NUREG/CR-4943
(ORNL/TM-10425)

ornl

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Preparation of Design Specifications and Design Reports for Pumps, Valves, Piping, and Piping Supports Used in Safety-Related Portions of Nuclear Power Plants

E. C. Rodabaugh
S. E. Moore

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Under Interagency Agreement DOE 40-550-75

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Available from

Superintendent of Documents
U.S. Government Printing Office
Post Office Box 37082
Washington, D.C. 20013-7982

and

National Technical Information Service
Springfield, VA 22161

NUREG/CR-4943
ORNL/TM-10425
Dist. Category RM

Engineering Technology Division

PREPARATION OF DESIGN SPECIFICATIONS AND DESIGN REPORTS FOR PUMPS, VALVES, PIPING, AND PIPING SUPPORTS USED IN SAFETY-RELATED PORTIONS OF NUCLEAR POWER PLANTS

E. C. Rodabaugh S. E. Moore

Manuscript Completed — June 8, 1987
Date Published — June 1987

Prepared for the
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Under Interagency Agreement No. 40-550-75

NRC FIN No. B0787

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DOE-AC05-840R21400

CONTENTS

PREFACE

This report is an outgrowth of our experience between 1981 and 1986 in assisting the Mechanical Engineering Branch, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission (USNRC), in the Design Documentation audit of a number of nuclear power plants undergoing review for Operating Licenses. During the course of that work, it became obvious that, in general, the preparation of clear, concise design specifications and design analysis reports for nuclear power piping systems that could be used as working documents as well as for third-party review had rather low priority. Although all the organizations interviewed had prepared, or were in the process of preparing, design documents to meet the requirements of the *ASME Boiler and Pressure Vessel Code*, only a few appeared to understand what information was needed or how to organize it into useful documents.

It also became clear that much of the problem was the direct result of inadequate or inappropriate guidance given in the nonmandatory appendixes of the *ASME Code*. It is our hope that the recommendations developed in this report will be seriously considered by the Code-writing bodies and that the needed improvements will be pursued with dispatch.

We extend our gratitude to R. J. Bosnak, D. Terao, and J. Brammer, USNRC, for their help and guidance on this project. We also thank the many competent, professional, and cooperative people that we came in contact with during our review audits.

PREPARATION OF DESIGN SPECIFICATIONS AND DESIGN REPORTS FOR PUMPS, VALVES, PIPING, AND PIPING SUPPORTS USED IN SAFETY-RELATED PORTIONS OF NUCLEAR POWER PLANTS

E. C. Rodabaugh S. E. Moore

ABSTRACT

Section III of the *ASME Boiler and Pressure Vessel Code* requires the preparation of Design Specifications and Design Reports as part of the design process leading to construction of a nuclear power plant, in compliance with provisions of Title 10 of the *Code of Federal Regulations* (10 CFR). Guidelines for preparing this documentation are contained in nonmandatory Appendixes B and C of the *ASME Code*. This report gives an in-depth review of the *ASME Code* requirements and guidance, beginning with the first edition of the Code in 1963 through the 1983 edition, Summer 1985 Addenda. Recommendations for substantial revisions to the Code are presented based on the authors experience in conducting design documentation audits of pumps, valves, piping, and piping supports for nuclear power plants undergoing Nuclear Regulatory Commission (NRC) review for Operating Licenses. It is concluded that adequate Design Specifications and Design Reports are absolutely necessary for the normal operating life of a plant and are vital if plant life extension is planned.

1. INTRODUCTION

The first (1963) edition of the Code*,[1] included requirements for Design Specifications and Design (Stress†) Reports. Those requirements, with various modifications, were included in all editions up to and including the present Code.

The Nuclear Regulatory Commission (NRC) provides guidance to applicants by means of the Standard Review Plan (SRP).[2] Section 3.9.3 of the

*The term "Code" as used in this report refers to the *ASME Boiler and Pressure Vessel Code*, Sect. III, Div. 1, "Nuclear Power Plant Components." Unless so indicated in the text, reference is to the 1983 edition with addenda through Summer 1985 (Ref. 1).

†The Code, up to the 1980 edition, used the terminology "Stress Report." The present terminology "Design Report" will be used throughout the remainder of this report.

SRP covers ASME Code Class 1, 2, and 3 components, component supports, and core support structures. Under "Review Procedures," SRP 3.9.3 states:

> By checking selected Code required Design Documents such as Design Reports, Load Capacity Data Sheets and related material, the OL [Operating License] stage review verifies that the design criteria have been utilized and that components have been designed to meet the objectives.

As a small part of NRC reviews of applications for operating licenses, audits of Design Specifications and Design Reports on specific plants were made as indicated in Table 1. The docket dates in Table 1 are significant because they show that the Code edition used was 1971 or later; thus, the Code covered pumps, valves, and piping.

These audits were generally conducted in the following steps:

1. The Applicant was informed that an audit of Design Specifications and Design Reports for selected pumps, valves, piping, and piping supports was to be made. The purpose of the audit was described to the Applicant as indicated in Table 2. During this first-contact period, specific components from each category were identified for audit, for example, auxiliary feedwater pumps.
2. A visit to the Applicant's site took place [e.g., the Architect Engineer's (AE's) offices] when documents and Applicant's representatives were made available. At that meeting, which usually lasted <8 h, the requested documents were quickly reviewed. The primary purpose of this meeting was to obtain a complete set of Design Specifications and corresponding Design Reports relevant to the selected Design Specification. These meetings ended by preparing a list of documents that the Applicant agreed to send to NRC for detailed review.
3. Upon receipt of the documents by NRC, a detailed review was undertaken. Usually, this review resulted in several questions that were transmitted to the Applicant, and, generally, the most expeditious way to address the questions was at a second meeting with the Applicant and his representatives.
4. When satisfactory answers to all questions were obtained, a completion letter for each specific plant audit was written, as indicated in Table 1.

Results of audits are discussed in Sects. 5–10 of this report. At this point, we make some general observations concerning the context in which our audits took place.

1. As suggested by the docket dates shown in Table 1, all the specific plants audited used the 1971 or later edition of the Code as their Code of Record. This fact is significant because the 1971 and later editions of the Code include coverage of pumps, valves, and piping.
2. Audits took place during the time period between October 1981 and June 1986. The audited plants were ordered around 1972, a period in which many plants were being ordered. Further, this is the period in

Table 1. Audits of design specifications and design reports

Plant	Docket date	Type[a]	NSSS[b]	Balance of plant	Audit period	
					Start	Completion
Beaver Valley	10/72	PWR	W	Stone & Webster	4/84	6/86
Catawba	10/72	PWR	W	Owner	10/81	7/83
GESSAR[c]		BWR	GE	C. F. Braun	10/82	7/83
Limerick	2/70	BWR	GE	Bechtel	3/83	8/83
River Bend	9/73	BWR	GE	Stone & Webster	3/82	3/84
Seabrook	7/73	PWR	W	United Engineers	1/82	12/85
Shearon-Harris	9/71	PWR	W	Ebasco	2/83	12/85
South Texas	7/74	PWR	W	Bechtel	4/85	9/85
Vogtle	2/73	PWR	W	Bechtel	11/84	12/85

[a]PWR = pressurized-water reactor
BWR = boiling-water reactor

[b]NSSS = nuclear steam supply system
W = Westinghouse
GE = General Electric

[c]GESSAR represents an attempt to standardize BWRs. However, the documents received in our audit consisted of documents for specific plants.

Table 2. Purposes of audit of Design Specifications and Design Reports for pumps, valves, piping, and piping supports

1.	Ensure that Design Specifications required by the Code have been (or will be) prepared and contain a complete basis for the construction of the components
2.	For Code Class 1 components, ensure that Design Reports as required by the Code have been (or will be) prepared, that the input data used are clearly traceable to and agree with the Design Specification, and that the analyses show compliance with Code requirements
3.	For Code Class 2 or 3 components, ensure that calculations have been (or will be) prepared and filed, that the input data are clearly traceable to and agree with the Design Specification, and that the calculations show compliance with Code requirements
4.	Verify that specifications include appropriate provisions to assure reliable performance of components during their anticipated service and that adequate documentation has been (or will be) received, which shows compliance with the specifications

which the concepts of normal, upset, emergency, and faulted conditions were being introduced into the Code and into NRC reviews. Accordingly, Applicants and their AEs had to recruit and train many employees in an attempt to complete what had grown to be a monumental amount of paperwork necessary to obtain an operating license. In later portions of this report, we will be criticizing some aspects of the documents that we reviewed. We do not mean to imply, however, that we could have done as well, given the same set of circumstances.

3. At the present time, construction of nuclear power plants in the United States is stopping. The recommendations given in Sect. 11 of this report assume that in the relatively near future, say 5 or 10 years, utilities will again start to build nuclear power plants, and those plants (while perhaps more standardized) will be similar to the present BWRs and PWRs. Further, we assume that the Code will continue to require Design Specifications and Design Reports.

Aside from the obvious reasons for writing adequate Design Specifications and Design Reports, a number of additional benefits accrue to the owner. The simple act of planning and organizing the reports will often force the owner to identify potential design and construction problems in the early stages of the project when they are most amenable to a less expensive solution. The activity may also force the owner to identify those potential problems associated with plant aging, so that provisions for trouble-free and inexpensive maintenance can be designed into the plant. In addition, if at some future date it becomes desirable to extend the operating life of the plant or to change the duty cycle from the original design condition (e.g., from base-line operation to peak-load operation), then a good set of Design Specifications and Design Reports is absolutely necessary to demonstrate the validity of life extension.

2. CODE REQUIREMENTS AND GUIDANCE

2.1 Design Specifications

The present Code requirements for Design Specifications are given in Paragraph NCA-3250. Appendix A gives relevant* portions of NCA-3250. NCA-3254.1 states that boundaries are defined in NX-1130, where X = B, C, D. These are identical Subarticles; Appendix A of this report includes NC-1130 for reference.

Code guidance or preparation of Design Specifications is given in Code nonmandatory Appendix B, relevant portions of which are included here in Appendix B.

2.2 Design Reports

The present Code requirements for Design Reports are given in NCA-3550. Appendix C gives relevant portions of NCA-3550. It is the responsibility of the N Certificate holders to provide Design Reports to the Owner for review, documentation of review, and filing at the site of the installation. As indicated on the second page of Appendix C, the Owner is then required to review the Design Report "to determine that all the Design and Service Loadings have been evaluated . . . ."

Code guidance for preparation of Design Reports is given in Code nonmandatory Appendix C, included here in its entirety as Appendix D.

---

*Portions concerning Code Div. 2 (concrete vessels, concrete containments) have been deleted in Appendix A.

3. CHRONOLOGY OF CODE REQUIREMENTS

A chronological description of Code requirements is needed because the Design Specifications and Design Reports audited were based on Codes of Record dated between 1971 and 1977. Further, a chronological description is informative because it explains aspects of Code requirements that, in view of the present Code coverage, appear to be anomalous.

The first (1963) edition of the Code included requirements for Design Specifications and Design (Stress) Reports as shown in Appendix E. Compared with the present Code, the 1963 Code was very simple; it covered nuclear vessels of Classes A, B, and C corresponding to present Code Classes 1, 2, and 3. Metal containment vessels were specifically identified as Class B vessels. Design Specifications were required for all three classes; Design Reports were required for Class A and B vessels. The concept of service conditions, as distinct from design conditions, had not been introduced. Class B and C vessels were essentially required to be designed to Sect. VIII of the Code (now Sect. VIII-Div. 1). Accordingly, in 1963, requirements for design documents could be described in relatively simple terms.

The second (1965) Code edition did not change the 1963 Code requirements for Design Specifications and Design Reports. However, the Summer 1965 Addenda revised Paragraph N-142 by changing "design conditions" to "design and operating conditions." The third (1968) Code edition, for the first time, indicated in the "hopper diagram" (Code Fig. N-414) that different considerations were to be given to "Design Loads" and "Operating Loads." The Design Specification became the responsibility of the "User," rather than the "Owner," in previous editions. (It is now the responsibility of the "Owner.") The 1968 edition required Design Reports for Class A, B, and C vessels rather than just Classes A and B as in the 1965 Code. Otherwise, the requirements for Design Specifications and Design Reports were essentially the same as in the 1963 and 1965 Codes. The 1968 Code introduced guidelines for preparation of a Design Report for Class A vessels as Appendix X, "Manufacturers' Stress Report," which is included here as Appendix F.

The fourth (1971) edition expanded the Code to cover pumps, valves, and piping; it also introduced the concept of normal, upset, emergency, and faulted conditions for Class 1 components. The 1971 Code included, for the first time, guidelines for preparation of a Design Specification as Code Appendix B, "Owner's Design Specification." The "Manufacturers' Stress Report," Appendix X of the 1968 Code, was relocated to Appendix C. Otherwise, despite the expansion of the Code to cover pumps, valves, and piping and the use or normal, upset, emergency, and faulted conditions, the technical contents of the guidance for preparation of Design (Stress) Reports remained the same as in the 1968 Code, that is, for Class 1 vessels.

The fifth (1974) Code expanded coverage to component supports in Subsection NF. The guidelines in Code Appendix B, "Owner's Design Specification," and in Code Appendix C, "Manufacturers' Stress Report," were essentially the same as in earlier Code editions.

The sixth (1977) Code introduced the concept of Design and Service Limits. The designations of normal, upset, emergency, and faulted became

levels A, B, C, and D limits, respectively. Further, Service Limits A, B, C, and D for Class 2 and 3 components were provided in the 1977 Code. Despite these major changes, the requirements for Design Specifications and Design Reports were essentially the same as in the 1974 Code. Similarly, the guidelines in Code Appendixes B and C were essentially the same as in the earlier Codes. The title of Code Appendix C was changed from "Manufacturers' Stress Report" to "Certificate Holder's Stress Report" in recognition of the fact that the manufacturer of a piping system, for example, was not well-defined.

The seventh (1980) Code changed "Stress Report" to "Design Report" and changed the title of Code Appendix C from "Certificate Holder's Stress Report" to "Certificate Holder's Design Report," with essentially no other change from the 1977 Code. The 1980 Code provided major revisions to Code Appendix B, "Owner's Design Specification."

The eighth (1983) Code requirements and guidelines for Design Specifications and Design Reports are included here in Appendixes A–D. The 1983 Code Appendix B, "Owner's Design Specification" (Appendix B herein) is almost identical to the 1980 version. In Paragraph B-2160, on overpressure protection, references to Code requirements have been updated and, in B-2164, "Safety Valve" was changed to "Pressure Relief Valve." Appendix G essentially represents the guidance for preparation of Design Specifications up to 1980, while Appendix B essentially represents the guidance from 1980 to the present.

The 1983 Code Appendix C, "Certificate Holder's Design Report" (Appendix D here), is quite similar to the 1968 Appendix X, "Manufacturers' Stress Report" (Appendix F here), as can be seen by comparing the contents of Appendixes D and F. In view of the tremendous increase in scope of the Code since 1968, this is a disconcerting similarity.

Code Appendix C (Appendix D) does a poor job of providing guidance for Design Reports for Class 2 or 3 pumps, valves, and piping systems. Consider, for example, a Class 2 pump. In the second sentence in Paragraph C-1131, "Nomenclature, definitions ... in accordance with NC-3200," we look in vain for a reference to NC-3400 on "Pump Design." Similarly, in C-1340, we look in vain for a reference to NC-3416, "Stress and Pressure Limits for Design and Service Conditions." Conversely, Code Appendix C covers, at considerable length, aspects that are completely irrelevant to Code requirements for Class 2 or 3 pumps or valves, for example, C-1200, "Thermal Analysis," and C-1400, "Fatigue Evaluation."

4. RETENTION OF DESIGN SPECIFICATIONS AND REPORTS

In Sects. 5, 6, and 7 of this report, we will discuss the results of our audits on ~50 different Design Specifications and ~50 different Design Reports. During these audits, an underlying question was: Will these documents be understandable at some future time? The question arises because the Code (see Table NCA-4134.17-1) requires that Design Specifications and Design Reports be kept for the life of the item. For this report, "items" include pumps, valves, piping, and piping supports for which we would usually expect the life to be that of the plant, say 40 years.

Granting that retention of Design Specifications and Design Reports for the life of the plant has a useful purpose, an obvious corollary is that those documents must be written with the objective that they are understandable to someone other than those who prepared the documents. Accordingly, when in subsequent sections of the report, we seem to be quibbling about legibility, references, and other editorial aspects, our underlying concern is: Will the documents be readable and understandable in the future?

5. PUMPS

Design Specifications and Design Reports for pumps are relatively simple because they are usually prepared for a specific type of pump, furnished by a specific manufacturer. (As discussed later, Design Specifications and Design Reports are relatively more complex for valves and even more complex for piping systems and supports.) The number of different safety-related pumps is small; thus, it is feasible to prepare a Design Specification for each type of pump, for example, for containment spray pumps. All Design Specifications and Design Reports received were for a specific type of pump.

However, pumps are very different from vessels because the primary requirement relates to their operation, for example, pump X gpm against Y head. Of course, to operate, a driver must be attached to the pump, for example, an electric motor or steam turbine. The rigidity of the common bedplate of the pump/driver assembly and the alignment of the pump and driver are vital aspects of long-term, minimum-maintenance operation. The pressure boundary requirements of the Code are relatively trivial in a pump specification.

5.1 Design Specifications

As might be expected and indeed desired, the pump specifications we reviewed were concerned primarily with pump operability. With some searching, the Design Pressure and Design Temperature could be found. Somewhere in the document the allowable pump nozzle loads were usually given and a reference to something similar to a "Seismic Design Manual" was usually made.

None of the Design Specifications received, however, indicate that the document was the Code-required Design Specification, prepared by (or for) the Owner. In some cases, the documents were identified as a purchase order or equipment specification. However, the Owner's name and plant name are shown on the cover sheet of the documents. In addition, either on the cover sheet or a few pages later, there is a "Certification of the Design Specification" as required by NCA-3255. One form of the certification is:

> This specification is certified to be correct and complete and in compliance with the requirements of paragraph NA-3252 of the ASME Boiler and Pressure Vessel Code, Section III.

The words in the Code (from 1971 to 1985) are:

> The Design Specifications shall be certified to be correct and complete and in compliance with the requirements of NCA-3250 by one or more Registered Professional Engineers, ...

Other forms of certifications are:

> This document complies with Paragraph NA-3250 of the ASME Boiler and Pressure Vessel Code, Section III.

and

> I hereby certify this specification to be in compliance with the ASME Boiler and Pressure Vessel Code Section III, dated 12/31/77.

These various forms of certification all indicate, directly or indirectly, that the document being certified is *correct and complete in compliance with the requirements of NCA-3250 (or NA-3250, for Codes through 1977)*. A common problem is that these documents are often revised. Each revision is certified to be "correct and complete." Each revision implies, of course, that the previous version was *not* correct or complete. This seems to trivialize the series of certifications. In our view, it would be better to identify the Code-required Design Specification by those words in the title; call it preliminary until such time that it is really "correct and complete" and then certify that it *is* correct and complete.

5.2 Design Reports

With one exception, the pump documentation reviewed was for Code Class 2 or 3 pumps. Up until the 1980 edition, the Code was not clear as to what design documentation, if any, was required by the Code. One hint that some sort of design documentation was expected to be available is contained in the 1971 Code "Form NPV-1 Manufacturers' Data Report for Nuclear Pumps or Valves." The "Certification of Design" block includes:

> "Stress analysis report on file at _____."

What we *did* receive for pumps, in response to our request (see item 3, Table 2), were documents with a title like "Seismic-Stress Analysis." Typically, these documents consider nozzle loads and seismic loads. These loads are *not* stated to come from the pump Design Specification but, in most cases, it turns out that they *do* agree with what is in the Design Specification.

That type of report, however, does not consider internal pressure loading and the adequacy of the pump pressure boundary. In the audit of one plant, the "Seismic Analysis" document included the sentence "Pressure boundary parts comply with the requirements of the ASME Boiler and Pressure Vessel Code, Section III ...". We asked the Applicant to verify the basis for the quoted sentence. He could not, but eventually agreed to ask the pump manufacturer to provide the basis for the sentence. Some 9 months later we received a report on the pump entitled, in part, "Pressure Boundary Calculations." The report, dated ~8 months after our request to the Applicant, states that "The design pressure conditions are

300 psig at 300°F for the pump." The report does not indicate that the design conditions came from the Design Specification, but, in fact, those conditions are stated in Paragraph 3.2.1.1 of the Design Specification.

The "Pressure Boundary Calculation" report refers to the pump Design Specification on the cover sheet; although it was identified as the "Customer Purchase Order No. -283," it used the wrong number (-283 should be -238, which presumably is a typographical error). In conjunction with our request that the "input data are clearly traceable to and agree with the Design Specification" (see Table 2), the report identifies nozzle loads by including a copy of a page from the Design Specification. Of all the "Design Reports" that we reviewed, this particular report constitutes a very rare example of where the input data are clearly traceable to the Design Specification.

5.3 In-service Testing of Pumps

Certain pumps are required to perform a specific function in shutting down a reactor or in mitigating the consequences of an accident. These pumps may not be used in routine operation; thus, their ability to function when called upon is checked under Code Section XI, Subsection IWP, "Inservice Testing of Pumps in Nuclear Power Plants." Such testing may require taps, valves, instrumentation, or by-pass lines. The Code cautions (see NCA 1110) that the rules for in-service inspection may influence Code construction, and Code Paragraph NCA-3752(a)(6) points out that the Design Specification should reference appropriate documents. Nevertheless, it appears from our audits that the ability to eventually perform in-service testing of pumps is being neglected in the construction stage. (See Chap. 11, recommendation 11.7.)

6. VALVES

Because the number of different safety-related valves is large, it is not feasible to prepare a Design Specification for each type of valve. For example, we estimate that there are about 500 different 2 1/2-in. and larger valves in a nuclear power plant that are Code Class 1, 2, or 3. They are different in nominal size, type (globe, gate, check, and butterfly), and pressure class (300, 600, and 900). We estimate that about 100 of those 500 types of valves would have either motor or air operators.

Valve bodies must be sufficiently rigid that the valve will operate when subjected to internal pressure and loads imposed by the attached piping. The rigidity is needed to minimize seat leakage and, for gate valves, to prevent binding of the disk in the body. Generally, the rigidity requirements are sufficient to ensure pressure boundary adequacy.

6.1 Design Specifications

A representative specification for valves received for review was titled:

> Technical Provisions for Nuclear Service Valves, 2 1/2 Inches and Larger, for the (Name of Owner), (Name of Plant)

The title page gave a specification number, the revision number as 9, and the date of October 13, 1982. Separately, we received a single sheet entitled:

> Certification of Design Specification for Nuclear Service Valves, 2 1/2 Inches and Smaller, (Name of Owner), (Name of Plant)

That sheet shows the revision as number 11, and the date of February 3, 1984. The certification reads:

> I, (Name of certifier), the undersigned certify that this design specification satisfies the requirements of ASME Boiler and Pressure Vessel Code, Section III, 1974 Edition with Addenda through Summer 1975, Subarticle NA-3250.

Because NA-3250 includes the words "correct and complete," it appears that there is a series of 11 revisions, each of which was certified to be correct and complete. Presumably, there will be more revisions before the document is really *correct and complete*.

The scope of the "Design Specification" discussed above is indicated by the following:

1.0 SCOPE OF WORK

> This specification defines the requirements for manual and power actuated (Automatic or Remote) Steel Gate, Globe and Check Valves, 2-1/2 Inches and Larger for nuclear power plant service, Code Classes 1, 2 and 3, as defined in the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III - Nuclear Power Plant Components.

Later in the document, it becomes apparent that the specification is essentially for valves covered by ANSI B16.5 (Ref. 3), up to 1973, and by ANSI B16.34 (Ref. 4) thereafter. Those standards cover 7 "Classes," about 12 nominal sizes in 2 1/2 NPS and larger and (in 1971) 13 different steels. Considering the 3 types of valves (Gate, Globe, and Check), the Specification covers ~3300 different valves.

The document addressed the Design Pressure and Design Temperature for the valves by the sentence:

> The design conditions used for all valves furnished by the contractor shall allow their use at all pressure-temperature conditions allowed by the Code for their primary-pressure rating and Code Class.

This implies that some engineer must determine that the Design Pressure and Design Temperature at the location where the valve is installed is less than the allowable pressure-temperature combination for the particular valve. For Class 2 or 3 valves, this means that some individual must look at a pre-1973 version of ANSI B16.5 because the 1974 Code (e.g., NC-3511) states: "The design shall conform to the applicable requirements for ANSI B16.5 including pressure temperature ratings." With respect to the retention issue raised in Sect. 4, the question arises: Will the reader of this document in, say, the year 2006 have a pre-1973 version of ANSI B16.5 available?

6.2 Design Reports

As stated in Sect. 5.2, up until the 1980 Code, it was not clear what design documentation, if any, was required for Class 2 or 3 valves. What we *did* receive for Class 2 and 3 valves, in response to our request No. 3 of Table 2, were documents relating to the adequacy of valves/operators for seismic loadings. None of these documents, however, addressed the adequacy of the valves for internal pressure loading.

We did receive two Design Reports for Class 1 valves. One is entitled "Design Report of 12 Inch-900 Lb. Carbon Steel Flex Wedge Gate Valve with SMB-1-60 Operator." The first 57 pages of this 116-page report are devoted to evaluating the adequacy of the valve body for internal pressure following the crude engineering guidance given in NB-3500 of the 1977 Code. The remaining ~60 pages are devoted to seismic analysis of the valve-operator assembly. This is a well-organized report.

The report mentions "the design specification" in several places. Apparently this is referring to the Technical Requirements prepared by

the AE for the plant. A Design Pressure is shown, but where it came from is not indicated. It does *not* agree with the Design Pressure given in the referenced Technical Requirements.

About 40 Code Class 1 valves are included in the Technical Requirements; thus, if a Design Report is prepared for each Class 1 valve, 50 Design Reports originate from this Technical Requirements document. Under the present Code, which requires Design Reports for Code Class 1, 2, and 3 components, 360 Design Reports originate from this Technical Requirements document.

The second Design Report for Class 1 valves is entitled:

> Stress Report for (Name of Organization) Class 1 Nuclear Valves, 6-Inch and Larger Gate Valves.

This 942-page report lists 46 valves in sizes 6 NPS through 16 NPS. The report starts with 18 pages of reasonably clear general information, but that is followed by 413 pages consisting of copies of computer printout sheets with many undefined symbols. Portions of these sheets are illegible. We suspect that this would happen in any reproduction of the report; the computer printout sheets are probably of inadequate quality to reproduce legibly.

However, if the reader of the report persists, he will get to pages 438–942 of the report where, apparently, the bases of the computer output are explained. From pages 438 to 942, it appears that engineering evaluations similar to those for the 12"-900 Class Valve have been performed for ~30 to 40 different valves. Mainly because of illegibility of important portions of the copies of the computer sheets, we were unable to ascertain exactly how many different valves are covered.

6.3 In-service Testing of Valves

Certain valves are required to perform a specific function in shutting down the reactor, in mitigating the consequences of an accident, or in providing overpressure protection. These valves may not be used in routine operation; thus, their ability to function when called upon to do so is checked under Sect. XI Subsect. IWV, "Inservice Testing of Valves in Nuclear Power Plants." Further, for some valves the leak rate must be checked. The testing may require pressure taps, downstream telltale connections, etc. As discussed in Sect. 5.3 for pumps, it appears that the ability to eventually perform in-service testing of valves is being neglected in the construction stage (see recommendation 11.7).

6.4 Differential Operating Pressure

Certain valves must have the capability to open and/or close with specified differential pressure across the seat. Apparently, in the past, valve manufacturers have been asked to quote on valves without being informed of the special operating requirements. While valve operability requirements are outside the scope of the Code, the Code [NCA-3252(a)(6)]

does require that the Design Specification make reference to appropriate documents that specify operating requirements. The Design Specification should clearly indicate (directly or by reference) valve operability requirements, and potential valve manufacturers should be made aware of those requirements at the earliest feasible stage in the procurement process. An addition to Code Appendix B is suggested (see recommendation 11.8).

7. PIPING AND PIPING SUPPORTS

In relationship to Code requirements, the following questions arise:

1. What is piping?
2. What is a piping system?

The word "piping" is used in many places in the Code. For example, it is used in NC-1131 as shown in Appendix A. The words in the first sentence, "piping or another component," suggest that piping might be a component. However, the second sentence defines boundaries for vessels, tanks, pumps, and valves but does not describe the boundaries of piping. The gap in NC-1131 is brought out by the question: Suppose a valve is welded to a pump nozzle, then where is the valve boundary and where is the pump boundary?

The words "piping system" occur several places in the Code, including NCA-1210, "Components," which reads:

> The components of a nuclear power plant include items such as vessels, concrete reactor vessels, concrete containments, piping systems, pumps, valves, core support structures, and storage tanks. Data Reports and Stamping shall be as required in NCA-8000.

The first sentence states that a piping system is a component. In NCA-8000, we see that piping systems are to be stamped according to their Code Class. However, piping systems are often identified in terms of their function. Table 3* shows those functional piping systems in a pressurized-water reactor (PWR) in which certain portions are constructed to different Code Classes. An obvious Code-requirements problem is that most piping systems, when defined by function, involve more than one Code Class.

The preceding situation reflects itself in Design Specifications and Design Reports, to wit, the Code has not yet adequately digested the complexities of piping or piping systems even though a Code definition for a piping system has finally been developed (Article NCA-9000, Ref. 1, 1986 ed. S86 ad.), that is,

> A piping system is an assembly of piping, piping supports, components, and if applicable, component supports of one or more Code Classes, with a defined function as described in the Design Specification for the piping system.

---

*Table 3 is taken from one of the piping design specifications received during our audit.

Table 3. Functionally designated piping systems in a PWR[a]

	System	ASME classification			Other
		1	2	3	ANSI B-31.1
1.	Reactor coolant	X	X		X
2.	Residual heat removal	X	X		X
3.	Safety injection	X	X	X	X
4.	Chemical and volume control	X	X	X	X
5.	Primary component cooling water		X	X	X
6.	Spent fuel pool cooling cleanup			X	X
7.	Reactor makeup water			X	X
8.	Containment spray		X	X	X
9.	Steam generator blowdown		X	X	X
10.	Sample		X	X	X
11.	Service water			X	X
12.	Nitrogen gas service		X	X	X
13.	Radioactive gaseous waste		X	X	X
14.	Demineralized water		X		X
15.	Floor and equipment drains		X		X
16.	Main steam		X	X	X
17.	Condensate			X	X
18.	Feedwater		X	X	X
19.	Diesel generator air			X	X
20.	Diesel generator fuel and lube oil			X	X
21.	Diesel generator cooling water			X	X
22.	Postaccident containment combustible gas control		X		
23.	Reactor coolant system pressurizer relief piping	X	X		X
24.	Deleted				
25.	Equipment vent		X		X
26.	Containment on-line purge		X		X
27.	Waste process liquid		X		X
28.	Fire protection		X		X

[a]Taken from one of the piping design specifications reviewed during our audit.

7.1 Design Specifications

Our audits included 12 "Design Specifications" for piping. These vary greatly in format and coverage. The largest of the specifications consisted of ~750 pages. It is entitled:

> Specification for Piping Engineering and Design, (Plant Name), (Owner Name)

This specification includes the usual certification that it is correct, complete, and in compliance with NA-3250. However, on page 2 of the specification, we read that this is not so. This specification, in conjunction with two other specifications, comprises a complete design specification.

At the other extreme, we have received Design Specifications that are essentially one-page documents. An example of one such Design Specification is shown in Table 4.

Some of the "design specifications" attempted to cover all piping systems with Code Class 1, 2, or 3 included therein, plus many other piping systems such as "Sanitary Systems." Other design specifications

Table 4. Example of a single-page piping design specification[a]

CERTIFICATION

I, the undersigned, do hereby certify that this Design Specification is in compliance with the requirements of Subsubarticle NA-3250 of Section III of the ASME Boiler and Pressure Vessel Code, Nuclear Power Plant Components. This Design Specification is comprised of the following documents.

	DOCUMENT TITLE	REVISION NO
400-36	HPCS System Piping Design ASME III	1
400-15	Piping Field Fabrication and Erection ASME III	3
400-16	Piping Shop Fabrication ASME III	6
400-17	Field Test of Piping ASME III	4
400-74	Piping Seismic Loading Data ASME III	0
400-02	Piping Materials (ASME Section III only)	7

[a]Taken from one of the piping design specifications reviewed during our audit.

were much more limited in scope, for example, a Design Specification that covered the Code Class 1 and 2 portions of the high-pressure core spray (HPCS) system.

Some of the "piping design specifications" cover valves even though, since 1971, the Code has identified valves as components with separate Code requirements (e.g., NB/NC/ND-3500) applicable to their construction.

Some of the design specifications cover piping supports; some do not. We did request and received several design specifications for supports or piping supports, or, in one case, "piping suspensions." We view the separation of piping supports from piping systems as an undesirable division of responsibilities. One of our recommendations is that both Design Specifications and Design Reports should cover the piping *and* its supports.

A common characteristic of all 12 of the design specifications we reviewed is that they incorporate many other specifications, drawings, design manuals, etc. Table 4 represents a minimum list of what might be called first-tier, subdocuments. More typically this kind of list identifies some 10 to 20 first-tier, subdocuments. Those subdocuments usually incorporate additional sub-subdocuments. We estimate that the total number of "Owner" specifications would be between 50 and 100. Those documents would be subject to periodic revision. The number of drawings (e.g., P & I.D.s, fabrication, isometrics) would, of course, vary with how many different piping systems are covered by the design specifications. For all of the systems indicated in Table 3, the number of drawings could total several hundred.

A formalistic problem encountered with piping design specifications is that, in some cases, there is more than one specification certified to be correct and complete and in accordance with NA-3250 or NCA-3251, for example, a specification for "Piping Engineering and Design," a specification for "Shop Fabricated Piping," and a third specification for "Field Fabrication and Erection of Piping."

7.2 Design Reports

Our audits included 13 "Design Reports." Eight of these cover Code Class 2 and/or 3 piping; the remaining five cover Code Class 1 piping. We will discuss these separately.

7.2.1 "Design Reports" for Code Class 2/3 Piping

While all are different, the eight "design reports" we received generally do a good job of summarizing the evaluations carried out under the vague term: piping. Table 5, taken from one of the "design reports," indicates the goals of these "design reports."

These "design reports" have titles such as "Pipe Line Package," "Pipe Stress Calculation," or, simply, "Calculation." The word "Package" perhaps best describes the documents. These packages are identified by a number, and the piping that is included is described by one or more drawings. The piping is also identified by its function, as indicated in

Table 5. Goals[a] of a Class 2/3 piping system design report

1. Show that the subject piping system has been designed to meet all Code requirements for stress considerations.
2. Summarize piping loads and displacements for the design of anchors and supports.
3. Summarize piping loads applied to equipment and show that they do not exceed allowable loads.
4. Summarize valve seismic accelerations where applicable to show that they do not exceed allowable accelerations.
5. Summarize piping displacements for floor and wall penetrations.
6. Summarize stresses for pipe break analysis.

[a]Taken from one of the "Design Reports" (packages) for Class 2/3 piping received during our audit.

Table 3. However, a package usually covers only a portion of a functional piping system. Rather, each package covers what would be called an "analytical piping system." We estimate that, for all of the Code-covered piping in a single nuclear power plant, ~250 of these roughly 100-page packages are produced.

7.2.2 Design Reports for Code Class 1 Piping

The five Design (or Stress) Reports for Class 1 Piping received show much greater variation in coverage than the eight "packages" for Class 2/3 piping. One Design Report, on recirculation piping in a BWR, consists of two volumes with contents as indicated in Table 6. Volume 1 contains 344 pages, and Volume 2 contains 185 pages. As indicated by Table 6 and the number of pages, this Design Report provides sufficient information to be potentially useful in the future.

Another Class 1 Design Report is on primary coolant loop piping in a PWR. About 45 pages of the 50-page report consist almost entirely of repetition of text from the Code or repetition of text from the Final Safety Analysis Report (FSAR). We view that as undesirable; see our recommendation 11.5, second paragraph under C-1131.

7.3 Weld Inspectability

Welded joints may require inspection under Sect. XI, Rules for In-service Inspection of Nuclear Power Plant Components. To perform those inspections, the welds must be accessible. Further, the details of the welds must be such that a meaningful volumetric examination (e.g.,

Table 6. Scope[a] of a design report for Class 1 recirculation piping in a BWR

Volume 1
1. Provides a summary of the most severe stress intensities throughout the piping system for the design and operating conditions defined in the Design Specification.
2. Shows that all pipe and fittings in the piping system satisfy the Pressure Design requirements of Article NB-3600 of ASME III for the conditions specified in the Design Specification.
3. Contains a listing of the forces, moments, and deflections at various nodes throughout the piping system for all loadings.
4. Contains the detailed results of the ASME III analysis required by Subarticle NB-3650 for all important joints in the piping system.
Volume 2
1. Summarizes the loads acting on the component supports, the vessel nozzle, and all pipe-mounted equipment.
2. Compares the total loading on equipment to the allowable loads as specified in the Design Specification.

[a]Taken from one of the Design Reports for Class 1 piping received during out audit.

ultrasonic) can be made. The Code cautions (see NCA 1110) that the rules for in-service inspection may influence Code construction. Nevertheless, it appears from our audits that requirements for weld inspectability are being neglected in the construction stage. (See recommendation 11.4(d) under B-6110.)

8. PRESSURE DESIGN

With the exception of pressure design, our reviews of Design Specifications and Design Reports led to the conclusion that the documents received were adequate. The Design Specifications for pumps and valves appear adequate in the sense that they should lead to purchase and installation of pumps and valves of good industrial quality and, thus, have the desired operating ability and long-time reliability. The Design Specifications for piping should lead to installed piping of good industrial quality. But, because of unrealistic earthquake requirements and, to a lesser extent, postulated pipe break requirements, nuclear power plant piping has many more supports and restraints (e.g., snubbers) than are used in industrial piping. These added restraints may actually reduce the reliability of nuclear power plant piping as compared with industrial piping.

In our view, pressure design for pumps and valves is not a major concern because the rigidity requirements for operability are usually such that the pressure boundary adequacy is assured. However, there could be exceptions, such as the casing bolting on some pumps and valve bonnet bolting on some non-B16.34 valves. If "something" concerning the pressure boundary of pumps and valves needs checking, we think the bolting should be included in the "something." As remarked in Sects. 5.2 and 6.2, most of the "Design Reports" we have received do *not* address pressure design.

In our view, pressure design is of first importance for piping. We would rank those evaluations concerned with normal operation such as weight and thermal expansion as of second importance. This ranking arises not so much from concern about the piping pressure boundary integrity, but rather its relevance to such aspects as equipment nozzle loads, support loads, clearances for normal pipe movements, and adequate supporting so that draining and venting can be obtained, thus avoiding potential water hammer conditions. We would rank those evaluations concerned with postulated conditions such as extreme earthquakes and pipe breaks as of third importance. What we saw in the "Design Reports" was coverage in inverse ratio to the above ranking.

For piping, pressure design requirements are given in NB/NC/ND-3640 of the Code. While there are some exceptions, most of the Design Reports (Stress Reports, packages) completely ignore the pressure design requirements of the Code.

To check compliance with NB/NC/ND-3640, a value of the corrosion/erosion allowance, A, must be selected. The Code does not say what value of A to use. In some cases, the selection of an appropriate value for A could be as significant as the design pressure. An example is in blowdown lines where a drop in pressure creates flashing-flow conditions that can, in time, cause significant erosion of the piping pressure boundary. Another example is wet-steam flow through an elbow. Some of the piping Design Specifications do address corrosion allowance at least perfunctorily, but others do not. None of the Design Specifications addressed erosion potential. Indeed, some Applicants had great difficulty in finding out what value of A they used to check compliance with NB/NC/ND-3640.

Our recommendations 11.3 and 11.5 in Sect. 11 are motivated, in part, by an intent to restore pressure design to major importance status. In recommendation 11.3, we list Design Pressure, Design Temperature, and Corrosion/Erosion allowance to direct attention to the pressure design. By suggesting that Design Reports include a leading section on pressure design, in 11.5, we again direct attention to that very important task.

9. FORMALISTIC ASPECTS OF DESIGN SPECIFICATIONS AND REPORTS

9.1 Certifications

Since its inception in 1963, the Code has required certification of Design Specifications. Starting in 1971, the Code has used the words "shall be certified to be correct and complete and to be in accordance with the requirements of NA (or NCA)-3250."

In Sects. 5.1 and 6.1, we discussed the aspect that "Design Specifications" were being certified as "complete and correct" when, in fact, they were subsequently revised; in some cases, the certified documents *themselves* said they were not complete.

In a broader sense, we doubt that any certifier can say that a Design Specification is correct and complete. He might say that "in his judgement" or "to the best of his knowledge and belief" the Design Specification is correct and complete. Indeed, some of the certifications do include such words.

However, there does seem to be a useful role that certification can play. That role would be an indication of when the Design Specification is finalized in the form in which it would be required to be retained for the life of the plant.

As a bit of background to the "finalized" aspect, during our audit we received about 50 documents that were identified by the certifications to be Code-required Design Specifications. However, when we asked if these were finalized, the answer was essentially, "not necessarily." (See recommendations in 11.1 and 11.2.)

9.2 Correlation Between Design Specifications and Design Reports

The first sentence under NCA-3256 reads (see p. 2 of Appendix A):

> The Design Specifications in their entirety shall become a principal document governing design and construction of items.

The first sentence under NCA-3260 reads (see p. 2 of Appendix C):

> The Design Report ... shall be reviewed by the Owner or his designee to determine that all the Design and Service Loadings as stated in the Design Specification have been evaluated, ...

The Design Reports (i.e., Stress Reports, packages), in most cases, acknowledge the existence of a Design Specification by including it in a long list of references. However, other than this proforma recognition, correlation of Design Specification loadings with Design Reports was not apparent.

The problem lies partly in the Code definition and use of the word "construction."

> An all-inclusive term comprising materials, design, fabrication, examination, testing, inspection, and certification required in the manufacture and installation of an item.

Despite this definition, which has been in the Code since 1971, there are several places in the Code where phrases like "design and construction" are used, for example, the first sentence under NCA-3256.

A "Design Specification" is required to provide a complete basis for construction, not just design. Perhaps the title should be Construction Specification. The Design Specifications received have attempted to provide a complete basis for construction; that is, aspects like materials, fabrication, examination, testing, inspection, and certification are addressed. Thus, the design requirements (e.g., design pressure and temperature) tend to get buried among the many other parts of the Design Specification. (See recommendation in 11.3.)

10. CODE APPENDIXES B AND C

10.1 Design Specifications, Code Appendix B

Code Appendix B, "Owner's Design Specification," is included herein as Appendix B; it is essentially the same as Appendix B in the 1980 Code. From 1971 to 1980, Code Appendix B was essentially as shown here.

In reviewing the "Design Specifications" received during our audits, we detect little evidence that the writers were aware of the existence of Code Appendix B. In particular, the suggestion that "Design Specifications should be as uniform throughout the nuclear industry as is reasonably attainable" has not been followed.

As discussed in Sect. 9.2 and as indicated by our recommendation 11.3, segregation of design data in the Design Specification would substantially improve Design Specifications for pumps, valves, and piping.

For piping, additional guidance is needed. An appropriate place for such guidance exists in Article B-6000 on Specific Piping Requirements. Our recommendation is shown in 11.4. Our motivation, in part, is to reduce the extreme diversity found in piping Design Specifications during our audits.

Code Appendix B, Article B-11000, includes a "Reference List of Regulatory Requirements." Even at this time, this list needs to be updated and supplemented by relevant NRC Standard Review Plan instructions. It is possible that, when and if construction of nuclear power plants in this country is restarted, substantial changes in regulatory policies will have occurred. There is ongoing work, particularly with respect to postulated pipe breaks and realistic earthquake evaluations, that could substantially change existing regulatory policies and, thus, change Design Specifications and Design Reports. However, a list of Regulatory Requirements probably will continue to be an important aspect of Design Specifications; thus, an updated version of Article B-11000 will be an essential part of Code Appendix B.

10.2 Design Reports, Code Appendix C

Code Appendix C is included here as Appendix D. As discussed earlier in Sect. 3, Code Appendix C is basically written for Class 1 vessels. However, it is poor guidance for Class 1 pumps, valves, or piping. Note, for example, that in C-1330 and C-1340, the relevant subarticles NB-3400 for pumps, NB-3500 for valves, and NB-3600 for piping, are not included.

The 1980 Code greatly expanded the number of Design Reports by the following words added to NCA-3551.1: "It is the responsibility of the N Certificate Holder to furnish a Design Report for each component and support, except as provided in NCA-3551.2." (NCA-3551.2 is on load capacity data sheets for component supports.) The 1971–1977 Codes required Design (Stress) Reports for Class 1 components, for example, Class 1 pumps, valves, and piping.

Code Appendix C (Appendix D here) is almost completely irrelevant to Code Class 2 or 3 pumps, valves, and piping. Accordingly, Appendix C needs a major rewrite to encompass what the Code now requires for Design Reports. Before such a rewrite is undertaken, however, careful consideration should be given to what should be included in a Design Report.

Until recently, the first sentence in NCA-3531.1 read:

> The Design Report is the design document which includes stress analysis or calculations or both to show that the allowable Limits are not exceeded for the loadings specified in the Design Specifications.

If this were interpreted to mean that *all* stress analyses and calculations, including computer printouts, should be embodied in the Design Report, the Design Report for a single functional piping system could be several feet thick. Because the Design Report must be made available to the Inspector and filed at the site, this would represent a large amount of paper duplication and filing space.

As an opposite extreme, the Design Report might consist simply of the following.

> Stress Analysis and calculations have been made which show that the allowable Limits are not exceeded for the loadings specified in the applicable Design Specification XXXX. Detail stress analyses and calculations are contained in the ABC Company File YYY.

The Design Reports (Stress Reports, packages) we received are compromises between these extreme possibilities.

Tables 5 and 6 list the categories of information that should be included in Design Reports for piping. The "Design Reports" received indicate that the information can be adequately summarized in about 100 pages.

Code Appendix C should be rewritten to cover Class 1, 2, and 3 components and component supports. Because "components" include vessels, containments, and core support structures, a complete rewrite of Code Appendix C is beyond the scope of this report. However, it would be helpful to rewrite Code Appendix C in parallel with the format of Code Appendix B, that is, a general section followed by specific sections for each type of component.

Our recommendation 11.5 gives appropriate guidance for preparation of Design Reports for piping.

11. RECOMMENDATIONS

11.1 NCA-3255, Certification of Design Specifications

Appendix A shows the present Code wording. We recommend that the words "correct and complete and to be" in the first sentence be deleted and a second sentence added. The first two sentences would then read:

> The Design Specifications shall be certified to be in compliance with the requirements of NCA-3250 by one or more Registered Professional Engineers, competent in the applicable field of design and related nuclear power plant requirements and qualified in accordance with the requirements of ANSI/ASME N626.3-1979. The certification shall be made to indicate that the Design Specification is in final form.

11.2 NCA-3555, Certification of Design Report

Appendix C shows the present Code wording. We recommend that the second sentence be expanded to read:

> The Design Report shall be certified only after all design requirements of this Section have been met and shall be made to indicate that the Design Report is in final form.

11.3 Appendix B, B2110.1

Page B-6 of Appendix B shows the present Code wording. In reviewing Code Appendix B, we noted several incorrect references to Code text; for example, in B-2112.4, referenced paragraph NCA-2145 does not exist. These references need to be corrected. We also recommend that the following be added to B-2110.1:

> (d) Those data that provide a direct basis for the Design Report (NCA-3551.1) should be segregated and identified as data to be used in the Design Report. Examples of such data are:
>
> Code Class
> Design Pressure
> Design Temperature
> Material
> Corrosion/Erosion Allowance

To the extent feasible, this portion of the Design Specification should be prepared so that it can be copied and used directly in the Design Report.

11.4 Appendix B, B-6000, Specific Piping Requirements

Article B-6000 in Appendix B shows the present wording. We recommend that B-6110 be revised to the following.

B-6110 GENERAL REQUIREMENTS

Preparation of Design Specifications for piping constitutes a difficult task because of the large number of functional piping systems and the complexities of each functional system. The format should be such that correlation with subsequent Design Reports (NCA-3260) is facilitated. The following format is suggested.

(a) The Design Specification, per se, should be a relatively brief document which provides an index to all other applicable documents. It should include a list of functional piping systems covered and their Code Classes.
(b) A specification (indexed in the Design Specification) which covers requirements for materials, fabrication, examination, testing, inspection, quality control and certification.
(c) Specifications (indexed in the Design Specification) for each functional piping system; giving, in particular, the data which provide a direct basis for the Design Report; see B-2110.1.
(d) A Specification (indexed in the Design Specification) that identifies welds which will be subjected to inservice examination and requirements associated therewith, such as accessibility and design amenable to volumetric examination.

11.5 Appendix C, Design Report Portion for Piping

Code Appendix C is included here as Appendix D. As discussed in Sect. 10.2, Appendix C needs a complete rewrite. The following recommendation is restricted to piping.

C-1000, C-1110, C-1120, C-1130 — No change from present wording

C-1131 General Requirements

Because the major purpose of the Design Report is to document the design in a way that will facilitate an independent review, it is important that it be simple to follow and free from ambiguity. Nomenclature, definitions, and symbols used should be in agreement with those established in NB/NC/ND-3600 for Class 1, 2, and 3 piping, respectively.

Where additional terms, definitions, or expressions are required, they should be clearly defined and explained and adequately referenced.

The Design Report should be as succinct as feasible. Toward this goal, repetition of Code text should be avoided. Where needed, specific references to Code text should be used; for example, NB-3643.3. Similarly, information available in the plant Safety Analysis Report, such as detailed descriptions of dynamic analysis methods or descriptions of computer programs, should be specifically referenced but not repeated in the Design Report. Generally, an effort should be made to keep the Design Report to less than 100 pages.

The Design Report should have a Table of Contents and pages numbered consecutively so that the intended contents of the Design Report will be clear.

Consideration should be given to the use of Design Reports during preoperational testing, because that consideration may dictate the amount of detail included in the Design Report.

C-1132 Contents

The Design Report should contain sections covering:

(a) Identifications
(b) Data from Design Specification
(c) Pressure Design
(e) Piping Loads for the Design of Anchors and Supports
(f) Piping Loads Applied to Equipment
(g) Valve Seismic Accelerations
(h) Piping Displacements
(i) Other Evaluations
(j) References

The contents of these sections are described further in C-1200.

C-1200 Details of Contents

C-1201 Identifications

Identify:

(a) The piping system by function (e.g., main steam) and drawing numbers
(b) The Code Class or Classes
(c) The applicable Design Specification and its revision number
(d) The applicable Code Edition and Addenda
(e) Code Cases used, if any

C-1202 Data from the Design Specification

The Design parameters to be used in the Design Report should be summarized. Ideally, the Design Specification will have these data segregated so that they may be copied and made into this part of the Design Report.

C-1203 Pressure Design

This section should summarize the evaluations required by NB/NC/ND-3640. The corrosion/erosion allowance, A, should be included in the evaluations.

C-1204 Analysis of Piping Systems

This section should summarize the evaluations required by NB/NC/ND-3650. A tabular summary of several of the highest stressed locations, with calculated and allowable stresses, should be included.

For Class 1 piping, a fatigue evaluation is required. A separate tabular summary of several of the highest usage factor locations, with their usage factors, should be included.

This section should include all Stress Indices for Class 1 piping and Stress Intensification Factors for Class 2 or 3 piping which are not obtained directly from the Code; and a justification for the Stress Indices or Stress Intensification Factors used should be included.

Computer programs used in these evaluations should be identified. The location at which detailed results are filed and a file identification should be included.

C-1205 Piping Loads for the Design of Anchors and Supports

This section should:

(a) Tabulate calculated loads on anchors and supports
(b) Reference anchor/support calculations which show that the anchors/supports are capable of withstanding the calculated loads

C-1206 Piping Loads Applied to Equipment

This section should include a tabulation of calculated loads acting on equipment (e.g., pumps) and the allowable loads for that equipment. The allowable loads for the equipment should be included in the Section on Data from the Design Specification.

C-1207 Valve Seismic Acceleration

If valves with operators are in the piping system and if these valves and operators are qualified in terms of maximum permissible accelerations, then this section should include a tabulation of calculated valve accelerations and their allowable accelerations. The allowable accelerations should be included in the Section on Data from the Design Specifications.

C-1208 Piping Displacements

This section should include tabulations of displacement that might lead to interference between piping and adjacent structures; e.g., at floor and wall penetrations. If it is anticipated that the data in this

section may be used in preoperational testing, the displacements needed for such testing should be included.

C-1209 Other Evaluations

Examples might be: postulated pipe breaks, dynamic effects of rapid valve closure and dynamic effects associated with BWR suppression pools. This section should summarize the evaluations and show that the applicable design criteria have been met.

C-1210 References

This section should include all references, other than those in C-1202, used in the Design Report. In particular, computer programs used should be referenced.

11.6 Piping Supports

In industrial piping codes, such as ANSI B31.1 for Power Piping, piping supports are included as part of piping systems. In separating piping supports from piping, the Code appears to have introduced unnecessary complications in keeping track of piping support construction and correlation with piping design. We believe that Design Specifications for nuclear piping systems should also include the piping supports. Further, Design Reports for nuclear piping should also include necessary calculation summaries and support drawings.

If adopted, this recommendation would require major changes in the Code. With more realistic evaluation of earthquakes, the number of seismic piping supports, particularly snubbers, will be substantially reduced. In zones of low seismic risk, such as Uniform Building Code Zones 0 and 1, perhaps seismic supports are not needed for nuclear piping systems. This elimination of supports would involve Regulatory changes, which might be made during the same time period as the Code changes needed to define piping systems as including piping supports.

11.7 In-service Testing of Pumps and Valves

In Sects. 5.3 and 6.3 we point out that the ability to perform in-service testing of pumps and valves apparently is being neglected in the construction stage. To correct this problem, we recommend that NCA-3252(a) (see Appendix A) be revised by changing the present (7) to (8) and inserting a new (7):

> (7) When inservice testing of the operability of a pump or valve is required, special needs for such testing (e.g., pressure taps, by-passes) shall be identified in the Design Specification for implementation in the construction stage.

11.8 Valve Differential Operating Pressure

In Sect. 6.4 we noted that valve manufacturers have been asked to quote on valves without being informed of special operating requirements. To avoid potential problems, we recommend that B-5210 (see Appendix B) be revised by adding the sentence:

> The Design Specification (directly or by reference) should indicate those valves which must be capable of opening and/or closing against a differential pressure across the seat, and the magnitude of that differential pressure.

REFERENCES

1. *ASME Boiler and Pressure Vessel Code*, Sect. III, Div. 1, "Nuclear Power Plant Components," 1983 ed. S85 ad., ASME, New York.

2. *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*, LWR ed., U.S. Nuclear Regulatory Commission, NUREG-0800, July 1981.

3. ANSI Standard B16.5-1961, *Steel Pipe Flanges and Flanged Fittings*, ASME, New York, 1961.

4. ANSI Standard B16.34-1973, *Valves — Flanged and Buttwelding End*, ASME, New York, 1973.

Appendix A

CODE REQUIREMENTS FOR DESIGN SPECIFICATIONS

NCA-3250 PROVISION OF DESIGN SPECIFICATIONS

NCA-3251 Provision and Correlation

It is the responsibility of the Owner to provide, or cause to be provided, Design Specifications for components, appurtenances, and component supports. The Owner, either directly or through his designee, shall be responsible for the proper correlation of all Design Specifications. Separate Design Specifications are not required for parts, piping subassemblies, appurtenances, or component supports when they are included in the Design Specification for a component (NCA-1210). However, the applicable data from the component Design Specification (Division 1) ~~or the Construction Specification and Design Drawings (Division 2)~~ shall be provided in sufficient documented detail to form the basis for fabrication in accordance with this Section.

NCA-3252 Contents of Design Specifications[4]

(a) The Design Specifications shall contain sufficient detail to provide a complete basis for Division 1 construction ~~or Division 2 design~~ in accordance with this Section. Such requirements shall not result in construction which fails to conform with the rules of this Section. All Design Specifications shall include (1) through (7) below:

(1) the functions and boundaries of the items covered (NCA-3254);

(2) the design requirements [NCA-2110(a) and (b) and NCA-2140] including all required overpressure protection requirements [NCA-3220(k)];

(3) the environmental conditions, including radiation;

(4) the Code classification of the items covered (NCA-2000);

(5) material requirements including impact test requirements;

(6) when operability of a component is a requirement, the Design Specification shall make reference to other appropriate documents which specify the operating requirements;

(7) the effective Code Edition, Addenda, and Code Cases to be used for construction.

[4]See Appendix B, except that for core support structures see Appendix J.

NCA-3253 Classification of Components, Parts, and Appurtenances

The Owner, either directly or through his designee, shall establish the Code classification of the items which comprise the nuclear power plant.

NCA-3254 Boundaries of Jurisdiction

In order to define the boundaries of components with respect to adjacent components and other structures, the Design Specifications shall include:

(a) the locations of each such boundary;

(b) the forces, moments, strains, or displacements which are imposed at each such boundary;

(c) the structural characteristics of the attached components or structures, whether or not they are within this Section's jurisdiction when such components or structures provide constraints to the movement of components or appurtenances;

(d) when the foundation support is constructed as an integral part of the concrete reactor vessel or concrete containment, it shall be included within this Section's Division 2 jurisdiction to the extent required by NCA-2132.

NCA-3254.1 Definition of Division 1 Boundaries

(a) The boundaries for Class 1 components are given in NB-1130.

(b) The boundaries for Class 2 components are given in NC-1130.

(c) The boundaries for Class 3 components are given in ND-1130.

NCA-3255 Certification of the Design Specifications

The Design Specifications shall be certified to be correct and complete and to be in compliance with the requirements of NCA-3250 by one or more Registered Professional Engineers, competent in the applicable field of design and related nuclear power plant requirements and qualified in accordance with the requirements of ANSI/ASME N626.3-1979. These Registered Professional Engineers are not required to be independent of the organization preparing the Design Specifications. ~~Document distribution for Division 2 construction is shown in Table NCA-3200-1.~~

NCA-3256 Filing of Design Specifications

(a) The Design Specifications in their entirety shall become a principal document governing design and construction of items. A copy of the Design Specification shall be made available to the Inspector at the manufacturing site before fabrication begins, and a copy shall be filed at the location of the installation and made available to the enforcement authorities having jurisdiction over the plant installation before components or appurtenances are placed in service. In the case of parts, piping subassemblies, appurtenances, and component supports, the Design Specifications need not be made available to the Inspector at the fabrication site (NCA-3251). However, the applicable data from the Design Specifications which form the basis for fabrication shall be made available to the Inspector at the fabrication site. ~~Document distribution for Division 2 construction is shown in Table NCA-3200-1.~~

(b) For pumps and valves 4 in. nominal pipe size and less, for linear supports used as mechanical snubbers, and for component standard supports, the Certificate Holder may provide his own Design Specification in accordance with NCA-3252 as a basis for construction. Prior to installation, the Owner or his designee shall be responsible for reconciling the Certificate Holder's Design Specification with his own Design Specification.

NC-1130 BOUNDARIES OF JURISDICTION APPLICABLE TO THIS SUBSECTION

NC-1131 Boundary of Components

The Design Specification shall define the boundary of a component to which piping or another component is attached. The boundary shall not be closer to a vessel, tank, pump, or valve than:

(a) the first circumferential joint in welded connections (the connecting weld shall be considered part of the piping);

(b) the face of the first flange in bolted connections (the bolts shall be considered part of the piping);

(c) the first threaded joint in screwed connections.

Appendix B

CODE GUIDANCE FOR PREPARATION OF DESIGN SPECIFICATIONS

APPENDIX B
OWNER'S DESIGN SPECIFICATIONS

* Not included

* Not included

* Not included

ARTICLE B-1000
INTRODUCTION AND SCOPE

B-1100 INTRODUCTION

B-1110 OBJECTIVE

(a) The objective of this Appendix is to provide a guide for the preparation of the Design Specification required by this Section. The writer of the Design Specification is not restricted as to what can be included therein except that, as a minimum, the information required by this Section must be included. Additional, but not less restrictive, requirements which modify the rules of this Section to make them complete for a specific component or to provide more specific or restrictive requirements should be identified.

(b) It is recognized that in order to prepare a document that provides a complete basis for construction of an item for a nuclear power plant, a number of considerations outside the scope of this Section may need to be addressed. Some of these which are addressed in this Appendix are:

(1) load combinations
(2) operability
(3) regulatory requirements

The additional guidance provided in this Appendix for these considerations is not required by this Section, is not a part of the Certification process, and should not be interpreted as extending the duties of the Inspector.

B-1120 FORMAT

B-1120.1 General. Design Specifications should be as uniform throughout the nuclear industry as is reasonably attainable. The format of this Appendix is presented as a guide to uniformity and is divided into major categories as follows:

(a) Generic Requirements applicable to all components (B-2000);

(b) Specific Requirements applicable to each component (B-3000 through B-10000, inclusive);

(c) Included in both the Generic and Specific Requirements are those considerations outside the scope of this Section (operability[1] and regulatory[2] requirements) which have an effect on construction but which are not required by this Section to be a part of the Certified Design Specification.

B-1120.2 Nomenclature, Definitions, and Symbols. Nomenclature, definitions, and symbols should be in agreement with those established in the applicable Article. Should a conflict exist between Articles, the Design Specification should be clear as to what is intended in each case.

B-1200 SCOPE OF CERTIFIED DESIGN SPECIFICATION

The Certified Design Specification should contain in sufficient detail the information which this Section requires to be provided. Operability[1] and regulatory[2] requirements which are beyond the jurisdiction of this Section are not covered by the Code required Certification of the Design Specification (NCA-1110).

---

[1]Applicable operability requirements are contained in the Subarticles designated 200 in this Appendix, such as B-2200, B-3200, etc.

[2]Applicable regulatory requirements are contained in the Subarticles designated 300 in this Appendix, such as B-2300, B-3300, etc.

ARTICLE B-2000
GENERIC REQUIREMENTS

B-2100 CERTIFIED DESIGN SPECIFICATION REQUIREMENTS

The information in this Article addresses those portions of the Certified Design Specification which are generic in nature and therefore applicable to the construction of all Section III items.

B-2110 GENERAL

B-2110.1 Contents of the Certified Design Specification

(a) NCA-3252 provides the minimum requirements for the contents of the Certified Design Specification.

(b) With respect to NCA-3252(a), it is important to recognize that the boundary defines an interface between two items that are dependent on each other for the transmittal of loads. In order to properly design the item on either side of the boundary, the effect of the attached item is required. The effect may be furnished directly by supplying the forces and moments that are transmitted across the boundary or, alternatively, by providing sufficient information to enable the designer to determine the interaction across the boundary. This Section provides rules to accomplish this in NCA-3254.

(c) Any Code Cases applicable to the construction of an item should be included in the Design Specification.

B-2110.2 Certification. NCA-3255 provides the requirements for Certification of the Design Specification. The required certification is not applicable to supplementary, regulatory, or operability requirements which are outside of the scope of this Section.

B-2110.3 Permanent Records. NCA-4134.17 provides the requirements for the continued maintenance and retention location for permanent records.

B-2110.4 Handling, Storage, and Shipping. The Design Specification should include any special measures to control handling, storage, and shipping of the component (NCA-4134.13).

B-2110.5 Identification of Enforcement Authorities. The Design Specification should include identification of enforcement authorities at locations of component installation with whom Data Reports must be filed.

B-2110.6 Filing. NCA-3256 provides the requirements for filing of the Design Specification.

B-2110.7 Review of Design Report. NCA-3260 provides the requirements for review of the Design Report.

B-2111 Classification

B-2111.1 Responsibility. NCA-2110 provides the requirements for classification of equipment.

B-2111.2 Multiple Code Class Components. NCA-2133 provides the requirements for multiple Code Class components.

B-2111.3 Optional Use of Code Classes. NCA-2134 provides the requirements for optional use of Code Classes.

B-2111.4 Special Requirements. NCA-2160 provides the requirements for contractual arrangements that are beyond the scope of this Section.

B-2112 Design Basis and Service Limits

B-2112.1 Plant and System Service Conditions. The definition of plant and system service conditions, and the determination of their significance to the design and operability of components and supports of a nuclear power system, may be derived from systems safety criteria documents for specific types of nuclear power systems and may be found in the requirements

of regulatory authorities having jurisdiction at the site [NCA-2141(b)].

B-2112.2 Design Loadings. The Design Specification shall include the Design Pressure [NCA-2142.1(a)], the Design Temperature [NCA-2142.1(b)], and the Design Mechanical Loads [NCA-2142.1(c)].

B-2112.3 Establishment of Component and Component Support Design and Service Limits

(a) For Class 1, MC, and CS components, and for Class 2 and 3 piping and its supports, Design and Service Loads should be specified and appropriate Service Limits designated [NCA-2142(a)].

(b) For Class 2 and 3 components and supports, other than piping and its supports, two options are available as follows:

(1) Design and Service Loads may be specified and appropriate Service Limits designated.

(2) Service Loadings are not required to be identified when the Design Pressure, Design Temperature, and Design Mechanical Loads result in stresses that are at least as high, relative to allowable values, as any which may occur for any Service Loading [NCA-2142(a)].

B-2112.4 Test Loadings. NCA-2145 provides the rules for consideration of Test Loadings.

B-2113 N Certificate Holder's Responsibilities

B-2113.1 Manufacturers of Small Pumps and Valves and of Component Standard Supports. Manufacturers of small pumps and valves (4 in. NPS and smaller) and component standard supports (including snubbers) who elect to provide their own Design Specification are responsible for compliance with the requirements of NCA-3256(b).

B-2113.2 Compliance with N Certificate Holder's Responsibilities. When the completed Code item involves work by more than one organization, the Design Specification shall be provided to the organization having overall responsibility.

B-2120 DESIGN

B-2121 Loadings

The Owner or Owner's designee shall identify the loadings and designate the appropriate Design and Service Limits for each component or support. The loadings that should be taken into account in designing a component include, but are not limited to, the following:

(a) internal and external pressure;

(b) weight of the component and normal contents under service test conditions, including additional pressure due to static and dynamic head of liquids and fluid flow effects;

(c) superimposed loads, such as other components, operating equipment, insulation, or corrosion resistant or erosion resistant linings and piping;

(d) vibrations and earthquake loads;

(e) reactions of supporting lugs, rings, saddles, or other types of supports;

(f) temperature effects;

(g) restrained thermal expansion;

(h) anchor and support movement effects;

(i) environmental loads, such as wind and snow.

B-2122 Design Loads

B-2122.1 Design Pressure. NCA-2142.1(a) and NB/NC/ND/NE-3112.1 provide the required definitions for Design Pressure.

B-2122.2 Design Temperature. NB/NC/ND/-NE/NF/NG-3112 and NCA-2142.1(b) provide the requirements for Design Temperature. The Design Temperature shall be used in computations involving the Design Pressure and coincidental Design Mechanical Loads. The actual metal temperature at the point under consideration shall be used in all computations where the use of the actual service pressure is required. Where a component is heated by tracing, induction coils, jacketing, or by internal heat generation, the effect of such heating shall be incorporated in the establishment of the Design Temperature.

B-2122.3 Design Mechanical Loads

(a) The specified Design Mechanical Loads should be selected so that when combined with the effects of Design Pressure, they represent the most severe coincident loadings for which the Level A Service Limits on primary stress are applicable.

(b) The determination of *most severe coincident loadings* may result in specification of pairs of Design Conditions since the one most severe combination may not be readily predicted. The specification may specify the maximum Design Mechanical Load for any situation which, when taken with the Design Pressure, would result in the worst combination of Design Conditions even though they may not be coincident.

(c) The Design Mechanical Loads that are considered are somewhat dependent on the component, its location, its attachment to other components, and for a Class 2 or 3 component, whether Service Loadings are to be specified (refer to B-2112.3 and NCA-2142).

B-2123 Service Loads

In order to properly specify Service Limits for the various types of loadings, the Owner or Owner's designee should recognize the basis for the establishment of those Limits. These are given in NCA-2142.2.

B-2123.1 Service Limits A and B

(a) For Class 1, MC, and CS components and for Class 2 vessels designed to NC-3200, Service Limits A and B are provided in order to evaluate the effect of system operating loads on the fatigue life of the component. For a fatigue analysis the loads applicable to the component being considered should be described in terms of quantities that the designer may use [NB-3222.4(e)]. The variation with respect to time of pressure, temperature, flow rate, etc., as well as the number of times these changes occur in the life of the component, is needed. In this regard, a service cycle is defined in NB-3213.15 as: ". . . the initiation and establishment of new conditions followed by a return to the conditions which prevailed at the beginning of the cycle." Thus, as an example, the conditions associated with plant startup do not constitute a service cycle. Startup and shutdown together constitute a service cycle, and if there are n_1 startups in the Design Specification, there should be the same number of shutdowns.

(b) Figure B-2123-1 is an illustration of the time-dependent load information which the designer needs. (Note that it provides only the startup portion of a service cycle.)

(c) For Class 2 and 3 piping and its supports, it is not necessary to define each service cycle in detail. What is needed is the maximum range of conditions and the number of occurrences to which the piping will be subjected. For example, the minimum temperature conditions could be 40°F while the maximum is 456°F. If all other service cycles did not impose a temperature condition less than the minimum or greater than the maximum, they would not have to be specified. An exception to this would be ranges of temperatures that occurred more than 7000 times which resulted in significant stresses.

(d) For all other Class 2 and 3 components and component supports, it is not necessary to define each service cycle in detail since no fatigue analysis is required. It is important for the designer to know the maximum loading condition on the component for these Service Limits.

B-2132.2 Service Limit C. Service Limit C is provided in order to evaluate the effect of plant operating loads on the structural integrity of a component for situations which are not anticipated to occur for a sufficient number of times to affect fatigue life and for which large deformations in areas of structural discontinuities are not objectionable. Since the occurrence of stress associated with this Limit may result in removal of the component from service for inspection or repair, the Owner should review the selection of this Limit for compatibility with established system safety criteria.

B-2123.3 Service Limit D. Service Limit D is provided in order to evaluate the effect of plant operating loads on the structural integrity of a component for situations in which gross general deformations, loss of dimensional stability, and damage requiring repair, excluding loss of pressure retaining function, are not objectionable. Since the occurrence of stress associated with this Limit may require removal of the component from service, the Owner should review the selection of this Limit for compatibility with established system safety criteria.

B-2124 Test Loads

Loads due to tests beyond those allowed by this Section should be classified in the appropriate Service Limit in accordance with NCA-2142.2(b) (NCA-2145).

B-2125 Load Combinations

In order to provide a complete definition of service loads, the combination of specific events must be considered. Since these combinations are a function of specific systems which make up a part of a specific type nuclear facility, this Section does not directly address this other than to provide different Stress Limits for various loadings. Specific guidance is provided in the approved Safety Analysis Report (SAR) for the plant.

B-2126 Deformation Limits

The Code does not provide specific deformation limits other than those that would be associated with a given allowable stress. If control of deformation is a requirement, the deformation limits should be provided.

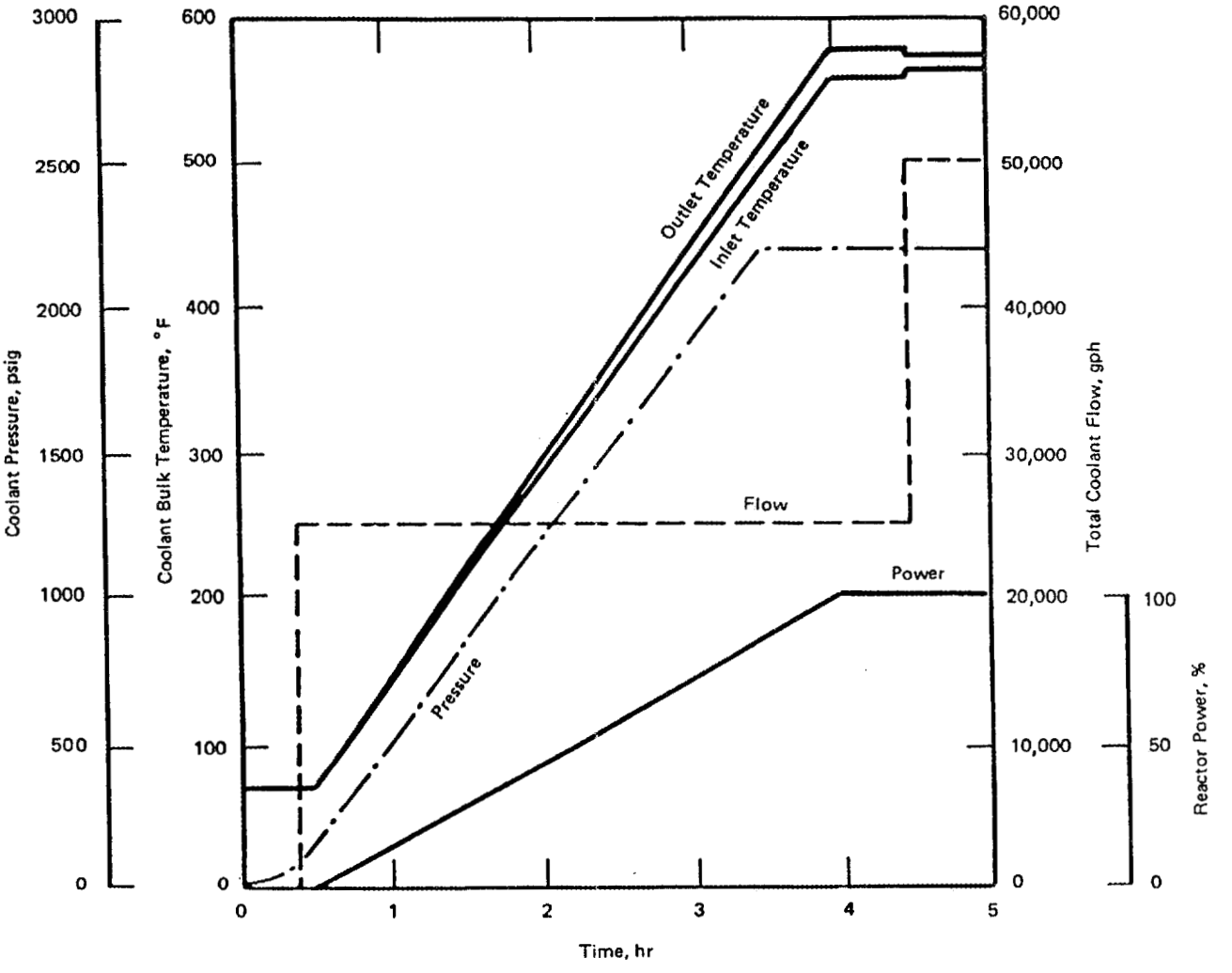

FIG. B-2123-1 TIME-DEPENDENT LOAD INFORMATION

B-2130 MATERIALS

B-2131 General Requirements

The Design Specification should provide information relative to materials as listed in (a) through (g) below:

(a) any hydrostatic testing or service temperature limits;

(b) any reductions to design stress intensity values, allowable stress, or fatigue curves necessitated by environmental conditions;

(c) any restrictions on cladding materials;

(d) materials which are acceptable from the standpoints of environment and location;

(e) any restrictions on heat treating;

(f) any requirements with respect to cleanliness;

(g) impact test requirements (B-2132);

(h) any corrosion or erosion allowances;

(i) postweld heat treatment times applied to the material or item after it is completed must be specified (NB/NC/ND/NE/NF/NG-4622).

B-2132 Impact Tests

For those cases where impact testing is optional, the Design Specification should state whether or not impact testing of the pressure retaining material of the component or the support material is required. The test temperature should be specified and the tests become part of the appropriate Subsection.

B-2140 FABRICATION

The Design Specification should specify any unusual restrictions on fabrication processes or techniques that would be deleterious to the suitability of the component in the expected service environment.

B-2150 TESTING

B-2151 Pneumatic Test

The Design Specification should identify if a pneumatic test should be used in lieu of hydrostatic testing for those components and appurtenances required to be pressure tested in accordance with the rules of this Section (NB-6111, NB-6112, NE-6112).

B-2152 Restriction on Testing

Any restrictions on the use of the test fluid should be provided (NB-6112, NE-6112). When selecting a fluid for the test, it should be determined that the test fluid does not have deleterious effects and that the test fluid may be safely used at the pressure and temperature specified for the test.

B-2153 Bellows Type Expansion Joints

Any requirements that supplement hydrostatic or pneumatic testing of bellows type expansion joints should be included.

B-2154 Leak Tightness

Leak tightness requirements for areas, such as permanent seals, seats, and gasketed joints for pressure retaining components or appurtenances, should be included (NB-6215).

B-2155 Additional Testing

If testing in addition to pressure testing is required, the loads due to such testing should be classified in accordance with NCA-2142.2(b) (NCA-2145).

B-2160 OVERPRESSURE PROTECTION

B-2161 General Requirements

B-2161.1 Scope. For steady state or transient conditions of pressure and coincident temperature that are in excess of design or service loadings and their combinations and associated limits specified in the Design Specifications, system overpressure protection is required for vessels, piping, pumps, and valves in service and subjected to the consequences of the application of these conditions (refer to NB/NC/ND-7110). S84

B-2161.2 Integrated Overpressure Protection. It should be recognized that the overpressure protection of pressure retaining components in a system require consideration of the pressure transients which may be imposed on the systems during all service loadings and testing conditions described in the component Design Specifications [refer to NB-7120(a)].

B-2162 Design Secondary Pressure S84

The design secondary pressure shall be specified in the Design Specification (refer to NB-7111(d) and NC/ND-7112).

S84 **B-2163 Maximum Anticipated Pressure and Temperature**

The Design Specification should identify the maximum anticipated pressure and coincident temperature among any systems components under the operating conditions of the system as a consequence of any transients occurring either within the system or in associated systems which may affect the system for which overpressure protection is intended (refer to NB/NC/ND-7300). Service conditions such as at startup and shutdown may require protection against nonductile failure [NB-3211(d)] at pressures lower than the component design pressure.

S84 **B-2164 Pressure Relief Valve Operating Requirements**

B-2164.1 Blowdown Requirements. The Design Specification may specify blowdown requirements with a greater tolerance than the values stated in NB/NC/ND-7500.

B-2164.2 Popping Point Tolerance. The Design Specification may specify a popping point tolerance greater than the value stated in NB/NC/ND-7500.

B-2165 Pressure Relief Valve Operating Characteristics (Refer to ANSI N278.1)

As applicable, the following pressure relief valve operating characteristics should be specified in the Design Specification when overpressure protection is dependent upon these factors:

(a) set pressure;

(b) set pressure range;

(c) set pressure tolerance;

(d) discharge capacity with due allowance for the effect of the back pressure on the capacity;

(e) accumulation;

(f) blowdown;

(g) static and dynamic back pressure, minimum and maximum;

(h) response time (maximum time delay between attainment of set pressure or reception of the energizing signal by the solenoid and valve lift).

B-2200 OPERABILITY

B-2210 INTRODUCTION

Operability requirements are outside the scope of this Section (NCA-2142); however, the Owner or Owner's designee is required to identify any such requirements in the Design Specifications (NCA-3252).

B-2220 ACTIVE PUMPS OR VALVES

The Design Specification should indicate if the specified pump or valve must perform a mechanical motion during the course of accomplishing a system safety function during or following the specified plant event. Such a pump or valve is designated as an active component.

B-2300 REGULATORY REQUIREMENTS

In the process of preparing a Design Specification, it is important to refer to and rely on the requirements contained in SAR documents since they provide the basis for complying with existing regulatory requirements. Conflicts between a Design Specification and the SAR could lead to construction of items not in compliance with the license requirements. A reference list of regulatory documents is provided in B-11000 which may be used in determining the applicable requirements to be included in Design Specification.

ARTICLE B-4000
SPECIFIC PUMP REQUIREMENTS

B-4100 CERTIFIED DESIGN SPECIFICATION REQUIREMENTS

In addition to the Design Specification Requirements indicated in B-2000, Generic Requirements, the Design Specification for pumps should include the other requirements of B-4110 and B-4120.

B-4110 GENERAL REQUIREMENTS

Covered by B-2110.

B-4120 DESIGN

B-4121 Loads From Connected Piping

The forces and moments produced by the connected piping on each pump inlet and outlet should be included (NB/NC/ND-3415).

B-4122 Earthquake Loadings

NB/NC/ND-3417 provide the requirements for consideration of earthquake loading.

B-4200 OPERABILITY REQUIREMENTS FOR PUMPS

B-4210 GENERAL REQUIREMENTS

B-4211 Applicability

The inclusion of functional operability requirements in the Design Specifications should be based on the functional requirements of the pump being specified. These requirements should be specified only if the pumps are considered to be active pumps.

B-4220 DESIGN

The Design Specification should include all applicable and pertinent information considered important to the functional operability of the pump.

B-4230 QUALIFICATION

B-4231 Methods

The method of pump qualification, if any, for functional operability should be defined in the Design Specification. Qualification by analysis, test, or combinations thereof should be specified. Available Codes or Standards which cover these areas should be referred to and used to the maximum extent possible.

B-4232 Analysis

Acceptable methods of analysis should be identified. The following areas, as a minimum, should be addressed:

(a) required analysis;

(b) load combinations, including deadweight, thermal loads, nozzle loads, seismic loads, etc.;

(c) allowable stresses for the various loading conditions.

B-4233 Testing

Acceptable methods of testing should be identified. The following areas, as a minimum, should be addressed:

(a) required tests and test sequences

(b) imposed loads and pump function during tests

(c) acceptance criteria

B-4240 FUNCTIONAL OPERABILITY PRODUCTION TESTS

Any special functional operability tests to be conducted on production pumps should be specified in the Design Specification.

B-4250 DOCUMENTATION

Documentation requirements for functional qualification or production tests should be specified.

B-4300 REGULATORY REQUIREMENTS

Regulatory requirements are covered in B-2300 and a reference list is given in B-11000.

ARTICLE B-5000
SPECIFIC VALVE REQUIREMENTS

B-5100 CERTIFIED DESIGN SPECIFICATION REQUIREMENTS

In addition to the Design Specification requirements indicated in B-2000, Generic Requirements, the Design Specification for valves should include the other requirements of B-5110 and B-5120.

B-5110 GENERAL REQUIREMENTS

Covered by B-2110.

B-5120 DESIGN

B-5121 Class 1 Valves

B-5121.1 Pipe Reactions for Valves Designed to Alternative Design Rules. NB-3512.2 provides the requirements concerning pipe reactions.

B-5121.2 Earthquake Loadings. NB-3524 provides the requirements concerning earthquake loadings.

B-5121.3 Level C Service Limits. NB-3526 provides the requirements concerning valve function during loading for which Level C Service Limits are specified.

B-5121.4 Pipe Reaction Stress. NB-3526.2 provides the requirements concerning pipe reaction stress computation for Level C Service Limits.

B-5121.5 Level D Service Limits. NB-3527 provides the requirements concerning valve function during loadings for which Level D Service Limits are specified.

B-5121.6 Hydrostatic Tests. NB-3531.2(c) provides the requirements concerning alternative test pressures, seat leakages, and test durations.

B-5121.7 Body Contours at Weld Ends. NB-3544.8 provides the requirements concerning alternative body contours at weld ends of valves.

B-5121.8 Bypass Piping. The Design Specification shall state which organization is responsible for the bypass piping design, if the responsible organization is not the piping system designer [NB-3546.3(b)].

B-5122 Class 2 Valves

B-5122.1 Alternative Rules. The Design Specification shall specify whether the alternative rules of NC-3513 are permitted to be used.

B-5122.2 Hydrostatic Tests. NC-3514 provides the requirements concerning alternative test pressures, seat leakages, and test durations.

B-5123 Class 3 Valves

B-5123.1 Alternative Rules. The Design Specification shall specify whether the alternative rules of ND-3513 are permitted to be used.

B-5123.2 Hydrostatic Tests. ND-3514 provides the requirements concerning alternative test pressures, seat leakages, and test durations.

B-5200 OPERABILITY REQUIREMENTS FOR VALVES

B-5210 INTRODUCTION

Operability requirements are outside the scope of this Section (NCA-2142); however, the Owner or Owner's designee is required to identify any valve operability requirements in the Design Specification [NB-3526(b) and NB-3527].

B-5220 DESIGN

The Design Specification should include all applicable and pertinent information required. A document pertaining to this information is ANSI N278.1. Additional information not covered in ANSI N278.1, but considered important to the functional operability of the valve should also be included. NB-3524, NC-3520, and ND-3520 provide guidance for analysis of valves with extended masses.

B-5230 QUALIFICATION

B-5231 Methods

The method of valve qualification, if any, for functional operability should be defined in the Design Specification. Qualification by analysis, test, or combinations thereof should be specified. Available Codes or Standards which cover these areas should be referenced and used to the maximum extent possible.

B-5232 Analysis

Acceptable methods of analysis should be identified. The following areas, as a minimum, should be addressed:

(a) required analysis;

(b) load combinations, including seismic, end loads, mechanical loads, etc.;

(c) allowable stresses for the various loading conditions.

B-5233 Testing

Acceptable methods of testing shall be identified. The following areas, as a minimum, should be addressed:

(a) required tests and test sequence

(b) imposed loads and valve function during tests

(c) acceptance criteria Y

B-5240 FUNCTIONAL OPERABILITY PRODUCTION TESTS

Any special functional operability tests to be conducted on production valves shall be specified in the Design Specification.

B-5250 DOCUMENTATION

Documentation requirements for functional qualification or production tests or both should be specified in the Design Specification.

B-5300 REGULATORY REQUIREMENTS

Regulatory requirements are covered in B-2300 and a reference list is given in B-11000.

ARTICLE B-6000
SPECIFIC PIPING REQUIREMENTS

B-6100 CERTIFIED DESIGN SPECIFICATION REQUIREMENTS

In addition to the Design Specification requirements indicated in B-2000, Generic Requirements, the Design Specification for piping should include the other requirements of B-6110 and B-6120.

B-6110 GENERAL REQUIREMENTS

Covered by B-2110.

B-6120 DESIGN

B-6121 Seismic

For piping, the loadings, movements, anchor motions, and number of cycles due to seismic events should be given. The associated Service Loadings which occur with, or as a result of, the specified seismic events should be stated.

B-6122 Other Dynamic Loads

Dynamic loadings, such as those resulting from sudden valve or pump operation, should be given. As a minimum, the information needed to determine this loading should be given (such as pressures, temperatures, flow rates, valve operating times).

B-6123 Peak Pressure

Peak pressure for Level B, C, and D Service Limits must be restricted to certain values in accordance with NC/ND-3611.2(c)(2), (3), and (4). In categorizing Service Loadings into appropriate Service Limits, the Design Specification should include the peak pressure.

Appendix C

CODE REQUIREMENTS FOR DESIGN REPORTS

NCA-3550 REQUIREMENTS FOR DESIGN DOCUMENTS

NCA-3551 Design Documents

(a) The Design Report and the drawings used for design and construction are the primary Design Documents. For some component supports, a Load Capacity Data Sheet is used in lieu of a Design Report. When a Load Capacity Data Sheet is used, the provisions of NCA-3554 and NCA-3556 shall also apply. The design shown by the drawings used for construction shall comply with the Design Specifications and the rules of this Section and shall be in agreement with the other Design Documents.

(b) It is the right of an N Certificate Holder to subcontract stress analysis or complete design of all or a portion of a component. However, the N Certificate Holder is responsible for the design of the component and for the Design Documents.

NCA-3551.1 Design Report.[5] The drawings used for design and construction shall be in agreement with the Design Report before it is certified and shall be identified and described in the Design Report. It is the responsibility of the N Certificate Holder to furnish a Design Report for each component and support, except as provided in NCA-3551.2. The Design Report shall be certified by a Registered Professional Engineer when it is for Class 1 components and component supports, Class CS core support structures, Class MC vessels and Class MC component supports, Class 2 vessels designed to NC-3200 (NC-3131.1), or Class 2 or Class 3 components designed to Service Loadings greater than Design Loadings. A Class 2 Design Report shall be prepared for Class 1 piping 1 in. nominal pipe size or smaller which is designed in accordance with the rules of Subsection NC.

NCA-3551.2 Load Capacity Data Sheet. The Load Capacity Data Sheet shall state the load capacity of the component support and identify the tests and calculations used to establish the load capacity. The Load Capacity Data Sheet shall adequately identify the support. The Load Capacity Data Sheet for supports for Class 1 components, Class MC vessels, and Class 2 vessels designed to NC-3200 shall be certified by a Registered Professional Engineer qualified in accordance with the requirements of ANSI/ASME N626.3-1979. The Load Capacity Data Sheet shall specify the organization responsible for retaining the data substantiating the stated load capacity. Such data shall be on file and available for review.

NCA-3554 Modification of Documents and Reconciliation With Design Report

Any modification of any document used for construction, from the corresponding document used for design analysis, shall be reconciled with the Design Report by the person or organization responsible for the design. A revision or addenda to the Design Report shall be prepared and (if required by NCA-3551.1) certified to indicate the basis on which this has been accomplished. All such revised documentation shall be filed with the completed Design Report.

NCA-3555 Certification of Design Report

(a) The Design Report for Class 1 components and component supports, Class CS core support structures, Class MC vessels and Class MC component supports, Class 2 vessels designed to NC-3200 (NC-3131.1), or Class 2 or Class 3 components designed to Service Loadings shall be certified by one or more Registered Professional Engineers competent in the applicable field of design and qualified in accordance with the requirements of ANSI/ASME N626.3-1979. The Design Report shall be certified only after all design requirements of this Section have been met. Such Registered Professional Engineers shall be other than the individuals certifying the Design Specifications (NCA-3255) but are not required by these rules to be independent of the organization holding the Certificate.

(b) It is the intent of this Section that the certification of the Design Report shall in no way relieve the N Certificate Holder of the responsibility for the structural integrity of the completed item for the conditions stated in the Design Specifications.

---

[5] See Appendix C of Div. 1

NCA-3556 Submittal of Design Report for Owner Review

The N Certificate Holder shall submit to the Owner or his designee a copy of the completed Design Report for all components and supports, for review and documentation of review to the extent required by NCA-3260.

NCA-3557 Availability of Design Report

The N Certificate Holder shall make a copy of the completed Design Report, Load Capacity Sheets, and the drawings used for construction available to the Inspector.

NCA-3260 REVIEW OF DESIGN REPORT

(a) The Design Report which the Certificate Holder or the Designer provides shall be reviewed by the Owner or his designee to determine that all the Design and Service Loadings as stated in the Design Specification have been evaluated, and that the acceptance criteria explicitly provided for in this Section, or additional acceptance criteria permitted by this Section when established in the Design Specification, associated with the specified Design and Service Conditions, have been considered. The responsibility for the method of analysis and the accuracy of the Design Report remains with the Certificate Holder or the Designer.

(b) Documentation shall be provided by the Owner or his designee to indicate that the review required by (a) above has been conducted. Prior to the stamping of the component, a copy of this documentation shall be attached to the copy of the Design Report which is made available to the Inspector. A copy of this documentation shall be included with the Design Report, which is filed at the location of the installation in accordance with NCA-4134.17 and made available to the regulatory and enforcement authorities having jurisdiction at the site of the nuclear power plant installation. Document distribution for Division 2 construction is shown in Table NCA-3200-1.

APPENDIX C
CERTIFICATE HOLDER'S DESIGN REPORT

ARTICLE C-1000
CERTIFICATE HOLDER'S DESIGN REPORT

C-1100 INTRODUCTION

C-1110 OBJECTIVE

The objective of this Appendix is to provide a guide for use by Certificate Holders in the preparation of Design Reports required by NCA-3551.1. Desirably, such Design Reports should be uniform as to format for all of the nuclear industry. Such uniformity is helpful in making for easier review by the Owner (NCA-3260), Inspectors, regulatory agencies, or independent groups. For NF supports designed by load rating (NF-3260), the preparation of a load capacity data sheet in accordance with NCA-3551.2 fulfills the requirements for preparation of a Design Report. The contents of this Appendix constitute only suggestions and are nonmandatory.

C-1120 BASIS

In order to meet the requirements of NCA-3551, the Design Report should be based upon analysis or testing adequate to demonstrate the validity of the structural design to sustain and meet in every respect the requirements and provisions of the relevant Certified Design Specifications and the requirements of this Section; the Report should include, as a minimum, the results, conclusions, and other considerations which show that the structural design meets these requirements.

C-1130 FORMAT

C-1131 General Requirements

Since a major purpose of the Design Report is to facilitate an independent review of its content, it is important that it be simple to follow and free from ambiguity. Nomenclature, definitions, and symbols used should be in agreement with those established in Subsection NB for Class 1 components, in Subsection NE for Class MC vessels, in Subsection NF for supports, in Subsection NG for Class CS core support structures, and in Subsection NC for vessels designed in accordance with NC-3200. Where additional terms, definitions, or expressions are required, they should be clearly defined and explained and adequately referenced. It is not the intention to limit the choice of analytical methods or computational techniques used for obtaining the values and results required for the Design Report.

C-1132 Presentation of Analysis

The analysis in the Design Report should be in three sections: Thermal Analysis, Structural Analysis, and Fatigue Evaluation. The desiderata listed in (a) through (j) below should be adhered to:

(a) pages and figures in each section of the Report should be consecutively numbered;

(b) reference data taken from other parts of the calculations should have the proper page number and section of the Report listed;

(c) a general description of the method of analysis should be given;

(d) all reference sources should be listed;

(e) all computer programs should be properly identified and described;

(f) stresses should be tabulated for each area of investigation;

(g) areas which have the most severe stress condition for design conditions or for any specified transient should be listed in the Report, along with the stress values in these areas;

(h) results should be summarized and a general summary of all stresses should be made in each section of the Report;

(i) drawings and sketches necessary for an understanding of the analysis should be part of the Report;

(j) the Report should include copies of sufficient computer printouts to justify the governing stress

values used in the Design Report and enable independent review. Copies of any manual calculations prepared which establish the final design should also be included.

C-1140 BASIC INFORMATION

It should be noted that the references in this Appendix to basic information which is to be obtained from the Certified Design Specifications (NCA-3250) are predicated on the requirement of NCA-3252 that such information be provided.

C-1150 DISTRIBUTION OF COPIES OF DESIGN REPORT

Copies of the completed certified Design Report (NCA-3355) should be made available for the Owner's review, certification, and distribution as required by NCA-3556, NCA-3260, and NCA-3270. The Certificate Holder shall also make a copy available to the Inspector (NCA-3557).

C-1200 THERMAL ANALYSIS

C-1210 DESCRIPTIONS OF OPERATING CYCLES

Data for the various transients and operating cycles should be obtained from the Certified Design Specifications. Typical cycles which should be considered are referenced in Appendix B.

C-1220 STEADY STATE CONDITION

The steady state condition to provide a thermal equilibrium condition for normal operating transients should be obtained from the Certified Design Specifications.

C-1230 GEOMETRY FROM TEMPERATURE DISTRIBUTION POINT OF VIEW

The geometrical structure of the component should be divided into suitable areas for thermal analysis. Sketches of the thermal model should be included in the Report. The areas listed in (a) through (m) below are typical of those that should be investigated:

(a) nozzle junctions in the component wall;

(b) stud bolts;

(c) cylinder junction with cylinder flange;

(d) point of support attachment;

(e) cylinder junction with head;

(f) junction of component wall and internal baffles, tubesheets, and attachments;

(g) tube-to-tubesheet junction for heat exchangers;

(h) heater penetrations to component junction for pressurizer;

(i) junction area between component supports and building structure;

(j) external attachments;

(k) changes in thickness within a component (such as a reducer, brand connection, component support, etc.) or across a welded joint (such as a socket weld, butt weld of different thickness, etc.);

(l) instrument penetrations to component junction (such as thermowells, flow devices, etc.);

(m) core barrel and core support plate.

C-1240 GEOMETRIES FROM STRESS INVESTIGATION POINT OF VIEW

The final breakdown of the geometries, which will correspond to the method of stress calculation, should be indicated in the calculations. Typical areas listed in C-1230 which are applicable to the component under consideration should be included.

C-1250 TEMPERATURE-DEPENDENT DATA FOR EACH THERMAL GEOMETRY AND TRANSIENT

The Certificate Holder should specify values for all parameters, such as coefficients for water and air, which are required for thermal calculations. References to sources should be given for all such data used.

C-1260 TEMPERATURE DISTRIBUTION FOR EACH GEOMETRY

The temperature profile of the applicable areas listed under C-1230 should be calculated and the temperature values attached to the calculations. The temperature distributions should be based on two or three dimensional heat transfer calculations. For calculating through wall (radial) temperature distributions to obtain values of ΔT_1 and ΔT_2 (NB-3650), one dimensional heat transfer calculations are acceptable.

C-1270 THERMAL GRADIENTS

Individual transients should be investigated separately for each area. The longitudinal, radial, and circumferential gradients should be plotted separately. The temperature gradients used in the stress calculations should be plotted.

C-1300 STRUCTURAL ANALYSIS

C-1310 IMPORTANT THERMAL AND MECHANICAL LOADING ON COMPONENT STRUCTURE

C-1311 Mechanical Loading

The mechanical loads used in the Design Report to calculate primary stresses should be obtained directly from the Design Specification (such as Design Pressure and Temperature) or from information contained in the Design Specification (such as seismic spectra, valve opening and/or closing times, etc.).

C-1312 Thermal and Mechanical Loading

Specific reference should be made to the thermal transients and resulting gradients which are to be used for the Design Report. The internal pressure and external loads to be used should be in accordance with the time and thermal condition analyzed. Values for external nozzle loads should include sign convention of the loadings and be referenced specifically to the geometries.

C-1320 METHODS OF CALCULATIONS

The Certificate Holder should submit a short description of the calculation methods used in connection with the stress analysis. All computer programs used in making calculations should be verified by comparing the program with the results of an appropriate analytical or experimental solution. The basic theories on which the calculations are based and the assumptions should also be included.

C-1330 PRINCIPAL STRESSES FOR EACH GEOMETRY

In calculating stress components, the requirements on NB-3200, NC-3200, NE-3200, NF-3220, NF-3230, or NG-3200 should be followed. The following are typical of stress components that should be considered:

(a) Mechanical stresses generated by:
- *(1)* pressure load
- *(2)* deadweight load
- *(3)* piping load
- *(4)* externally applied load
- *(5)* seismic loads
- *(6)* dynamic loads

(b) Thermal stresses generated by:
- *(1)* radial gradient
  - *(a)* thermal stress
  - *(b)* thermal discontinuity stress
- *(2)* longitudinal gradient
  - *(a)* thermal stress
  - *(b)* thermal discontinuity stress

C-1340 ALLOWABLE LIMITS

Each individual stress component and combination of the stress components should satisfy the requirements of NB-3220, NC-3220, NE-3220, NF-3220, NF-3230, or NG-3220.

C-1400 FATIGUE EVALUATION

C-1410 SCOPE OF FATIGUE EVALUATION

Fatigue evaluation when required should include the considerations and investigations described in this Subarticle.

C-1420 LOCATIONS OF STRESS CONCENTRATIONS

Stress concentration should be investigated at any geometrical changes in the structure, such as difference in wall thickness, joints and corners, and junctions of dissimilar metals. A list of the locations subject to fatigue evaluation should be included in the Report. For piping, K indices are given for standard piping components in NB-3600 which represent elastic stress concentration factors.

C-1430 FATIGUE STRENGTH REDUCTION FACTORS AS FUNCTION OF LOCATIONS AND TYPES OF STRESS

Fatigue strength reduction factors should be numerically listed for the stresses where they are to be applied. The references and methods of finding the

fatigue strength reduction factors should be included in the Report.

C-1440 PROPER STRESS CONCENTRATION OR FATIGUE STRENGTH REDUCTION FACTOR APPLICATION TO STRESSES

The numerical value of the individual stress components should be listed with and without the stress concentration or fatigue strength reduction factor applied. Factors should be applied to each individual stress component and not applied to the total stress at a point or to the stress intensity.

C-1450 COMBINED STRESSES AND ALLOWABLE NUMBER OF CYCLES

Where the rules do not specifically control this, as they do in NB-3500 and NB-3600, methods of combining stresses, determining principal stresses, determining alternating stress intensity, and determining cumulative damage effects and allowable number of cycles should be shown in the Report. These results should be reconciled with the required values.

Appendix E

CODE REQUIREMENTS FOR DESIGN DOCUMENTS IN 1963 AND 1965 EDITIONS

N-140 RESPONSIBILITY

The various parties involved in the work of producing vessels under this Section have definite responsibilities in meeting Code requirements. The responsibilities set forth hereinafter relate only to Code compliance and are not to be construed as involving contractual relations or legal liabilities.

N-141 Design Specification – The owner requiring that a vessel or vessels be designed, constructed, tested and certified to be a Code vessel in compliance with these rules shall provide or cause to be provided for each such vessel a specification of functions and design requirements including its classification, related to operating conditions in such detail as will provide a complete basis for design, construction, and inspection in accordance with these rules.

(a) The Design Specification shall be certified as to compliance with the above requirements by a registered Professional Engineer experienced in pressure vessel design.

(b) A copy of the Design Specification shall be filed with the enforcement authority responsible at the point of installation.

N-142 Stress Report – The structural integrity of a Class A or Class B vessel or part thereof including its ability to contain pressure is the responsibility of the manufacturer of the pressure part. A minimum requirement is compliance with the rules of this Section. As part of the design responsibility for pressure containment, the manufacturer or a design agent responsible to him shall make a complete set of stress analysis calculations establishing that the design as shown by the drawings complies with the requirements of this Section for the design conditions that have been specified by the user in the Design Specification. A Stress Report shall be prepared which shall include stress calculations and pressure part design drawings and which shall be certified by a registered Professional Engineer, experienced in pressure vessel design. Copies of this Stress Report shall be filed with the qualified Inspector at the manufacturer's plant and with the enforcement authority at the point of installation of the equipment. The filing of this Report shall not relieve the manufacturer of responsibility for the structural integrity of the vessel. The manufacturer is also responsible for use of materials, fabrication methods, and inspection techniques in accordance with the requirements of this Section. The manufacturer shall certify to compliance with these requirements by the execution of the appropriate Manufacturer's Data Report.

Appendix F

GUIDELINES FOR PREPARATION OF MANUFACTURERS' STRESS REPORT FROM 1968 EDITION OF CODE

APPENDIX X

Manufacturers' Stress Report

1. Scope – To provide guidelines for users of Section III for preparation of the Stress Report for Class A vessels in a format for easier independent review, review by purchaser, inspectors and regulatory agencies. This Appendix is *non-mandatory* and is provided only as suggested guidelines to provide a more standard report for all of the nuclear industry.

The Stress Report must be based upon analytical calculations or experimental testing adequate to demonstrate the validity of the structural design to sustain and meet in every respect the requirements and provisions of the relevant Certified Design Specification and the requirements of this section of the Code; the Report must, therefore, include the results, conclusions and other considerations that are considered as proof that the structural design does, in fact, meet these requirements.

2. Format – Since a major purpose of the Stress Report is to facilitate an independent review of its content, it is important that it be simple to follow and free from ambiguity. Nomenclature, definitions and symbols used should be in agreement with the articles of the Code. Where additional terms, definitions or expressions are required, they should be clearly defined and explained and adequately referenced. It is not the intention to limit the choice of analytical methods or computational techniques used for obtaining the values and results required for the Stress Report.

The analysis in the Stress Report should be in two sections. (1) Thermal Analysis and (2) Structural Analysis, including fatigue evaluation, and the following requirements should be adhered to:

(a) Pages and figures in each section of the report should be consecutively numbered.

(b) Reference data taken from other parts of the calculations should have the proper page number and section of the report listed.

(c) A general description of the method of analysis should be given.

(d) All reference sources should be listed.

(e) All computer programs should be properly identified and described.

(f) Areas which have the most severe stress condition at any transient should be listed in the report, along with the stress values in these areas.

(g) Results should be summarized in each section of the report, as well as a general summary of all stresses.

(h) Drawings and sketches used during the performance of the analysis should be part of the report.

(i) Stresses shall be tabulated for each area of investigation in format consistent with Section III, Article 4 of the Code.

(j) The Report shall include copies of the computer printouts and any hand calculations prepared which establish the final design.

Copies of the completed Stress Report shall be made available for the purchaser's distribution required by the Code. It should be noted that references in this Appendix to basic information that is to be obtained from the Certified Design Specification is based upon the requirement of N-141 that such information be provided.

3. Thermal Analysis

(a) Descriptions of Operating Cycles

Data for the various transients and operating cycles should be obtained from the Certified De-

sign Specification. Typical cycles which should be considered are:

(1) Normal heat up and start up cycles

(2) Normal shut down and cool down cycles

(3) Operating transients

(4) Scram transients

(5) Emergency condition transients

(b) Steady State Condition

The steady state condition to provide a thermal equilibrium condition for normal operating transients should be obtained from the Certified Design Specification.

(c) Geometry from Temperature Distribution Point of View

The geometrical structure of the vessel should be divided into suitable areas for thermal analysis. Sketches of the thermal model shall be included in the report. The following areas are typical of those that should be investigated:

(1) Nozzle junctions in the vessel wall

(2) Stud bolts and gaskets

(3) Cylinder junction with cylinder flange

(4) Point of vessel support attachment(s)

(5) Cylinder junction with head(s)

(6) Junction of vessel wall and internal baffles, tube sheets and attachments

(7) Tube to tube sheet junction (for heat exchangers)

(8) Heater penetrations to vessel junction (for pressurizer)

(9) Junction area between vessel supports and building structure

(10) External attachments

(d) Geometries from Stress Investigation Point of View

The final breakdown of the geometries, which will correspond to the method of stress calculation, should be indicated in the calculations. Typical areas listed in 3(c) should be included.

(e) Temperature Dependent Data for Each Thermal Geometry and Transient

The manufacturer shall specify values for all parameters, such as coefficients for water and air, which are required for thermal calculations. Reference to sources should be given for all such data used.

(f) Temperature Distribution for Each Geometry

The temperature profile of the areas listed under 3(c) above should be calculated and the temperature values attached to the calculations. The temperature distributions should be based on two or three dimensional heat transfer calculations.

(g) Thermal Gradients

Individual transients should be investigated separately for each area. The longitudinal, radial, and circumferential gradients should be plotted separately. The temperature gradients using stress calculations should be plotted.

4. Structural Analysis

(a) Important Thermal and Mechanical Loading on the Vessel Structure.

Specific reference should be made to the thermal gradients which are to be used for the design report. The internal pressure to be used should be in accordance with the time and thermal condition analyzed. Values for external nozzle loads should be supplied by the Certified Design Specification. Direction and sign convention of the loadings should be indicated and referred specifically to the geometries.

(b) Methods of Calculations

The manufacturer should submit a short description of the calculation methods used in connection with the thermal and mechanical stress analysis. All computer programs used during calculations should be identified and described. The basic theories on which the calculations are based and the assumptions should also be included.

(c) Principal Stresses for Each Geometry

In calculating stress components, the requirements of Section III, Article 4 should be followed. However, if the calculation techniques used result in a direct combination of primary, secondary and peak stresses, it is not necessary to make any separation (See Fig. N-414, Note 2). The following are typical of components that should be considered:

(1) Thermal Stresses Generated by:

a) Radial Gradient:

Thermal stress

Thermal discontinuity stress

b) Longitudinal Gradient

Thermal stress

Thermal discontinuity stress

(2) Mechanical Stresses Generated by:

a) Pressure Load
b) Dead weight load
c) Piping load
d) Externally applied load
e) Seismic loads
f) Dynamic loads

(d) Allowable Limits

Each individual stress component and the combination of the components shall satisfy the requirements of N-414.

5. Fatigue Evaluation

Fatigue evaluation in accordance with the requirements of Section III should include the following considerations and investigations:

(a) Locations of Stress Concentrations

Stress concentration should be investigated at any geometrical changes in the structure, such as difference in wall thickness, joints and corners, and junctions of dissimilar metals. A list of the locations subject to fatigue evaluation should be included in the report.

(b) Fatigue Strength Reduction Factors as Function of Locations and Type of Stress

Fatigue strength reduction factors should be numerically listed for the stresses where they are to be applied. The references and methods (theoretical or experimental) of finding the fatigue strength reduction factors should be included in the report.

(c) Proper Stress Concentration or Fatigue Strength Reduction Factor Application to the Stresses

The numerical value of the individual stress components should be listed with and without the stress concentration or fatigue strength reduction factor applied. Factors should be applied to each individual stress component and not applied to the total stress at a point or to the stress intensity.

(d) Combined Stresses and Allowable Number of Cycles

Methods of combining stresses, determining principal stresses, determining alternating stress intensity, and determining cumulative damage effects and allowable number of cycles shall be shown in the report. These results shall be reconciled with the values called for in the Certified Design Specification or Section III by colisting or other suitable means.

Appendix G

GUIDELINES FOR PREPARATION OF OWNER'S DESIGN SPECIFICATIONS FROM 1977 EDITION OF CODE

APPENDIX B
Owner's Design Specifications

Article B-1000

ARTICLE B-1000

B-1100 INTRODUCTION

B-1110 OBJECTIVE

The objective of this Appendix is to provide a guide for Owners in the preparation of Design Specifications. Desirably, such Design Specifications should be as uniform throughout the nuclear industry as is reasonably attainable. Such uniformity is helpful in promoting adequacy of coverage and clarity of intent.

B-1120 SCOPE OF DESIGN SPECIFICATIONS

The Design Specifications must contain sufficient detail to provide a complete basis for the construction of the plant.

B-1130 FORMAT

The Design Specifications shall be organized in a logical manner and be free from ambiguity. Nomenclature, definitions and symbols shall be in agreement with those established in the applicable Articles.

B-1140 DISTRIBUTION OF COPIES OF THE DESIGN SPECIFICATIONS

Copies of the Design Specifications shall be filed in accordance with NA-3256.

B-1200 INFORMATION TO BE INCLUDED

B-1210 GENERAL INFORMATION

The Design Specifications shall include the provisions of (a) through (i) below, as applicable:

(a) the functions of the components or appurtenances, including any dimensions upon which the functional performance depends;

(b) the design requirements, stipulating the mechanical and operational loadings including vibration and shock;

(c) the environmental conditions, including radiation;

(d) the classification of the component or appurtenance (NA-2000);

(e) the definition of the component and piping boundaries (NA-3254 and NE-1140);

(f) the procedure for review and certification of the Stress Reports by those responsible for the Design Specifications;

(g) the procedure for the preparation, certification and filing of the Overpressure Protection Report;

(h) the procedure for handling the various Data Reports, particularly with respect to transmittal to enforcement authorities;

(i) the certification of the Design Specifications (NA-3255).

B-1220 SPECIFIC INFORMATION

B-1221 Relation of the Components to the System

The Design Specifications should relate components to the system of which they are a part by providing the information listed in (a), (b), and (c) below.

(a) For each boundary of Code applicability, other than piping, the following shall be provided as given in (1), (2), and (3) below:

(1) the specific dimensional location of the component;

(2) the forces and moments imposed at each boundary;

(3) the structural characteristics of structures which are excluded from Code jurisdiction but which provide constraints to the deflections or rotations of components covered by the Design Specifications. The most desirable form of defining these structural characteristics is to provide an influence or stiffness matrix for each structure. If this is not practicable,

completely detailed drawings should be provided for those portions of the structures which are significant in providing constraint;

(b) the provisions required for support location and access to surveillance specimens;

(c) location, dimensions, and material of attached piping.

B-1222 Materials

The Design Specifications should provide the following information relative to materials listed in (a) through (g) below:

(a) any hydrostatic testing or service temperature limits;

(b) any reductions to design stress intensity values, allowable stresses or fatigue curves necessitated by environmental conditions;

(c) any restrictions on cladding materials;

(d) materials which are acceptable from the standpoints of environment and location when cladding is required;

(e) any restrictions on heat treating furnace atmospheres;

(f) any requirements with respect to cleanliness;

(g) impact test requirements.

B-1223 Design

With the exception of the design related items covered in B-1221, the major design items which shall be treated in the Design Specifications are those which specify the Design Loadings and Service Conditions and those requirements which are beyond the jurisdiction of this Section.

B-1223.1 Design Loadings. The Design Loadings to be treated should be as listed in (a) through (f) below but are not necessarily limited thereto:

(a) internal and external design pressure; secondary pressure for closed system safety, safety relief, and relief valve applications;

(b) weight of the component and normal contents under operating or test conditions;

(c) superimposed loads, such as other components, operating equipment, insulation, and corrosion resistant or erosion resistant linings and piping;

(d) wind loads, snow loads and earthquake loads, where specified;

(e) reactions of supporting lugs, rings, saddles, or other types of supports;

(f) thermal expansion loads from attachments.

B-1223.2 Design Pressure, Design Temperature and Design Mechanical Loads. The Design Loadings are related to and should be supplemented by the information listed in (a), (b), and (c) below.

(a) Design Pressure. The Design Specifications should state whether the Design Pressure is internal, external or both an internal and an external pressure. The Design Specifications should include the effects of the static and dynamic heads of liquids and state how these differ for different zones of the component.

(b) Design Temperature. The Design Specifications should state the maximum metal temperature which will exist under the specified operating conditions for the component and for each area in which the metal temperature will differ significantly.

(c) Design Mechanical Loads. The Design Specifications should stipulate the loads, the effect of which must be combined with the Design Pressure effects for comparison with the several primary stress intensity limits at the design temperature.

B-1223.3 Operating Conditions

(a) The Owner must stipulate in the Design Specifications a set of operational cycles and the number of occurrences of each. In defining the conditions to be considered for an operation cycle, a complete description shall be given of the time variation of each of the loadings and of the following quantities:

(1) coolant pressure
(2) coolant temperature
(3) flow rate
(4) internal heat generation in the vessel
(5) reactions of attached piping

(b) It is also essential that the Design Specifications provide these data for the following categories of operating conditions when applicable:

(1) Level A Service Limits
(2) Level B Service Limits
(3) Level C Service Limits
(4) Level D Service Limits

B-1223.4 System Considerations

(a) The system's function, the environmental conditions under which these functions are performed, and the loading combinations shall be evaluated from the system standpoint. This Section does not provide guidance in the identification of these system functions, conditions, and loading combinations. Such guidance is derived from systems safety criteria applicable to specific types of power systems as specified in standards prepared by ANSI N18 or as may be required by regulatory authorities having jurisdiction at the plant site.

(b) Although requirements for the acceptability of a component are not intended to assure the functional adequacy of the component, the higher stress limits permitted for Level C and Level D Service Limits evaluation may result in deformations which preclude operability during or after the event. The Owner may provide more restrictive limits for components which require close dimensional control and which are intended to operate during and after the event. Such requirements are beyond the scope of this Section.

B-1224 Requirements Beyond the Jurisdiction of Section III

(a) The Design Specifications shall stipulate any additional requirements which the Owner intends to be incorporated in the specific system or any additional requirements intended to be more specific or more restrictive than the rules of this Section.

(b) The Design Specifications shall stipulate any supplementary technical requirements which are beyond the jurisdiction of this Section. Some examples are given in (1), (2), and (3) below:

(1) tolerances on important dimensions for use as deformation limits;

(2) definition of specific action to be taken by the Certificate Holder with respect to any region of a component which will be subject to corrosion, erosion, mechanical abrasion or other environmental effects;

(3) definition of the regions of a component where high fluence level may exist if the material of the component is ferritic.

B-1225 Handling, Storage, Shipping, and Delivery Requirements

The Design Specifications shall stipulate the requirements for handling, storage, shipping and delivery of components.

NUREG/CR-4943
ORNL-TM-10425
Dist. Category RM

Internal Distribution

1. J. J. Blass
2. C. J. Chang
3. R. D. Cheverton
4. C. J. Claffey
5. J. A. Clinard
6. W. L. Cooper
7. J. M. Corum
8. J. A. Getsi
9. W. L. Greenstreet
10. R. C. Gwaltney
11. W. R. Hendrich
12. R. L. Huddleston
13. R. C. Hudson
14. Y. L. Lin
15. C. S. Luttrell
16. A. P. Malinauskas
17. M. F. Marchbanks
18. J. G. Merkle
19-28. S. E. Moore
29. H. L. Mosley
30. D. G. O'Conner
31. C. B. Oland
32. C. E. Pugh
33. J. J. Robinson
34. W. K. Sartory
35. H. E. Trammell
36. G. T. Yahr
37. F. C. Zapp
38-39. Structural Design Criteria, Bldg. 9204-1, MS 11
40. ORNL Patent Office
41. Central Research Library
42. Document Reference Section
43-44. Laboratory Records Department
45. Laboratory Records (RC)

External Distribution

46. E. C. Rodabaugh, 4625 Cemetery Rd., Hilliard, OH 43026
47-74. J. D. Page, Engineering Issues Branch, Nuclear Regulatory Commission, Washington, DC 20555
75. Office of Assistant Manager for Energy Research and Development, Department of Energy, ORO, Oak Ridge, TN 37831
76-77. Technical Information Center, DOE, Oak Ridge, TN 37831
78-337. Given distribution as shown under category RM
338-372. Kevin Ennis, American Society of Mechanical Engineers, Dept. M/S 8F, 47th Street, New York, NY 10017 (Special ASME Code Distribution)