incorporates vendor data

FINAL DESIGN IN PROCESS
(Greater than Level 2)
MECHANICAL SYSTEMS – DESIGN PRODUCTS AT EACH DESIGN PHASE
NUCLEAR ISLAND – PRIMARY COOLANT SYSTEM / CONTAINMENT

MECHANICAL DESIGN (NUCLEAR ISLAND)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
CONCEPTUAL PHASE				
Functional design criteria	X	X	X	
performance requirements				
redundancy requirements				
reliability requirements				
separation criteria				
Conceptual engineering diagrams	X	X	X	
flow diagram (major flow paths)				
general layout drawings				
Major equipment list	X	X	X	
List of safety–related components	X	X	X	
List of evaluation and studies	X	X		
Enveloping calculations or analyses (scoping calculations based upon fundamental design assumptions and site–specific bounding assumptions)	X	X		
Primary NSSS accident analysis	X	X	X	
PRELIMINARY PHASE				
Preliminary system design description	X	X	X	
incorporates design criteria				
describes system performance				
identifies interfacing systems				
supporting systems				
systems receiving support				

MECHANICAL DESIGN (NUCLEAR ISLAND)
PRELIMINARY PHASE

	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Preliminary piping & instrument diagram (P&ID) system equipment major flow paths pipe sizes protective devices safety/seismic class breaks	X	X	X	
Process flow diagram -- all modes (normal, upset, emergency) pressure temperature flow	X	X		
General arrangements major equipment location	X	X	X	Within specified tolerances
Calculations and analyses sufficient to demonstrate performance within design criteria, e.g. flow rates/flow balance network heat transfer rates surge volumes NPSH make-up rates accumulator capacity	X	X		
Piping requirements design pressure design temperature over-pressure protection wall thickness	X	X	X	
Piping requirements vacuum-breaker requirements maximum fluid velocities maximum pressure drops heat tracing thermal insulation	X	X		

MECHANICAL DESIGN (NUCLEAR ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Detailed equipment lists Q-list EQ-list	X	X		
Safety/seismic classes and boundaries	X	X	X	
Process safety limits minimum tank levels maximum allowable temperatures minimum flow rates	X	X		
Materials selection	X	X		
Special fabrication process (e.g. welding)	X	X		
HVAC requirements heat sources heat sinks design room temperature limits	X	X		
HVAC duct routing	X	X	X	Undimensioned layout to obtain basic routing.
Preliminary FMEA, hazards & safety analyses single failure provisions flooding missiles	X	X		
Major equipment functional and performance specifications reactor vessel, reactor internals, fuel, heat exchangers, pumps, large valves, etc.	X	X	X	Within specified tolerances to allow for vendor specific data.
Major equipment type and configuration (e.g. centrifugal pump, deep draft)	X	X	X	
DETAILED PHASE				
Accident/off-normal analyses Reactor thermal/hydraulic analyses Appendix R transient (water hammer) post-accident environments safe shutdown	X	X		

MECHANICAL DESIGN (NUCLEAR ISLAND) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Hazards analyses and calculations internal and external missiles internal and external flooding seismic interactions seismic/non-seismic interactions pipe whip prot protection fluid jet protection radiation shielding	X	X		
Detailed P&ID	X	X		
Installation specifications and details	X	X		
Sumps and floor drains	X	X		
Equipment functional and performance specifications	X	X		
FINAL PHASE				
Construction drawings engineering piping drawings composite piping drawings isometric drawings	X	X		
Vendor data reconciliations analyses studies design assumptions	X	X		
FMEA off-normal analyses hazards analyses				
Design basis document Updates & finalizes SDD References calcs & analyses	X	X		

DETAILED DESIGN COMPLETE
(Level 2)
MECHANCIAL SYSTEMS
BALANCE OF NUCLEAR ISLAND – ECCS, CVCS, etc.

MECHANICAL DESIGN (BALANCE OF NUCLEAR ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Site specific envelope (bounding site parameters/ maximum cooling water temperature seismic acceleration response spectra maximum and minimum ambient temperatures atmospheric dispersion factors	X	X	X	
Functional design criteria performance requirements redundancy requirements reliability requirements separation criteria	X	X	X	
Conceptual engineering diagrams flow diagram (major flow paths) general layout drawings	X	X	X	
Major equipment list	X	X	X	
List of major safety-related components	X	X	X	
List of evaluation and studies	X	X		
Enveloping calculations or analyses scoping calculations based upon fundamental design assumptions site-specific bounding assumptions	X	X		
PRELIMINARY PHASE				
Preliminary system design description incorporates design criteria describes system performance identifies interfacing systems supporting systems systems receiving support	X	X	X	

MECHANICAL DESIGN (BALANCE OF NUCLEAR ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Preliminary piping & instrument diagram (P&ID) all system equipment flow paths and major connections pipe sizes protective devices safety/seismic class breaks	X	X	X	
Process flow diagram -- all modes (normal, upset, emergency) pressure temperature flow	X	X		
General arrangements major equipment location	X	X	X	Within specified tolerances
Calculations and analyses (sufficient to demonstrate performance within design criteria) e.g. flow rates/ flow balance network heat transfer rates surge volumes NPSH make-up rates accumulator capacity	X	X		
Piping requirements design pressure design temperature over-pressure protection wall thickness	X	X	X	
Piping requirements vacuum-breaker requirements maximum fluid velocities maximum pressure drops heat tracing thermal insulation	X	X		

MECHANICAL DESIGN (BALANCE OF NUCLEAR ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Detailed equipment lists Q-list EQ-list	X	X		
Safety/seismic classes and boundaries	X	X	X	
Process safety limits minimum tank levels maximum allowable temperatures minimum flow rates	X	X		
Materials selection	X	X		
HVAC duct routing	X	X		Within specified tolerances.
HVAC requirements heat sources heat sinks design room temperature limits	X	X		
Preliminary FMEA, hazards & safety analyses single failure provisions flooding missiles	X	X		
Major equipment functional and performance specifications heat exchangers, pumps, large valves, etc.	X	X		
DETAILED PHASE				
Accident/off-normal analyses Appendix R transient (water hammer) post-accident environments safe shutdown	X	X		

MECHANICAL DESIGN (BALANCE OF NUCLEAR ISLAND) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Hazards analyses and calculations:				
internal and external missiles	X	X		
internal and external flooding	X	X		
seismic interactions		X		Interactions, whip, jets need
seismic/non-seismic interactions		X		to wait for isometric information
pipe whip protection		X		
fluid jet protection		X		
radiation shielding	X	X		
Detailed P&ID	X	X		
Installation specifications and details	X	X		
Sumps and floor drains	X	X		
Equipment functional and performance specifications	X	X		

FINAL PHASE

Construction drawings
- engineering piping drawings
- composite piping drawings
- isometric drawings

Vendor data reconciliations
- analyses
- studies
- design assumptions

FMEA
- off-normal analyses
- hazards analyses

Design basis document
- Updates & finalizes system design doc.
- References to calcs & analyses
- Incorporates vendor info

DETAILED DESIGN COMPLETE
(Level 2)
MECHANICAL SYSTEMS – DESIGN PRODUCTS AT EACH DESIGN PHASE
TURBINE ISLAND

MECHANICAL DESIGN (TURBINE ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Site specific envelope (bounding site parameters/ maximum cooling water temperature seismic acceleration response spectra maximum and minimum ambient temperatures	X	X	X	
Functional design criteria performance requirements	X	X	X	
Conceptual engineering diagrams flow diagram (major flow paths) general layout drawings	X	X	X	
Major equipment list	X	X	X	
List of major safety–related components	X	X	X	
List of evaluation and studies	X	X		
Enveloping calculations or analyses scoping calculations based upon fundamental design assumptions site–specific bounding assumptions	X	X		

MECHANICAL DESIGN (TURBINE ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Preliminary system design description incorporates design criteria describes system performance identifies interfacing systems supporting systems systems receiving support	X	X	X	
Preliminary piping & instrument diagram (P&ID) system equipment flow paths and major connections	X	X	X	
Process flow diagram -- all modes (normal, upset, emergency) pressure temperature flow	X	X		
General arrangements major equipment location	X	X	X	Within specified tolerances
Calculations and analyses sufficient to demonstrate performance within design criteria, e.g. flow rates/flow balance network heat transfer rates surge volumes NPSH make-up rates accumulator capacity	X	X		

MECHANICAL DESIGN (TURBINE ISLAND) PRELIMINARY PHASE

MECHANICAL DESIGN (TURBINE ISLAND) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Piping requirements design pressure design temperature over-pressure protection wall thickness	X	X	X	
Piping requirements vacuum-breaker requirements maximum fluid velocities maximum pressure drops heat tracing thermal insulation	X	X		
Materials selection	X	X		
HVAC requirements heat sources heat sinks design room temperature limits	X	X		
HVAC duct routing	X	X		Within specified tolerances
Major equipment functional and performance specifications heat exchangers, pumps, large valves, etc.	X	X		
DETAILED PHASE				
Accident/off-normal analyses (where applicable) transient (water hammer) post-accident environments	X	X		
Hazards analyses and calculations (where applicable) radiation shielding	X	X		

MECHANICAL DESIGN (TURBINE ISLAND) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Detailed P&ID	X	X		
Installation specifications and details	X	X		
Sumps and floor drains		X		Detail not needed for BOP systems
Equipment functional and performance specifications	X	X		

FINAL PHASE

Construction drawings
- engineering piping drawings
- composite piping drawings
- isometric drawings

Vendor data reconciliations
- analyses
- studies
- design assumptions

FMEA
- off-normal analyses
- hazards analyses

CONCEPTUAL DESIGN COMPLETE
(Level 4)
MECHANICAL SYSTEMS – DESIGN PRODUCTS AT EACH DESIGN PHASE
SITE SPECIFIC SYSTEMS, STRUCTURES AND COMPONENTS

MECHANICAL DESIGN (SITE SPECIFIC) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Site specific envelope (bounding site parameters) maximum cooling water temperature seismic acceleration response spectra maximum and minimum ambient temperatures	X	X	X		
Functional design criteria performance requirements redundancy requirements reliability requirements separation criteria Codes and Standards	X	X	X		
Conceptual engineering diagrams flow diagram (major flow paths) general layout drawings	X	X			
Major equipment list	X	X			
List of major safety-related components	X	X			
List of evaluation and studies	X	X			
Enveloping calculations or analyses scoping calculations based upon fundamental design assumptions site-specific bounding assumptions	X	X			

MECHANICAL DESIGN (SITE SPECIFIC) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
System design description				X	
incorporates design criteria					
describes system performance					
identifies interfacing systems					
supporting systems					
systems receiving support					
Piping & instrument diagram (P&ID)				X	
system equipment					
flow paths and connections					
instrument positions					
pipe sizes					
protective devices					
class breaks					
vents and drains					
Process flow diagram — all modes				X	
(normal, upset, emergency)					
pressure					
temperature					
flow					
General arrangements				X	Within specified tolerances
major equipment location					
Calculations and analyses				X	
sufficient to demonstrate performance					
within design criteria, e.g. flow					
rates/flow balance network					
heat transfer rates					
surge volumes					
NPSH					
make-up rates					

MECHANICAL DESIGN (SITE SPECIFIC) PRELIMINARY PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Piping requirements				X	
design pressure					
design temperature					
over-pressure protection					
vacuum-breaker requirements					
maximum fluid velocities					
maximum pressure drops					
wall thickness					
heat tracing					
thermal insulation					
Detailed equipment lists				X	
Q-list					
EQ-list					
Safety classes and boundaries				X	
Process safety limits				X	
minimum tank levels					
maximum allowable temperatures					
minimum flow rates					
Materials selection				X	
HVAC requirements				X	
heat sources					
heat sinks					
design room temperature limits					
HVAC duct routing				X	Within specified tolerances.
Preliminary FMEA, hazards & safety analyses				X	
single failure provisions					
flooding					
missiles					
Major equipment specifications				X	
heat exchangers, pumps, large valves, etc.					

MECHANICAL DESIGN (SITE SPECIFIC) DETAILED PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Accident/off-normal analyses				X	
Appendix R					
transient (water hammer)					
post-accident environments					
safe shutdown					
Hazards analyses and calculations					
internal and external missiles					
internal and external flooding				X	
seismic interactions				X	
seismic/non-seismic interactions					
pipe whip prot protection					
fluid jet protection					
radiation shielding					
Installation specifications and details				X	
Sumps and floor drains				X	
Equipment functional and performance specifications				X	
FINAL PHASE					
Construction drawings					
engineering drawings					
composite piping drawings					
isometric drawings					
Approved vendor documents and drawings					

MECHANICAL DESIGN (SITE SPECIFIC) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Reconciliations with vendor information					
calculations					
analyses					
studies					
design assumptions					
FMEA					
off-normal analyses					
hazards analyses					
Reconciliation with as-built information					
Design basis document					
Updates & finalizes SDD					
References calcs & analyses					
Incorporates vendor data					

FINAL DESIGN IN PROCESS
(Greater than Level 2)
ENGINEERING MECHANICS – DESIGN PRODUCTS AT EACH DESIGN PHASE
NUCLEAR ISLAND – PRIMARY COOLANT SYSTEM / CONTAINMENT

ENGINEERING MECHANICS (NUCLEAR ISLAND) CONCEPTUAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
General design specifications	X	X	X	
Major equipment general location	X	X	X	
List of safety related systems/components	X	X	X	
PRELIMINARY PHASE				
Component fabrication processes, e.g. field welds	X	X		
Design specifications	X	X	X	e.g., piping and components
Equipment preliminary analyses	X	X		
Piping arrangements/preliminary routing	X	X	X	ASME 1N piping larger than 1", high energy piping 2 1/2" and larger, and other piping 6" and larger with specified tolerances
Preliminary pipe stress analysis	X	X		ASME 1N piping larger than 1", high energy piping 2 1/2" and larger, and other piping 6" and larger with specified tolerances
Safety classes and boundaries	X	X	X	
Preliminary loadings for penetrations and equipment nozzles	X	X		
Seismic qualification program	X	X	X	
Component inspection program	X	X	X	Including provisions for accessibility
DETAILED PHASE				
Pipe stress isometrics	X	X		
Pipe stress analysis	X	X		
Pipe support loadings	X	X		
Typical pipe support designs	X	X		
Component loading details	X	X		
Interference resolution	X	X		
Seismic qualification of equipment	X	X		
Transient analyses of fluid systems	X	X		
Hazards analyses for missiles, pipe whip, line break	X	X		

ENGINEERING MECHANICS (NUCLEAR ISLAND) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Reconciled pipe stress analysis	X	X		Only if all vendor information is known (i.e. valves, pumps, etc.)
Pipe support calculations and drawings	X	X		
Completed equipment seismic and qualification reports	X	X		
Final loadings for equipment nozzles, wall/floor penetrations	X	X		
Pipe supports and embed plates	X	X		
Installation specifications	X	X		

DETAILED DESIGN COMPLETE
(Level 2)
ENGINEERING MECHANICS – DESIGN PRODUCTS AT EACH DESIGN PHASE
BALANCE OF NUCLEAR ISLAND AND TURBINE ISLAND

ENGINEERING MECHANICS (BALANCE OF NUCLEAR & TURBINE ISLANDS)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
CONCEPTUAL PHASE				
General design specifications	X	X	X	
Major equipment general location	X	X	X	
List of safety related systems/components	X	X	X	
PRELIMINARY PHASE				
Design specifications	X	X	X	e.g., piping
Equipment preliminary analyses	X	X		
Piping arrangements/preliminary routing	X	X	X	Piping 6" and larger and high energy piping 2 1/2" and greater within specified tolerances excluding equipment terminations
Preliminary pipe stress analysis	X	X		6" & larger piping
Safety classes and boundaries	X	X	X	
Preliminary loadings for penetrations and equipment nozzles	X	X		6" & larger piping
DETAILED PHASE				
Pipe stress isometrics	X	X		6" & larger plus high energy lines 2 1/2" and greater
Pipe stress analysis	X	X		6" & larger plus high energy lines 2 1/2" and greater
Pipe support loadings	X	X		6" & larger plus high energy lines 2 1/2" and greater
Typical pipe support designs	X	X		6" & larger plus high energy lines 2 1/2" and greater
Component loading details		X		
Interference resolution		X		
Seismic qualification of equipment		X		
Transient analyses of fluid systems		X		
Hazards analyses for missiles, pipe whip, line break		X		

ENGINEERING MECHANICS (BALANCE OF NUCLEAR & TURBINE ISLANDS) FINAL PHASE	Complete at Design Certification	Maximum Technically Achievable	Tier I	Remarks
Reconciled pipe stress analysis				
Pipe support calculations and drawings				
Completed equipment seismic and qualification reports				
Final loadings for equipment nozzles, wall/floor penetrations				
Pipe supports and embed plates				
Installation specifications				

PRELIMINARY

CONCEPTUAL DESIGN COMPLETE
(Level 4)
ENGINEERING MECHANICS – DESIGN PRODUCTS AT EACH DESIGN PHASE
SITE SPECIFIC SYSTEMS, STRUCTURES AND COMPONENTS

ENGINEERING MECHANICS (SITE SPECIFIC)	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
CONCEPTUAL PHASE					
General design specifications	X	X	X		
Major equipment general location	X	X			
List of safety related systems/components	X	X			
PRELIMINARY PHASE					
Design specifications	X	X	X		e.g., piping
Equipment preliminary analyses				X	
Piping arrangements/preliminary routing				X	
Preliminary pipe stress analysis				X	6" & larger pipe
Safety classes and boundaries				X	
Preliminary loadings for penetrations and equipment nozzles				X	6" & larger pipe
DETAILED PHASE					
Pipe stress isometrics				X	6" & larger or high energy lines 2 1/2" & greater
Pipe stress reports				X	6" & larger or high energy lines 2 1/2" & greater
Pipe support loadings				X	6" & larger or high energy lines 2 1/2" & greater
Typical pipe support designs				X	6" & larger or high energy lines 2 1/2" & greater
Component loading details				X	
Interference resolution				X	
Seismic qualification of equipment				X	
Transient analyses of fluid systems				X	
Hazards analyses for missiles, pipe whip, line break				X	

ENGINEERING MECHANICS (SITE SPECIFIC) FINAL PHASE

	Complete at Design Certification	Maximum Technically Achievable	Tier I	Additional Design Comp. at COL Issuance	Remarks
Reconciled pipe stress analysis					
Pipe support calculations and drawings					
Completed equipment seismic qualification reports					
Final loadings for equipment nozzles, wall/floor penetrations					
Pipe supports and embed plates					
Installation specifications					
Intake structure considerations – barge impact, flooding					

PRELIMINARY

ATTACHMENT C - PLANT SCOPE

This Attachment defines the scope of "nuclear island", "balance of nuclear island", "turbine island", and "site-specific" by presenting examples, by technical discipline, of typical structures, systems, and components that could be included in these categories. The list of structures, systems, and components was not intended nor should it be interpreted as being complete. The examples included in this Attachment are based on a recently built PWR and demonstrate the application of the concept of the graded approach for the level of detail required to be completed at the time of design certification.

Attachment B and Attachment C should be used together. By reference to specific engineering products, Attachment B further defines the level of design completion required by the staff at the time of design certification for the nuclear island, balance of nuclear island, turbine island, and site specifics.

FINAL DESIGN IN PROCESS

(GREATER THAN LEVEL 2)

NUCLEAR ISLAND

PRIMARY COOLANT SYSTEM
ENGINEERED SAFETY FEATURES ACTUATION SYSTEM
REACTOR PROTECTION SYSTEM
REACTIVITY CONTROL SYSTEM
REACTOR CONTROLS AND INSTRUMENTATION
ASME CLASS 2N STEAM AND FEEDWATER
CONTAINMENT

INSTRUMENTATION & CONTROL

Process instrumentation for primary reactor coolant system
Reactor protection system
Engineered safety features actuation system
Reactor and NSSS control systems
Feedwater control system
Main control room systems and equipment
Neutron monitoring system

ENGINEERING MECHANICS

Piping systems inside or outside containment whose postulated failure would necessitate actuation of accident mitigation systems, e.g., ASME Section III Class 1N piping, including pipe supports and components, ASME Class 2N steam and feedwater piping, pipe supports and components to and including the outboard containment isolation valve.

CIVIL

Containment building and penetrations

ELECTRICAL POWER SYSTEMS

Electrical power systems for the Nuclear Island – Primary Coolant System are included under the Balance of Nuclear Island. Greater than Level 2 detail is not considered feasible because of the dependence on vendor specific information for components not normally designed by the NSSS vendor.

MECHANICAL SYSTEMS

Reactor/Primary Coolant System
Control Rod Drive System

DETAILED DESIGN COMPLETED

(LEVEL 2)

BALANCE OF NUCLEAR ISLAND (BONI)

EMERGENCY CORE COOLING SYSTEMS
CHEMICAL VOLUME AND CONTROL SYSTEM
RESIDUAL HEAT REMOVAL SYSTEM
COMPONENT COOLING WATER SYSTEM
DIESEL GENERATOR AUXILIARY SYSTEMS
HVAC (Reactor and Auxiliary Building)
MAIN STEAM SYSTEM (up to and including MSIVs)
CONTAINMENT SPRAY SYSTEM
CONTAINMENT HEAT REMOVAL SYSTEM
ESSENTIAL INSTRUMENT AIR SYSTEM
CONTROL ROOM HABITABILITY SYSTEMS
SPENT FUEL POOL COOLING
FIRE PROTECTION SYSTEM
RADIOACTIVE WASTE SYSTEM

INSTRUMENTATION & CONTROL

- Remote safe shutdown panel systems and equipment
- Flux mapping system
- Rod position indication
- Primary coolant leak detection system
- Loose parts monitoring system
- Process instrumentation for remaining BONI systems (e.g., ECCS, CVC, CCW):
  - Class 1E and safe shutdown
  - Non-Class 1E
- Radiation monitoring system
- Radwaste systems instrumentation
- Installed test instrumentation (e.g., check valve leak test instruments)
- Instrumentation "important to safety" but not Class 1E:
  - RG 1.97 instrumentation
  - RG 1.47 instrumentation
  - NUREG 0696 instrumentation
  - NUREG 0737 instrumentation
- Plant computer (non-safety)

DETAILED DESIGN COMPLETED

(LEVEL 2)

BALANCE OF NUCLEAR ISLAND (BONI) – cont'd

ENGINEERING MECHANICS

ASME Section III Class 2N and 3N piping, pipe supports plus significant non–ASME Section III piping systems which have influence on performance of Section III piping.

CIVIL

Auxiliary building, control room, fuel building, diesel generator building, radwaste building and all other Seismic Cat. I building.

ELECTRICAL POWER SYSTEMS

Medium Voltage AC Switchgear Distribution System
Low Voltage AC Switchgear Distribution System
Emergency Diesel Generator System
AC and DC Motor Control Center Distribution System
120V AC Vital Instrument Power System
250/125V DC Distribution System
Cabling and Raceway System
Grounding System

MECHANICAL SYSTEMS

Emergency Core Cooling Systems
Chemical Volume and Control System
Residual Heat Removal System
Component Cooling System
Diesel Generator Auxiliary Systems
HVAC (Reactor and Auxiliary Building)
Main Steam System (up to and including MSIVs)
Containment Spray System
Containment Heat Removal System
Essential Instrument Air
Control Room Habitability System
Spent Fuel Cooling System
Fire Protection System
Radioactive Waste Systems

DETAILED DESIGN COMPLETED

(LEVEL 2)

TURBINE ISLAND

FEEDWATER SYSTEM
CONDENSATE SYSTEM
MAIN STEAM SYSTEM
AUXILIARY STEAM SYSTEM
HEATER DRAIN SYSTEM
TURBINE BUILDING COOLING WATER SYSTEM
TURBINE BUILDING HVAC
TURBINE LUBE OIL SYSTEM
PLANT COMPRESSED AIR

INSTRUMENTATION & CONTROL

Process instrumentation for turbine island systems (e.g., steam cycle and turbine)

- Class 1E and safe shutdown
- Non-Class 1E

Installed test instrumentation (e.g., power test code instrumentation)

ENGINEERING MECHANICS

All BOP (turbine island) piping, pipe supports and equipment not covered in Levels I and II. These systems would generally be governed by ASME Section VIII or B31.1 requirements.

CIVIL

Turbine building, control building and all non-Cat. I buildings.

ELECTRICAL POWER SYSTEMS

Main Generator
Medium Voltage AC Switchgear Distribution System
Low Voltage AC Switchgear Distribution System
AC and DC Motor Control Center Distribution System
250/125V DC Distribution System
Cabling and Raceway System
Grounding System

DETAILED DESIGN COMPLETED

(LEVEL 2)

TURBINE ISLAND - cont'd

MECHANICAL SYSTEMS

Feedwater System
Condensate System
Main Steam System
Auxiliary Steam System
Heater Drain System
Turbine Building Cooling Water System
Turbine Building HVAC
Turbine Lube Oil System
Plant Compressed Air

CONCEPTUAL DESIGN COMPLETED

(LEVEL 4)

SITE-SPECIFIC

ULTIMATE HEAT SINK
ESSENTIAL SERVICE WATER SYSTEM
CIRCULATING WATER SYSTEM
SCREEN WASH SYSTEM
TRAVELING SCREENS
NON-ESSENTIAL SERVICE WATER SYSTEM
INTAKE STRUCTURE HVAC SYSTEM

INSTRUMENTATION & CONTROL

Plant security systems
Personnel communication systems
EOF datalink
Intake structure & systems instrumentation (e.g., forebay level)
Health physics instrumentation and data processing
Meteorological tower instrumentation

ENGINEERING MECHANICS

All safety related site specific piping, pipe supports and components such as service water.

CIVIL

Service and circulating water intake structure, pipe tunnels, circulating water tunnels

ELECTRICAL POWER SYSTEMS

Switchyard Design and Transformer Distribution System
Cable and Raceways System (Manholes, underground cables)
Plant Ground System (External ground points)

CONCEPTUAL DESIGN COMPLETED

(LEVEL 4)

SITE-SPECIFIC

MECHANICAL SYSTEMS

Ultimate Heat Sink
Essential Service Water System
Circulating Water System
Screen Wash System
Traveling Screens
Non-Essential Service Water System
Intake Structure HVAC System

ATTACHMENT D

DESIGN FINALITY

DESIGN FINALITY vs. ENGINEERING HOURS

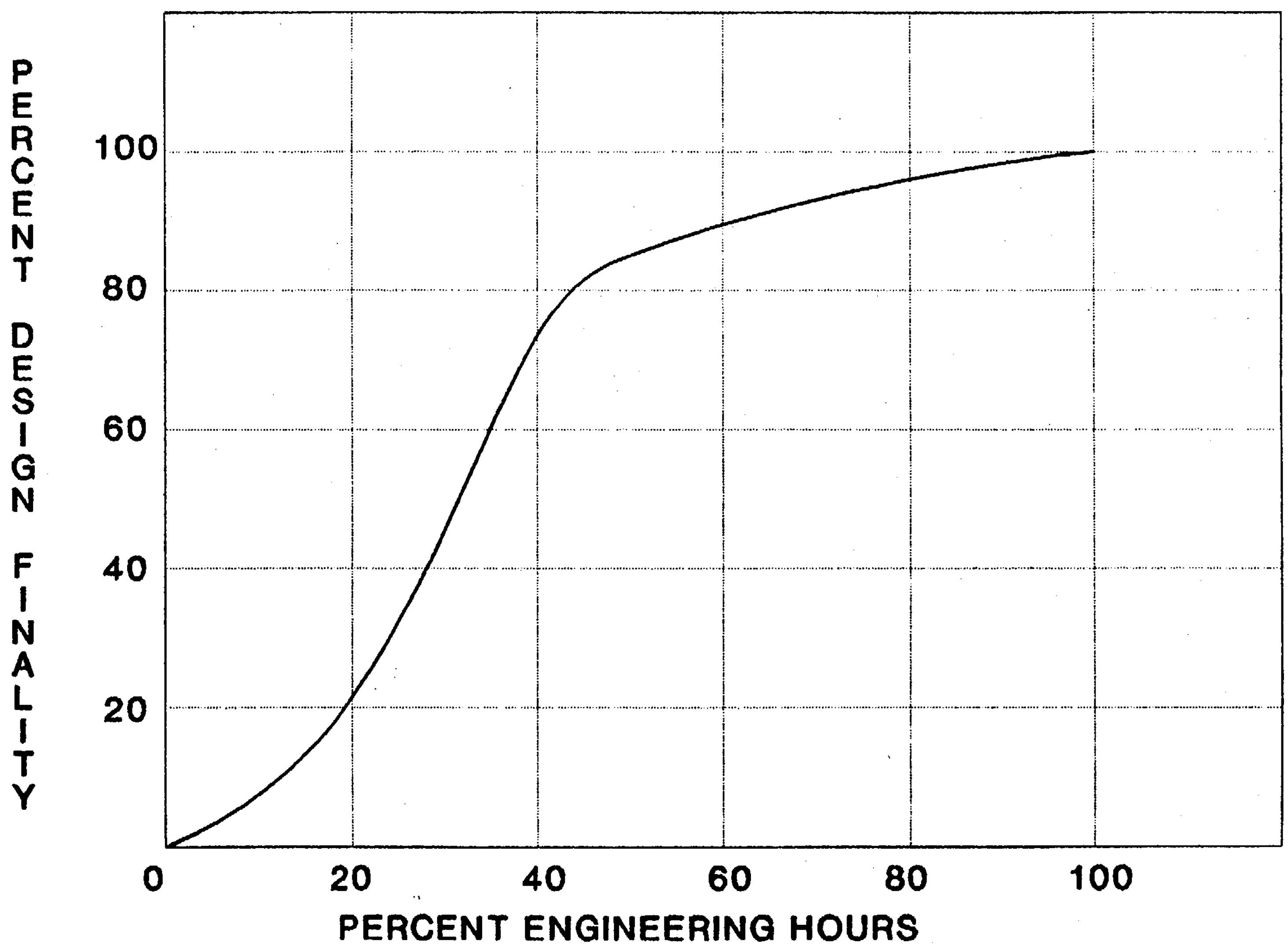


Figure D - 1

DESIGN FINALITY vs. ENGINEERING HOURS

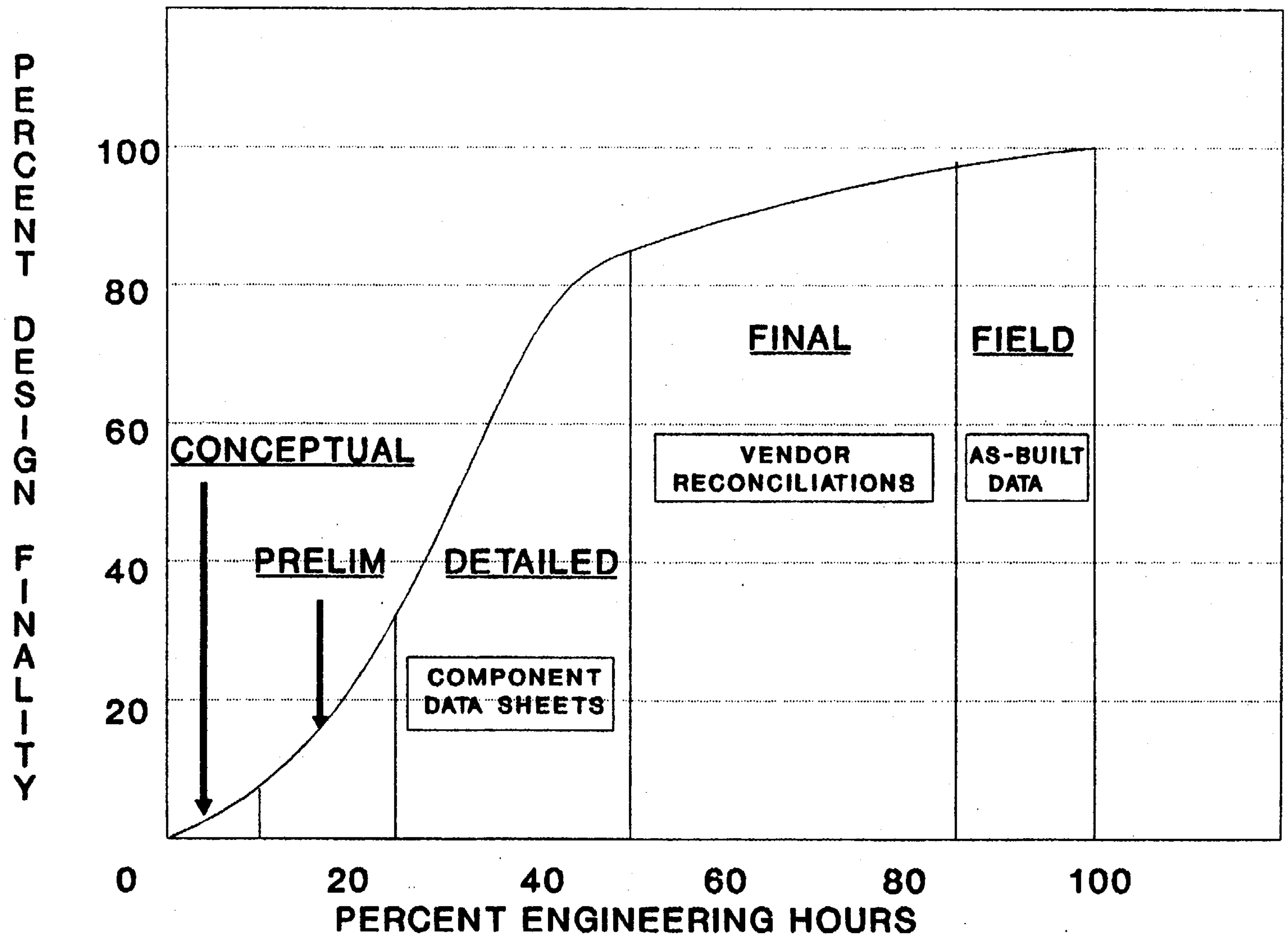


Figure D - 2

DESIGN FINALITY vs. ENGINEERING HOURS

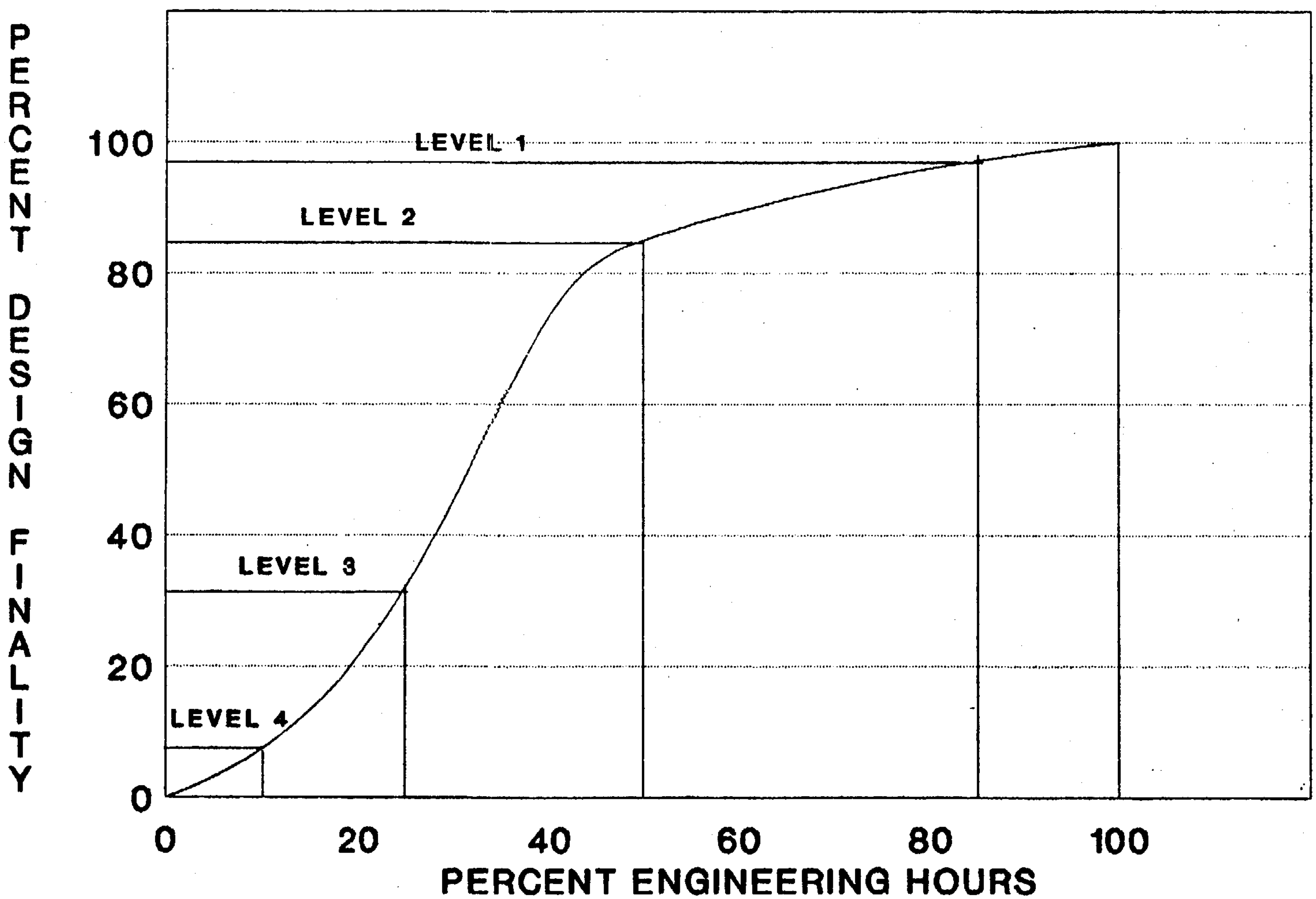


Figure D - 3

DESIGN FINALITY vs. ENGINEERING HOURS

AT DESIGN CERTIFICATION

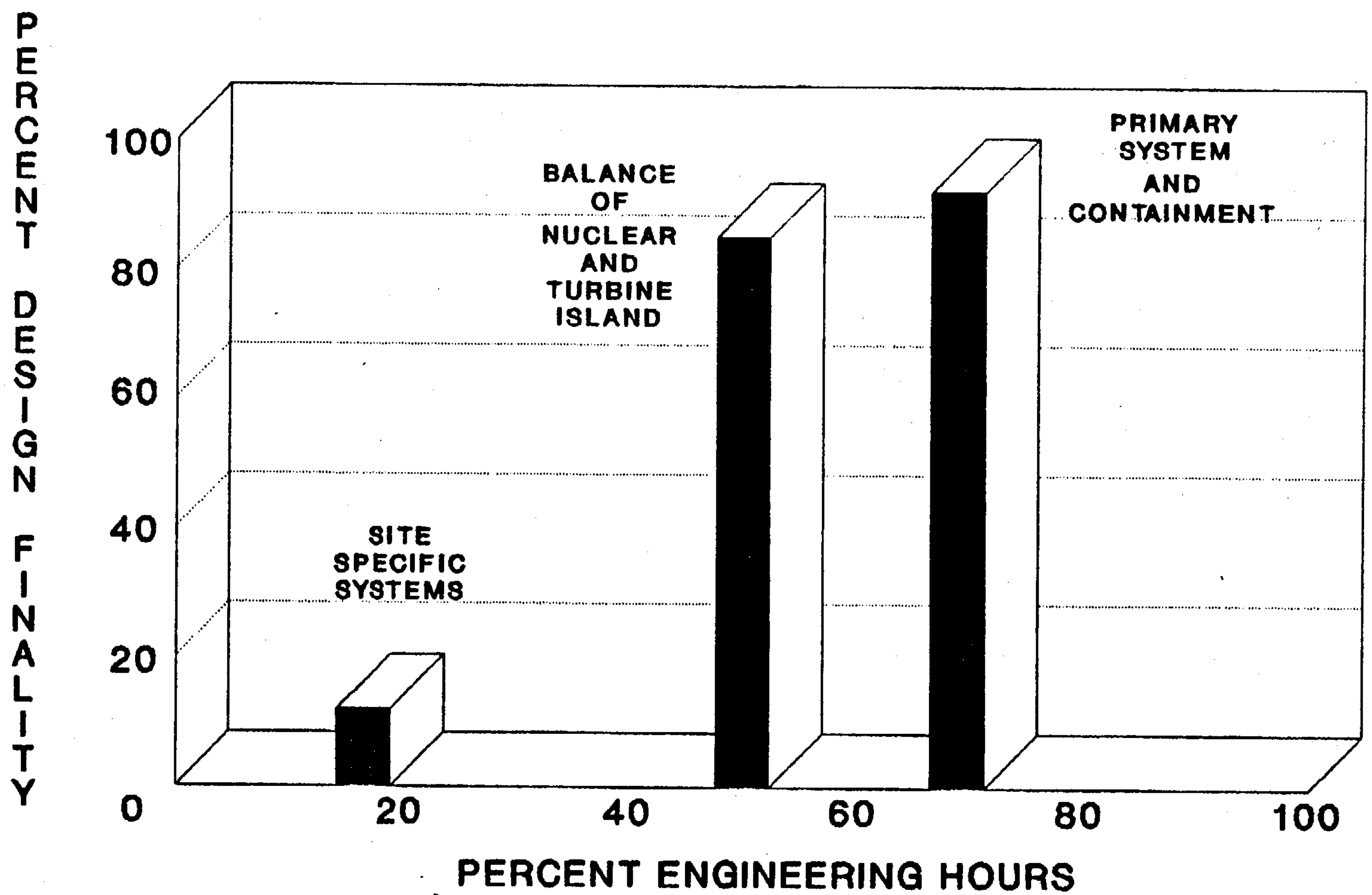


Figure D - 4

DESIGN FINALITY vs. ENGINEERING HOURS

AT COMBINED OPERATING LICENSE

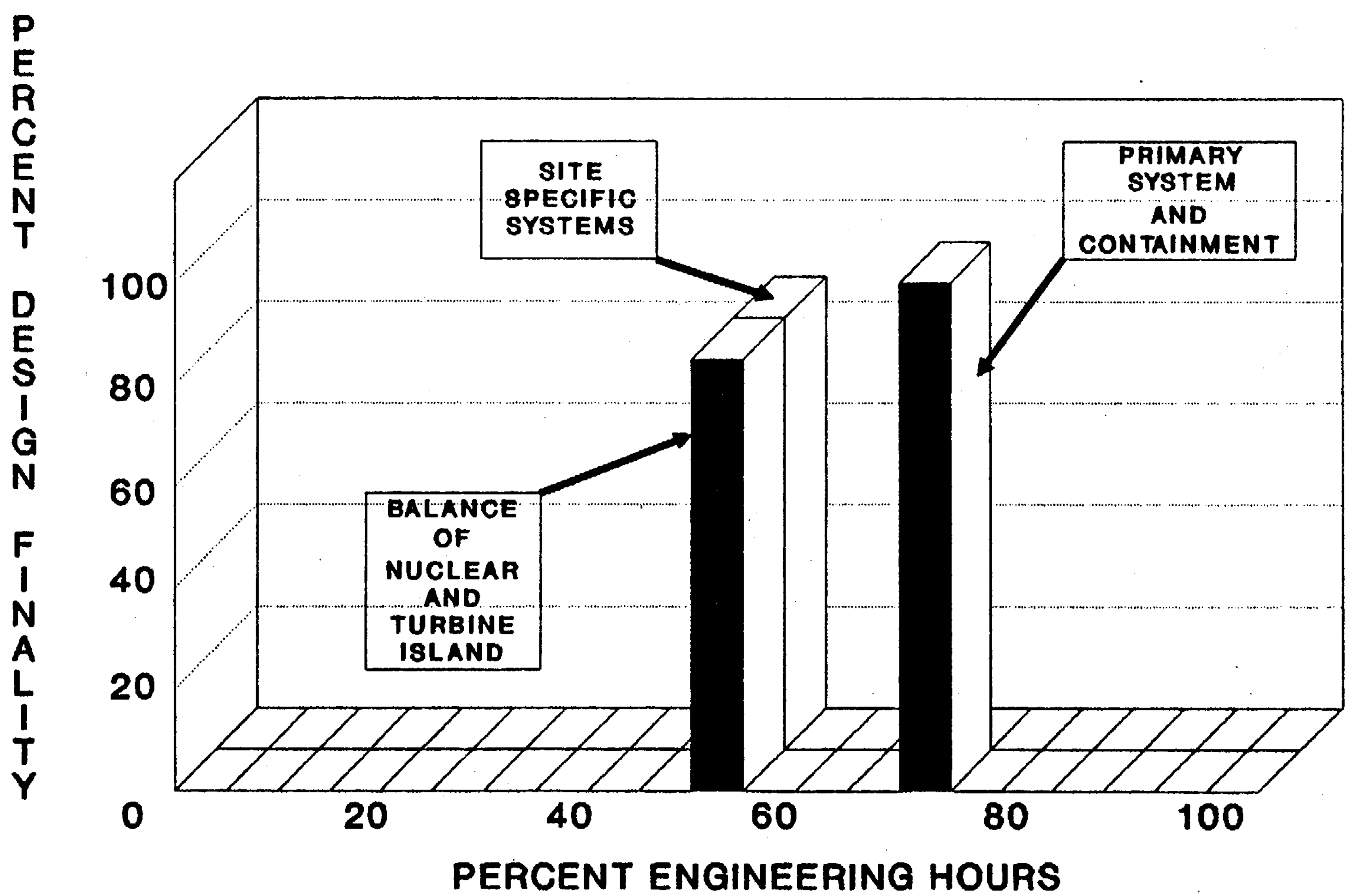


Figure D - 5

DESIGN FINALITY vs. TIME

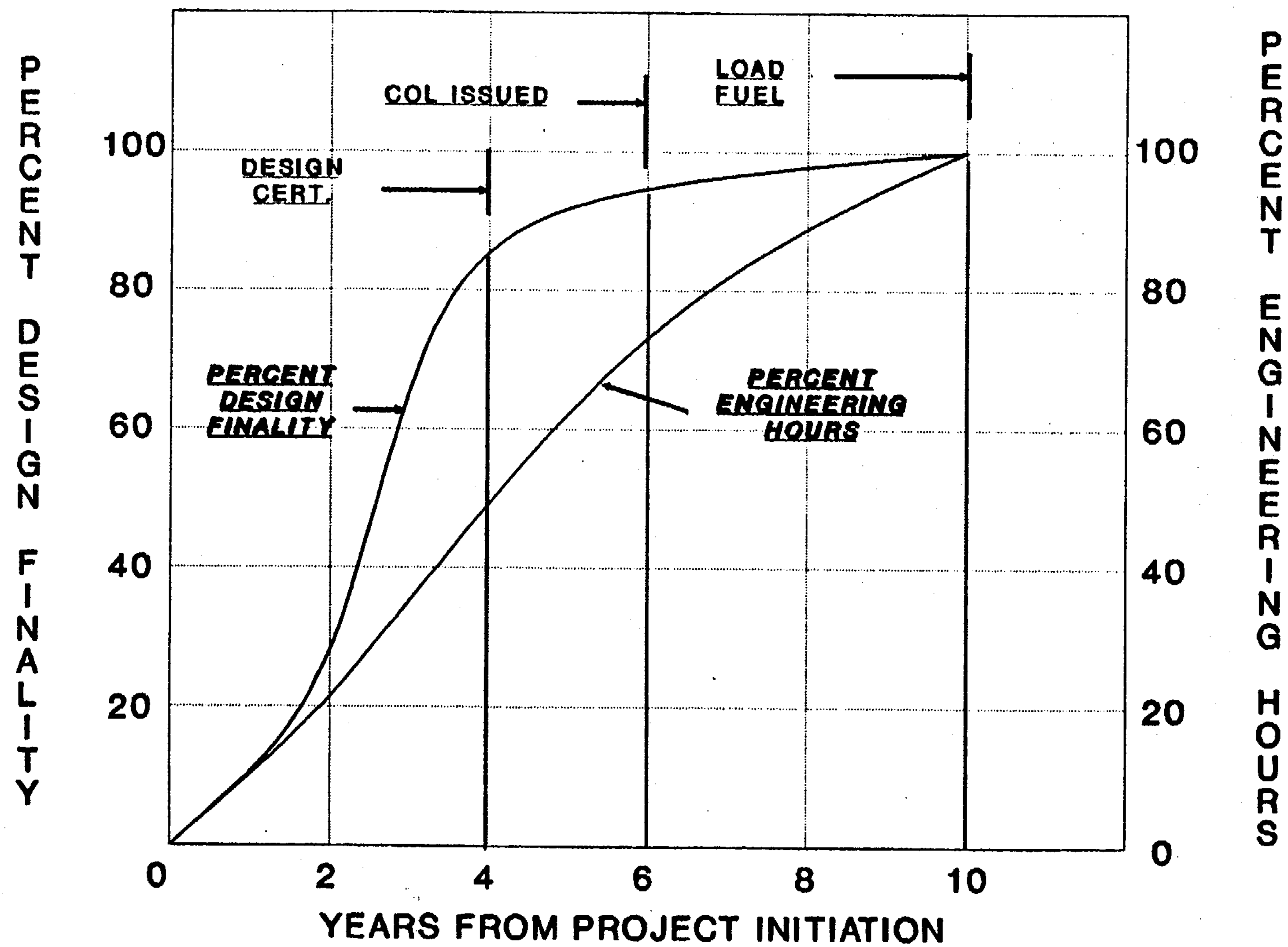
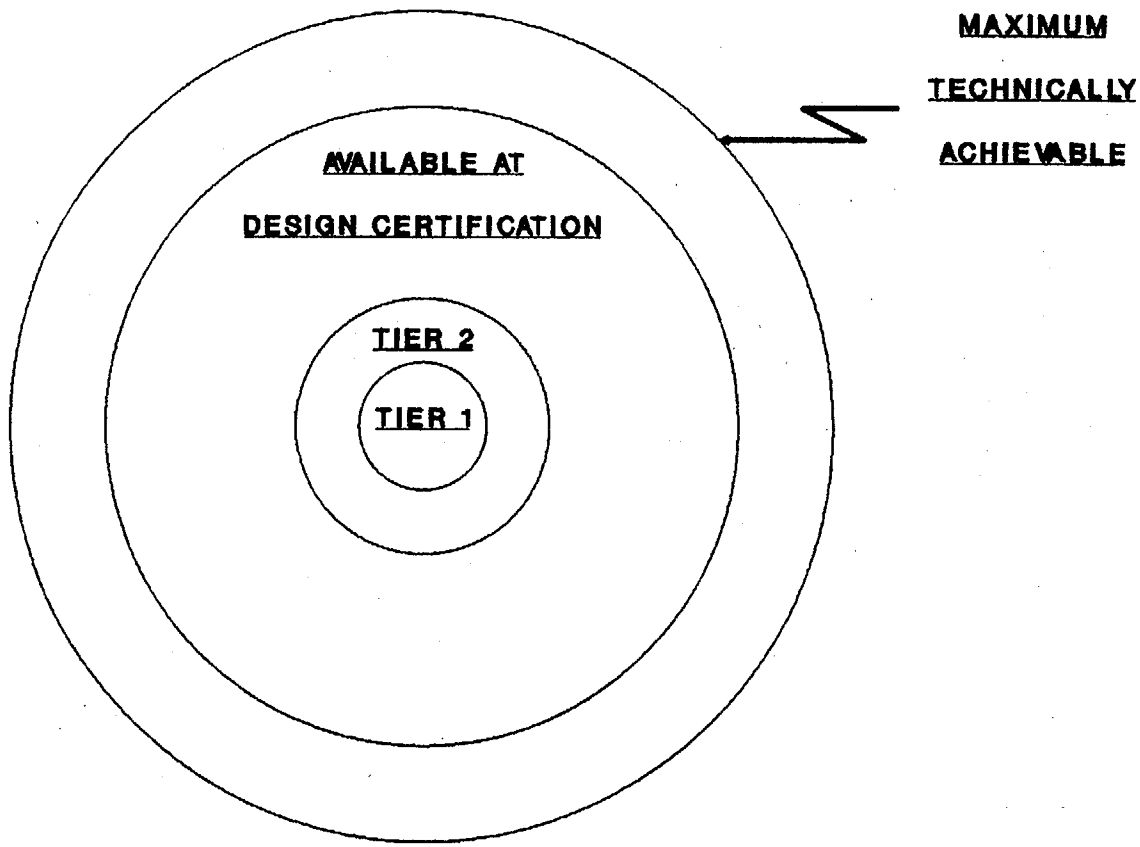


Figure D - 6

RELATIVE QUANTITIES OF INFORMATION
AVAILABLE AT DESIGN CERTIFICATION



ATTACHMENT F

RAMIFICATIONS FOR THE ABWR DESIGN

The staff has previously reviewed the design information available at the General Electric Company (GE) to support the design certification for the advanced boiling water reactor (ABWR). The summary of the staff findings is provided in Attachment F-1. A correlation of the staff findings and the expectations of design product availability to support a design certification is presented in Attachment F-2. The staff found that a large amount of design information was not available to support the ABWR certification. We envision that substantial additional engineering effort would be required for GE to reach the level of design completion recommended by the staff in Attachment B. Our information is based upon a visit to the GE offices in February 1990.

ATTACHMENT F-1

OBSERVATIONS REGARDING ABWR DESIGN DOCUMENTATION COMPLETION

Instrumentation and Control

- The control room man-machine interface had not been specified. The team could not readily determine how "advanced" the control room technology would be, and how it would be specifically applied.
- The design of the hardware and software for the reactor protection and engineered safety features actuation system hardware and software had not been defined much beyond the functional level.
- The essential multiplexing system, which supports most of the safety systems data communication, had not been specified to sufficient detail. For example, the data network configuration and protocol had not been established.
- Software design specifications lacked the level of detail suggested by the IEEE Standard 729-1983. Missing information included algorithms, control logic, data structures, input/output format, and interface descriptions for software.
- A field instrument list existed and piping and instrumentation diagrams (P&IDs) were available. However it was not always possible to determine the type or configuration of the field instrument (for example, a level instrument).
- The team noted that the advanced boiling water reactor (ABWR) safety-related instrumentation includes significant departures from previous BWR technology applications (for example, the use of distributed micro-processors, fiber optics, and local area networks [multiplexers]). The team concluded that additional depth and breadth of detail would be required for the staff's safety evaluation.

Engineering Mechanics

- Piping layouts have not been performed even though the NRC had specified this as part of an essentially complete design. Therefore, the General Electric Company (GE) will not perform piping analyses.
- Only design criteria documents will be available for review.

Civil/Structural

- No detailed design criteria regarding structural steel design have been developed. Only codes and load combinations have been provided.
- No specific calculations were available for building design.
- Seismic analysis (II/I) of turbine building will not be performed as a part of the design certification package.

Mechanical Systems

- For the nuclear island systems that the NSSS vendor typically supplies (e.g., the reactor coolant system and the control rod drive system), the U.S. ABWR design was largely complete. These systems most nearly conformed to the level of detail for design certification. For example, process flow diagrams contained flow, temperature, and pressure information throughout the systems at various operating modes. P&IDs contained line sizes, safety class boundaries, line numbers, piping pressure classes, and instrument locations. In addition, equipment design requirement specifications were available to support procurement of major components. Nevertheless, considerable engineering may be needed to bring the physical drawings (e.g. piping arrangements and isometric drawings) and various hazards and off-normal analyses to the level needed for design certification.

- The balance of the nuclear island systems, particularly the typical emergency core cooling systems, have a level of detail similar to the NSSS systems. However, some of the design information has been developed for the K6/K7 design and therefore may require some translation, as well as confirmation of compliance with U.S. codes and standards.

- Turbine island systems have been designed for the K6/K7 units. Therefore, a large amount of design information exists, including drawings, calculations, analyses, and specifications. The major problem is that most of this information is written in Japanese and must be translated to English. Design decisions need to be made to determine how much of the K6/K7 design will carry over to the U.S. ABWR, and what changes will be required to conform with the U.S. codes and standards. While the conversion effort is underway, the development of the U.S. ABWR design is probably between the conceptual phase and the preliminary phase. Consequently, the level of detail for these systems may be less than 50 percent of the level that is necessary for design certification.

- Site-specific systems have been designed for the K6/K7 units. Assuming that these designs will be refined and modified as GE standards for the U.S. ABWR, the designs are at least conceptual and probably do not require a great deal of effort to reach design certification levels.

- Standard safety analysis report (SSAR) information for the ABWR does not provide tolerances or minimum performance standards. Specific numbers are provided, which may not be compatible with vendor equipment.

Electrical Power

- An insufficient quantity of design information exists to support direct preparation of procurement and construction specifications.

- Cable tray arrangement and conduit routing have not been performed.

- Cable sizing, short circuit calculations, and allowable cable length have not been evaluated.

- Control room design is undefined.

- Panels for motor control centers (MCCs) and multiplexer have not been located.

- Actual electrical loads were not tabulated.

- Minimum acceptable voltages at equipment were not established.

- The following criteria documents have not been prepared:

  - Reduced voltage starting capacity
  - Voltage and frequency on switchgear load centers and MCCs
  - Protective relay setting

- The following calculations have not been performed:

  - Direct current battery sizing
  - Voltage drop and allowable cable length
  - Diesel generator loading
  - Short circuit analysis and load flow analysis

ATTACHMENT F-2

LEVEL OF ABWR DESIGN DOCUMENTATION COMPLETION

	NUCLEAR ISLAND AND CONTAINMENT	BALANCE OF NUCLEAR ISLAND	TURBINE ISLAND	SITE SPECIFIC
DESIRED	>2	2	2	3-4
ACTUAL-MECHANICAL SYSTEMS	2	2-3	3-4	3-4
ACTUAL-OTHER DISCIPLINES *	3-4	3-4	3-4	3-4

* INCLUDES: CIVIL/STRUCTURAL, ENGINEERING MECHANICS, ELECTRICAL, AND INSTRUMENTATION AND CONTROLS.