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Guide to Life Cycle Management of Pressure Equipment Integrity

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SETTING THE STANDARD

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FOREWORD

In 1993, ASME initiated activity to address the development of post construction standards in response to an identified need for recognized and generally accepted engineering standards for the inspection and maintenance of pressure equipment after it has been placed in service. In 1995 the Post Construction Committee (PCC) was appointed to develop and maintain standards addressing common issues and technologies related to post-construction activities, and to work with other consensus committees in the development of separate, product-specific codes and standards addressing issues encountered after initial construction of non-nuclear pressure equipment such as boilers, pressure vessels (including heat exchangers), piping and piping components, pipelines, and storage tanks. Subcommittees were formed on bolted flange joint assembly, repair and testing, and inspection planning. The subcommittees were charged with preparing standards dealing with several aspects of the inservice inspection and maintenance of pressure equipment. As a result, ASME PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly was published in 2000; ASME PCC-2 Repair of Pressure Equipment and Piping was published in 2006 and ASME PCC-3 Inspection Planning Using Risk-Based Methods was published in 2007.

In the course of preparing the documents described above, the Post Construction Committee recognized the need to provide a guideline or “roadmap” to help users of pressure equipment and their designated agents, as well as manufacturers, owners, regulators and other stakeholders, identify the codes, standards, recommended practices, specifications and guidelines that apply to the life cycle management of pressure equipment integrity. Accordingly, ASME held a workshop in March 2009 to review a proposal for guidance that provides an integrated approach to the understanding and application of technologies in these standards in engineering programs for management of the life cycle of pressure equipment, including inspection, fitness for continued service and repair. The transition from new construction to post construction was an essential part of this study, as new construction standards address inspectability and provide a baseline critical to any post-construction assessment. The post construction standards presented and reviewed included:

PCC-1-2000 Guidelines for Pressure Boundary Bolted Flange Joint Assembly

PCC-2-2006 Repair of Pressure Equipment and Piping Standard

PCC-3-2007 Inspection Planning Using Risk-Based Methods

API 579-1/ASME FFS-1 2007 Fitness-For-Service

This Guide is intended to fill that need. It is not intended to be an industry standard, but rather to provide general guidance. Also note that this document is not intended to be a complete listing of all of the publications related to pressure equipment integrity, which would fill many bookshelves, but rather lists the most pertinent references in the opinion of the author and the reviewers.

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1. Scope

This guide provides a summary of some of the more commonly used codes, standards, recommended practices (RPs), specifications and guidelines produced by organizations based in the United States that assist manufacturers, owners, users and their designated agents, regulators and other stakeholders in maintaining the integrity of fixed pressure equipment in process plants and in general industrial use. For the convenience of the user of this guide, the term "documents" will be used throughout to refer collectively to "codes, standards, recommended practices, specifications and guidelines." This guide is not all-inclusive.

There are many documents that are useful for specific applications of pressure equipment that have not been described or included as references in this guide. This does not imply that these documents should not be used or that they have any deficiencies. Note also that engineering knowledge and experience is necessary for the proper application of most of the standards listed.

The following applications for pressure equipment are not specifically included in the scope. However, the owner of these categories of equipment may use those portions of this guide that are applicable:

(a) Upstream "non-process" equipment in the oil and gas industry (e.g., pressure equipment used in oil and gas exploration and production such as Christmas trees, wellhead equipment, flow lines, subsea equipment)

(b) Equipment in commercial nuclear power plants

(c) Domestic plumbing and other domestic pressure equipment such as hot water heaters. Portable air receivers (air tanks) used by homeowners and contractors are excluded from the scope but air receivers in industrial facilities are included

(d) Liquefied natural gas (LNG) and liquefied petroleum gas (LPG) transport and storage (API and ship classification societies)

(e) Pipelines

(f) Pressure equipment used in transport service.

This guide includes only documents that are pertinent to maintaining equipment integrity (e.g., pressure containment) through appropriate design, construction, inspection, maintenance, alteration and repair. Standards related to areas such as identification schemes, plant or pipeline operator qualification, etc. are outside of its scope.

The inclusion of a document in this guide does not imply that the document is endorsed by ASME. This listing is provided only for the convenience of manufacturers, users and their designated agents, regulators and other stakeholders to help identify documents that are potentially applicable.

2. Abbreviations

API – American Petroleum Institute

ANSI – American National Standards Institute

ASCE – American Society of Civil Engineers

ASME – American Society of Mechanical Engineers

ASME B&PVC – ASME Boiler and Pressure Vessel Code

ASNT – American Society for Non-Destructive Testing

B&PVC – Boiler and Pressure Vessel Code (ASME)

CFR – Code of Federal Regulations

NB – National Board of Boiler and Pressure Vessel Inspectors

NBBPVI – National Board of Boiler and Pressure Vessel Inspectors

RP – Recommended Practice

SDO – Standards Developing Organization that, for the purpose of this guide, is accredited by ANSI

SEI – Structural Engineering Institute

TEMA – Tubular Exchanger Manufacturers Association

3. Definitions

Code – A document published by a standards developing organization that should be considered to be mandatory for use within its stated scope. In the past, some defined a code to be a document that has been adopted as a requirement by one or more legal entities but this definition is not universally applicable.

Construction – An all-inclusive term comprising materials, design, fabrication, examination, inspection, testing, certification and pressure relief.

Jurisdiction – A legal entity, such as a state or provincial government that has established laws and/or regulations governing the construction and in-service inspection, repair and alteration of pressure equipment.

NB – National Board of Boiler and Pressure Vessel Inspectors.

Petroleum and Chemical Process Industries – This term is self-explanatory and is used consistently in the main body of this document to refer to that segment of the process industry that is addressed by API Codes, Standards and Recommended Practices. However, other terms such as "hydrocarbon and chemical process industries," "refineries and related industries" and "petrochemical facilities" are used in some of the documents that are referenced in this guide,. These alternative terms are used in the document summaries in Appendix A but are considered to be equivalent to petroleum and chemical process industries for the purpose of the main body of this guide.

Publication, aka,Technical Publication – A document that contains useful information but is not considered to contain either mandatory requirements or guidelines.

Recommended Practice (RP) – A document published by an SDO that contains guidelines that are usually not considered to be mandatory but that should be followed unless justification for not doing so can be developed.

Specification – A document that contains requirements for construction of specific types of equipment items.

Standard – A document published by an SDO that contains standardized methods and requirements. Requirements in standards should be considered to be mandatory unless written documentation has been developed to justify alternatives.

4. Organization of this Guide

This guide is organized by type of equipment as described below. Each equipment type section is intended to stand alone, such that it includes all of the documents for that equipment type. This results in a lot of duplication but should provide a more user-friendly reference. The following equipment types are included.

(a) Guide to documents that apply to boilers including:

(1) Power (steam) boilers

(2) Heat recovery steam generators (HRSGs)

(3) Heating boilers

(4) Unfired steam boilers.

(b) Guide to documents that apply to pressure vessels including:

(1) Typical pressure vessels including towers, drums, reactors, heat exchangers, condensers, air receivers, accumulators, etc.

(2) Large, heavy wall vessels [e.g. >50 mm (2 in)] wall thickness and vessels with high design temperature [e.g. > 370^{o}C (700^{o}F)]

(3) High pressure vessels [e.g. > 70 MPa (10 ksi)] design pressure

(4) Heat exchangers (as a class of pressure vessels).

(c) Guide to documents that apply to storage tanks.

(d) Guide to documents that apply to piping systems.

(e) Guide to documents that apply to piping components including fittings

(1) Some pressure equipment contains components such as flanges, valves, expansion joints and other fittings. Specifications and standards for these components are generally referenced in the new construction codes. A listing of these documents is provided in paragraph 8 of this guide.

(f) Guide to documents that apply to overpressure protection.

(g) Guide to documents that are focused on specific tasks, such as welding and non-destructive examination, that are routinely performed as a part of both new and post construction.

Appendix A contains a summary of each document that is referenced in this guide describing:

(a) Title of the document

(a) Edition that was current when this guide was prepared. The user should check for updates. In particular, note that the general practice is to update or to reaffirm documents that have been ANSI approved every 5 years. Therefore, if an ANSI approved document has an edition date more that 5 years old, it would be prudent to check for updates.

(b) An alternative number for the document (e.g., an ISO number) if applicable

(c) Whether or not the document has been approved by ANSI

(d) Summary of the scope of the document with comments

(e) A description of the way in which the document is typically applied. For example:

(1) Referenced in a purchase specification

(2) Manufacturer uses in construction

(3) Regulator has available to be able to audit compliance

(4) Allow users to manage the complete life cycle of pressure equipment in an effective manner.

(f) Comments containing a summary of the contents of the document. This is intended to allow a potential purchaser of the document to determine what to expect. For example, a document's scope may state that pressure-temperature ratings for the components covered by the standard are included, when in reality there is only a reference to another standard that contains the ratings.

(g) A listing of the categories of users of the document.

Appendix B contains a summary of documents that are not necessarily codes, standards or recommended practices, which may be useful for additional reading on the topics covered.

5. Overview

For each equipment type listed above, this guide provides a discussion of the documents that should be considered by purchasers, manufacturers, regulators and other stakeholders for new construction and for post-construction (in-service) inspection, maintenance and repair. For the purpose of this guide, the term "maintain" will be used to include all aspects of post-construction activities. This is a shorthand way of saying "maintain equipment integrity." The discussion of documents within each equipment type section is intended to provide a brief overview. A more detailed summary of each document can be found in Appendix A.

In specifying and purchasing pressure equipment, it is important to differentiate between "specifically engineered" equipment and "packaged or pre-engineered equipment." In the former case, it is anticipated that the owner or user of the equipment will specify the requirements for construction, including the documents to be used. In the later case, the owner or user typically provides only performance requirements, or may purchase a "stock" item. However, in both cases, the owner or user should understand the tasks needed to properly maintain the equipment.

Before acquiring new pressure equipment, it is important for the equipment owner/user to consider the requirements for in-service inspection, testing, maintenance and repair that may be necessary during the lifetime of the equipment so that the design and construction can be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are listed under each equipment type.

Note also that the US federal OSHA has established regulations that apply under some conditions. For example, CFR 29, Part 1910.106 "Flammable and Combustible Liquids" and Part 1910.110 "Storage and Handling of Liquefied Petroleum Gasses" require the use of ASME and/or API-ASME codes and standards under certain conditions. In addition, a requirement that pressure equipment be constructed, operated and maintained in accordance with "recognized and generally accepted good engineering practices" (RAGAGEP) appears in the Code of Federal Regulations, CFR 29, Part 1910.119. Although Part 1910.119 applies only to process safety management of highly hazardous chemicals, it is a good practice for all industrial facilities.

6. Power (Steam) Boilers

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this Guideline, the document number in Table 1 is hyperlinked to the description in Appendix A.

Table 1: Power (Steam) Boilers

Specification / Purchase	Design / Construction	Operation
NB-370 NB-23 PCC-3 RP 578 ASCE/SEI 7	BPVC Section I BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1	BPVC Section VII
In-Service Inspection	**Fitness-For-Service**	**Repair**
NB-23 NB-370 PCC-3 RP 573 BPVC Section VII EPRI CS-523 EPRI CS-5208 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 EPRI CS-5208	NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

6.1. Specification (Purchase) of Power (Steam) Boilers

Before acquiring a new boiler, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 6.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations

available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post construction (in-service) documents that should be considered in the design/specification/ new construction phase are listed in the following paragraphs. Note that some post-construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) NB-23 National Board Inspection Code Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b), above).

(2) PCC-3 Inspection Planning Using Risk-Based Methods can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (Also, see 6.4(b))

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

6.2. Design and Construction of Power (Steam) Boilers

The ASME Boiler and Pressure Vessel Code, Section I (BPVC Section I) provides rules for construction of power boilers. These rules are mandatory in most jurisdictions in the US and Canada, and are frequently used worldwide. Section I references many other codes and standards, a few of which are listed below. If a user requires Section I construction in a purchase document, the internal references in Section I become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(a) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(b) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(c) BPVC Section II – Materials – Part D *Properties (Customary)*

(d) BPVC Section II – Materials – Part D *Properties (Metric)*

(e) BPVC Section V *Nondestructive Examination*

(f) BPVC Section IX *Welding and Brazing Qualifications*

(g) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 6.4(b))

(h) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(i) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

6.3. Operation of Power (Steam) Boilers

BPVC Section VII *Recommended Guidelines for the Care of Power Boilers*.

6.4. In-service Inspection of Power (Steam) Boilers

The following documents apply to the in-service inspection of power boilers. They should be considered to be good engineering practices, with applicability that depends on the situation. However, in many cases, the manufacturers of power boilers have compiled the guidance of the applicable documents in an installation and operating manual (IOM).

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 6.1(b)).

(b) ASCE/SEI 7 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers.

(d) BPVC Section VII *Recommended Guidelines for the Care of Power Boilers*

(e) EPRI CS-523 *Recommended Practices for Operating and Maintaining Steam Surface Condensers*

(f) EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings)*.

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents:

(a) BPVC Section V *Nondestructive Examination*

(a) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(b) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

6.5. Fitness-for-service Analysis of Power (Steam) Boilers

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 6.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

(a) EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings)*.

6.6. Repair of Power (Steam) Boilers

If the FFS assessment (see paragraph 6.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 6.4(b))

(f) BPVC Section IX *Welding and Brazing Qualifications.*

7. Heat Recovery Steam Generators (HRSGs)

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 2 is hyperlinked to the description in Appendix A.

Table 2: Heat Recovery Steam Generators (HRSGs)

Specification / Purchase	Design / Construction	Operation
NB-370 RP 534 RP 573 NB-23 PCC-3 RP-580 RP 578 ASCE/SEI 7	BPVC Section I BPVC Section VIII - Division 1 BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1	BPVC Section VII
In-Service Inspection	Fitness-For-Service	Repair
NB-23 NB-370 PCC-3 RP-580 RP 573 BPVC Section VII BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 EPRI CS-5208	NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

7.1. Specification (Purchase) of HRSGs

Before acquiring a new HRSG, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 7.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations

available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) RP 534 *Heat Recovery Steam Generators* is a useful reference for specification and design of HRSG systems.

(f) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and HRSGs.

(2) NB-23 *National Board Inspection Code Part 2 (Inspection)* provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b), above).

(3) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(4) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(g) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses.

This can be determined by a risk assessment using the methods of risk-based inspection (see 7.4(b)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

7.2. Design and Construction of HRSGs

The ASME Boiler and Pressure Vessel Code, Section I (BPVC Section I) provides rules for construction of power boilers, including HRSGs. These rules are mandatory in most jurisdictions in the US and Canada, and are frequently used worldwide. Section I references many other codes and standards, a few of which are listed below. If a user requires Section I construction in a purchase document, the internal references in Section I become mandatory as well.

Unless ASME Section I is required by the local jurisdiction, BPVC Section VIII - Division 1 *Rules for Construction of Pressure Vessels Division 1* may be used for construction of HRSGs. Section VIII references many other codes and standards, a few of which are listed below. If a user requires Section I construction in a purchase document, the internal references in Section I become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Customary Properties*

(e) BPVC Section II – Materials – Part D *Metric Properties*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications*

(h) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 7.4(b)).

(i) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(j) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

7.3. Operation of HRSGs

BPVC Section VII *Recommended Guidelines for the Care of Power Boilers*.

7.4. In-service Inspection of HRSGs

The following documents apply to the in-service inspection of HRSGs. They should be considered to be good engineering practices, with applicability that depends on the situation. However, in many cases, the manufacturers of HRSGs have compiled the guidance of the applicable documents in an installation and operating manual (IOM).

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 7.1(b)).

(b) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3 above.

(d) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and HRSGs.

(e) BPVC Section VII *Recommended Guidelines for the Care of Power Boilers.*

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents:

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

7.5. Fitness-for-service Analysis of HRSGs

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 7.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

(b) EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings)*.

7.6. Repair of HRSGs

If the FFS assessment (see paragraph 7.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 6.4(b)).

(f) BPVC Section IX *Welding and Brazing Qualifications*.

8. Heating Boilers

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 3 is hyperlinked to the description in Appendix A.

Table 3: Heating Boilers

Specification / Purchase	Design / Construction	Operation
NB-370 Std 560 RP 573 NB-23 PCC-3 RP-580 RP 578 ASCE/SEI 7	BPVC Section IV BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1	BPVC Section VI
In-Service Inspection	**Fitness-For-Service**	**Repair**
NB-23 NB-370 PCC-3 RP-580 RP 573 BPVC Section VI BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 EPRI CS-5208	NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

8.1. Specification (Purchase) of Heating Boilers

Before acquiring a new heating boiler, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 8.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Std 560 *Fired Heaters for General Refinery Services*. This document applies primarily to process heaters in refineries, but contains information that may be of use in other industries. It is intended to be used as a supplement to a design code, such as ASME Section I or Section IV.

(f) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and heating boilers.

(2) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(3) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(4) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(g) Determine if there are additional documents that should be referenced in the purchase specification. For Example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. “Positive Materials Identification” (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses.

This can be determined by a risk assessment using the methods of risk-based inspection (see (f)(3)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

8.2. Designs and Construction of Heating Boilers

The ASME Boiler and Pressure Vessel Code (BPVC) Section IV (BPVC Section IV) provides rules for construction of heating boilers. These rules are mandatory in most jurisdictions in the US and Canada, and are frequently used worldwide. Section IV references many other codes and standards, a few of which are listed below. If a user requires Section IV construction in a purchase document, the internal references in Section IV become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications*

(h) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 8.1(f)(3)).

(i) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(j) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

8.3. Operation of Heating Boilers

BPVC Section VI *Recommended Rules for the Care and Operation of Heating Boilers.*

8.4. In-service Inspection of Heating Boilers

The following documents apply to the in-service inspection of heating boilers. They should be considered to be good engineering practices, with applicability that depends on the situation. However, in many cases, the manufacturers of heating boilers have compiled the guidance of the applicable documents in an installation and operating manual (IOM).

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 8.1(b)).

(b) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3 above.

(d) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and heating boilers. However, for typical applications of heating boilers constructed to Section IV, the rules and guidelines in the post-construction documents previously referenced are adequate, without the need to refer to RP 573.

(e) BPVC Section VI *Recommended Rules for the Care and Operation of Heating Boilers.*

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents:

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

8.5. Fitness-for-service Analysis of Heating Boilers

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 8.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help he user determine whether re-rating or repairs are needed.

(b) EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings).*

8.6. Repair of Heating Boilers

If the FFS assessment (see paragraph 8.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 – *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive materials Identification", (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 8.4(b))

(f) BPVC Section IX *Welding and Brazing Qualifications*.

9. Unfired Steam Boilers

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this Guideline, the document number in Table 4 is hyperlinked to the description in Appendix A.

Table 4: Unfired Steam Boilers

Specification / Purchase	Design / Construction	Operation
NB-370 RP 573 NB-23 NB-370 PCC-3 RP-580 RP 578 ASCE/SEI 7	BPVC Section I BPVC Section VIII - Division 1 BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1	BPVC Section VII
In-Service Inspection	**Fitness-For-Service**	**Repair**
NB-23 NB-370 PCC-3 RP-580 BPVC Section VII BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 EPRI CS-5208	NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

9.1. Specification (Purchase) of Unfired Steam Boilers

Before acquiring a new unfired steam boiler, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provisions for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 9.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual Jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post construction (in-service) documents that should be considered in the design / specification / new construction phase are listed in the following paragraphs. Note that some post construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy the all of the new construction rules after the equipment has been placed in service.

(1) RP 573 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and Unfired Steam Boilers.

(2) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(3) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(4) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3 above.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 9.4(b)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

9.2. Designs and Construction of Unfired Steam Boilers

The ASME Boiler and Pressure Vessel Code, Section I (BPVC Section I) provides rules for construction of power boilers, including Unfired Steam Boilers. These rules are mandatory in most jurisdictions in the US and Canada, and are frequently used worldwide. Section I references many other codes and standards, a few of which are listed below. If a user requires Section I construction in a purchase document, the internal references in Section I become mandatory as well.

Unless ASME Section I is required by the local jurisdiction, BPVC Section VIII - Division 1 *Rules for Construction of Pressure Vessels Division 1* may be used for construction of unfired steam boilers. Section VIII references many other codes and standards, a few of which are listed below. If a user requires Section I construction in a purchase document, the internal references in Section I become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications*

(h) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 9.4(b)).

(i) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(j) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

9.3. Operation of Unfired Steam Boilers

BPVC Section VII *Recommended Guidelines for the Care of Power Boilers*.

9.4. In-service Inspection of Unfired Steam Boilers

The following documents apply to the in-service inspection of Unfired Steam Boilers. They should be considered to be good engineering practices, with applicability that depends on the situation.

However, in many cases, the manufacturers of unfired steam boilers have compiled the guidance of the applicable documents in an installation and operating manual (IOM).

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 9.1(b))

(b) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(d) PCC-3 *Inspection of Fired Boilers and Heaters*. Although this document was written based primarily on refinery experience, it can be considered to be generally applicable. It covers process heaters as well as power (steam) boilers and unfired steam boilers.

(e) BPVC Section VII *Recommended Guidelines for the Care of Power Boilers.*

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

9.5. Fitness-for-service Analysis of Unfired Steam Boilers

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 9.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

(b) EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings).*

9.6. Repair of Unfired Steam Boilers

If the FFS assessment (see paragraph 9.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 9.4(b)).

(f) BPVC Section IX *Welding and Brazing Qualifications.*

10. Typical Pressure Vessels

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this Guideline, the document number in Table 5 is hyperlinked to the description in Appendix A.

Table 5: Typical Pressure Vessels

Specification / Purchase	Design / Construction	Operation
NB-370 API 510 NB-23 NB-370 RP 572 PCC-3 RP-580 RP 578 ASCE/SEI 7 Publication 945 NACE SP0472 NACE SP0590	BPVC Section VIII - Division 1 BPVC Section VIII - Division 2 BPVC Section VIII - Division 3 BPVC Section X BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1 ASME BPE	None listed
In-Service Inspection	**Fitness-For-Service**	**Repair**
API 510 NB-23 NB-370 PCC-3 RP-580 RP-581 RP 571 RP 572 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 API 510	API 510 NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

10.1. Specification (Purchase) of Typical Pressure Vessels

Before acquiring a new pressure vessel, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provisions for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 10.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(2) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(3) RP 572 *Inspection of Pressure Vessels*. Written for the petroleum and chemical process industries, but can be applied elsewhere.

(4) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(5) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to

minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 10.4(c)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(3) Publication 945 *Avoiding Environmental Cracking in Amine Units*. This RP should be considered only if the equipment will be in amine service.

(4) NACE SP0472 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*. This standard should be considered only if the equipment will be in an environmental cracking service as determined by reviewing RP 571.

(5) NACE SP0590 *Prevention, Detection, and Correction of Deaerator Cracking*. This standard should be considered only for deaerators.

10.2. Design and Construction of Typical Pressure Vessels

Typical pressure vessels include towers, drums, reactors, heat exchangers, condensers, air receivers, accumulators, etc. Heavy wall vessels [e.g. >50 mm (2 in) wall thickness] and vessels with high design pressures [e.g. > 70 MPa (10,000 psi)] and/or temperatures [e.g. > 370°C (700°F)] are covered in subsequent sections. The ASME Boiler and Pressure Vessel Code (BPVC Section VIII - Division 1) provides rules for construction of typical pressure vessels. In many jurisdictions, this code, or an equivalent internationally recognized code of construction, is required. The requirements of the local jurisdiction should be determined. Section VIII, Division 1 references many other codes and standards, a few of which are listed in paragraph 10.5, below. If a user requires Section VIII construction in a purchase document, the internal references in Section VIII become mandatory as well.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 2 (BPVC Section VIII - Division 2) provides alternative rules for pressure vessels. The rules for design analysis in Division 2 are typically more complex and detailed than in Division 1 and may be more costly to implement. In addition, examination and testing requirements are more stringent. For design by analysis, the maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, many components can be designed using the rules without the need for design by analysis. In that case, the maximum temperature limits are the same as in Division 1. Division 2 offers lower design margins, which can result in weight and cost savings in fabrication. Division 2 can be selected for construction of most typical pressure vessels at the option of the owner/user, but it is used primarily for large vessels or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 3 (BPVC Section VIII - Division 3) provides alternative rules for high pressure vessels. The rules for design analysis in Division 3 are more complex and detailed than in Divisions 1 and 2, particularly for fatigue (cyclic service) analysis. In addition, examination and impact testing requirements are more stringent. The maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, Division 3 offers lower design margins than Division 2 in some cases, which can result in weight and cost savings in fabrication. Division 3 also has rules for low temperature hydrogen service and for steel wire and composite fiber reinforced plastic (FRP), hoop wrapped pressure vessels (Code Cases 2390 and 2579). Division 3 can be selected for construction of most typical pressure vessels at the option of the owner/user, but it is used primarily for large, relatively high pressure vessels, or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The ASME Boiler and Pressure Vessel Code (BPVC) Section X (BPVC Section X) provides rules for fiber reinforced plastic pressure vessels, except that rules for hoop wrapped FRP vessels are covered in Section VIII, Division 3 through Code Cases 2390 and 2579.

The Section VIII Codes reference many other codes and standards, a few of which are listed below. If a user requires Section VIII construction in a purchase document, the internal references in the Section VIII Codes become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications.*

RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 10.4(c)).

ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

ASME BPE provides rules for bioprocessing equipment, primarily related to cleanability requirements.

10.3. Operation of Typical Pressure Vessels

No documents listed.

10.4. In-service Inspection of Typical Pressure Vessels

The following documents apply to the in-service inspection of typical pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 10.1(b)).

(c) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(d) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(e) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(f) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

(g) RP 572 *Inspection of Pressure Vessels*.

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

10.5. Fitness-for-service Analysis of Typical Pressure Vessels

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 10.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help he user determine whether re-rating or repairs are needed.

(b) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

10.6. Repair of Typical Pressure Vessels

If the FFS assessment (see paragraph 10.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(c) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(d) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(e) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(f) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 10.4(c)).

(g) BPVC Section IX *Welding and Brazing Qualifications*.

11. Large, Heavy Wall and High Temperature Pressure Vessels

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 6 is hyperlinked to the description in Appendix A.

Table 6: Large, Heavy Wall and High Temperature Pressure Vessels

Specification / Purchase	Design / Construction	Operation
NB-370 API 510 NB-23 NB-370 RP 572 PCC-3 RP-580 RP 578 ASCE/SEI 7 Publication 945 NACE SP0472 NACE SP0590	BPVC Section VIII - Division 1 BPVC Section VIII - Division 2 BPVC Section VIII - Division 3 BPVC Section X BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1 RP 934A RP 934C RP 934E Publication 941	None listed
In-Service Inspection	**Fitness-For-Service**	**Repair**
API 510 NB-23 NB-370 PCC-3 RP-580 RP-581 RP 571 RP 572 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 API 510	API 510 NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

11.1. Specification (Purchase) of Large, Heavy Wall and High Temperature Pressure Vessels

Before acquiring a new pressure vessel, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 11.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post-construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(2) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(3) RP 572 *Inspection of Pressure Vessels*. Written for the petroleum and chemical process industries, but can be applied elsewhere.

(4) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(5) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 11.4(c)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(3) Publication 945 *Avoiding Environmental Cracking in Amine Units*. This RP should be considered only if the equipment will be in amine service.

(4) NACE SP0472 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*. This standard should be considered only if the equipment will be in an environmental cracking service as determined by reviewing RP 571.

(5) NACE SP0590 *Prevention, Detection, and Correction of Deaerator Cracking*. This standard should be considered only for deaerators.

11.2. Design and Construction of Large, Heavy Wall and High Temperature Pressure Vessels

Large, heavy wall [e.g. >50 mm (2 in)] or high temperature [e.g. > 370°C (700°F)] pressure vessels should be purchased to the same general requirements as the typical pressure vessels described in paragraph 9.6(f), but with some additional considerations and documents as applicable. This section of the guideline includes the applicable documents from paragraph 9.6(f), as well as the additional documents that should be considered. The ASME Boiler and Pressure Vessel Code (BPVC Section VIII - Division 1) provides rules for construction of heavy wall pressure vessels, but Section VIII, Division 2 (BPVC Section VIII - Division 2) is generally preferred for this application. Section VIII, Division 2 can also be used for some high temperature vessels, but most high temperature vessels are constructed to Section VIII, Division 1. In many jurisdictions, one of these codes, or an equivalent internationally recognized code of construction, is required. The requirements of the local jurisdiction should be determined. The Section VIII Codes reference many other codes and standards, a few of which are listed in paragraph 11.5, below. If a user requires Section VIII construction in a purchase document, the internal references in Section VIII become mandatory as well.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 2 (BPVC Section VIII - Division 2) provides alternative rules for pressure vessels. The rules for design analysis in Division 2 are typically more complex and detailed than in Division 1 and may be more costly to implement. In addition, examination and testing requirements are more stringent. For design by analysis, the maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, many components can be designed using the rules without the need for design by analysis. In that case, the maximum temperature limits are the same as in Division 1. Division 2 offers lower design margins, which can result in weight and cost savings in fabrication. Division 2 can be selected for construction of most typical pressure vessels at the option of the owner/user, but it is used primarily for large vessels or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 3 (BPVC Section VIII - Division 3) provides alternative rules for high pressure vessels. The rules for design analysis in Division 3 are more complex and detailed than in Divisions 1 and 2, particularly for fatigue (cyclic service) analysis. In addition, examination and impact testing requirements are more stringent. The maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, Division 3 offers lower design margins than Division 2 in some cases, which can result in weight and cost savings in fabrication. Division 3 also has rules for low temperature hydrogen service and for steel wire and composite fiber reinforced plastic (FRP), hoop wrapped pressure vessels. Division 3 can be selected for construction of most pressure vessels at the option of the owner/user, but it is used primarily for large, relatively high pressure vessels, or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The Section VIII Codes reference many other codes and standards, a few of which are listed below. If a user requires Section VIII construction in a purchase document, the internal references in the Section VIII Codes become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications.*

RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 11.1(e)(4)).

ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

RP 934A *Materials And Fabrication of 2 ¼ Cr - 1 Mo, 2 ¼ Cr - 1 Mo - ¼ V, 3 Cr - 1 Mo, And 3 Cr - 1 Mo - ¼ V Steel Heavy Wall Pressure Vessels For High-Temperature, High-Pressure Hydrogen Service*.

RP 934C *Materials and Fabrication of 1 ¼ Cr - ½ Mo Steel Heavy Wall Pressure Vessels for High-Pressure Hydrogen Service Operating at or Below 825 Degrees F (441 Degrees C)*.

RP 934E *RP for Materials and Fabrication of 1¼Cr-½Mo and 1Cr-½Mo Steel Pressure Vessels for Service above 825°F (441°C)*. This document has not been published as of this writing.

Publication 941 *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*.

11.3. Operation of Large, Heavy Wall and High Temperature Pressure Vessels

No documents listed.

11.4. In-service Inspection of Large, Heavy Wall and High Temperature Pressure Vessels

The following documents apply to the in-service inspection of large, heavy wall and high temperature pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 11.1(b)).

(c) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(d) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(e) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(f) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

(g) RP 572 *Inspection of Pressure Vessels*.

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

11.5. Fitness-for-service Analysis of Large, Heavy Wall and High Temperature Pressure Vessels

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph ASCE/SEI 7) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

(b) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

11.6. Repair of Large, Heavy Wall and High Temperature Pressure Vessels

If the FFS assessment (see paragraph 11.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(c) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(d) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(e) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(f) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note

that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 11.4(c)).

(g) BPVC Section IX *Welding and Brazing Qualifications.*

12. High Pressure Vessels

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 7 is hyperlinked to the description in Appendix A.

Table 7: High Pressure Vessels

Specification / Purchase	Design / Construction	Operation
NB-370 API 510 NB-23 RP 572 PCC-3 RP-580 RP 578 ASCE/SEI 7	BPVC Section VIII - Division 3 BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1 RP 934A Publication 941	None listed
In-Service Inspection	**Fitness-For-Service**	**Repair**
NB-23 NB-370 PCC-3 RP-580 RP 572 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1	NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

12.1. Specification (Purchase) of High Pressure Vessels

Before acquiring a new high pressure vessel, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 12.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations

available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post-construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(2) RP 572 *Inspection of Pressure Vessels*. Written for the petroleum and chemical process industries, but can be applied elsewhere.

(3) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(4) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 12.4(b)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

12.2. Design and Construction of High Pressure Vessels

High pressure vessels [e.g. > 70 MPa (10 ksi) design pressure] should be purchased to the requirements of BPVC Section VIII - Division 3 because it was written specifically to cover high pressure applications. The requirements of the local jurisdiction should be determined. The Section VIII Codes reference many other codes and standards, a few of which are listed below. If a user requires Section VIII construction in a purchase document, the internal references in Section VIII become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications.*

RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 12.1(e)(3)).

ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

Publication 941 *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*.

12.3. Operation of High Pressure Vessels

No documents listed.

12.4. In-service Inspection of High Pressure Vessels

The following documents apply to the in-service inspection of high pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 12.1(b)).

(b) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(d) RP 572 *Inspection of Pressure Vessels*.

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

12.5. Fitness-for-service Analysis of High Pressure Vessels

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 12.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. However, some of the fitness-for-service analysis rules in API 579-1/ASME FFS-1 do not extend to very heavy wall construction. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help he user determine whether re-rating or repairs are needed.

12.6. Repair of High Pressure Vessels

If the FFS assessment (see paragraph 12.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods. However, note that welding is prohibited on some of the materials used in high pressure vessels, so many of the rules in ASME PCC-2 and other repair documents do not apply.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 6.4(b)).

(f) BPVC Section IX *Welding and Brazing Qualifications*.

13. Heat Exchangers

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 8 is hyperlinked to the description in Appendix A.

Table 8: Heat Exchangers

Specification / Purchase	Design / Construction	Operation
NB-370 API 510 NB-23 RP 572 PCC-3 RP-580 RP 578 ASCE/SEI 7 Publication 945 NACE SP0472 RP 571	BPVC Section VIII - Division 1 BPVC Section VIII - Division 2 BPVC Section VIII - Division 3 BPVC Section II – Materials - Part A BPVC Section II – Materials - Part B BPVC Section II - Materials Part C BPVC Section II – Materials – Part D BPVC Section V BPVC Section IX Std 660 Std 661 Std 662, Part 1 Std 662, Part 2 Standards of the Tubular Exchanger Manufacturers Association RP 578 ASCE/SEI 7 PCC-1	None listed
In-Service Inspection	**Fitness-For-Service**	**Repair**
API 510 NB-23 NB-370 PCC-3 RP-580 RP-581 RP 571 RP 572 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 API 510	API 510 NB-23 NB-370 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

13.1. Specification (Purchase) of Heat Exchangers

Before acquiring a new pressure vessel, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the equipment, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 13.2.

(b) Determine legally mandated new construction and in-service inspection requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(c) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(d) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(e) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post-construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(2) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in many jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph (b)).

(3) RP 572 *Inspection of Pressure Vessels*. Written for the petroleum and chemical process industries, but can be applied elsewhere.

(4) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(5) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(f) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 13.4(c)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(3) Publication 945 *Avoiding Environmental Cracking in Amine Units*. This RP should be considered only if the equipment will be in amine service.

(4) NACE SP0472 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*. This standard should be considered only if the equipment will be in an environmental cracking service as determined by reviewing RP 571.

13.2. Design and Construction of Heat Exchangers

There are many types of heat exchangers, condensers, etc. The ASME Boiler and Pressure Vessel Code (BPVC Section VIII - Division 1) provides rules for construction of typical heat exchangers. In many jurisdictions, this code, or an equivalent internationally recognized code of construction, is required. In addition, there are API documents that cover many specific types of heat exchangers, as described below. The requirements of the local jurisdiction should be determined. Section VIII, Division 1 references many other codes and standards. If a user requires Section VIII construction in a purchase document, the internal references in Section VIII become mandatory as well.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 2 (BPVC Section VIII - Division 2) provides alternative rules for pressure vessels, including heat exchangers, but the majority of heat exchangers are constructed to Division 1. The rules for design analysis in Division 2 are typically more complex and detailed than in Division 1 and may be more costly to implement. In addition, examination and testing requirements are more stringent. For design by analysis, the maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, many components can be designed using the rules without the need for design by analysis. In that case, the maximum temperature limits are the same as in Division 1. Division 2 offers lower design margins, which can result in weight and cost savings in fabrication. Division 2 can be selected for construction of most typical pressure vessels at the option of the owner/user, but it is used primarily for large vessels or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The ASME Boiler and Pressure Vessel Code (BPVC) Section VIII, Division 3 (BPVC Section VIII - Division 3) provides alternative rules for high pressure vessels and heat exchangers, but the majority of heat exchangers are constructed to Division 1. The rules for design analysis in Division 3 are more complex and detailed than in Divisions 1 and 2, particularly for fatigue (cyclic service) analysis. In addition, examination and impact testing requirements are more stringent. The maximum design temperature is limited to values that result in allowable stresses that are not based on time dependent (creep) values. However, Division 3 offers lower design margins than Division 2 in some cases, which can result in weight and cost savings in fabrication. Division 3 also has rules for low temperature hydrogen service and for steel wire and composite fiber reinforced plastic (FRP), hoop wrapped pressure vessels. Division 3 can be selected for construction of most typical pressure vessels at the option of the owner/user, but it is used primarily for large, relatively high pressure vessels, or those made from expensive alloys where the savings in fabrication cost are greater than the increase in design/analysis costs.

The Section VIII Codes reference many other codes and standards, a few of which are listed below. If a user requires Section VIII construction in a purchase document, the internal references in the Section VIII Codes become mandatory as well.

(a) BPVC Section II – Materials - Part A *Ferrous Material Specifications*

(b) BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

(c) BPVC Section II - Materials Part C *Specifications for Welding Rods Electrodes and Filler Metals*

(d) BPVC Section II – Materials – Part D *Properties (Customary)*

(e) BPVC Section II – Materials – Part D *Properties (Metric)*

(f) BPVC Section V *Nondestructive Examination*

(g) BPVC Section IX *Welding and Brazing Qualifications.*

Std 660 *Shell-and-Tube Heat Exchangers*.

Std 661 *Air-Cooled Heat Exchangers for General Refinery Service*.

Std 662, Part 1 *Plate Heat Exchangers for General Refinery Services, Part 1 – Plate-and-Frame Heat Exchangers.*

Std 662, Part 2 *Plate Heat Exchangers for General Refinery Services, Part 2 – Brazed Aluminum Plate-fin Heat Exchangers*.

Standards of the Tubular Exchanger Manufacturers Association

RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 13.4(c)).

ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

13.3. Operation of Heat Exchangers

No documents listed.

13.4. In-service Inspection of Heat Exchangers

The following documents apply to the in-service inspection of typical pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 13.1(b)).

(c) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(d) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(e) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(f) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

(g) RP 572 *Inspection of Pressure Vessels*.

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

13.5. Fitness-for-service Analysis of Heat Exchangers

If damage is discovered in a pressure retaining item, the damage should be either repaired (see paragraph 13.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help he user determine whether re-rating or repairs are needed.

(b) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

13.6. Repair of Heat Exchangers

If the FFS assessment (see paragraph 13.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration* for pressure vessels in the petroleum and chemical process industries.

(b) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(c) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(d) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(e) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(f) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 13.4(c)).

(g) BPVC Section IX *Welding and Brazing Qualifications*.

14. Storage Tanks

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 9 is hyperlinked to the description in Appendix A.

Table 9: Storage Tanks

Specification / Purchase	Design / Construction	Operation
Publication 327 Std 653 RP 575 PCC-3 RP-580 RP 578 ASCE/SEI 7 Publication 945 NACE SP0472 RP 571	Std 650 RP 651 Std 2000 RP 652 Std 620 RTP-1 BPVC Section V BPVC Section IX RP 578 API 570 PCC-1	None listed
In-Service Inspection	**Fitness-For-Service**	**Repair**
Std 653 RP 575 PCC-3 RP-580 RP-581 RP 571 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1 Std 653	Std 653 PCC-2 PCC-1 RP 577 RP 578 BPVC Section IX

14.1. Specification (Purchase) of Storage Tanks

Before acquiring a new storage tank, it is important for the equipment owner/user to consider the life cycle cost and integrity requirements for the tank, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 14.2.

(b) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of storage tanks.

(c) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post construction codes provide for the evaluation of damage in pressure equipment using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) Publication 327 *Aboveground Storage Tank Standards: A Tutorial*

(2) Std 653 *Tank Inspection, Repair, Alteration, and Reconstruction* for storage tanks. Although this standard was developed primarily for the petroleum and chemical process industries, it is widely used in other industries.

(3) RP 575 *Inspection of Atmospheric & Low Pressure Storage Tanks*

(4) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(5) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(d) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 13.4(c)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(3) Publication 945 *Avoiding Environmental Cracking in Amine Units*. This recommended practice should be considered only if the equipment will be in amine service.

(4) NACE SP0472 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*. This standard should be considered only if the equipment will be in an environmental cracking service as determined by reviewing RP 571.

14.2. Design and Construction of Storage Tanks

Storage tanks in many industries are purchased in accordance with the requirements of API standards:

(a) Std 650 *Welded Steel Tanks for Oil Storage*. This standard covers tanks that are essentially at atmospheric pressure.

(b) RP 651 *Cathodic Protection of Aboveground Storage Tanks*

(c) Std 2000 *Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated*

(d) RP 652 *Lining of Aboveground Petroleum Storage Tank Bottoms*.

(e) Std 620 *Design and Construction of Large, Welded, Low-pressure Storage Tanks*. This standard covers tanks that have design pressures up to 1 bar (15 psig), with design temperatures up to 120°C (250°F).

(f) RTP-1 – Reinforced Thermoset Plastic Corrosion-Resistant Equipment. This standard covers pressure vessels with internal pressures up to 15 psig. However, it is listed in the storage tank section of this document because equipment constructed to this standard is used primarily for atmospheric or low pressure storage.

In addition, the following documents are referenced or should be considered for storage tank construction.

(a) BPVC Section V *Nondestructive Examination*

(b) BPVC Section IX *Welding and Brazing Qualifications*

(c) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 14.1(c)(4)).

(d) API 570 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(e) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

14.3. Operation of Storage Tanks

No documents listed.

14.4. In-service Inspection of Typical Pressure Vessels

The following documents apply to the in-service inspection of storage tanks. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) Std 653 *Tank Inspection, Repair, Alteration, and Reconstruction* for storage tanks. Although this standard was developed primarily for the petroleum and chemical process industries, it is widely used in other industries.

(b) RP 575 *Inspection of Atmospheric & Low Pressure Storage Tanks*

(c) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(d) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(e) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(f) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

In implementing an in-service inspection plan, various non-destructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

14.5. Fitness-for-service Analysis of Storage Tanks

If damage is discovered in a storage tank, the damage should be either repaired (see paragraph 14.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions.

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following documents can be used for the fitness-for-service (FFS) assessment.

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

(b) Std 653 *Tank Inspection, Repair, Alteration, and Reconstruction* for storage tanks. Although this standard was developed primarily for the petroleum and chemical process industries, it is widely used in other industries.

14.6. Repair of Storage Tanks

If the FFS assessment (see paragraph 14.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods.

(a) Std 653 *Tank Inspection, Repair, Alteration, and Reconstruction* for storage tanks. Although this standard was developed primarily for the petroleum and chemical process industries, it is widely used in other industries.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 14.4(c)).

(f) BPVC Section IX *Welding and Brazing Qualifications*.

15. Piping Systems

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 10 is hyperlinked to the description in Appendix A.

Table 10: Piping Systems

Specification / Purchase	Design / Construction	Operation
API 570 RP 574 PCC-3 RP-580 RP 578 ASCE/SEI 7 NACE SP0472 RP 571 B36.10M B36.19M	B31.1 B31.3 B31.5 B31.9 B31E 5UE Std 650 BPVC Section V BPVC Section IX RP 578 ASCE/SEI 7 PCC-1 Std 1104	None listed
In-Service Inspection	Fitness-For-Service	Repair
API 570 RP 574 PCC-3 RP-580 RP-581 RP 571 Std 598 BPVC Section V CP-189 RP SNT-TC-1A	API 579-1/ASME FFS-1	API 570 PCC-2 PCC-1 RP 577 RP 621 RP 1107 RP 2201 RP 578 BPVC Section IX

15.1. Specification (Purchase) of Piping Systems

Before acquiring a new piping system, it is important for the equipment owner/user to consider the life cycle cost and pressure integrity requirements for the system, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step are:

(a) Determine which design and construction codes will be specified. These are described in paragraph 15.2.

(b) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of piping systems. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(c) Determine the methods and frequency of in-service inspection that will be needed to ensure equipment integrity. Post-construction (in-service) documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs. Note that some post-construction codes provide for the evaluation of damage in piping systems using methods and acceptance criteria that are not permitted by the new construction codes. This is consistent with the intent of many new construction codes to provide a margin for deterioration in service. Therefore, it is not necessary to satisfy all of the new construction rules after the equipment has been placed in service.

(1) API 570 *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems* for piping in the petroleum and chemical process industries. However, the scope states that it may be used in other industries where practical.

(2) RP 574 *Inspection Practices for Piping System Components*.

(3) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(4) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(d) Determine if there are additional documents that should be referenced in the purchase specification. For example:

(1) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 15.4(c)).

(2) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(3) NACE SP0472 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*. This standard should be considered only if the equipment will be in an environmental cracking service as determined by reviewing RP 571.

(4) B36.10M *Welded and Seamless Wrought Steel Pipe*. This standard provides standard dimensions for pipe NPS 12 and smaller.

(5) B36.19M *Stainless Steel Pipe*. This standard provides standard dimensions for stainless steel pipe.

15.2. Design and Construction of Piping Systems

The codes and standards for new construction of piping systems are organized by the industry or application in which they will be used, as described below. Note that piping components and fittings are covered in paragraph 16.

(a) B31.1 *Power Piping*. This standard covers piping in electric power generating stations, industrial and institutional plants (except as covered by B31.3), geothermal heating systems and central and district heating and cooling systems.

(b) B31.3 *Process Piping*. This standard covers piping in petroleum refineries and chemical, pharmaceutical, textile, paper, semiconductor, cryogenic and related processing plants and terminals.

(c) B31.5 *Refrigeration Piping*. This standard covers piping for refrigerants and secondary coolants.

(d) B31.9 *Building Services Piping*. This standard covers piping in industrial, institutional, commercial, and public buildings and in multi-unit residences, which do not require the range of sizes, pressures and temperatures covered in B31.1.

(e) B31E *Standard for the Seismic Design and Retrofit of Above-Ground Piping Systems*

(f) 5UE *Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections*. Although developed primarily for application to drill pipe and casing in the petroleum and natural gas exploration and production industry, 5UE can be used for critical piping systems where detection and characterization of small flaws is important to integrity.

The piping codes reference many other codes and standards, a few of which are listed below.

(a) BPVC Section V *Nondestructive Examination*

(b) BPVC Section IX *Welding and Brazing Qualifications*.

The following standard is generally applicable to piping systems other than those constructed using plain carbon steel.

(a) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. RP 578 should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 15.4(c)).

Other standards that should be considered for construction include.

(a) ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*. This document is used primarily by manufacturers and designers of pressure equipment to determine the magnitude of earthquake and wind loads.

(b) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(c) Std 1104 *Welding of Pipelines and Related Facilities*. Although 1104 was developed for pipelines, it can be used for large diameter or critical piping in process units.

15.3. Operation of Piping Systems

No documents listed.

15.4. In-service Inspection of Piping Systems

The following documents apply to the in-service inspection of typical pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) API 570 *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems* for piping in the petroleum and chemical process industries. However, the scope states that it may be used in other industries where practical.

(b) RP 574 *Inspection Practices for Piping System Components*

(c) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(d) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(e) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(f) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

(g) Std 598 *Valve Inspection and Testing*

In implementing an in-service inspection plan, various nondestructive examination (NDE) techniques are often used. Guidance in this area can be found in the following documents.

(a) BPVC Section V *Nondestructive Examination*

(b) CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

(c) RP SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing. The major difference between RP SNT-TC-1A and CP-189 is that the latter is a standard while the former is a recommended practice. It is probably not necessary to use both.

15.5. Fitness-for-service Analysis of Piping Systems

If damage is discovered in a piping component, the damage should be either repaired (see paragraph 15.6) or subjected to a fitness-for-service (FFS) assessment to determine whether the item is acceptable for continued service without repair. These methods can also be used in combination (e.g., some portions of the damaged area can be repaired while others could be assessed). The fitness-for-service assessment could result in one or more of the following actions:

(a) Continue operation at current operating conditions with periodic inspection or monitoring for further damage.

(b) De-rate the equipment by reducing pressures, temperatures and/or other loads to reduce stresses.

(c) Repair the equipment.

The following document can be used for the fitness-for-service (FFS) assessment:

(a) API 579-1/ASME FFS-1 *Fitness-For-Service*. This document provides detailed guidance on the evaluation of many types of flaws to help the user determine whether re-rating or repairs are needed.

15.6. Repair of Piping Systems

If the FFS assessment (see paragraph 15.5) indicates that a repair is necessary for continued operation, the following documents provide guidance on many repair methods:

(a) API 570 *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems* for piping in the petroleum and chemical process industries. However, the scope states that it may be used in other industries where practical.

(b) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

(d) RP 577 *Welding Inspection and Metallurgy*. This document can also be used for inspection of new construction.

(e) RP 621 *Reconditioning of Metallic Gate, Globe and Check Valves*

(f) RP 1107 *Pipeline Maintenance Welding Practices*. Although 1107 was developed for pipelines, it can be used for large diameter or critical piping in process units.

(g) RP 2201 *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*. Although 2201 was developed for pipelines, it can be used for large diameter or critical piping in process units.

(h) RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*. The use of material other than the material specified can result in failures in service. "Positive Materials Identification" (PMI) is one way to minimize these failures. Although RP 578 is targeted toward piping systems, the principles can be used for other alloy equipment. Note that PMI is not normally performed on equipment constructed of carbon steel. However, it should be applied in cases where substitution of another alloy for a specified alloy can result in failure with significant safety, health, environmental or financial losses. This can be determined by a risk assessment using the methods of risk-based inspection (see 15.4(c)).

(i) BPVC Section IX *Welding and Brazing Qualifications*.

16. Acquisition (Purchase) of Components, Including Fittings

The codes and standards for construction of components are organized by component or fitting type, as described below. Although these standards are frequently used in construction of pressure equipment, they are used primarily by the component or fitting manufacturer. However, a user may wish to refer to these standards for new construction dimensions and design requirements that could be used for reference in a fitness-for-service analysis.

(a) Valves

(b) Flanges and flanged fittings

(c) Gaskets

(d) Fittings.

New construction codes, standards and recommended practices for valves are listed below:

(a) B16.10 *Face to Face and End to End Dimensions of Valves*

(b) B16.34 *Valves – Flanged, Threaded, and Welding End*

(c) RP 591 *Process Valve Qualification Procedure*

(d) Std 594 *Check Valves: Flanged, Lug, Wafer and Butt-Welding*

(e) Std API 600/ISO 10434 *Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries – Modified National Adoption*

(f) Std 602 *Steel Gate, Globe and Check Valves for Sizes DN 100 and Smaller for the Petroleum and Natural Gas Industries*

(g) Std 607 *Testing of Valves – Fire Type-testing Requirements*

(h) Std 60 *Metal Ball Valves – Flanged, Threaded and Butt-Welding Ends*

(i) Std 609 *Butterfly Valves: Double Flanged, Lug and Wafer-Type*

(j) RP 622 *Type Testing of Process Valve Packing for Fugitive Emissions.*

New construction codes, standards and recommended practices for flanges and flanged fittings are listed below:

(a) American Society of Mechanical Engineers (ASME) Standards

(b) B16.1 Gray Iron Flanges and Flanged Fittings

(c) B16.5 *Pipe Flanges and Flanged Fittings*. This is the most common standard that is used for flanges and flanged fittings.

(d) B16.24 *Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500*

(e) B16.36 *Orifice Flanges*

(f) B16.42 *Ductile Iron Pipe Flanges and Flanged Fittings: Classes150 and 300*

(g) B16.47 *Large Diameter Steel Flanges.*

New construction codes, standards and recommended practices for gaskets are listed below:

(a) B16.20 *Metallic Gaskets for Pipe Flanges: Ring Joint, Spiral Wound, and Jacketed*

(b) B16.42 *Nonmetallic Flat Gaskets for Pipes Flanges.*

New construction codes, standards and recommended practices for fittings are listed below:

(a) BPVC Section IX *Malleable Iron Threaded Fittings (Classes 150 and 300)*

(b) B16.4 *Gray Iron Threaded Fittings (Classes 125 and 250)*

(c) B16.9 *Factory-Made Wrought Butt-Welding Fittings*

(d) B16.11 *Forged Fittings, Socket-Welding and Threaded*

(e) B16.14 *Ferrous Pipe Plugs, Bushings And Locknuts With Pipe Threads*

(f) B16.15 *Cast Copper Alloy Threaded Fittings; Classes 125 and 250*

(g) B16.18 *Cast Copper Alloy Solder Joint Pressure Fittings*

(h) B16.22 *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*

(i) B16.24 *Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500*

(j) B16.25 *Butt-Welding Ends*

(k) B16.26 *Cast Copper Alloy Fittings for Flared Copper Tubes*

(l) B16.39 *Malleable Iron Threaded Pipe Unions*

(m) B16.48 *Line Blanks*

(n) B16.50 *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

(o) B40.100 *Pressure Gauges and Gauge Attachments.*

17. Post-construction Documents for Components, Including Fittings

Post-construction codes, standards and recommended practices for valves are listed below:

(a) Std 598 *Valve Inspection and Testing*

(b) RP 621 *Reconditioning of Metallic Gate, Globe and Check Valves.*

18. Overpressure Protection Systems

These documents are briefly summarized in the paragraphs that follow. A more detailed summary of each document can be found in Appendix A. In electronic versions of this guideline, the document number in Table 11 is hyperlinked to the description in Appendix A.

Table 11: Overpressure Protection

Note: Almost all of the new construction codes have overpressure protection requirements, so these will not be repeated here.		
Specification / Purchase	Design / Construction	Operation
NB-370 Std 526 RP 520 RP 520 Part II Std 521 National Board of Boiler and Pressure Vessel Inspectors (NBBPVI) Standards NB-18 PCC-3 RP-580	NB-23 NB-370 PTC 25 PCC-1	None listed
In-Service Inspection	Fitness-For-Service	Repair
NB-23 NB-370 PCC-3 RP-580 RP-581 RP 571 RP 576	None listed	PCC-2 PCC-1

18.1. Specification (Purchase) of Overpressure Protection Systems

Before specifying an overpressure protection system, it is important for the equipment owner/user to consider life cycle cost and in-service testing requirements, including requirements for in-service inspection, testing, maintenance and repair. This will allow the design and construction to be optimized to provide appropriate access for these activities, as well as provide ways for minimizing the impact of possible repairs. Some of the steps in this consideration, and the documents that should be considered for each step, are:

(a) Determine legally mandated new construction and in-service testing requirements. Requirements of legal jurisdictions in the US and Canada can be obtained from NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*. Most individual jurisdictions have made the full version of applicable laws and regulations available on their respective web sites and hard copies are generally made available on request.

(b) Determine potential manufacturers. One useful reference is the National Board *Manufacturer and Repair Directory*, an online searchable directory containing a listing of manufacturers of pressure equipment and pressure relief devices and repair organizations.

(c) Determine third-party or other contractual requirements, such as insurance requirements, that may exist. Some insurance companies have specific requirements for design, construction, inspection and operation of pressure equipment. Some building owners or owner entities impose conditions for use of their facilities that may apply to pressure equipment.

(d) Determine the methods and frequency of in-service testing that will be needed to ensure equipment integrity and to comply with jurisdictional regulations. Documents that should be considered in the design/specification/new construction phase are listed in the following paragraphs.

(1) Std 526 *Flanged Steel Pressure Relief Valves*

(2) RP 520 *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries, Part I – Sizing and Selection*

(3) RP 520 Part II *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries, Part II – Installation*

(4) Std 521 *Guide for Pressure-relieving and Depressuring Systems*

(5) NB-18 *Pressure Relief Device Certifications*. This document contains a listing of the device designs certified by the National Board. Also listed are the certifications issued to pressure relief device manufacturers and assemblers to apply the National Board "NB" and construction code symbols as well as companies holding "VR" Certificates of Authorization for the repair of pressure relief valves. Also included is a listing of combination capacity factors determined for various rupture disk devices installed in series with pressure relief valves.

(6) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(7) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

18.2. Design and Construction of Overpressure Protection Systems

The following documents apply to the construction of overpressure protection devices.

(a) NB-23 *National Board Inspection Code* Part 3 (Repairs/Alterations) provides rules for repairs and alterations that are mandatory in many jurisdictions. NB-370 provides some guidance on this.

(b) PTC 25 *Pressure Relief Devices*. This document contains procedures for determining the relieving pressure and flow capacity of pressure relief devices.

(c) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

18.3. Operation of Overpressure Protection Systems

No documents listed.

18.4. In-service Inspection of Overpressure Protection Systems

The following documents apply to the in-service inspection of typical pressure vessels. They should be considered to be good engineering practices, with applicability that depends on the situation.

(a) NB-23 *National Board Inspection Code* Part 2 (Inspection) provides rules for in-service inspection that are mandatory in some jurisdictions. NB-370 provides some guidance on this. (Also, see paragraph 18.1(a)).

(b) PCC-3 *Inspection Planning Using Risk-Based Methods* can be used to develop an optimum, cost-effective inspection program for all pressure equipment. This standard uses an analytical risk-based approach to provide more detailed guidance on developing an optimum inspection plan than does NB-23. However, PCC-3 should be used as a supplement to the basic requirements in NB-23, as permitted by that document. For a small, simple boiler, the basic guidance in NB-23 may be sufficient.

(c) RP-580 *Risk-based Inspection* is similar to ASME PCC-3, but is focused on equipment in the petroleum and chemical process industries. See comments under ASME PCC-3, above.

(d) RP-581 *Base Resource Document-Risk-Based Inspection*. This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable.

(e) RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry* provides detailed descriptions of damage mechanisms and can be used to supplement the general summary descriptions in ASME PCC-3 and API RP 580. It is important to determine the damage mechanisms that can affect the equipment in the design stage because that can steer the selection of materials of construction, the corrosion allowance and possibly the design (e.g., if crevice corrosion is an applicable damage mechanism, it may be possible to eliminate crevices during design).

(f) RP 576 *Inspection of Pressure Relieving Devices.*

18.5. Fitness-for-service Analysis of Overpressure Protection Systems

No documents listed.

18.6. Repair of Overpressure Protection Systems

The following documents provide some guidance on repair methods, but most do not apply to overpressure protection devices.

(a) PCC-2 *Repair of Pressure Equipment and Piping*. PCC-2 provides guidance on a broad range of repair techniques that can be employed.

(b) PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly* provides guidance on techniques for flange joint assembly to minimize leakage in service.

19. Specific Tasks

The following documents are focused on tasks that are performed as a part of both new and post construction activities. They should be referenced when the subject activity is to be performed.

(a) RP 577 *Welding Inspection and Metallurgy*

(b) RP 582 *Welding Guidelines for the Chemical, Oil and Gas Industries*

(c) Std 1104 *Welding of Pipelines and Related Facilities*. Although 1104 was developed for pipelines, it can be used for large diameter or critical piping in process units.

(d) RP 1107 *Pipeline Maintenance Welding Practices*. Although 1107 was developed for pipelines, it can be used for large diameter or critical piping in process units.

(e) RP 2201 *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*. Although 2201 was developed for pipelines, it can be used for large diameter or critical piping in process units.

APPENDIX A SUMMARY OF STANDARDS REFERENCED

AMERICAN PETROLEUM INSTITUTE (API) STANDARDS

A-1 5UE *Recommended Practice for Ultrasonic Evaluation of Pipe Imperfections*

Current Edition:	Second Edition, June 2005 (22 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP describes procedures which may be used to “prove-up” the depth of imperfections. Included in this practice are the recommended procedures for ultrasonic prove-up inspection of new pipe using the Amplitude Comparison Technique and the Amplitude-Distance Differential Technique for evaluation of 1) surface breaking imperfections in the body of pipe, 2) surface breaking and subsurface imperfections in the weld area of electric resistance, electric induction or laser welded pipe and 3) surface breaking and subsurface imperfections in the weld area of arc welded pipe. For the purpose of this document, pipe is defined as including casing, plain-end casing liners, tubing, plain-end drill pipe, line pipe, coiled line pipe, pup joints, coupling stock and connector material. The applicable API specification, supplemental specification or contract shall constitute the basis for acceptance and disposition of the pipe inspected in accordance with this RP.
Application:	Purchasers can reference this RP in a purchase specification and manufacturers and inspection personnel can use it for conducting the test. The specifications or contract shall be the basis to determine the type and location of imperfection which must be detected by inspection, and the acceptance/rejection criteria for the imperfection.
Comments:	Prove-up inspection is a method to evaluate the radial depth of imperfections detected by automated inspection equipment or other nondestructive testing (NDT) technique(s) to determine acceptance criteria compliance with the appropriate API specification. This RP covers application, certification of testing personnel, a description of inspection methods, calibration and standardization procedures, testing procedures and quantification of imperfections and testing record contents.
User:	Purchaser: P; Manufacturer: P; Owner: ; Inspector: P; Regulator: P – Primary User S – Secondary User

A-2 Publication 327 *Aboveground Storage Tank Standards: A Tutorial*

Current Edition:	September 1994 (81 pages)
Alt. Number::	None
ANSI Approved?	No
Scope:	This document is published to help owner/ operators of aboveground storage tanks (ASTs) maintain ASTs in an environmentally safe manner. This tutorial is applicable to both the design of new tanks and the evaluation of existing tanks.
Application:	This tutorial can be used by personnel involved with the design, fabrication, maintenance, and inspection of ASTs fabricated and/or maintained per the following standards. • API SPEC 12B: Bolted Tanks for Storage of Production Liquids • API SEPC 12D: Field Welded Tanks for Storage of Production Liquids • API SPEC 12F: Shop Welded Tanks for Storage of Production Liquids • API RP 12R1: Setting, maintenance, Operation, and Repair of Tanks in Production Service • API STD 650: Welded Steel Tanks for Oil Storage • API RP 651: Cathodic Protection of Aboveground Storage Tank Bottoms • API STD 653: Tank Inspection, Repair, Alteration and Reconstruction. Application of the principles discussed in this tutorial to ASTs constructed to differing design criteria should be based on sound engineering judgments. This tutorial does not attempt to address additional rules and requirements that may be imposed by individual jurisdictions or states.
Comments:	This tutorial presents a set of procedures and examples to aid in understanding and complying with API recommended practices, specifications and standards regarding the prevention of leaks caused by bottom or shell corrosion, brittle fracture and excessive settlement. Also, they show how the API inspection and maintenance documents influence the design of new or proposed tanks. This tutorial is not meant to be used by itself; rather it is meant to be used as an aid in understanding the relevant Recommended Practices, Specifications, and Standards and to be used in conjunction with those documents.
User:	Designer: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-3 API 510 *Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration*

<table>
<tr><td>Current Edition:</td><td>Ninth Edition, 2006 (56 pages)</td></tr>
<tr><td>Alt. Number::</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>Provides rules for in-service inspection, repair, overpressure protection, alteration and rerating of pressure vessels in the petroleum and chemical process industries. Applies to vessels whether or not constructed to a recognized code. Application of API 510 is restricted to owner/users that have access to the following technically qualified individuals and organizations.
An authorized inspection agency
A repair organization
An engineer
An inspector and
Examiners.</td></tr>
<tr><td>Application:</td><td>Owners and users of pressure vessels can use API 510 to develop an in-service (post - construction) inspection program for their equipment. Other inspection planning documents as listed below can be used for inspection planning if permitted by local jurisdictional authorities:
API RP 580 “Risk-based Inspection”
API RP 581 “Base Resource Document – Risk Based Inspection.” This document provides specific, detailed guidance for risk-based inspection.
ASME PCC-3 “Inspection Planning Using Risk-Based Methods.” This document is very similar to API RP 580, but applies to equipment in areas in addition to the hydrocarbon and chemical process industries.
Owners and users of pressure equipment can use API 510, in combination with other documents as listed below, to evaluate flaws and to plan for repairs and alterations to pressure equipment. Other documents include:
API 579-1/ASME FFS-1 – “Fitness-For-Service”
ASME PCC-2 “Repair of Pressure Equipment and Piping”</td></tr>
<tr><td>Comments:</td><td>API 510 provides administrative requirements for certification of authorized pressure vessel inspectors as well as requirements for owner-user inspection organizations. API 510 also provides:
General guidance on examination techniques and pressure testing.
Descriptions of a limited number of damage (deterioration) mechanisms.
General requirements for inspection of pressure vessels.
Requirements for inspection and repair of overpressure protection devices.
Methods for determining inspection intervals.
General requirements for repairs and alterations and re-rating.</td></tr>
</table>

User:	Purchase	Consultant	Owner	Inspector	Regulator
		S	**P**	**P**	**S**
	P – Primary User S – Secondary User				

A-4 RP 520 Part I *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part I: Sizing and Selection*

Current Edition:	Seventh Edition, January 2000 (85 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This recommended practice applies to the sizing and selection of pressure relief devices used in refineries and related industries for equipment that has a maximum allowable working pressure (MAWP) of 15 psig [103 kPag] or greater. The pressure relief devices covered in this RP are intended to protect unfired pressure vessels and related equipment against overpressure from operating and fire contingencies. Atmospheric and low pressure storage tanks covered in API Standard 2000 and pressure vessels used for transportation of products in bulk or shipping containers are not within the scope of this RP. The rules for overpressure protection of fired vessels are provided for in Section 1 of the ASME Boiler and Pressure Vessel Code and ASME B31.1, and are not within the scope of this RP.
Application:	This RP can be used by pressure vessel and/or instrument designers to aid in selecting the type of pressure relief device and then to determine the appropriate size. Manufacturers of pressure vessels can use this RP to assess the adequacy of the pressure-relieving device specified by the purchaser.
Comments:	This RP includes basic definitions and information about the operational characteristics and applications of various pressure relief devices. It also includes sizing procedures and methods based on steady flow of Newtonian fluids. Pressure relief devices protect a vessel against overpressure only; they do not protect against structural failure when the vessel is exposed to extremely high temperatures such as during a fire. See API RP 521 for information about appropriate ways of reducing pressure and restricting heat input. The information in this RP is intended to supplement the information contained in Section VIII, "Pressure Vessels," of the ASME Boiler and Pressure Vessel Code. The recommendations presented in this publication are not intended to supersede applicable laws and regulations.
User:	Designer: **P**; Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-5 RP 520 Part II *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part II: Installation*

Current Edition:	Fifth Edition, August 2003 (29 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP covers methods of installation for pressure-relief devices for equipment that has a maximum allowable working pressure (MAWP) of 15 psig [103kPAg] or greater. Pressure-relief valves or rupture disks may be used independently or in combination with each other to provide the required protection against excessive pressure accumulation. As used in this RP, the term pressure-relief valve includes safety-relief valves used in either compressible or incompressible fluid service, and relief valves used in compressible fluid service. This RP covers gas, vapor, steam, two-phase and incompressible fluid service; it does not cover special applications that require unusual installation consideration.
Application:	This RP can be used by the pressure vessel designer, fabricator, and erector to aid in determining how pressure relief devices, along with the associated piping and supports, should be installed.
Comments:	This RP covers following topics: inlet piping to pressure-relief devices, discharge piping from pressure-relief devices, isolation (stop) valves in pressure-relief piping, bonnet or pilot vent piping, drain piping, pressure-relief device location and position, bolting and gasketing, multiple pressure-relief valves with staggered settings, pre-installation handling and inspection, rupture disk installation guidelines, and installation and maintenance of pin-actuated non-reclosing pressure-relief devices.
User:	Designer: **P**; Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: **P** P – Primary User S – Secondary User

A-6 Std 521 *Guide for Pressure-Relieving and Depressuring Systems*

Current Edition:	Fifth Edition, January 2007 (196 pages) (Includes errata June 2007)
Alt. Number:	ISO 23251 (Identical)
ANSI Approved?	Yes
Scope:	This international standard specifies requirements and gives guidelines for examining the principal causes of overpressure; and determining individual relieving rates; and selecting and designing disposal systems, including such component parts as piping, vessels, flares and vent stacks. This international standard does not apply to direct-fired steam boilers. This international standard is applicable to pressure-relieving and vapor-depressuring systems. Although intended for use primarily in oil refineries, it is also applicable to petrochemical facilities, gas plants, liquefied natural gas (LNG) facilities and oil and gas production facilities. The information provided is designed to aid in the selection of the system that is most appropriate for the risks and circumstances involved in various installations. This international standard is intended to supplement the practices set forth in ISO 4126 or API RP 520-I for establishing a basis of design.
Application:	For new construction, this standard can be used by process designers to aid in 1) assessing the cause of overpressure associated with various process operations, 2) determining relieving rates and 3) selecting and designing disposal systems. It can also be used for evaluating existing systems.
Comments:	This international standard covers the following topics: causes of overpressure determination of individual relieving rates, selection and design of disposal systems, determination of fire relief rates, sample calculations for sizing a subsonic flare stack, typical details and sketches and high integrity protection systems (HIPS). This International Standard is based on the draft 5th edition of API RP 521, with the intent that the 6th edition of API RP 521 will be identical to this International Standard. The portions of this international standard dealing with flares and flare systems are an adjunct to API Std 537 which addresses mechanical design, operation and maintenance of flare equipment. It is important for all parties involved in the design and use of a flare system to have an effective means of communicating and preserving design information about the flare system. To this end, API has developed a set of flare data sheets, which can be found in API Std 537, Appendix A. The use of these data sheets is both recommended and encouraged as a concise, uniform means of recording and communicating design information.
User:	Designer: **P** ; Manufacturer: ; Owner: **P** ; Inspector: **S** ; Regulator: P – Primary User S – Secondary User

A-7 Std 526 *Flanged Steel Pressure Relief Valves*

Current Edition:	Fifth Edition, June 2002 (41 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard is a purchase specification for flanged steel pressure-relief valves. Basic requirements are given for direct spring-loaded pressure-relief valves and pilot-operated pressure-relief valves as follows. • Orifice designation and area • Valve size and pressure rating, inlet and outlet • Materials • Pressure-temperature limits • Center-to-face dimensions, inlet and outlet.
Application:	Purchasers can use this standard to determine the information required for the purchase specification. Purchasers can also reference this standard in a purchase specification. Valve manufacturers can use this standard to assess the adequacy of a purchase specification.
Comments:	The topics covered in this standard are purchaser and manufacturer responsibilities, orifice area designations, determination of effective orifice area, valve selection, valve material, inspection and shop tests, identification, preparation for shipment, pressure-relief valve specification sheets and nameplate nomenclature.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: ; Regulator: P – Primary User S – Secondary User

A-8 Std 530 *Calculation of Heater-Tube Thickness in Petroleum Refineries*

Current Edition:	Sixth Edition, September 2008 (146 pages)
Alt. Number:	ISO 13704:2007 (Identical)
ANSI Approved?	Yes
Scope:	This international standard specifies the requirements and gives recommendations for the procedures and design criteria for calculating the required wall thickness of new tubes and associated component fittings for petroleum-refinery heaters. These procedures are appropriate for designing tubes for service in both corrosive and non-corrosive applications. These procedures have been developed specifically for the design of refinery and related process-fired heater tubes (direct-fired, heat-absorbing tubes within enclosures). These procedures are not intended to be used for the design of external piping, nor do they apply to boiler tubes. This international standard does not give recommendations for tube retirement thickness; Annex A describes a technique for estimating the life remaining for a heater tube.
Application:	For new equipment, this standard can be used by heater designers to determine the required thickness of the heater/boiler tubes. It can also be used for estimating the remaining life of existing heater tubes. However, the preferred mothod for remaining life assessment is provided in: • API 579-1/ASME FFS-1 *Fitness-For-Service.* This standard can be referenced in a purchase specification.
Comments:	This is a comprehensive design document intended for use by persons knowledgeable in stress calculations and materials properties.
User:	Purchaser: (blank); Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: **P** P – Primary User S – Secondary User

A-9 RP 534 *Heat Recovery Steam Generators*

Current Edition:	Second Edition, February 2007 (60 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP provides guidelines for the selection or evaluation of heat recovery steam generator (HRSG) systems. Details of related equipment designs are considered only where they interact with HRSG system design. This publication does not provide rules for design, but indicates areas that need attention and offers information and description of HRSG types available to the designer or user to aid in the selection of the appropriate HRSG system. The HRSG systems discussed are those currently in industry use. A general description of fire tube and water tube HRSG systems is given. The description of an HRSG system in this document does not imply other systems are not available or recommended. Many individual features described in these guidelines will be applicable to any type of HRSG system.
Application:	This RP can be used by designers and owners to aid in the selection of an appropriate HRSG system.
Comments:	The main topics covered in this RP are firetube heat recovery steam generators, watertube heat recovery steam generators, steam drums, heat flux and circulation ratio and sootblowers. An HRSG may be subject to boiler licensing rules, which require all inspection, maintenance, and repair tasks be conducted in accordance with specific codes, as adopted by local jurisdictions. In almost all US jurisdictions, the governing codes are the ASME Boiler and Pressure Vessel Code (BPVC) and the National Board of Boiler and Pressure Vessel Inspectors Code. The appropriate portions of the Boiler and Pressure Vessel Code include: • Section I: “Power Boilers” • Section II: “Materials” • Section III: “Nondestructive Testing” • Section VII: “Guidelines for the Care of Power Boilers” • Section IX: “Welding and Brazing Qualifications.” Of these, Section VII most directly affects the maintenance of HRSGs because it contains specific inspection and repair guidelines. Section VIII can be used as the design code when allowed by the local jurisdiction.
User:	Purchaser: [ ] · Manufacturer: [ ] · Owner: P · Inspector: P · Regulator: [ ] P – Primary User S – Secondary User

A-10 Std 560 *Fired Heaters for General Refinery Service*

Current Edition:	Fourth Edition, August 2007 (266 pages)
Alt. Number:	ISO 13705:2006 (Identical)
ANSI Approved?	Yes
Scope:	This international standard specifies requirements and gives recommendations for the design, materials, fabrication, inspection, testing, preparation for shipment and erection of fired heaters, air preheaters, fans and burners for general refinery service. This international standard is not intended to apply to the design of steam reformers or pyrolysis furnaces.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of fired heaters. This standard includes equipment data sheets for fired-heater, burner, air-preheater, fan and sootblower. The data sheets are started by the purchaser and completed by the purchaser. The information in the standard on field erection is very limited.
Comments:	The topics covered in this standard are pressure design code; regulations, purchaser's and manufacturer's responsibilities; documentation and final records; process, combustion and mechanical design; tubes; headers and return bends; piping, terminals and manifolds; tube supports; refractories and insulation; structures and appurtenances; stacks, ducts and breaching; burners and auxiliary equipment (sootblowers, fans, dampers); instrument and auxiliary connections; shop fabrication and field erection; and inspection, examination and testing. The annex titles are Equipment data sheets, Purchaser's check list, Proposed shop-assembly conditions, Stress curves for use in the design of tube-support elements, Centrifugal fans for fired-heater systems, Air preheat systems for fired-process heaters, Measurement of efficiency of fired-process heaters and Stack design. There are numerous (67) documents referenced in this standard that are stated to be indispensable for the application of the standard.
User:	Purchasser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: **S** P – Primary User S – Secondary User

A-11 API 570 *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems*

Current Edition:	Second Edition, 1998 through Addendum 4, June 2006 (38 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	Provides rules for in-service inspection, repair, alteration and rerating of piping. It was developed for the petroleum and chemical process industries, but may be used, where practical, for any piping system. Applies to piping whether or not constructed to a recognized code. It is intended for use by organizations that have access to the following. • An authorized inspection agency, • A repair organization, • Technically qualified piping engineers, • Inspectors, and • Examiners
Application:	Owners and users of piping systems can use API 570 to develop an in-service (post-construction) inspection program for their equipment. Other inspection planning documents as listed below can be used for inspection planning if permitted by local jurisdictional authorities: • API RP 580 "Risk-based Inspection" • API RP 581 "Base Resource Document – Risk Based Inspection." This document provides specific, detailed guidance for risk-based inspection. • ASME PCC-3 "Inspection Planning Using Risk-Based Methods." This document is very similar to API RP 580, but applies to equipment in areas in addition to the hydrocarbon and chemical process industries. Owners and users of pressure equipment can use API 570, in combination with other documents as listed below, to evaluate flaws and to plan for repairs and alterations to pressure equipment. Other documents include: • API 579-1/ASME FFS-1 *Fitness-For-Service* • ASME PCC-2 "Repair of Pressure Equipment and Piping."
Comments:	API 570 provides administrative requirements for certification of authorized piping inspectors as well as requirements for owner-user inspection organizations. API 570 also provides: • Guidance on examination techniques, including specific guidance for: o Injection points o Deadlegs o Corrosion under insulation o Environmental and fatigue cracking o Corrosion under linings and deposits o Creep cracking o Buried piping • Methods for selecting thickness measurement locations (TMLs) and for determining inspection intervals based on piping classification. • General requirements for repairs, alterations and re-rating.

<table>
<tr><td rowspan="1">User:</td><td>

Purchaser	Consultant	Owner	Inspector	Regulator
	S	**P**	**P**	**S**

P – Primary User
S – Secondary User
</td></tr>
</table>

A-12 RP 571 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

Current Edition:	First Edition, December 2003 (257 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	Provides detailed descriptions of the damage mechanisms that can affect pressure equipment in the refining and petrochemical industries.
Application:	Owners and users of piping systems, particularly plant inspection personnel, can use API 571 to assist in identifying the likely causes of damage in equipment. When the most likely types of damage have been identified, an inspection program can be designed to locate the damage before a failure occurs.
Comments:	API 571 provides detailed descriptions of approximately 70 damage mechanisms. Of these, 44 apply generally to a broad range of industries. The description of each damage mechanism includes: A description of the damage and the materials affected. A list of the “critical factors” or variables that lead to the damage. The appearance or morphology of the damage, often with photographs. Prevention/mitigation, inspection and monitoring techniques The descriptions of the damage mechanisms are much more detailed than the descriptions in ASME PCC-3 and API RP 580. Note that WRC Bulletin 489 is a “sister document” to API RP 571.
User:	Purchaser: — ; Consultant: **S** ; Owner: **P** ; Inspector: **P** ; Regulator: **S** P – Primary User S – Secondary User

A-13 RP 572 *Inspection of Pressure Vessels (Towers, Drums, Reactors, Heat Exchangers, and Condensers)*

Current Edition:	Second Edition, February 2001 (65 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP covers the inspection of pressure vessels. It includes a description of the various types of pressure vessels and the standards for their construction and maintenance. The reasons for inspection, causes of deterioration, frequency and methods of inspection, methods of repair and preparation of records and reports are covered. Safe operation is emphasized.
Application:	This RP can be used by inspectors and plant owners as an aid in the proper inspection of refinery and petrochemical plant pressure vessels. It can also be used by consultants and regulators as an aid in assessing the adequacy of a plant's inspection program.
Comments:	The main topics covered in this RP are types of pressure vessels, construction standards, maintenance inspection, reasons for inspections, causes of deterioration, frequency and time of inspection, inspection methods and limitations, methods of repair and records and reports. It also has an appendix describing heat exchanger types and an appendix with sample inspection sheets and report forms. The information contained in this RP was previously presented as Chapter VI and Chapter VII of the Guide for Inspection of Refinery Equipment. The information in this RP does not constitute, and should not be construed as, a code of rules, regulations or minimum safe practices. The practices described in this publication are not intended to supplant other practices that have proven satisfactory, nor is this publication intended to discourage innovation and originality in the inspection of pressure vessels. Users of this RP are reminded that no book or manual is a substitute for the judgment of a responsible, qualified person.
User:	Purchaser: (blank); Consultant: **S**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-14 RP 573 *Inspection of Fired Boilers and Heaters*

Current Edition:	Second Edition, February 2003 (69 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP covers the inspection practices for fired boilers and process heaters (furnaces) used in petroleum refineries and petrochemical plants. It includes a description of the common heater and boiler designs, and a synopsis of reliability programs/philosophy for these items. The practices described in this document are focused to improve equipment reliability and plant safety by describing the operating variables which impact reliability, and to ensure that inspection practices obtain the appropriate data, both on-stream and off-stream, to assess current and future performance of the equipment.
Application:	This RP can be used by inspectors and plant owners as an aid in the proper inspection of refinery and petrochemical plant fired boilers and heaters. It can also be used by consultants and regulators as an aid in assessing the adequacy of a plant's inspection program.
Comments:	The main topics covered in this RP are common heater and boiler designs; heater and boiler mechanical reliability; deterioration mechanisms; frequency and timing of inspections; safety precautions, preparatory work and cleaning; outage inspection programs; boiler outage inspection; on-stream inspection programs; tube reliability assessment; method of inspection for foundations, settings and other appurtenances; repairs; and records and reports. It also includes three appendices: 1) Sample inspection checklists for heaters and boilers, 2) Sample heater inspection records and 3) Sample semiannual stack inspection record.
User:	Purchaser: (blank); Consultant: **S**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-15 RP 574 *Inspection Practices for Piping System Components*

Current Edition:	Second Edition, June 1998 (53 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP covers the inspection practices for piping, tubing, valves (other than control valves) and fittings used in petroleum refineries and petrochemical plants. Although this publication is not specifically intended to cover specialty items, many of the inspection methods described in this RP are applicable to specialty items such as control valves, level gages, instrument controls columns, etc.
Application:	This RP can be used by inspectors and plant owners as an aid in the proper inspection of piping systems in refineries and petrochemical plants. It can also be used by consultants and regulators in assessing the adequacy of a plant's inspection program.
Comments:	The main topics covered in this RP are piping components; reasons for inspection; inspecting for deterioration in piping; frequency and time of inspection; safety precautions and preparatory work; inspection tools; inspection procedures; determination of retirement thickness; and records. It also contains a one page appendix, External Inspection Checklist for Process Piping, with the headings: leaks, misalignment, vibration, supports, corrosion and insulation. Some of the information contained in this RP was previously presented as a Chapter XI of the Guide for Inspection of Refinery Equipment, which is currently being reorganized as individual RPs. The information in this RP does not constitute and should not be construed as a code of rules, regulations or minimum safe practices. The practices described on this RP are not intended to supplant other practices that have proven satisfactory, nor is this RP intended to discourage innovation and originality in the inspection of refineries and chemical plants. Users of this RP are reminded that no book or manual is a substitute for the judgment of a responsible, qualified inspector or piping engineer.
User:	Purchaser: – ; Consultant: S ; Owner: P ; Inspector: P ; Regulator: S P – Primary User S – Secondary User

A-16 RP 575 *Guidelines and Methods for Inspection of Existing Atmospheric and Low-pressure Storage Tanks*

Current Edition:	Second Edition, May 2005 (68 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This document provides useful information and recommended practices for the maintenance and inspection of atmospheric and low-pressure storage tanks. While some of these guidelines may apply to other types of tanks, these practices are intended primarily for existing tanks that were constructed to API Spec 12A and API Spec 12C, and API Std 620 and API Std 650.
Application:	This RP can be used by inspectors and plant owners as an aid in the proper inspection of atmospheric and low-pressure storage tanks used in refineries and petrochemical plants. It can also be used by consultants and regulators in assessing the adequacy of a plant's inspection program.
Comments:	The main topics covered in this RP are reasons for inspection; causes of deterioration; inspection frequency and scheduling; methods of inspection; leak testing and hydraulic integrity of the bottom; integrity of repairs and alterations; and records. It also includes three appendices: 1) Selected nondestructive examination (NDE) methods, 2) Similar service evaluation tables and 3) Selected bibliography. Some of the information contained in this RP was previously presented as Chapter XIII of the API Guide for Inspection of Refinery Equipment, which is being reorganized as an individual RP. The information in this RP does not constitute, and should not be construed as, a code of rules, regulations or minimum safe practices. The practices described on this RP are not intended to supplant other practices that have proven satisfactory, nor is this recommended practice intended to discourage innovation and originality in the inspection of refineries and chemical plants. Users of this RP are reminded that no book or manual is a substitute for the judgment of a responsible, qualified inspector or piping engineer.
User:	Purchaser: — ; Consultant: **S** ; Owner: **P** ; Inspector: **P** ; Regulator: **S** P – Primary User S – Secondary User

A-17 RP 576 *Inspection of Pressure-Relieving Devices*

Current Edition:	Second Edition, December 2000 (46 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP describes the inspection and repair practices for automatic pressure-relieving devices commonly used in the oil and petrochemical industries. As a guide to the inspection and repair of these devices in the user's plant, it is intended to ensure their proper performance. This RP covers such automatic devices as pressure-relief valves, pilot-operated pressure-relief valves, rupture disks and weight-loaded pressure vacuum vents. The recommendations in this RP are not intended to supersede requirements established by regulatory bodies. This RP does not cover weak seams or sections in tanks, explosion doors, fusible plugs, control valves or other devices that either depend on an external source of power for operation or are manually operated. Inspections and tests made at manufacturers' plants, which are usually covered by codes or purchase specifications, are not covered by this publication. This RP does not cover training requirements for mechanics involved in the inspection and repair of pressure-relieving devices. Those seeking these requirements should see API 510, which gives the requirements for a quality control system and specifies that the repair organization maintain and document a training program ensuring that personnel are qualified.
Application:	This RP can be used by inspectors and plant owners as an aid in the proper inspection of pressure-relieving devices used in the oil and petrochemical industries. It can also be used by consultants and regulators in assessing the adequacy of a facility's inspection program.
Comments:	The main topics covered in this RP are dimensional and operational characteristics; pressure-relieving valves (descriptions, applications and limitations); pressure-relieving rupture disks (descriptions, applications and some limitations); causes of improper performance; inspection and testing; and records and reports. It also includes two appendices: 1) Sample record and report forms and 2) Pressure relief valve testing. The repair practices given in this RP are limited.
User:	Maintenance: **S** Consultant: **S** Owner: **P** Inspector: **P** Regulator: **S** P – Primary User S – Secondary User

A-18 RP 577 *Welding Inspection and Metallurgy*

Current Edition:	First Edition, October 2004 (100 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP provides guidance to the API authorized inspector on welding inspection as encountered with fabrication and repair of refinery and chemical plant equipment and piping. Common welding processes, welding procedures, welder qualifications, metallurgical effects from welding and inspection techniques are described to aid the inspector in fulfilling his role implementing API 510, API 570, API Std 653 and API RP 582. The level of learning and training obtained from this document is not a replacement for the training and experience required to be an American Welding Society (AWS) Certified Welding Inspector (CWI). This RP does not require all welds to be inspected; nor does it require welds to be inspected to specific techniques and extents. Welds selected for inspection, and the appropriate inspection techniques, should be determined by the welding inspectors, engineers or other responsible personnel using the applicable code or standard. The importance, difficulty, and problems that could be encountered during welding should be considered by all involved. A welding engineer should be consulted on any critical, specialized or complex welding issues.
Application:	This RP can be used by inspectors as an aid in proper welding inspection. It can also be used as a general welding resource by manufacturers, erectors and consultants.
Comments:	The main topics covered in this RP are welding inspection tasks (prior to, during and upon completion of welding); welding processes (for 6 types–descriptions, advantages and limitations); welding procedure (specification and qualification record); welding materials; welder qualification; non-destructive examination; metallurgy; and refinery and petrochemical plant welding issues. It also includes five appendices: 1) Terminology and symbols, 2) Actions to address improperly made production welds, 3) Welding procedure review, 4) Guide to common filler metal selection, and 5) Example report of RT results.
User:	Erector: **S**; Manufacturer: **S**; Consultant: **S**; Inspector: **P**; Regulator: (blank) P – Primary User S – Secondary User

A-19 RP 578 *Material Verification Program for New and Existing Alloy Piping Systems*

Current Edition:	First Edition, May 1999 (7 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	The purpose of this RP is to provide the guidelines for a material and quality assurance system to verify that the nominal composition of alloy components within the pressure envelope of a piping system is consistent with the selected or specified construction materials to minimize the potential for catastrophic release of toxic or hazardous liquids or vapors. This RP provides the guidelines for material control and material verification programs on ferrous and nonferrous alloys during the construction, installation, maintenance and inspection of new and existing process piping systems covered by ASME B31.3 and API 570 piping codes. This practice applies to metallic alloy materials purchased for use either directly by the owner/user or indirectly through vendors, fabricators, or contractors and includes the supply, fabrication and erection of these materials. **Carbon steel components specified in new or existing piping systems are not specifically covered under the scope of this document.**
Application:	A material verification program for piping systems may involve participation of several groups within the operating plant or the shop of a contractor, vendor or fabricator. When establishing a material verification program, consideration should be given to the roles and responsibilities that each group has within the specific organization. These roles and responsibilities should be clearly defined and documented. Within the operating plant, this can include those groups responsible for purchasing, engineering, warehousing/receiving, operating, reliability, maintenance and inspection.
Comments:	The main topics covered in this RP are extent of verification (new and existing piping); material verification program test methods; evaluation of PMI test results; and marking and record-keeping. When determining the need to perform material verification on carbon steel systems, the effect that the process steam could have on substituted alloy materials should be evaluated. In some cases, the substitution of hardenable alloy materials in carbon steel piping systems resulted in failure and loss of containment. Examples of such systems include wet hydrogen sulfide (H_2S), hydrofluoric acid (HF) and sulfuric acid (H_2SO_4) services.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Erector: **P** P – Primary User S – Secondary User

A-20 API 579-1/ASME FFS-1 *Fitness-For-Service*

Current Edition:	June 5, 2007 (approx. 925 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Provides methods for evaluating flaws that are found in pressure equipment, usually as a result on an in-service inspection, to determine acceptability for continued service
Application:	Owners and users of pressure equipment can use the methods in this standard to evaluate flaws that are discovered during an inspection of boilers, pressure vessels, piping and storage tanks.
Comments:	Detailed rules for the evaluation of the following types of flaws and damage are provided. • Potential for brittle fracture and creep damage • General or widespread metal loss due to corrosion, erosion or other causes • Local metal loss due to corrosion, pitting, erosion, gouging or other causes • Misalignment, distortion, dents, etc. • Cracking due to fatigue, the environment, creep, hydrogen damage, etc. Three levels of evaluation are provided covering screening that can be done by plant inspection personnel (Level 1), engineering evaluations that can be done by plant engineers (Level 2) and more detailed evaluations that require the services of experts (Level 3).
User:	Purchaser: – ; Consultant: P ; Owner: P ; Inspector: P ; Regulator: S P – Primary User S – Secondary User

A-21 RP-580 *Risk-Based Inspection*

Current Edition:	First Edition, May 2002 (46 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Provides guidance for developing and implementing a risk-based inspection program for fixed pressure-containing equipment and components in the hydrocarbon and chemical process industry. The approach is focused on maintaining mechanical integrity.
Application:	Owners and users of pressure equipment can use the guidance in this standard to develop an in-service (post-construction) inspection program for their equipment. The guidance applies broadly to boilers, pressure vessels, piping, pipelines and storage tanks. However, other standards that are specific to one or more of these equipment types should also be consulting in developing inspection plans. These include: • API RP 581 "Base Resource Document – Risk Based Inspection." This document provides specific, detailed guidance for risk-based inspection. • API 510 – "Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair, and Alteration" for pressure vessels in refining and chemical process services. • API 570 – "Inspection, Repair, Alteration, and Rerating of In-service Piping Systems" for piping systems. Although developed for the refining and chemical process industries, it may be used, where practical, for any piping system.
Comments:	API RP 580 provides an overall methodology that can be used to develop an inspection plan using risk-base methods. It provides guidance and detailed tables to assist in defining the damage (deterioration) mechanisms that can affect pressure equipment. It provides methods for establishing RBI teams to determine the probability and consequence of failure and to calculate the risk of continued operation. The result of applying the process is an optimized, cost-effective inspection plan.
User:	Purchaser: — ; Consultant: **S** ; Owner: **P** ; Inspector: **P** ; Regulator: **S** P – Primary User S – Secondary User

A-22 RP-581 *Risk-Based Inspection: Base Resource Document*

Current Edition:	September 2008 (607 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This document provides a detailed, prescriptive methodology for determining inspection methods and intervals. It provides one method of implementing the more general guidance in ASME PCC-3 and API RP 580 for refinery and some chemical plant equipment. Since the document relies on damage mechanism information that is specific to certain refinery processes (e.g., fluid catalytic cracking), it is not universally applicable. The methodology is based on the experience of experts in the refining industry and provides consistent results among refineries with similar process units.
Application:	The RP can be applied to most refinery units by typical refinery inspection and materials engineering personnel.
Comments:	This RP is particularly valuable for refineries that have smaller or less experienced staffs, since it provides probabilities (likelihoods) and consequences of failure based on input of parameters that are readily obtained, such as process fluids, materials of construction, temperatures, pressures and volume of fluid in the equipment. This reduces the need to make judgments based on experience and expertise.
User:	Purchaser: – ; Consultant: **S**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-23 RP 582 *Welding Guidelines for the Chemical, Oil and Gas Industries*

<table>
<tr><td>Current Edition:</td><td>First Edition, March 2001 (14 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>No</td></tr>
<tr><td>Scope:</td><td>This RP, initiated and developed through the joint efforts of API and Process Industry Practices (PIP), provides supplementary guidelines and practices for welding and welding-related topics for shop and field fabrication, repair and modification of:
• Pressure-containing equipment (such as pressure vessels, heat exchangers, tankage, piping, heater tubes, pressure boundaries or rotating equipment, and attachments welded thereto)
• Non-removable internals for pressure vessels
• Structural items attached and related to process equipment
• Any other equipment or component item when referenced by an applicable purchase document.
This document is general in nature and is intended to augment the welding requirements of ASME Section IX and similar codes, standards and practices such as those issued by API, ASME, ASTM, AWS, NACE and the National Board. The intent of this document is to be inclusive of chemical, oil and gas industry standards, although there are many areas not covered, e.g., pipeline welding and offshore structural welding.
This document is based on industry experience and any restrictions or limitations may be waived or augmented by the purchaser.</td></tr>
<tr><td>Application:</td><td>This RP can be used by manufacturers and field contractors as an aid in establishing welding procedures. It can also be used by the equipment owners as an aid in developing a welding specification.</td></tr>
<tr><td>Comments:</td><td>The main topics covered in this RP are general welding requirements; welding processes; filler metal and flux; shielding and purging gases; preheating and interpass temperature; postweld heat treatment; cleaning and surface preparation; special procedure qualification requirements/testing (general and tube-to-tubesheet welding); and other items (backing materials, peening, overlay and clad restoration, temporary attachments, stud welding and hardness testing). It also includes two appendices: 1) Welding consumables for shielded metal arc welding and 2) Weld overlay and clad restoration (back cladding).
As indicated in Scope above, this is not a stand-alone document and is intended to augment other welding codes, standards and practices.</td></tr>
<tr><td>User:</td><td><table><tr><td>Field Contractor</td><td>Manufacturer</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr><tr><td>**P**</td><td>**P**</td><td>**P**</td><td></td><td></td></tr></table>P – Primary User
S – Secondary User</td></tr>
</table>

A-24 RP 591 *Process Valve Qualification Procedure*

Current Edition:	Third Edition, September 2003 (9 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP provides recommendations for evaluation of a manufacturer's valve construction and quality assurance program for the purpose of determining a manufacturer's capability to provide new valves manufactured in accordance with the following API standards: 594, 599, 600, 602, 603, 608 and 609. Qualification of valves under this RP is "manufacturing facility specific" and does not cover valves manufactured by other manufacturing facilities, whether owned by the same manufacturer or a third party.
Application:	This RP can be used by the valve end user or purchaser, e.g., contractor, as an aid in assessing a valve manufacturer's capability to supply quality products.
Comments:	The main topics covered in this RP are purchaser responsibilities; manufacturer quality assurance program (documentation, control of purchased items and services, in-house inspection and testing, handling, storage, shipment, corrective action and audits); valve qualification (independent testing laboratory requirements, selection of valves to be tested, required testing and documentation of test results); and post qualification. It also includes two appendices: 1) Suggested selection quantities for examination and test of valves made in accordance with API Valve Standards and 2) Strength tests for stem-shaft-to-closure-element connections.
User:	Purchaser: — ; Consultant: **P** ; Owner: **P** ; Inspector: — ; Regulator: — P – Primary User S – Secondary User

A-25 Std 594 *Check Valves: Flanged, Lug, Wafer and Butt-Welding*

Current Edition:	Sixth Edition, September 2004 (11 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	Design, material, face-to-face dimensions, pressure-temperature ratings and examination, inspection and test requirements for check valves.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. Regulators can reference as desired.
Comments:	This standard covers lug and wafer type check valves in sizes NPS 2 through 48 and pressure-temperature classes 125 through 2500. Actual pressure-temperature ratings are not provided, but follow the ratings for the applicable class in ASME B16.1, B16.42 or B16.34 depending on the material. Standard face-to-face dimensions are provided, as well as body thickness requirements.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: **S** P – Primary User S – Secondary User

A-26 Std 598 *Valve Inspection and Testing*

Current Edition:	Eighth Edition, May 2004 (7 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers inspection, examination, supplementary examinations and pressure test requirements for resilient-seated, nonmetallic-seated (e.g., ceramic) and metal-to-metal-seated valves of the gate, globe, plug, ball, check and butterfly types. Resilient seats are considered to be: • Soft seats, both solid and semi-solid grease type (e.g., lubricated plug) • Combination soft and metal seats • Any other type valve designed to meet resilient seat leakage rates as specified in Table 5 of this standard. API Std 598 supplements API standards that reference it, but it may also be applied to other types of valves by agreement between the purchaser and the valve manufacturer. The inspection requirements pertain to examinations and testing by the manufacturer and any supplementary examinations that the purchaser may require at the valve manufacturer's plant. The test requirements cover both required and optional pressure tests at the valve manufacturer's plant.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers need it to comply with the purchase specification when the standard is cited therein. It can also be used as a reference for shop inspection.
Comments:	The main topics covered in this standard are inspection at the manufacturer's plant; inspection outside the manufacturer's plant; examination; pressure tests; pressure test procedures; and certification and retesting. The following tests and examinations are specified in this standard: • Shell test • Backseat test • Low-pressure closure test • High-pressure closure test • Visual examination of castings • High-pressure pneumatic shell test.
User:	Purchaser: **P** / Manufacturer: **P** / Owner: / Inspector: **S** / Regulator: P – Primary User S – Secondary User

A-27 Std API 600/ISO 10434 *Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries*

Current Edition:	Eleventh Edition, October 2001 (41 pages) Reaffirmed, November 2006
Alt. Number:	ISO 10434:2001 (Modified)
ANSI Approved?	Yes
Scope:	This international standard specifies the requirements for a heavy duty series of bolted bonnet steel gate valves for petroleum refinery and related applications where corrosion, erosion and other service conditions indicate a need for full port openings, heavy wall sections and extra large stem diameters. This specification sets forth the requirements for the following gate valve features. • Bolted bonnet • Outside screw and yoke • Rising stems • Non-rising handwheels • Single or double gate • Wedge or parallel seating • Metallic seating surfaces • Flanged or butt-welded ends. It covers valves of the nominal sizes DN: 25, 32, 40, 50, 65, 80, 100, 150, 200, 250, 300, 350, 400, 450, 500, 600, and is applicable for pressure designations PN: 20, 50, 110, 150, 260, 420, when metric sized bolt holes are provided in end flanges and PN designations are marked on the valve body. It also covers valves of the corresponding nominal pipe sizes NPS: 1, 1 ¼, 2, 2 ½, 3, 4, 6, 8, 10, 12, 14, 16, 18, 20, 24 and applies for equivalent nominal Class ratings: 150, 300, 600, 900, 1500, 2500, when inch-sized bolt holes are provided in end flanges and class designations are marked on the valve body. It also covers additional marking requirements for valves that are PN (or class) designated but have flanges drilled for inch (or metric) bolt holes.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of bolted bonnet steel gate valves. It can also be used as a reference for shop inspection.
Comments:	The purpose of this international standard is to establish, in ISO format, the basic requirements and practices for flanged and butt-welding end steel gate valves of bolted bonnet construction which parallel those given in American Petroleum Institute Standard API 600, Tenth Edition. In order to maintain compatibility with the flanges defined in ISO 7005-1 and the flanges in the American National Standard ASME B16.5, valves have been designated to be PN-marked for the former and Class-marked for the latter. It is not the purpose of this international standard to replace ISO 6002 or any other international standard which is not identified with petroleum refinery or natural gas industry applications. It does, however, supersede API 600, Tenth Edition. This standard gives thickness and/or other requirements (directly or by reference to other standards) for the following valve components: body, bonnet, flanged ends, welded ends, gate, yoke, stem, stem nut, packing, bolting and auxiliary connections. It also covers (directly or by reference to other standards) materials, repair, testing, inspection, examination, marking and preparation for shipment.

User:	Purchaser	Manufacturer	Owner	Inspector	Regulator
	P	**P**		**S**	
	P – Primary User S – Secondary User				

A-28 Std 602 *Steel Gate, Globe and Check Valves for Sizes DN 100 and Smaller for the Petroleum and Natural Gas Industries*

Current Edition:	Eighth Edition, February 2005 (59 pages)
Alt. Number:	ISO 15761:2002
ANSI Approved?	Yes
Scope:	This international standard specifies the requirements of a series of compact steel gate, globe and check valves for petroleum and natural gas industry applications. It is applicable to valves of: • Nominal size DN 8, 10, 15, 20, 25, 32, 40, 50, 65, 80 and 100 • Corresponding to nominal pipe sizes NPS ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2 ½, 3 and 4 • Corresponding to pressure designations of Class 150, Class 300, Class 600, Class 800 and Class 1500. Class 800 is not a listed class designation, but is an intermediate class number widely used for socket-welding and threaded end compact valves. It includes provisions for the following valve characteristics. • Outside screw with rising stems (OS &Y), in sizes 8 ≤ DN ≤ 100 and pressure designations 150 ≤ Class ≤ 1500 including Class 800 • Inside screw with rising stem (ISRS), in sizes 8 ≤ DN ≤ 65 and pressure designations of Class < 800 • Socket-welding or threaded ends, in sizes 8 ≤ DN ≤ 65 and pressure designations of Class 800 and Class 1500 • Flanged or butt-welding ends, in sizes 15 ≤ DN ≤ 100 and pressure designations of 150 ≤ Class ≤ 1500, excluding flanged end Class 800 • Bonnet joint construction – bolted, welded and threaded with seal weld for Class ≤ 1500 and union nut for Class < 800 • Body seat openings • Materials, as specified • Testing and inspection. This international standard is applicable to valve end flanges in accordance with ASME B 16.5 and valve body ends having tapered pipe threads to ISO 7-1 or ASME B 1.20.1. It is applicable to extended body construction in sizes 15 ≤ DN ≤ 50 and pressure designations of Class 800 and Class 1500, and to bellows and bellows assembly construction as may be adaptable to gate or globe valves in sizes 8 ≤ DN ≤ 50. It covers bellows steam seal type testing requirements.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of steel gate, globe and check valves. It can also be used as a reference for shop inspection.

Comments:	The purpose of this international standard is to establish basic requirements and practices for socket-welding, butt-welding, threaded and flanged end, steel gate, globe and check valves with reduced body seat openings, whose general construction parallels that specified by the American Petroleum Institute standard API 602 and the British Standard BS 5352. The main topics covered by this standard are design; materials; marking; testing and inspection; and preparation for shipment. There are seven annexes in support of these topics: 1) Requirements for extended body gate valve bodies, 2) Requirements for valves with bellows stem seals, 3) Type testing of bellows stem seals, 4) Identification of valve parts, 5) Information to be specified by the purchaser, 6) Valve material combinations and 7) Modifications to ISO 15761.
User:	<table><tr><td>Purchaser</td><td>Manufacturer</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr><tr><td>**P**</td><td>**P**</td><td></td><td>**S**</td><td></td></tr></table>P – Primary User S – Secondary User

A-29 Std 607 *Testing of Valves-Fire Type—Testing Requirements*

Current Edition:	Fifth Edition, June 2005 (16 pages)
Alt. Number:	ISO 10497
ANSI Approved?	Yes
Scope:	Specifies fire type-testing requirements and a fire type-test method for confirming the pressure-containing capability of a valve under pressure during and after the fire test. It does not cover the testing requirements for valve actuators other than manually operated gear boxes or similar mechanisms when these form part of the normal valve assembly. Other types of valve actuators (e.g., electrical, pneumatic or hydraulic) may need special protection to operate in the environment considered in this valve test, and the fire testing of such actuators is outside the scope of this standard.
Application:	This standard is intended for use by valve manufacturers and testing facilities for conducting and reporting on fire testing of valves.
Comments:	This standard covers straightway soft-seated quarter-turn valves. It applies to all classes and sizes of such valves that are made of materials listed in ASME B16.34.
User:	Purchaser: — ; Manufacturer: **P** ; Testing Laboratory: — ; Inspector: — ; Regulator: — P – Primary User S – Secondary User

A-30 Std 608 *Metal Ball Valves-Flanged, Threaded and Butt-Welding Ends*

Current Edition:	Fourth Edition, December 2008 (17 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers Class 150 and 300 metal ball valves used in on-off service that have butt-welding of flanged ends for nominal pipe sizes NPS ½ through NPS 12 and threaded or socket-welding ends for sizes NPS ½ through NPS 2, corresponding to the nominal pipe sizes in ASME B36.10M. Also covers additional requirements for ball valves that are otherwise in full conformance to the requirements of ASME B16.34, Standard Class.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also reference for inspection at the manufacturer's plant.
Comments:	This standard establishes requirements for bore sizes described as: • Full bore • Single reduced bore • Double reduced bore.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-31 Std 609 *Butterfly Valves: Double Flanged, Lug- and Water-Type*

Current Edition:	Sixth Edition, May 2004
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers design, materials, face-to-face dimensions; pressure-temperature ratings; and examination, inspection and test requirements for gray iron, ductile iron, bronze, steel, nickel-base alloy or special alloy butterfly valves that provide tight shutoff in the closed position and are suitable for flow regulation.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspection at the manufacturer's plant.
Comments:	Two categories of butterfly valves are included: • Category A: Sizes covered are NPS 2 to NPS 48 for ASME Class 125 or Class 150 • Category B: Sizes covered are NPS 3 to NPS 48 for ASME Classes 150, 300 and 600. The ranges of size/class vary with the style of the valve.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-32 Std 620 *Design and Construction of Large, Welded, Low-pressure Storage Tanks*

Current Edition:	Eleventh Edition, February 2008 (Approx 200 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	**General** The API Downstream Segment has prepared this standard to cover large, field-assembled storage tanks of the type described below that contain petroleum intermediates (gases or vapors) and finished products, as well as other liquid products commonly handled and stored by the various branches of the industry. The rules presented in this standard cannot cover all details of design and construction because of the variety of tank sizes and shapes that may be constructed. Where complete rules for a specific design are not given, the intent is for the manufacturer – subject to the approval of the purchaser's authorized representative – to provide design and construction details that are as safe as those which would otherwise be provided in this standard. The manufacturer of a low-pressure storage tank that will bear the API 620 nameplate shall ensure that the tank is constructed in accordance with the requirements of this standard. The rules presented in this standard are further intended to ensure that the application of the nameplate shall be subject to the approval of a qualified inspector who has made the checks and inspections that are prescribed for the design, materials, fabrication and testing of the completed tank. **Coverage** This standard covers the design and construction of large, welded, low-pressure carbon steel above ground storage tanks (including flat-bottom tanks) that have a single vertical axis of revolution. This standard does not cover design procedures for tanks that have walls shaped in such a way that the walls cannot be generated in their entirety by the rotation of a suitable contour around a single vertical axis of revolution. The tanks described in this standard are designed for metal temperatures not greater than 250°F and with pressures in their gas or vapor spaces not more than 15 $lbf/in.^2$ gauge. The basic rules in this standard provide for installation in areas where the lowest recorded 1-day mean atmospheric temperature is –50°F. Appendix S covers stainless steel low-pressure storage tanks for refrigerated products at temperatures from +40°F to –60°F. Appendix Q covers low-pressure storage tanks for liquefied hydrocarbon gases at temperatures not lower than –270°F. The rules in this Standard are applicable to tanks that are intended to (a) hold or store liquids with gases or vapors above their surface or (b) hold or store gases or vapors alone. These rules do not apply to lift-type gas holders. Although the rules in this standard do not cover horizontal tanks, they are not intended to preclude the application of appropriate portions to the designs and construction of horizontal tanks designed in accordance with good engineering practice. The details for horizontal tanks not covered by these rules shall be equally as safe as the design and construction details provided for the tank shapes that are expressly covered by this standard.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication/erection of large, welded, low-pressure storage tanks. It can also be used as a reference for shop and field fabrication/erection inspection. Regulators can reference as desired.

Comments:	This is a comprehensive document covering the following main topics: materials; design; fabrication; inspection, examination and testing; marking; and pressure and vacuum-relieving devices. It also includes 19 appendices in support of these topics.
User:	Purchaser: **P** Manufacturer: **P** Owner: Inspector: **P** Regulator: **S** P – Primary User S – Secondary User

A-33 RP 621 *Reconditioning of Metallic Gate, Globe, and Check Valves*

Current Edition:	Second Edition, December 2005 (18 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP provides guidelines for reconditioning heavy wall (API 600 type) carbon steel, ferritic alloy (up to 9% Cr), stainless steel, and nickel alloy gate, globe and check valves for ASME pressure classes 150, 300, 400, 600, 900, 1500 and 2500. Guidelines contained in this RP apply to flanged and butt-weld cast or forged valves. This RP does not cover reconditioning or re-manufacturing of used or surplus valves intended for resale. The only intent of this RP is to provide guidelines for refurbishing an end user's (owner's) valves for continued service in the owner's facility. Valves reconditioned or re-manufactured to this RP may not meet API standard requirements for new valves. The correct application of a valve reconditioned to this practice remains the responsibility of the owner. It is an expectation of this RP that a contractual agreement shall be established between the owner and the valve reconditioning facility. The reconditioning facility may be OEM owned/operated, or directly associated and approved by the OEM. At the owner's option, an independent facility may be used. The owner shall determine that the facility selected for valve reconditioning has a documented and established working quality assurance program. The quality assurance program should include the essential elements described in Section 7 of API RP 591 or follow the principles of an appropriate standard from the ISO 9000 Series.
Application:	This RP can be used by the owner and the reconditioner as an aid in reconditioning valves.
Comments:	This RP covers what information should be provided to the reconditioner by the owner, and how the owner should prepare the valve for shipment to the reconditioner. For the reconditioner, it provides guidance on how to assess and take action on each valve component. It also covers, for the reconditioner (some with owner approval or input), welding, non-destructive examination, pressure test, preparation for shipment and tagging.
User:	Purchaser: ; Reconditioner: **P**; Owner: **P**; Inspector: ; Regulator: P – Primary User S – Secondary User

A-34 RP 622 *Type Testing of Process Valve Packing for Fugitive Emissions*

<table>
<tr><td>Current Edition:</td><td>First Edition, August 2006 (24 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>No</td></tr>
<tr><td>Scope:</td><td>This API standard specifies the requirements for comparative testing of block valve stem packing for process applications where fugitive emissions are a consideration. Packing(s) shall be suitable for use at –20°F to 1000°F (–29°C to 538°C). Factors affecting fugitive emissions performance that are considered by this standard include temperature, pressure, thermal cycling, mechanical cycling and corrosion.
This standard does not provide acceptance criteria for valve packing, nor is it intended to replace proof testing of valve assemblies or valve production testing.
This standard establishes requirements and parameters for the following packing tests.
• Fugitive emissions
• Corrosion
• Packing material.
Test methods apply to valve packing for use with the following stem motion(s):
• Rising stem (e.g., gate valves)
• Rotating stem (e.g., ball valves).
The test for fugitive emissions is based upon elements of EPA Method 21, providing comparative values of packing performance.
Suitability of packing tested to this standard for use in a manufacturer’s valve may be confirmed by re-testing the packing in the actual valve in accordance with the procedures in Section 4 of this standard. Acceptance criteria shall be by mutual agreement between the valve manufacturer and purchaser.</td></tr>
<tr><td>Application:</td><td>This standard can be used by packing manufacturers and testing laboratories to design and build test facilities, and to perform the testing. It can also be referenced by packing and valve manufacturers, and valve end users, in a purchase specification for packing testing services.</td></tr>
<tr><td>Comments:</td><td>The purpose of this API standard is to establish a uniform off-valve procedure for the evaluation of process valve stem packing. The testing approaches defined within this standard provide a method for evaluating packing systems independent of a particular manufacturer’s valve(s). This testing program will provide a basis for the comparison of the emissions and life cycle performance of packing. This standard includes test documentation data sheets and test fixture construction information.</td></tr>
<tr><td>User:</td><td>Manufacturer: P; Consultant: P; Owner: S; Inspector: ; Regulator:
P – Primary User
S – Secondary User</td></tr>
</table>

A-35 Std 650 *Welded Steel Tanks for Oil Storage*

Current Edition:	Eleventh Edition, June 2007 (Approx 200 pages) Addendum 1, November 2008
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard establishes minimum requirements for material, design, fabrication, erection and testing for vertical, cylindrical, aboveground, closed and open-top, welded storage tanks in various sizes and capacities for internal pressures approximating atmospheric pressure (internal pressures not exceeding the weight of the roof plates), but a higher internal pressure is permitted when additional requirements are met (see 1.1.12). This standard applies only to tanks whose entire bottom is uniformly supported and to tanks in non-refrigerated service that have a maximum design temperature of 93°C (200°F) or less (see 1.1.19). This standard is designed to provide industry with tanks of adequate safety and reasonable economy for use in the storage of petroleum, petroleum products and other liquid products. This standard does not present or establish a fixed series of allowable tank sizes; instead, it is intended to permit the purchaser to select whatever size tank may best meet his needs. This standard is intended to help purchasers and manufacturers in ordering, fabricating and erecting tanks; it is not intended to prohibit purchasers and manufacturers from purchasing or fabricating tanks that meet specifications other than those contained in this standard.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication/erection of welded oil storage tanks. It can also be used as a reference for shop and field fabrication/erection inspection. Regulators can reference as desired.
Comments:	This is a comprehensive document covering the following main topics: materials; design; fabrication; erection; inspection; vacuum testing; welding procedure and welder qualifications; and marking. It also includes 26 appendices in support of these topics.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-36 RP 651 *Cathodic Protection of Aboveground Storage Tanks*

Current Edition:	Third Edition, January 2007 (33 pages)
Alt. Number:	No
ANSI Approved?	Yes
Scope:	This RP presents procedures and practices for achieving effective corrosion control on aboveground steel storage tank bottoms through the use of cathodic protection. It is the intent of this RP to provide information and guidance for the application of cathodic protection to existing and new storage tanks in hydrocarbon service. Specific cathodic protection designs are not provided. Certain practices recommended herein may also be applicable to tanks in other services. Corrosion control methods based on chemical control of the environment or the use of protective coatings are not covered in detail.
Application:	Tank owners and manufacturers, and consultants, can use this RP to develop specific cathodic protection designs.
Comments:	The intent of this RP to provide information and guidance specific to aboveground steel storage tanks in hydrocarbon service. Certain practices recommended herein may also be applicable to tanks in other services.
User:	Consultant: **P**; Manufacturer: **P**; Owner: **P**; Inspector: ; Regulator: P – Primary User S – Secondary User

A-37 RP 652 *Lining of Aboveground Petroleum Storage Tank Bottoms*

Current Edition:	Third Edition, October 2005 (15 pages)
Alt. Number:	No
ANSI Approved?	Yes
Scope:	This RP provides guidance on achieving effective corrosion control by the application of tank bottom linings in aboveground storage tanks in hydrocarbon service. It contains information pertinent to the selection of lining materials, surface preparation, lining application, cure and inspection of tank bottom linings for existing and new storage tanks. In many cases, tank bottom linings have proven to be an effective method of preventing internal corrosion of steel tank bottoms.
Application:	Tank owners and manufacturers, and consultants, can use this RP to develop specific tank bottom lining designs and lining specifications.
Comments:	The intent of this RP is to provide information and guidance specific to aboveground steel storage tanks in hydrocarbon service. Certain practices recommended herein may also be applicable to tanks in other services. This RP is intended to serve only as a guide and detailed tank bottom lining specifications are not included.
User:	Consultant: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **P** P – Primary User S – Secondary User

A-38 Std 653 *Tank Inspection, Repair, Alteration, and Reconstruction*

Current Edition:	Third Edition, December 2001 (Approx 100 pages) Addendum 1, September 2003 Addendum 2, November 2005 Addendum 3, February 2008 Errata, April 2008
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers steel storage tanks built to API Standard 650 and its predecessor API 12C. It provides minimum requirements for maintaining the integrity of such tanks after they have been placed in service and addresses inspection, repair, alteration, relocation and reconstruction. The scope is limited to the tank foundation, bottom, shell, structure, roof, attached appurtenances and nozzles to the face of the first flange, first threaded joint, or first welding-end connection. Many of the design, welding, examination and material requirements of API Std 650 can be applied in the maintenance inspection, rating, repair and alteration of in-service tanks. In the case of apparent conflicts between the requirements of this standard and API Std 650 or its predecessor API 12C, this standard shall govern for tanks that have been placed in service. This standard employs the principles of API Std 650; however, storage tank owner/ operators, based on consideration of specific construction and operating details, may apply this standard to any steel tank constructed in accordance with a tank specification. This standard does not contain rules or guidelines to cover all the varied conditions which may occur in an existing tank. When design and construction details are not given, and are not available in the as-built standard, details that will provide a level of integrity equal to the level provided by the current edition of API Std 650 must be used.
Application:	This standard is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in tank design, fabrication, repair, construction and inspection. Regulators may use as desired.
Comments:	The main topics covered in this standard are suitability for service; brittle fracture considerations; inspection; materials; design considerations for reconstructed tanks; tank repair and alteration; dismantling and reconstruction; welding; examination and testing; and marking and record keeping. It also contains 9 appendices in support of these topics.
User:	Purchaser: (blank); Contractor: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-39 Std 660 *Shell-and-Tube Heat Exchangers*

Current Edition:	Eighth Edition, August 2007 (40 pages)
Alt. Number:	ISO 16812:2007 (Identical)
ANSI Approved?	Yes
Scope:	This international standard specifies requirements and gives recommendations for the mechanical design, material selection, fabrication, inspection, testing and preparation for shipment of shell-and-tube heat exchangers for the petroleum, petrochemical and natural gas industries. This international standard is applicable to the following types of shell-and-tube heat exchangers: heaters, condensers, coolers and reboilers. This International Standard is not applicable to vacuum-operated steam surface condensers and feed-water heaters.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of shell-and-tube heat exchangers. It can also be used as a reference for shop inspection.
Comments:	The main topics covered in this standard are: manufacturer's proposal requirements; design; materials; fabrication; inspection and testing; preparation for shipment; and supplemental requirements (if specified by the purchaser). It also includes four appendices: 1) Recommended practices, 2) Shell-and-tube heat exchanger checklist, 3) Shell-and-tube heat exchanger data sheets and 4) Responsibility data sheet. The completion of the heat exchanger data sheets is the joint responsibility of the purchaser and the manufacturer. The purchaser is responsible for the process data on the data sheets. This standard states that the pressure design code shall be specified by, or agreed to by, the purchaser. Some welding requirements are included in the standard, but no guidance on a welding code is given.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-40 Std 661 *Air-Cooled Heat Exchangers for General Refinery Service*

Current Edition:	Sixth Edition, February 2006 (115 pages)
Alt. Number:	ISO 13706-1:2005 (Identical)
ANSI Approved?	Yes
Scope:	This international standard gives requirements and recommendations for the mechanical design, materials, fabrication, inspection, testing and preparation for shipment of air-cooled heat exchangers for use in the petroleum, petrochemical and natural gas industries. This international standard is applicable to air-cooled heat exchangers with horizontal bundles, but the basic concepts can also be applied to other configurations.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of air-cooled heat exchangers. It can also be used as a reference for shop inspection. This standard includes data sheets whose completion is the joint responsibility of the purchaser and the manufacturer. The purchaser is responsible for the process data on the data sheets.
Comments:	The main topics covered in this standard are manufacturer's proposal requirements; documentation; design; materials; fabrication of tube bundle; inspection, examination, and testing; preparation for shipment; and supplemental requirements (if specified by the purchaser). It also includes three annexes: 1) Recommended practices, 2) Checklist, data sheets and electronic data exchange and 3) Winterization of air-cooled heat exchangers. The completion of the heat exchanger data sheets is the joint responsibility of the purchaser and the manufacturer. The purchaser is responsible for the process data on the data sheets. This standard states that the pressure design code shall be specified by, or agreed to by, the purchaser, and that welding shall be in accordance with the pressure design code.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-41 Std 662, Part 1 *Plate Heat Exchangers for General Refinery Services, Plate-and-Frame Heat Exchangers*

Current Edition:	First Edition, February 2006 (26 pages)
Alt. Number:	ISO 15547-1:2005 (Identical)
ANSI Approved?	Yes
Scope:	This Part 1 of the standard gives requirements and recommendations for the mechanical design, materials selection, fabrication, inspection, testing and preparation for shipment of plate-and-frame heat exchangers for use in petroleum, petrochemical and natural gas industries. It is applicable to gasketed, semi-welded and welded plate-and-frame heat exchangers.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of plate-and-frame heat exchangers. It can also be used as a reference for shop inspection.
Comments:	The main topics covered in this standard are manufacturer's proposal requirements; drawings and other data requirements; design; materials; fabrication; inspection and testing; preparation for shipment. It also includes three annexes: 1) Recommended practices, 2) Plate-and frame heat exchanger check list and 3) Plate-and frame heat exchanger data sheets. The completion of the heat exchanger data sheets is the joint responsibility of the purchaser and the manufacturer. The purchaser is responsible for the process data on the data sheets. This standard states that the pressure design code and the structural welding code shall be specified, or agreed to, by the purchaser.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-42 Std 662, Part 2 *Plate Heat Exchangers for General Refinery Services, Brazed Aluminum Plate–Fin Heat Exchangers*

Current Edition:	First Edition, February 2006 (34 pages)
Alt. Number:	ISO 15547-2:2005 (Identical)
ANSI Approved?	Yes
Scope:	This Part 2 of the standard gives requirements and recommendations for the mechanical design, materials selection, fabrication, inspection, testing and preparation for shipment of brazed aluminum plate-fin heat exchangers for use in petroleum, petrochemical and natural gas industries.
Application:	Purchasers can reference this standard in a purchase specification and manufacturers can use it in the design and fabrication of brazed aluminum plate-fin heat exchangers. It can also be used as a reference for shop inspection.
Comments:	The completion of the heat exchanger data sheets is the joint responsibility of the purchaser and the manufacturer. The purchaser is responsible for the process data on the data sheets.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-43 Publication 920 *Prevention of Brittle Fracture of Pressure Vessel*

Current Edition:	First Edition, March 1990 (13 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP has been withdrawn by API. It provided guidance on choosing a toughness level that is more stringent than the requirements of the ASME Code.
Application:	Purchasers used this document to optimize material selection and to impose additional requirements in a purchase specification to achieve improved resistance to brittle fracture.
Comments:	For Level I protection, the basic philosophy was to adhere to the requirements of the ASME Code. For Level II protection, the basic philosophy was to restrict the use of certain as-rolled plate steels that have been responsible for several brittle failures and to limit the application of some of the exemptions from impact testing in the ASME Code. The document also included guidance on toughness evaluation of existing pressure vessels. However, the more current guidance found in Part 3 of API 579-1/ASME FFS-1 should be used for this purpose.
User:	Purchaser: **P**; Manufacturer: **S**; Owner: **P**; Inspector: **S**; Regulator: **S** P – Primary User S – Secondary User

A-44 RP 934A *Materials and Fabrication of 2¼Cr-1Mo, 2¼Cr-1Mo-¼V, 3Cr-1Mo and 3Cr-1Mo-¼V Steel Heavy Wall Pressure Vessels for High-Temperature, High-Pressure Hydrogen Service*

Current Edition:	Second Edition, May 2008 (32 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP presents materials and fabrication requirements for new 2-¼Cr and 3Cr steel heavy wall pressure vessels for high temperature, high pressure hydrogen service. It applies to vessels that are designed, fabricated, certified and documented in accordance with ASME Code Section VIII, Division 2, including Appendix 26, Mandatory Rules for Cr-Mo Steels and Additional Requirements for Welding and Heat Treatment and ASME Code Case 2151, if applicable. Materials covered by this RP are conventional steels including standard 2-¼Cr-1Mo and standard 3Cr-1Mo steels, advanced steels including enhanced 2-¼Cr-1Mo, 2-¼Cr-1Mo-¼V, 3Cr-1Mo-¼V-Ti-B and 3Cr-1Mo-¼V-Cb-Ca steels. The interior surfaces of these heavy wall pressure vessels may have an austenitic stainless steel weld overlay to provide additional corrosion resistance. Licensors and owners of process units in which these heavy wall pressure vessels are to be used may modify and/or supplement this RP with additional proprietary requirements.
Application:	Purchasers can reference this document in a purchase specification and manufacturers can use it in the design and fabrication of pressure vessels. It can also be used as a reference for shop inspection, and as a resource when modifying existing pressure vessels.
Comments:	This RP is based on decades of industry operating experience and the results of experimentation and testing conducted by independent manufacturers, fabricators and users of heavy wall pressure vessels for this service. The main topics covered in this RP are design (per ASME Code); two design issues (weld seam layout and nozzle neck transition); base metal requirements; welding requirements; heat treatment; testing requirements; nondestructive examination (NDE); hydrostatic testing; preparation for shipping; and documentation.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-45 RP 934C *Materials and Fabrication of 1¼Cr-½Mo Steel Heavy Wall Pressure Vessels for High-Pressure Hydrogen Service Operating at or Below 825°F (441°C)*

Current Edition:	First Edition May, 2008 (26 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP presents materials and fabrication requirements for new 1 ¼Cr-½Mo steel heavy wall pressure vessels and heat exchangers for high-temperature, high-pressure hydrogen service. It applies to vessels that are designed, fabricated, certified and documented in accordance with ASME *BPVC*, Section VIII, Division 1 or Division 2. This document may also be used as a resource for equipment fabricated of 1Cr-½2Mo Steel. This document may also be used as a resource when planning to modify an existing heavy wall pressure vessel. The interior surfaces of these heavy wall pressure vessels may have an austenitic stainless steel or ferritic stainless steel weld overlay or cladding to provide additional corrosion resistance. For this RP, the heavy wall is defined as shell thickness 2 in. (50 mm) or greater but less or equal to 4 in. (100 mm). Integrally reinforced nozzles, flanges, tubesheets, bolted channel covers, etc. can be greater than 4 in. (100 mm). At shell or head thicknesses greater than 4 in. (100 mm), 1 ¼Cr-½Mo has been shown to have difficulty meeting the toughness requirements given in this document. Although outside of the scope of this document, it can be used as a resource for vessels down to 1 in. (25 mm) shell thickness with changes defined by the purchaser. This RP is not intended for use for equipment operating above 825°F (441°C) or in the creep range.
Application:	Purchasers can reference this document in a purchase specification and manufacturers can use it in the design and fabrication of pressure vessels. It can also be used as a reference for shop inspection, and as a resource when modifying existing pressure vessels.
Comments:	This RP is based on decades of industry operating experience and the results of recent experimentation and testing conducted by independent manufacturers, fabricators and users of pressure vessels for this service. The main topics covered in this RP are design (per ASME Code); three design issues (thickness allowance, weld seam layout and nozzle neck transition); base metal requirements; welding requirements; heat treatment; testing requirements; nondestructive examination (NDE); hydrostatic testing; preparation for shipping; and documentation.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-46 RP 934E *RP for Materials and Fabrication of 1¼Cr-½Mo and 1Cr-½Mo Steel Pressure Vessels for Service above 825°F (441°C)*

Current Edition:	First Edition (Draft #2) April 9, 2008 – Not Yet Published (13 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP includes materials and fabrication requirements for new 1¼Cr-½Mo and 1Cr-½Mo steel pressure vessels and heat exchangers for high temperature service in petroleum refining, petrochemical and chemical facilities. It applies to vessels that are designed, fabricated, certified and documented in accordance with ASME Code Section VIII, Division 1. This document may also be used as a resource when planning to modify existing pressure vessels. This RP is not intended for use for equipment operating below 825°F (441°C). Refer to API-RP 934-C for information on design for lower temperature ranges. When designing equipment that operates in the 825-850°F (441-454°C) temperature range, refer to guidelines in both of these RPs.
Application:	Purchasers can reference this document in a purchase specification and manufacturers can use it in the design and fabrication of pressure vessels. It can also be used as a reference for shop inspection, and as a resource when modifying existing pressure vessels.
Comments:	This RP is based on decades of industry operating experience and the results of recent experimentation and testing conducted by independent manufacturers, fabricators and users of pressure vessels for this service. The main topics covered in this RP are design (per ASME Code); three design issues (thickness allowance, weld seam layout and nozzle neck transition); base metal requirements; welding requirements; heat treatment; testing requirements; nondestructive examination (NDE); hydrostatic testing; preparation for shipping; and documentation.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **S**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-47 Publication 941 *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*

Current Edition:	Seventh Edition, August 2008 (41 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP summarizes the results of experimental tests and actual data acquired from operating plants to establish practical operating limits for carbon and low alloy steels in hydrogen service at elevated temperatures and pressures. The effects on the resistance of steels to hydrogen at elevated temperature and pressure that result from high stress, heat treating, chemical composition and cladding are discussed. This RP does not address the resistance of steels to hydrogen at lower temperatures [below about 400°F (204°C)], where atomic hydrogen enters the steel as a result of an electrochemical mechanism. This RP applies to equipment in refineries, petrochemical facilities and chemical facilities in which hydrogen or hydrogen-containing fluids are processed at elevated temperature and pressure. The guidelines in this RP can also be applied to hydrogenation plants such as those that manufacture ammonia, methanol, edible oils and higher alcohols. Hydrogenation processes require standards and materials that may not be warranted in other operations of the petroleum industry. At certain combinations of elevated temperature and hydrogen partial pressure, both chemical and metallurgical changes occur in carbon steel, which, in advanced stages, can render it unsuitable for safe operation. Alloy steels containing chromium and molybdenum can be used under such conditions. The steels discussed in this RP resist high temperature hydrogen attack (HTHA) when operated within the guidelines given. However, they may not be resistant to other corrosives present in a process stream or to other metallurgical damage mechanisms operating in the HTHA range. This RP also does not address the issues surrounding possible damage from rapid cooling of the metal after it has been in high temperature, high pressure hydrogen service (e.g., possible need for outgassing hydroprocessing reactors). This RP will discuss in detail only the resistance of steels to HTHA.
Application:	This RP can be used by pressure vessel designers as an aid in selecting steels for new pressure vessels at elevated temperature and pressure. It can also be used by pressure vessel fabricators to assess the adequacy of the materials specified by the purchaser. It can also be used by inspectors as an aid in selecting an inspection method(s) for detecting high temperature hydrogen attack in existing pressure vessels.

<table>
<tr><td>Comments:</td><td>Presented in this document are curves that indicate the operating limits of temperature and hydrogen partial pressure for satisfactory performance of carbon steel and Cr-Mo steels in elevated temperature, hydrogen service. In addition, it includes a summary of inspection methods to evaluate equipment for the existence of HTHA.

At normal atmospheric temperatures, gaseous molecular hydrogen does not readily permeate steel, even at high pressures. Carbon steel is the standard metal for cylinders that are used to transport hydrogen at pressures of 2000 psi (14 MPa). Many postweld heat treated carbon steel pressure vessels have been used successfully in continuous service at pressures up to 10,000 psi (69 MPa) and temperatures up to 430°F (221°C). However, under these same conditions, highly stressed carbon steels and hardened steels have cracked due to hydrogen embrittlement.

The recommended maximum hydrogen partial pressure at atmospheric temperature for carbon steel fabricated in accordance with the ASME Boiler and Pressure Vessel Code is 13,000 psia (90 MPa). Below this pressure, carbon steel equipment has shown satisfactory performance. Above this pressure, very little operating and experimental data are available. If plants are to operate at hydrogen partial pressures that exceed 13,000 psia (90 MPa), the use of an austenitic stainless steel liner with venting in the shell should be considered.

At elevated temperatures, molecular hydrogen dissociates into the atomic form, which can readily enter and diffuse through the steel. Under these conditions, the diffusion of hydrogen in steel is more rapid. As discussed in Section 4 of this RP, hydrogen reacts with the carbon in the steel to cause either surface decarburization or internal decarburization and fissuring, and eventually cracking. This form of hydrogen damage is called high temperature attack (HTHA) and this RP discusses the resistance of steels to HTHA.

The main topics covered by this RP are pressure/temperature operating limits for carbon and Cr-Mo steels; forms of HTHA; factors influencing HTHA; and inspection for HTHA. It also includes five technical annexes: High temperature attack (HTHA) of 0.5 Mo steels, 2) HTHA of 1.25 Cr-0.5 Mo steel, 3) HTHA of 2.25 Cr-0.5 Mo steel, 4) Effective pressures of hydrogen in steel covered by clad/overlay and 5) Summary of inspection methods.</td></tr>
<tr><td>User:</td><td><table><tr><td>Purchaser</td><td>Manufacturer</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr><tr><td>P</td><td>P</td><td></td><td>P</td><td></td></tr></table>
P – Primary User
S – Secondary User</td></tr>
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A-48 Publication 945 *Avoiding Environmental Cracking in Amine Units*

Current Edition:	Third Edition, June 2003 (25 pages) Reaffirmed, April 2008
Alt. Number:	None
ANSI Approved?	No
Scope:	This RP discusses environmental cracking problems of carbon steel equipment in amine units. Stress corrosion cracking of stainless steels in amine units is beyond the scope of this document although there have been isolated reports of such problems. This practice does provide guidelines for carbon steel construction materials including their fabrication, inspection and repair to help assure safe and reliable operation. The steels referred to in this document are defined by the ASTM designation system, or are equivalent materials contained in other recognized codes or standards. Welded construction is considered the primary method of fabricating and joining amine unit equipment
Application:	This RP can be used by process designers (owner or contractor) as an aid in specifying steels and fabrication requirements for new and replaced/repaired equipment in amine units. It can also be used for guidance for the inspection and repair of existing equipment used to handle amines.
Comments:	This document is based on current engineering practices and insights from recent industry experience. Older amine units may not conform exactly to the information contained in this RP, but this does not imply that such units are operating in an unsafe or unreliable manner. No two amine units are alike, and the need to modify a specific facility depends on its operating, inspection and maintenance history. This RP presents information covering amine unit description and problems, construction materials and fabrication, inspection guidelines, repair guidelines, cracking mechanisms and corrosion control.
User:	Purchaser: — ; Contractor: **P** ; Owner: **P** ; Inspector: **P** ; Regulator: — P – Primary User S – Secondary User

A-49 Std 1104 *Welding of Pipelines and Related Facilities*

Current Edition:	Twentieth Edition, October 2005 (70 pages) Errata/Addendum, July 2007 Errata 2, December 2008
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers the gas and arc welding of butt, fillet and socket welds in carbon and low-alloy steel piping used in the compression, pumping and transmission of crude petroleum, petroleum products, fuel gases, carbon dioxide, nitrogen and, where applicable, covers welding on distribution systems. It applies to both new construction and in-service welding. The welding may be done by a shielded metal-arc welding, submerged arc welding, gas tungsten-arc welding, gas metal-arc welding, flux-cored arc welding, plasma arc welding, oxyacetylene welding or flash butt welding process or by a combination of these processes using a manual, semi-automatic, mechanized or automatic welding technique or a combination of these techniques. The welds may be produced by position or roll welding or by a combination of position and roll welding. This standard also covers the procedures for radiographic, magnetic particle, liquid penetrant and ultrasonic testing, as well as the acceptance standards to be applied to production welds tested to destruction or inspected by radiographic, magnetic particle, liquid penetrant, ultrasonic and visual testing methods.
Application:	Pipeline owners and operators can reference this standard in a purchase specification for new pipeline construction welding and for in-service pipeline welding. Pipeline construction contractors can refer to this document to insure compliance when it is cited in the purchase specification. It can also provide guidance to inspectors.
Comments:	The purpose of this standard is to present methods for the production of high-quality welds through the use of qualified welders using approved welding procedures, materials and equipment. Its purpose is also to present inspection methods to ensure the proper analysis of welding quality through the use of qualified technicians and approved methods and equipment. It applies to both new construction and in-service welding. The main topics covered in this standard are welding equipment; weld filler metal; weld shielding gases; qualification of welding procedures; qualification of welders; design and preparation of a joint for production welding; inspection and testing of production welds; acceptance standards for nondestructive testing; repair and removal of defects; procedures for nondestructive testing; mechanized welding with filler metal additions; automatic welding without filler-metal additions; alternative acceptance standards for girth welds; and in-service welding.
User:	Purchaser: **P** · Manufacturer: **P** · Owner: **P** · Inspector: **S** · Regulator: (blank) P – Primary User S – Secondary User

A-50 RP 1107 *Pipeline Maintenance Welding Practices*

Current Edition:	Third Edition, April 1991 (21 pages) Reaffirmed, July 1997
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This RP covers recommended maintenance welding practices that may be used when making repairs to, or installing appurtenances on, piping systems which are, or have been, in service in the compression, pumping and transmission of crude petroleum, petroleum products and fuel gases and, where applicable, when making repairs to distribution piping systems for these products. The welding may be done by shielded metal-arc welding, gas tungsten-arc welding, gas metal-arc welding, flux-cored arc welding or oxyacetylene welding using a manual or semiautomatic welding technique or a combination of techniques. This RP does not preclude using other methods besides welding to install appurtenances or make repairs. The scope of this document is limited to the necessary operations of welding and to the associated activities of welding necessary for preparing materials for welding and for inspecting completed welds.
Application:	Pipeline owners and operators can use this RP as an aid in making pipeline weld repairs using their own personnel, or in establishing agreement on welding practices with a repair contractor. It can also provide guidance to inspectors.
Comments:	This RP presents methods for producing high-quality maintenance welds on piping systems. These methods require that the welds be performed by qualified welders who use approved welding procedures, materials and equipment. This RP also presents methods for inspecting these welds. The main topics covered in this RP are welding equipment; weld filler metal; weld shielding gases; qualification of welding procedures; welder qualification; suggested maintenance; inspection and testing of maintenance welds; standards of acceptability: nondestructive testing (including visual); and repair or removal of defects.
User:	Purchaser: [ ] · Repair Contractor: **P** · Owner/ Operator: **P** · Inspector: **S** · Regulator: [ ] P – Primary User S – Secondary User

A-51 Std 2000 *Venting Atmospheric and Low-Pressure Storage Tanks, Nonrefrigerated and Refrigerated*

Title:	Venting Atmospheric and Low-Pressure Storage Tanks, Nonrefrigerated and Refrigerated
Current Edition:	Fifth Edition, April 1998 (40 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers the normal and emergency vapor venting requirements for aboveground nonrefrigerated liquid petroleum or petroleum products storage tanks and aboveground and underground refrigerated storage tanks designed for operation at pressures from vacuum through 15 pounds per square inch gauge (1.034 bar gauge). Engineering studies of a particular tank may indicate that the appropriate venting capacity for the tank is not the venting capacity estimated in accordance with this standard. The many variables associated with tank venting requirements make it impractical to set forth definite, simple rules that are applicable to all locations and conditions. Larger venting capacities may be required on tanks in which liquid is heated, on tanks that receive liquid from wells or traps and on tanks that are subjected to pipeline surges. Larger venting capacities may also be required on tanks that use flame arresters or have other restrictions that may build up pressure under certain conditions. This standard does not apply to external floating roof tanks or free vented internal floating roof tanks.
Application:	This standard can be used by storage tank designers and/or instrument engineers as an aid in determining a tank's venting requirement, and also in selecting the type of venting device. It can also be used by a storage tank supplier to assess the adequacy of the venting device specified by the purchaser.
Comments:	The main topics covered in this standard are causes of overpressure or vacuum; determination of venting requirements; means of venting; selection, installation and maintenance of venting devises; and testing and marking of venting devices. These topics are presented separately for nonrefrigerated and refrigerated storage tanks. There is also an appendix on Types and Characteristics of Venting Devices.
User:	Designer/Engineer: **P**; Manufacturer: **P**; Owner: ; Inspector: ; Regulator: P – Primary User S – Secondary User

A-52 RP 2201 *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*

Current Edition:	Fifth Edition, June 2003 (27 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This publication provides information to assist in safely conducting hot tapping operations on equipment in service in the petroleum and petrochemical industries. No document can address all situations nor answer all potential questions, however, the understanding of potential hazards, and application of this knowledge, can help reduce the probability and severity of incidents.
Application:	Hot tapping is performed in refineries and chemical plants when it is impractical to shut down and de-inventory equipment to add a branch connection.
Comments:	
User:	Designer/Engineer: (blank); Manufacturer: (blank); Owner: **P**; Inspector: **S**; Regulator: **S** P – Primary User S – Secondary User

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE) STANDARDS

A-53 ASCE/SEI 7 *Minimum Design Loads for Buildings and Other Structures*

Current Edition:	2005
Alt. Number:	
ANSI Approved?	Yes
Scope:	This standard may be used to determine the magnitude of wind and earthquake loadings to apply to structures, including pressure vessels and piping systems
Application:	Designers of pressure equipment can use the methods in this standard to determine the appropriate design magnitude of wind and earthquake loadings for new construction. Owners and users of pressure equipment can use the methods for post-construction integrity assessments.
Comments:	Rules are provided for locating earthquake zones and for estimating maximum wind speeds depending on the location of the installation of the equipment.
User:	Purchaser / Consultatnt / Owner / Inspector / Regulator P – Primary User S – Secondary User

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) STANDARDS

A-54 B16.1 *Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250)*

Current Edition:	2005 (58 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers Classes 25, 125 and 250 Gray Iron Pipe Flanges and Flanged Fittings. It includes pressure-temperature ratings; sizes and methods of designating openings of reducing fittings; marking; materials; dimensions and tolerances; bolting and gaskets; and pressure testing.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This standard covers flanges, 45 and 90 degree elbows, tees, crosses, 45 degree laterals, reducers and true Y's in sizes NPS 4 through 96 (Class 25), NPS 1 through 48 (Class 125) and NPS 1 through 30 (Class 250).
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-55 B16.3 *Malleable Iron Threaded Fittings (Classes 150 and 300)*

Current Edition:	2006 (38 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers malleable iron threaded fittings, Class 150 and 300. It also contains provisions for using steel for caps and couplings in Class 150 for NPS ⅜ and smaller. This standard includes: a) pressure-temperature ratings; b) size and method of designating openings of reducing fittings; c) marking; d) material; e) dimensions and tolerances; f) threading; g) ribs; h) plugs, bushings and locknuts; i) face bevel; and j) coatings.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This standard covers flanges, 45 and 90 degree elbows, tees, crosses, 45 degree Y branches, reducers, street tees and elbows, couplings, caps and return bends and generally in NPS sizes ⅛ through 6 (Class 150) and NPS ¼ through 3 (Class 300). There is some variation in the smallest and largest size based on the particular type of fitting, e.g., Class 300 return bend sizes are NPS 1 and 2.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-56 B16.4 *Gray Iron Threaded Fittings (Classes 125 and 250)*

Current Edition:	2006 (22 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard for gray iron threaded fittings, Classes 125 and 250, covers: a) pressure-temperature ratings; b) size and method of designating openings of reducing fittings; c) marking; d) material; e) dimensions and tolerances; f) threading; g) ribs; h) plugs, bushings and locknuts; i) face bevel; and j) coatings.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This Standard covers Classes 125 and 250 45 and 90 degree elbows, tees and crosses in sizes NPS ¼ through 12. It also covers Class 125 90 degree reducing elbows (NPS ½ x ⅜ through 8 x 6), reducing crosses (NPS ¾ x ¾ x ½ x ½ through 8 x 8 x 4 x 4), reducing tees (NPS ½ x ½ x ⅜ through 6 x 6 x 8) and caps, reducing couplings and return bends (NPS ½ through 12).
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-57 B16.5 *Pipe Flanges and Flanged Fittings*

<table>
<tr><td>Current Edition:</td><td>2003 (223 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, testing and methods of designating openings for pipe flanges and flanged fittings. Included are:
Flanges with rating class designations 150, 300, 400, 600, 900, 1500 and 2500 in sizes NPS ½ through NPS 24, with requirements given in both metric and US customary units with diameter of bolts and flange bolt holes expressed in inch units
Flanged fittings with rating class designation 150 and 300 in sizes NPS ½ through NPS 24, with requirements given in both metric and US customary units with diameter of bolts and flange bolt holes expressed in inch units
Flanged fittings with rating class designations 400, 600, 900, 1500 and 2500 in sizes NPS ½ through NPS 24 that are acknowledged in Annex G in which only US customary units are provided.
This standard is limited to:
Flanges and flanged fittings made from cast or forged materials
Blind flanges and certain reducing flanges made from cast, forged or plate materials.
Also included in this standard are requirements and recommendations regarding flange bolting, flange gaskets and flange joints.</td></tr>
<tr><td>Application:</td><td>Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Manufacturers can also use this document as a reference for the required flange dimension details, including those applicable to welding.
Designers can use this standard to select the appropriate class flange or fitting based on the specific design conditions (pressure and temperature) and the material of construction.
In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspection at the manufacturer's plant.</td></tr>
<tr><td>Comments:</td><td>This is a comprehensive document that contains the pressure-temperature ratings for 42 groups of materials, with each group broken down according to forgings, castings and plates.
The flanged fittings covered by this standard include 90 and 45 degree standard elbows, 90 degree long radius elbows, tees, crosses, true Y's and reducers.</td></tr>
<tr><td>User:</td><td><table><tr><td>Purchaser</td><td>Manufacturer</td><td>Designer</td><td>Inspector</td><td>Regulator</td></tr><tr><td>P</td><td>P</td><td>P</td><td>S</td><td></td></tr></table>P – Primary User
S – Secondary User</td></tr>
</table>

A-58 B16.9 *Factory-Made Wrought Butt-Welding Fittings*

Current Edition:	2007 (36 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers overall dimensions, tolerances, pressure ratings, testing, markings, material and end preparation for factory-made wrought butt-welding fittings in sizes NPS ½ through NPS 48 (DN 15 through DN 1200).
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met.
Comments:	This standard covers 45 and 90 degree long radius elbows (NPS ½ through 48), 90 degree long radius reducing elbows (NPS 2 x ½ through 24 x 12), long radius returns (NPS ½ through 24), short radius elbows (NPS 1 through 24), short radius 180 degree returns (NPS 1 through 24), 3D elbows (NPS ¾ through 48), straight tees and crosses (NPS ½ through 48), reducing outlet tees and crosses (NPS ½ x ½ x ⅜ through 48 x 48 x 22), lap joint stub ends (NPS ½ through 24), caps (NPS ½ through 48) and reducers (NPS ¾ x ½ through 48 x 40). The allowable pressure ratings for fittings designed in accordance with this standard may be calculated as for straight seamless pipe of equivalent material in accordance with the rules established in the applicable sections of ASME B31, Code for Pressure Piping. For the calculations, applicable data for the pipe size, wall thickness and material that is equivalent to that of the fitting shall be used. Pipe size, wall thickness (or schedule number) and material identity on the fittings are in lieu of pressure rating markings.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: ; Regulator: P – Primary User S – Secondary User

A-59 B16.10 *Face-to-Face and End-to-End Dimension of Valves*

Current Edition:	2000 (41 pages) Reaffirmed 2003
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers face-to-face and end-to-end dimensions of straightway valves and center-to-face and center-to-end dimensions of angle valves. Its purpose is to assure installation interchangeability for valves of a given material, type, size, rating class and end connection. Face-to-face and center-to-face dimensions apply to flanges end valves with facing defined in paragraph 2.3.1 of this standard and to other valves intended for assembly between flat face or raised face flanges. End-to-end dimensions apply to grooved end, butt-welding end and flanged end valves with facing defined in paragraph 2.3.3 of this standard. Center-to-end dimensions apply to butt-welding end and to flanged end valves with facings defined in paragraph 2.3.3 of this standard. For cast iron and ductile iron valves, only flanged end valves (and others intended for assembly between flanges) are covered by this standard. For carbon, alloy and stainless steel valves, and nonferrous materials listed in ASME B16.34, this standard covers flanged, butt-welding and grooved ends, as well as the types of valves intended for assembly between flanges.
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Designers can reference this standard in preparing piping layout drawings. It can also be referenced for inspections at the manufacturer's plant.
Comments:	For cast iron valves, this standard covers: 1) Class 125 and 250 gate, plug, check, globe, angle and wafer swing check valves and 2) Class 25 and 125 butterfly valves. For ductile iron valve, this standard covers Class 150 and 300 gate, plug, check, globe and angle valves. For steel and alloy valves, this standard covers: 1) Class 150 through 2500 gate, globe, angle, check, plug and ball valves; 2) Class 150 Y-pattern globe and swing check valves; 3) Class 150 wafer knife gate valves; 4) Class 150 through 2500 wafer swing check valves; and 4) Class 150, 300 and 600 butterfly valves. This sizes covered by this Standard are NPS ¼ through 72, but the range varies depending on class and valve type.
User:	Purchaser: **P**; Manufacturer: **P**; Designer: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-60 B16.11 *Forged Fitting, Socket-Welding and Threaded*

Current Edition:	2001 (18 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers ratings, dimensions, tolerances, marking, material requirements and testing for forged fittings, both socket-welding and threaded.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This standard covers 45 and 90 degree elbows, tees, crosses, couplings, half-couplings, caps, plugs and bushings forged fittings in sizes NPS ⅛ through 4 and pressure classes 3000 through 9000 (welded) and 6000 (threaded). Standard dimensions are provided, as well as body thickness requirements.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-61 B16.14 *Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads*

Current Edition:	1991 (9 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard for ferrous pipe plugs, bushings, and locknuts with pipe threads covers: a) pressure-temperature ratings; b) size; c) marking; d) materials: e) dimensions and tolerances; f) threading; and g) pattern taper.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspections at the manufacturer's plant.
Comments:	The types of components covered by this standard are solid and cored square head plugs; bar and slotted head plugs; countersunk plugs; outside head, inside head and face bushings; and locknuts. The sizes covered are NPS ⅛ through 8, but the range varies depending on the type of component.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-62 B16.15 *Cast Copper Alloy Threaded Fittings (Classes 125 and 250)*

Current Edition:	2006 (30 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers cast Classes 125 and 250 copper alloy threaded pipe fittings with provisions for substituting wrought copper alloys for plugs, bushings, caps and couplings in small sizes. This standard includes: a) pressure-temperature ratings; b) size and method of designating openings of reducing pipe fittings; c) marking requirements; d) minimum requirements for casting quality and materials; e) dimensions and tolerances in SI (metric) and US customary units; f) threading requirements; and g) pressure test requirements.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspections in a manufacturer's plant.
Comments:	For Class 125 fittings this standard covers 45 and 90 degree elbows, tees, crosses, 45 degree Y branches, reducers, street elbows, couplings, caps, reducing elbows and tees and return bands, and generally in NPS sizes ⅛ through 4. For Class 250 fittings, this standard covers 45 and 90 degree elbows, tees, crosses, couplings, bushings, plugs, and reducing elbows and tees, and generally in NPS sizes ¼ through 4.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-63 B16.18 *Cast Copper Alloy Solder Joint Pressure Fittings*

Current Edition:	2001 (53 pages) Reaffirmed 2005
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard for cast copper alloy solder joint pressure fittings designed for use with copper water tube establishes requirements for: a) pressure-temperature ratings; b) abbreviations for end connections; c) sizes and methods of designating openings of fittings; d) marking; e) material; f) dimensions and tolerances; and g) tests.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspections at the manufacturer's plant.
Comments:	This standard covers various types of copper fittings such as elbows, tees, return bends, plugs, caps, couplings, in both straight and reducing styles, if applicable. Fittings with both soldered and threaded connections are also covered. The water tube sizes covered are ¼ through 12 inches, but the range varies depending on the type of fitting.
User:	Purchaser: **P** Manufacturer: **P** Owner: Inspector: **S** Regulator: P – Primary User S – Secondary User

A-64 B16.20 *Metallic Gaskets for Pipe Flanges (Ring Joint, Spiral-Wound, and Jacketed)*

Current Edition:	2007 (55 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers materials, dimensions, tolerances and markings for metal ring-joint gaskets, spiral-wound metal gaskets and metal-jacketed gaskets. These gaskets are dimensionally suitable for use with flanges described in reference flange standards ASME B16.5, ASME B16.47, API Specification 6A (ISO 10423). This standard covers spiral-wound metal gaskets and metal-jacketed gaskets for use with raised-face and flat-face flanges.
Application:	Purchasers (end users or fabricators) can reference this standard in a purchase specification. Manufacturers and fabricators need it to comply with the purchase specification when the standard is cited therein.

Comments:	Ring-joint gaskets shall be identified by an R, RX or BX number that relates to flange size (NPS), pressure class and appropriate flange standards (ASME B16.5, ASME B16.47, API Specification 6A or ISO 10423). The pipe sizes and pressure classes covered by this standard are:

	ASME B16.5					API 6B				
Gasket Type	150	300-600	900	1500	2500	720-960 (1)	2000	3000	5000	10000 (1)
R (min)	1	½	½	½	½	1	1	1	1	1
R (max)	24	24	24	24	12	20	20	20	10	10

ASME B16.47 Series A

Gasket Type	150	300-600	900
R (min)	-	26	26
R (max)	-	36	36

API 6B

Gasket Type	720-960(1) and 2000	2900 (1)	3000	5000
RX (min)	1 ½	1	1 ½	1 ½
RX (max)	20	10	20	14

API 6BX

Gasket Type	2000	3000	5000	10000	15000	20000
BX (min)	26 ½	26 ¾	13 ⅝	1 11/16	1 11/16	1 13/16
BX (max)	30	30	21 ¼	21 ¼	18 ¾	13 ⅝

(1) Class 720, 960, 2900 and 10000 flanges to API 6B are obsolete. Data for information only.

User:

Purchaser	Manufacturer	Fabricator	Inspector	Regulator
P	**P**	**P**	**S**	

P – Primary User
S – Secondary User

A-65 B16.21 *Nonmetallic Flat Gaskets for Pipe Flanges*

Current Edition:	2005 (13 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers types, sizes, materials, dimensions, tolerances and markings for nonmetallic flat gaskets. These gaskets are dimensionally suitable for use with flanges described in the referenced flange standards: ASME B16.1, B16.5, B16.24, B16.47 (Series A & B) and MSS SP-51.
Application:	Purchasers (end users or fabricators) can reference this standard in a purchase specification. Manufacturers and fabricators need it to comply with the purchase specification when the standard is cited therein. It can also be used as a reference for inspections in a manufacturer's plant.
Comments:	The pressure classes and pipe sizes covered by this standard are ASME B16.1 Class 25 (NPS 4 to 96), Class 125 (NPS 1 to 48), Class 250 (NPS 1 to 48); ASME B16.5 Classes 150, 300, 400, 600 and 900 (NPS ½ to 24); ASME B16.24 Classes 150 and 300 (NPS ½ to 12); ASME B16.47 Series A Classes 150, 300, 400 and 600 (NPS 22 to 60); ASME B16.47 Series B Classes 75, 150, 300, 400 and 600 (NPS 26 to 60); and MSS SP-51 Class 150 LW (NPS ¼ to 12).
User:	Purchaser: **P**; Manufacturer: **P**; Fabricator: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-66 B16.22 *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*

Current Edition:	2001
Alt. Number:	None (16 pages)
ANSI Approved?	Yes
Scope:	This standard establishes specifications for wrought copper and wrought copper alloy, solder-joint, seamless fittings, designed for use with seamless copper tube conforming to ASTM B 88 (water and general plumbing systems), B 280 (air conditioning and refrigeration service) and B 819 (medical gas systems), as well as fittings intended to be assembled with soldering materials conforming to ASTM B 32, brazing materials conforming to AWS A5.8 or with tapered pipe thread conforming to ASME B1.20.1. This standard is allied with ASME B16.18, which covers cast copper alloy pressure fittings. It provides requirements for fitting ends suitable for soldering. This standard covers: a) pressure-temperature ratings; b) abbreviations for end connections; c) size and method of designating openings of fittings; d) marking; e) material; f) dimensions and tolerances; and g) tests.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspection at the manufacturer's plant.
Comments:	This standard covers various types of copper fittings such as adapters, bushings, elbows, tees, return bends, plugs, caps, couplings, P-traps, in both straight and reducing styles, if applicable. Fittings are mostly soldered, but some with both soldered and threaded connections are also covered. The water tube and threaded pin sizes covered are ¼ through 8 inches. This standard states that, due to widely varying manufacturing processes, meaningful laying-length requirements of fittings cannot be established and to consult the manufacturer for these dimensions.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-67 B16.24 *Cast Copper Alloy Pipe Flanges and Flanged Fittings (Classes 150, 300, 600, 900, 1500, and 2500)*

Current Edition:	2006 (20 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers cast copper alloy threaded-joint pipe flanges and blind pipe flanges having rating class designations 150, 300, 600, 900, 1500 and 2500. This standard also covers fittings having rating class designations 150 and 300. It establishes requirements for: a) pressure-temperature ratings; b) size and method of designation openings for reduced fittings; c) markings; d) materials; e) dimensions; f) bolting and gaskets; g) tolerances; and h) tests. This standard also provides dimensional requirements for flanged ends of valves conforming to MSS SP-80.
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Designers can reference this standard in preparing piping layout drawings. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspection in the manufacturer's plant.
Comments:	This standard covers flanges, 45 and 90 degree elbows, tees, crosses, 45 degree laterals, reducers, and true Y's in sizes NPS ½ through 12 (Class 150) and NPS ½ through 8 (Class 300). The dimensions for the other classes of flanges **only** are by reference to ASME B16.5. The pressure-temperature ratings for Class 150 and 300 are provided for ASTM B61 Alloy C92200 and B62 Alloy C83600 for flanges and flanged fittings. The pressure-temperature ratings for Classes 150 through 2500 are provided for ASTM B148 Alloy C95200 for flanges only.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-68 B16.25 *Butt-Welding Ends*

Current Edition:	2007 (19 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers the preparation of butt-welding ends of piping components to be joined into a piping system by welding. It includes requirements for welding bevels, for external and internal shaping of heavy-wall components and for preparation of internal ends (including dimensions and tolerances). Coverage includes preparation for joints with the following: a) no backing rings; b) split or noncontinuous backing rings; c) solid or continuous backing rings; d) consumable insert rings; e) gas tungsten arc welding (GTAW) of root pass. Details of preparation for any backing ring must be specified when ordering the component.
Application:	Purchasers can reference this standard in a purchase specification and fabricators and field contractors require it to comply with the purchase specification when the standard is cited therein. It can also be used as a reference for shop or field inspection.
Comments:	The main topics covered by this standard are scope; transition contours; welding bevel design; preparation of inside diameter of welding end; and tolerances. Specific details are provide for maximum envelope for welding end transitions; bevels for wall thickness 3 mm (0.12 in) to 12 mm (0.88 in.); weld bevel details for wall thickness over 22 mm (0.88 in.); weld bevel details for GTAW root pass [wall thickness 3 mm (0.12 in.) to 10 mm (0.38 in.)]; weld bevel details for GTAW root pass [wall thickness 10 mm (0.38 in.) to 25 mm (1.0 in.)]; and weld bevel details for GTAW root pass [wall thickness over 25 mm (1.0 in.)].
User:	Purchaser: **P**; Fabricator: **P**; Contractor: **P**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-69 B16.26 *Cast Copper Alloy Fittings for Flared Copper Tubes*

Current Edition:	2006 (9 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard establishes specifications for cast copper alloy fittings and nuts used with flared seamless copper tube conforming to ASTM B 88 (water and general plumbing systems). Included are requirements for the following: (a) pressure rating; (b) size; (c) marking; (d) material; (e) dimensions; (f) threading; and (g) hydrostatic testing.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspections at the manufacturer's plant.
Comments:	This standard covers tees, 90 degree elbows, and 45 degree elbows in standard water tube sizes 3/8 through 2 inches. All fitting connections are threaded to accept flared copper tubes. The fittings covered by this standard are designed for a maximum cold water service-pressure of 1200 kPa (175 psig).
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-70 B16.34 *Valves – Flanged, Threaded, and Welding End*

Current Edition:	2004 (192 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard applies to new construction and covers pressure-temperature ratings, dimensions, tolerances, materials, nondestructive examination requirements, testing and marking for cast, forged and fabricated flanged, threaded and welding end and wafer or flangeless valves of steel, nickel-base alloys and other alloys. Wafer or flangeless valves, bolted or through-bolt types, which are installed between flanges or against a flange, are treated as flanged-end valves. Alternative rules for NPS 2 ½ and smaller valves are given in Mandatory Appendix V.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspection at the manufacturer's plant. In addition, the thickness requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This standard covers Pressure Classes 150, 300, 400, 600, 900, 1500, 2500 and 4500 (4500 applies only to welding end valves). The range of inside valve diameters covered is 0.12 mm to 1300 mm.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-71 B16.36 *Orifice Flanges*

Current Edition:	2006 (20 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers flanges (similar to those covered in ASME B16.5) that have orifice pressure differential connections. Coverage is limited to the following: a) welding neck flanges Classes 300, 600, 900, 1500 and 2500; b) slip-on and threaded Class 300; and c) welding neck flanges Class 400 (in U.S. customary units only).
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Manufacturers can also use this document as a reference for the required flange dimension details, including those applicable to welding. Designers can use this standard to select the appropriate class flange based on the specific design conditions (pressure and temperature) and the material of construction. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspection at the manufacturer's plant.
Comments:	This standard references ASME B16.5 in regard to pressure-temperature ratings and materials. B16.5 contains the pressure-temperature ratings for 42 groups of materials, with each group broken down according to forgings, castings and plates. This sizes covered by this standard are NPS 1 through 24 (Classes 300, 400, 600, 900 and 1500) and NPS 1 through 12 (Class 2500).
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-72 B16.39 *Malleable Iron Threaded Pipe Unions*

Current Edition:	1998 (15 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard for threaded malleable iron unions, Classes 150, 250 and 300 provides requirements for the following: a) design; b) pressure-temperature ratings; c) size; d) marking; e) materials; f) joints and seats; g) threads; h) hydrostatic strength; i) tensile strength; j) air pressure test; k) sampling for air pressure test; l) coatings; and m) dimensions.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspections at the manufacturer's plant.
Comments:	The sizes of the pipe unions covered by this standard are NPS 1/8 through 4.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-73 B16.42 *Ductile Iron Pipe Flanges and Flanged Fittings (Classes 150 and 300)*

Current Edition:	1998 (25 pages) Reaffirmed 2006
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers minimum requirements for Class 150 and 300 cast ductile iron pipe flanges and flanged fittings. The requirements covered are as follows: a) pressure-temperature ratings; b) sizes and method of designating openings; c) marking; d) materials; e) dimensions and tolerances; f) bolts, nuts and gaskets; and g) tests.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program.
Comments:	This standard covers flanges, 45 and 90 degree elbows, tees, crosses, 45 degree laterals, reducers, and true Y's in sizes NPS 1 through 24 in Classes 150 and 300.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-74 B16.47 *Large Diameter Steel Flanges (NPS 26 through NPS 60 Metric/Inch Standard)*

Current Edition:	2006 (100 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking and testing for pipe flanges in sizes NPS 26 through NPS 60. Included here are flanges with rating class designations 75, 150, 300, 400, 600 and 900 with requirements given in both SI (metric) and US customary units, with diameter of bolts and flange bolt holes expressed in inch units. This standard is limited to: • Flanges made from cast or forged materials • Blind flanges made from cast, forged or plate materials. Also, included in this standard are requirements and recommendations regarding flange bolting, flange gaskets and flange joints.
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Manufacturers can also use this document as a reference for the required flange dimension details, including those applicable to welding. Designers can use this standard to select the appropriate class flange based on the specific design conditions (pressure and temperature) and the material of construction. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspection in a manufacturer's plant.
Comments:	This is a comprehensive document that contains the pressure-temperature ratings for 25 groups of materials, with each group broken down according forgings, castings and plates.
User:	Purchaser: **P**; Manufacturer: **P**; Designer: **P**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-75 B16.48 *Line Blanks*

Current Edition:	2005 (42 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking and testing for operating line blanks in sizes NPS ½ through NPS 24 for installation between ASME B16.5 flanges in the 150, 300, 600, 900, 1500 and 2500 pressure classes.
Application:	Purchasers can reference this standard in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. Manufacturers can also use this document as a reference for the required flange dimension details. Designers can use this standard to select the appropriate class line blank based on the specific design conditions (pressure and temperature) and the material of construction. In addition, the thickness and dimensional requirements may be useful in evaluating the results of an in-service examination program. It can also be used as a reference for inspection in the manufacturer's plant.
Comments:	This standard covers raised face figure-8 blanks, female ring-joint facing figure-8 blanks and male oval ring-joint facing figure-8 blanks. Materials and pressure-temperature ratings are by reference to ASME B16.5.
User:	Purchaser: **P**; Manufacturer: **P**; Designer: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-76 B16.50 *Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings*

Current Edition:	2001 (15 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard establishes requirements for wrought copper and wrought copper alloy braze-joint seamless fittings designed for use with seamless copper tube conforming to ASTM Standard Specification B 88 (Water and General Plumbing Systems), B 280 (Air Conditioning and Refrigeration Service) and B 819 (Medical Gas Systems). This standard covers joints assembled with brazing materials conforming to ANSI/AWS A5.8. This standard is allied to ASME Standards B16.18 and B16.22. It provides requirements for fitting-ends suitable for brazing. This standard covers: a) pressure-temperature ratings; b) abbreviations for end connections; c) size and method for designating openings for fittings; d) marking; e) materials; f) dimensions and tolerances; and g) testing.
Application:	Purchasers can reference this document in an equipment purchase specification and manufacturers can use it to certify that requirements have been met. It can also be referenced for inspection at the manufacturer's plant.
Comments:	This standard covers various types of copper fittings such as adapters, bushings, elbows, tees, return bends, plugs, cap, couplings, P-traps, in both straight and reducing styles, if applicable. Fittings are mostly soldered, but some with both soldered and threaded connections are also covered. The water tube and pipe thread sizes covered are 1/8 through 8 inches. This standard states that due to widely varying manufacturing processes, meaningful laying-length requirements of fittings cannot be established and to consult the manufacturer for these dimensions.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: ; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-77 B31.1 *Power Piping*

Current Edition:	2007 (312 pages) 2008 Addenda
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Rules for this code section have been developed considering the needs for application which include piping typically found in electric power generating stations, in industrial and institutional plants, geothermal heating systems and central and district heating and cooling systems. This code prescribes requirements for the design, materials, fabrication, erection, test, inspection, operation and maintenance of piping systems. Piping as used in this code includes pipe, flanges, bolting, gaskets, valves, relief devices, fittings and the pressure containing portions of other piping components, whether manufactured in accordance with standards listed in Table 126.1 or specifically designed. It also includes hangers and supports and other equipment items necessary to prevent overstressing the pressure containing components. Rules governing piping for miscellaneous appurtenances, such as water columns, remote water level indicators, pressure gages, gage glasses, etc., are included within the scope of this code, but the requirements for boiler appurtenances shall be in accordance with Section I of the ASME Boiler and Pressure Vessel Code, PG-60. Power piping systems as covered by this code apply to all piping and their component parts except as excluded in paragraph 100.1.3. They include, but are not limited to, steam, water, oil, gas and air services. This code covers boiler external piping for power boilers and high temperature, high pressure water boilers in which steam or vapor is generated at a pressure of more than 15 psig (100 kPag) and high temperature water is generated at pressures exceeding 160 psig (1103 kPag) and/or temperature exceeding 250°F (120°C).
Application:	This code is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in power boiler piping design, fabrication, repair, construction and inspection. Regulators may use as desired.
Comments:	The general philosophy underlying this Power Piping Code is to parallel those provisions of Section I, Power Boilers, of the ASME Boiler and Pressure Vessel Code, as they can be applied to power piping systems. The allowable stress values for power piping are generally consistent with those assigned for power boilers. This code is more conservative than some other piping codes, reflecting the need for long service life and maximum reliability in power plant installations. The Power Piping Code as currently written does not differentiate between the design, fabrication and erection requirements for critical and noncritical piping systems, except for certain stress calculations and mandatory nondestructive tests of welds for heavy wall, high temperature application.
User:	Manufacturer: **P**; Consultant: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-78 B31.3 *Process Piping*

Current Edition:	2008 (358 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Rules for the Process Piping Code Section B31.3 have been developed considering piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. This code prescribes requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping. This code applies to piping for all fluids, including: • Raw, intermediate and finished chemicals • Petroleum products • Gas, steam, air and water • Fluidized solids • Refrigerants • Cryogenic fluids. Fig. 300.1.1 of this code illustrates the application of B31.3 piping at equipment. The joint connecting piping to equipment is within the scope of B31.3. Also included within the scope of this code is piping which interconnects pieces or stages within a packaged equipment assembly. This code excludes the following. • Piping systems designed for internal gage pressures at or above zero but less than 105 kPa (15 psi), provided the fluid handled is nonflammable, nontoxic and not damaging to human tissues • power boilers in accordance with BPV Code Section I and boiler external piping which is required to conform to B31.1 • tubes, tube headers, crossovers and manifolds of fired heaters, which are internal to the heater enclosure • pressure vessels, heat exchangers, pumps, compressors and other fluid handling or processing equipment, including internal piping and connection for external piping.
Application:	This code can be used by persons knowledgeable in the design, fabrication, erection, testing and repair of piping components and systems.
Comments:	This is a comprehensive document intended for use by persons knowledgeable in stress calculations and materials properties. It covers metallic and nonmetallic piping. It has a part on piping for Category M (high pressure, toxic, flammable, damaging to human skin) fluid service. There is also information on interpretations and code cases relevant to B31.1.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **P** P – Primary User S – Secondary User

A-79 B31.5 *Refrigeration Piping and Heat Transfer Components*

<table>
<tr><td>Current Edition:</td><td>2006 (80 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>Rules for this code section have been developed considering the needs for applications that include piping and heat transfer components for refrigerants and secondary coolants.
This code prescribes requirements for the materials, design, fabrication, assembly, erection, test and inspection of refrigerant, heat transfer components and secondary coolant piping for temperatures as low as –320°F (–196°C), whether erected on the premises or factory assembled, except as specifically excluded as noted.
This code shall not apply to any of the following.
• Any self-contained or unit systems subject to the requirements of Underwriters Laboratories or other nationally recognized test laboratory
• Water piping, other than where water is used as a secondary coolant or refrigerant
• Piping designed for external or internal gage pressure not exceeding 15 psi (105 kPa) regardless of size
• Pressure vessels, compressors or pumps, but does include all connecting refrigerant and secondary coolant piping starting at the first joint adjacent to such apparatus.</td></tr>
<tr><td>Application:</td><td>This code can be used by persons knowledgeable in the design, fabrication, construction and testing of piping components and systems.</td></tr>
<tr><td>Comments:</td><td>This document is intended for use by persons knowledgeable in stress calculations, materials properties and mechanical engineering principles. It applies primarily to new construction using metallic components.</td></tr>
<tr><td>User:</td><td>

Purchaser	Manufacturer	Owner	Inspector	Regulator
P	**P**	**P**	**S**	

P – Primary User
S – Secondary User</td></tr>
</table>

A-80 B31.9 *Building Services Piping*

Current Edition:	2008 (73 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This code section has rules for the piping in industrial, institutional, commercial and public buildings and multi-unit residences, which do not require the range of sizes, pressures and temperatures covered in B31.1. This code prescribes requirements for the design, materials, fabrication, installation, inspection, examination and testing of piping systems for building services. It includes piping systems for building services. It includes piping systems in the building or within the property limits. This code applies to the following building services. • Water and antifreeze solutions for heating and cooling • Condensing water • Steam or other condensate • Other nontoxic liquids • Steam • Vacuum • Compressed air • Other nontoxic, nonflammable gases • Combustible liquids including fuel oil. The scope of this code includes boiler external piping within the following limits. • For steam boilers, 15 psig max. • For water heating units, 160 psig max. and 250°F max. Boiler external piping above these pressure or temperature limits is within the scope of ASME B31.1. This code does not apply to economizers, heaters, pumps, tanks, heat exchangers or equipment covered by the ASME Boiler and Pressure Vessel Code.
Application:	This code is intended for use by building designers, construction contractors and building inspectors. It can also be used as a resource by regulators and lawmakers for input into building codes.

Comments:	Piping systems of the following materials are within the scope of this code, through the indicated maximum size (and wall thickness if noted): • Carbon steel: NPS 48 and 0.50 in. wall • Stainless steel: NPS 24 and 0.50 in. wall • Aluminum: NPS 12 • Brass and copper: NPS 12 and 12.125 in. O.D. for copper tubing • Thermoplastics: NPS 24 • Ductile iron: NPS 48 • Reinforced thermosetting resin: 24 in. nominal. Other materials may be used as noted in Chapter III of this code. Piping systems with working pressure not in excess of the following limits are within the scope of this code. • Steam and condensate: 150 psig • Liquids: 350 psig • Vacuum: 1 atm. external pressure • Compressed air and gas: 150 psig. Piping systems with working temperatures not in excess of the following limits are within the scope of this code. • Steam and condensate: 366°F • Other gases and vapors: 200°F • Other nonflammable liquids: 250°F. The minimum temperature for all services is 0°F.
User:	Purchaser: — ; Contractor: **P** ; Designer: **P** ; Inspector: **P** ; Regulator: **P** P – Primary User S – Secondary User

A-81 B31E *Standard for the Seismic Design and Retrofit of Above-Ground Piping Systems*

Current Edition:	2008 (5 pages)
Alt. Number:	No
ANSI Approved?	Yes
Scope:	This standard establishes a method for the seismic design of above-ground piping systems in the scope of the ASME B31 Code for Pressure Piping. This standard applies to above-ground, metallic piping systems in the scope of the ASME B31 Code for Pressure Piping (B31.1, B31.3, B31.4, B31.5, B31.8, B31.9 and B31.11). The requirements described in this standard are valid when the piping system complies with the materials, design, fabrication, examination, testing and inspection requirements of the applicable ASME B31 Code section.
Application:	This standard can be used by piping and/or mechanical designers as an aid in designing new or retrofitting existing piping systems to withstand seismic loads.
Comments:	This standard provides guidance on the design method that should be used based on: a) the classification of the piping system (critical or noncritical); b) the magnitude of the seismic input; and c) the pipe size. This standard can be used by persons knowledgeable in the design of piping systems.
User:	Purchaser: [ ] Designer: **P** Owner: **P** Inspector: [ ] Regulator: [ ] P – Primary User S – Secondary User

A-82 B31G *Manual for Determining the Remaining Strength of Corroded Pipelines*

Current Edition:	1991 (55 pages) Reaffirmed 2004
Alt. Number:	None
ANSI Approved?	Yes
Scope:	The scope of this manual includes all pipelines within the scope of the pipelines codes that are part of ASME B31 Code for Pressure Piping, i.e., ASME B31.4, Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia and Alcohols; ASME B31.8, Gas Transmission and Distribution Piping Systems; and ASME B31.11, Slurry Transportation Piping Systems. Parts 2, 3 and 4 are based on material included in ASME Guide for Gas Transmission and Distribution Piping Systems, 1983 Edition. This manual is not applicable to new construction covered under the B31 Code sections. That is, it is not intended for this manual be used to establish acceptance standards for pipe that may have become corroded prior to or during fabrication and/or installation. The limitations of this manual are: • This manual is limited to corrosion on weldable pipeline steels categorized as carbon steels or high strength low alloy steels. Typical of these materials are those described in ASTM A 53, A 106, A 381 and API 5L. • This manual applies only to defects in the body of line pipe which have relatively smooth contours and cause low stress concentrations (e.g., electrolytic or galvanic corrosion, loss of wall thickness due to erosion). • This procedure should not be used to evaluate the remaining strength of corroded girth or longitudinal welds or related heat affected zones, defects caused by mechanical damage, such as gouges and grooves or defects introduced during pipe and plate manufacture, such as seams, laps, rolled ends, scabs or slivers. • The criteria for corroded pipe to remain in service presented in this manual are based only upon the ability of the pipe to maintain structural integrity under internal pressure. It should not be the sole criterion when the pipe is subject to significant secondary stresses (e.g., bending), particularly if the corrosion has a significant transverse component. • This procedure does not predict leaks or rupture failures.
Application:	This manual is intended for the purpose of providing guideline information for the designer/owner/operator. The specific use of this manual is the responsibility of the designer/owner/operator. This manual can also be used by consultants who are contracted by pipeline owners/operators.
Comments:	The development of the procedure presented in this manual began in the early 1970s and is based on pressurizing to failure tests on full-size corroded pipes. These tests led to mathematical expressions to calculate the pressure strength of corroded pipe. Based on the table in Part 3 of this manual, the range of pipe sizes covered is NPS 2 and 0.083 in. wall thickness through NPS 60 and 1.250 in. wall thickness. Although the Scope states that this manual is applicable to ASME B31.4, B31.8 and B31.11 pipelines, it can be used to assess other piping systems constructed of the same steels as used for pipelines.

User:	Purchaser	Designer	Owner/ Operator	Consultant	Regulator
		P	**P**	**P**	
	P – Primary User S – Secondary User				

A-83 B36.10M *Welded and Seamless Wrought Steel Pipe*

Current Edition:	2004 (18 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers the standardization of dimensions of welded and seamless wrought steel pipe for high or low temperatures and pressures. The word "pipe" is used, as distinguished from "tube," to apply to tubular products of dimensions commonly used for pipeline and piping systems. Pipe NPS 12 (DN 300) and smaller have outside diameters numerically larger than their corresponding sizes. For pipes NPS 14 (DN 350) and larger, the outside diameter and size are numerically identical. In contrast, the outside diameters of tubes are numerically identical to the size number for all sizes.
Application:	Designers can use this standard to select an available standard pipe thickness after the minimum thickness for the required conditions has been determined. The standard provides a tabulation of pipe weight per unit of length which can be used in determining piping support loads and shipping weights.
Comments:	This standard covers nominal pipe sizes from NPS ⅛ (DN 6) through 80 (DN 2000). This standard does not cover the possible variations in pipe dimensions. These tolerances are given in the individual pipe material specifications.
User:	Purchaser: [ ] Manufacturer: [ ] Designer: [P] Inspector: [ ] Regulator: [ ] P – Primary User S – Secondary User

A-84 B36.19M *Stainless Steel Pipe*

Current Edition:	2004 (5 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard covers the standardization of dimensions of welded and seamless wrought stainless steel pipe for high or low temperatures and pressures. The word “pipe” is used, as distinguished from “tube,” to apply to tubular products of dimensions commonly used for pipeline and piping systems. Pipe NPS 12 (DN 300) and smaller have outside diameters numerically larger than their corresponding sizes. For pipes NPS 14 (DN 350) and larger, the outside diameter and size are numerically identical. In contrast, the outside diameters of tubes are numerically identical to the size number for all sizes. The wall thickness for NPS 14 through 22, inclusive (DN 350-550, inclusive), of Schedule 10S; NPS 12 (DN 300) of Schedule 40D; and NPS 10 and 12 (DN 250 and 300) of Schedule 80S are not the same as those of ASME B36.10M. The suffix “S” in the schedule number is used to differentiate B36.19M pipe from B36.10M pipe. ASME B36.10M includes other pipe thicknesses that are commercially available with stainless steel material.
Application:	Designers can use this standard to select an available standard pipe thickness after the minimum thickness for the required conditions has been determined. The standard provides a tabulation of pipe weight per unit of length which can be used in determining piping support loads and shipping weights.
Comments:	This standard covers nominal pipe sizes from NPS ⅛ (DN 6) through 30 (DN 750). This standard does not cover the possible variations in pipe dimensions. These tolerances are given in the individual pipe material specifications.
User:	Purchaser: — ; Manufacturer: — ; Designer: P ; Inspector: — ; Regulator: — P – Primary User S – Secondary User

A-85 B40.100 *Pressure Gauges and Gauge Attachments (B40.1, B40.2, B40.5, B40.6, and B40.7)*

Current Edition:	2005 (108 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard (B40.100) consolidates the following individual standards, which cover terminology and definitions, dimensions, safety, construction and installation issues, test procedures and general recommendations. ASME B40.1 – Gauges: Pressure Indicating Dial Type-Elastic Element • This standard is confined to analog, dial-type gauges, which, utilizing elastic elements, mechanically sense pressure and indicate it by means of a pointer moving over a graduated scale. • This standard does not include gauges of special configuration designed for specific applications, edge reading, deadweight or piston gages or any other gauges not using an elastic element to sense pressure. ASME B40.2 – Diaphragm Seals • This standard is confined to mechanical separators utilizing diaphragms or bladders together with a fill fluid to transmit pressure from the medium to the pressure element assembly of pressure gauges or other pressure measuring instruments such as transducers, transmitters and switches. • It does not include diaphragm actuated pressure instruments that employ mechanical linkages to transmit the applied pressure or other separation devices designed to protect the pressure element assembly. ASME B40.5 – Snubbers • This standard is confined to devices that are installed between the pressure source and the pressure-sensing element and are used to minimize the effect of pressure surges on positive and negative pressure-sensing instruments. ASME B40.6 – Pressure Limiter Valves • This standard is confined to devices that protect pressure-sensing instruments from pressure sources in the event of system pressure rising above the adjusted closing pressure of the device. These devices are not pressure regulators. Pressure limiter valves are designed only to prevent the passage of excessive pressure to downstream pressure-sensing instruments. Hereafter, pressure limiter valves may be referred to as “devices.” ASME B40.7 – Gauges: Pressure Digital Indicating • This standard is confined to digital gauges with integral pressure transducers, which respond to pressure and indicate numerically. • It does not include panel meters with remote mounted transducers, nonindicating pressure transmitters or pressure switches.
Application:	This standard is an advisory document that can provide guidance to manufacturers, instrument engineers and users. For manufacturers, it provides suggested configuration guidelines; for engineers, it can be a resource in preparing a specification; and, for users, it explains the construction, operation, application, and procedures associated with pressure gauges and attachments.
Comments:	This Standard can serve as a tutorial type reference for process and mechanical engineers.

User:	Engineer	Manufacturer	User	Inspector	Regulator
	P	**P**	**P**	**S**	
	P – Primary User S – Secondary User				

A-86 ASME BPE *Bioprocessing Equipment*

Current Edition:	2005 (111 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard provides the requirements applicable to the design of equipment used in the bioprocessing, pharmaceutical and personal care product industries, including aspects related to sterility and cleanability, materials, dimensions and tolerances, surface finish, material joining, seals, examinations, inspections, testing and certifications. These apply to: • Components that are in contact with the product, raw materials or product intermediates during manufacturing, development or scale-up • Systems that are a critical part of product manufacture [e.g., water-for injection (WFI), clean steam, filtration and intermediate product storage]. The main sections in this standard are: General requirements; Design for sterility and cleanability; Dimensions and tolerances for stainless steel automatic welding and hygienic clamp tube fittings and process components; Material joining; Stainless steel and higher alloy product contact surface finishes; Equipment seals; and Polymer-based materials.
Application:	This standard is intended for use by persons involved in the design and manufacture of bioprocessing equipment. It can also be used as a reference by shop inspectors, regulators and owners.
Comments:	This standard does not apply to those components of the system that are not in contact with the finished product or are a part of the intermediate manufacturing stages (e.g., computer systems, electrical conduits and external system support structures). Steam sterilized systems normally meet pressure vessel design codes. Other equipment or systems as agreed to by the manufacturer and owner/user may not require adherence to these codes.
User:	Purchaser: (blank); Designer/Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-87 BPVC Section I *Rules for Construction of Power Boilers*

Current Edition:	2007 (248 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This code covers rules for construction of power boilers, electric boilers, miniature boilers, high-temperature water boilers and heat recovery steam generators to be use in stationary service and includes those power boilers used in locomotive, portable and traction service. The scope of jurisdiction of Section I applies to the boiler proper and to the boiler external piping. Superheaters, economizers and other pressure parts connected directly to the boiler without intervening valves shall be considered as parts of the boiler proper, and their construction shall conform to Section I rules.
Application:	This standard is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in boiler design, fabrication, repair, construction and inspection. Regulators may use as desired.
Comments:	The first part of this document contains a section covering the general requirements for all methods of construction. Subsequent sections cover requirements for boilers fabricated by welding, requirements for boilers fabricated by riveting, requirements for boilers fabricated by brazing, requirements for watertube boilers, requirements for firetube boilers, optional requirements for feedwater heater, requirements for miniature boilers, requirements for electric boilers, requirements for organic fluid vaporizers and requirements for heat recovery steam generators.
User:	Manufacturer: **P**; Consultatnt: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-88 BPVC Section II – Materials - Part A *Ferrous Material Specifications*

Current Edition:	2007 (1662 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This document contains the individual specifications for the ferrous materials that are allowed to be used by the ASME Code, Sections I, II, III, IV, VIII-1, VIII-2, VIII-3 and XII. It also designates for each ferrous material the specific ASME Code that allows its use. The forms of ferrous material covered by this document are steel pipe; steel tubes; steel flanges, fittings, valves and parts; steel plates, sheets and strip for pressure vessels; structural steel; steel bars; steel bolting materials; steel billets and forgings; steel castings; corrosion-resisting and heat-resisting steels; and wrought iron, cast iron and malleable iron. This document also has specifications covering test and examination methods.
Application:	This document can be used as an aid by pressure vessel, piping and structural designers to select a ferrous material for a specific application. It can also be referenced by inspections and by persons involved in the review of equipment designs.
Comments:	The areas addressed by the individual specifications vary based on the characteristics of the ferrous material and the final use/form for which it is intended. Some examples are ordering information, heat treatment, chemical composition, mechanical properties, tests and examination, dimensions and tolerances and steel making practice. In addition to the individual material specifications, there are several general requirement specifications, e.g., General Requirements for Steel Plate for Process Vessels. The general specification is referenced by the applicable individual specifications.
User:	Designer: **P**; Consultant: **P**; Owner: **P**; Inspector: **P**; Regulator: P – Primary User S – Secondary User

A-89 BPVC Section II – Materials - Part B *Nonferrous Material Specifications*

Current Edition:	2007 (1120 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This document contains the individual specifications for the nonferrous materials that are allowed to be used by the ASME Code, Sections I, II, III, IV, VIII-1, VIII-2, VIII-3 and XII. It also designates for each nonferrous material the specific ASME Code that allows its use. The forms of ferrous material covered by this document are aluminum and aluminum alloys; cobalt alloys; copper and copper alloy plate, sheet, strip and rolled bar; copper and copper alloy rod, bar, and shapes; copper and copper alloy pipe and tubes; copper alloy castings; nickel and nickel alloy plate, sheet and strip; nickel and nickel alloy rod, bar and wire; nickel and nickel alloy pipe and tubes; nickel alloy castings; nickel and nickel alloy fittings; titanium and titanium alloys; and zirconium and zirconium alloys. Test requirements are typically by reference to ASTM standards.
Application:	This document can be used as an aid by pressure vessel, piping and structural designers to select a nonferrous material for a specific application. It can also be referenced by inspectors and by persons involved in the review of equipment designs.
Comments:	The areas addressed by the individual specifications vary based on the characteristics of the ferrous material and the final use/form for which it is intended. Some examples are ordering information, chemical composition, mechanical properties, tests and examination and dimensions and tolerances. In addition to the individual material specifications, there are several general requirement specifications, e.g., General Requirements for Nickel and Nickel Alloy Welded Pipe. The general specification is referenced by the applicable individual specifications.
User:	Designer: **P**; Consultant: **P**; Owner: **P**; Inspector: **P**; Regulator: P – Primary User S – Secondary User

A-90 BPVC Section II - Materials Part C *Specifications for Welding Rods, Electrodes, and Filler Metals*

Current Edition:	2007 (723 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This is a service book to the other code sections providing material specifications for the manufacture, acceptability, chemical composition, mechanical usability, surfacing, testing requirements and procedures, operating characteristics and intended uses for welding rods, electrodes and filler metals. These specifications are designated by SFA numbers and are derived from American Welding Society (AWS) specifications.
Application:	This document can be used by persons who are responsible for: 1) developing welding procedures and 2) purchasing welding materials. It can also be used as a reference by inspectors.
Comments:	This document only includes specifications that are applicable to the ASME B&PVC Code.
User:	Purchaser: **P**; Consultant: **P**; Owner: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-91 BPVC Section II – Materials – Part D *Materials Properties (Customary)*

Current Edition:	2007 (906 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This is a service book to other code sections providing tables of design stress values, tensile and yield strength values and tables and charts of material properties. Part D facilitates ready identification of specific materials to specific sections of the Boiler and Pressure Vessel Code. Part D contains appendices which present criteria for establishing allowable stress, the bases for establishing external pressure charts and information required for approval of new materials. Access to the online version of the Stress Tables is included with the purchase of this hard copy.
Application:	This standard is intended for use by organizations that maintain, or have access to, engineering and inspection personnel technically trained and experienced in ASME Code design, fabrication, repair, construction and inspection.
Comments:	The three subparts in this document are: Subpart 1: Interactive Tables – Stress Tables, Subpart 2: Physical Properties Tables and Subpart 3: Charts and Tables for Determining Shell Thickness of Components Under External Pressure. The Subpart 1 Stress Tables are provide for ASME Code Sections I, III, VIII-1, VIII-2, VIII-3 and XII, and include all ferrous and nonferrous materials contained in Section II, Parts A and B.
User:	Designer: **P**; Consultant: **P**; Owner: **P**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-92 BPVC Section II – Materials – Part D *Materials Properties (Metric)*

Current Edition:	2007 (897 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This is a service book to other code sections providing tables of design stress values, tensile and yield strength values and tables and charts of material properties. Part D facilitates ready identification of specific materials to specific sections of the Boiler and Pressure Vessel Code. Part D contains appendices which present criteria for establishing allowable stress, the bases for establishing external pressure charts and information required for approval of new materials. Access to the online version of the Stress Tables is included with the purchase of this hard copy.
Application:	This standard is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in ASME Code design, fabrication, repair, construction and inspection.
Comments:	The three subparts in this document are: Subpart 1: Interactive Tables – Stress Tables, Subpart 2: Physical Properties Tables and Subpart 3: Charts and Tables for Determining Shell Thickness of Components Under External Pressure. The Subpart 1 Stress Tables are provide for ASME Code Sections I, III, VIII-1, VIII-2, VIII-3 and XII, and include all ferrous and nonferrous materials contained in Section II, Parts A and B.
User:	Designer: **P**; Consultant: **P**; Owner: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

A-93 BPVC Section IV *Rules for Construction of Heating Boilers*

Current Edition:	2007 (250 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This section of the code covers rules for minimum construction requirements for the design, fabrication, installation and inspection of steam heating, hot water heating, hot water supply boilers that are direction fired with oil, gas, electricity, coal or other solid or liquid fuels, and for operation at or below the pressure and temperature limits set forth in this document. Similar rules for potable water heaters are also included. The scope of jurisdiction of Section IV applies to the boiler proper at the supply and return connections to the system or the supply and feedwater connections of a hot water supply boiler. Included within the scope of the boiler are pressure-retaining covers for inspection openings, such as manhole covers, handhold covers and plugs; and headers required to connect individual coils, tubes or cast sections within a boiler.
Application:	This standard is intended for use by organizations that maintain or have access to engineering and inspection personnel technically trained and experienced in heating boiler design, fabrication, repair, construction and inspection. Regulators may use as desired.
Comments:	The first part of this document contains a section covering the general requirements for all methods of construction. Subsequent sections cover requirements for boiler fabricated by welding, requirements for boilers fabricated by brazing, requirements for boilers constructed of cast iron and requirements for boilers constructed of cast aluminum. There is also a section on the requirements for potable water heaters.
User:	Manufacturer: **P**; Consultant: **P**; Owner: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-94 BPVC Section V *Nondestructive Examination*

Current Edition:	2007 (631 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This section of the code contains requirements and methods for nondestructive examination (NDE), which are code requirements to the extent they are specifically referenced and required by other code sections or referencing document. These NDE methods are intended to detect surface and internal imperfections in materials, welds, fabricated parts and components. They include radiographic examination, ultrasonic examination, liquid radiographic examination, magnetic particle examination, liquid penetrant examination, magnetic particle examination, eddy current examination, visual examination, leak testing and acoustic emission examination. Appendix A of Subsection A presents a listing of common imperfections and damage mechanisms and the NDE methods that are generally capable of detecting them.
Application:	This document can be used by owners, manufacturers and inspection service companies as an aid in selecting an NDE method(s) and performing the test for inspecting new and existing equipment. It also presents guidance for the evaluation of the test results.
Comments:	This is a comprehensive guidance document intended for use by persons knowledgeable in inspection methods and procedures and in the types of defects and damage mechanisms.
User:	Consultant: **S**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: P – Primary User S – Secondary User

A-95 BPVC Section VI *Recommended Rules for the Care and Operation of Heating Boilers*

Current Edition:	2007 (92 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This section of the ASME Code is intended to cover general descriptions, terminology and basic fundamentals of heating boilers, controls and automatic fuel burning equipment. Because of the wide variety of makes and types of equipment in use, it is general in scope. The boilers discussed in this section will be those limited to the operating ranges of Section IV, Heating Boilers, of the ASME Boiler and Pressure Vessel Code as follows. • Steam boilers for operation at pressure not exceeding 15 psi (100kPa) • Hot water heating and hot water supply boilers for operation at pressures not exceeding 160 psi (1100 kPa) and/or temperatures not to exceed 250°F (120°C).
Application:	This section is intended to provide general guidance to owners in the care and operation of steam and hot water boilers. For detailed information on any specific unit, the manufacturer's information should be consulted. It also includes information on the periodic inspection of existing boilers.
Comments:	This section is a tutorial type document. The main topics covered are types of boilers; accessories and installation; fuels; fuel burning equipment and fuel burning controls; boiler room facilities; operation, maintenance and repair – steam boilers; operation, maintenance and repair – hot water boilers and hot water heating boilers; and water treatment. It also includes sample maintenance, testing and inspection logs for steam heating boilers and hot water heater boilers.
User:	Purchaser: – ; Manufacturer: – ; Owner: **P** ; Inspector: **S** ; Regulator: – P – Primary User S – Secondary User

A-96 BPVC Section VII *Recommended Guidelines for the Care of Power Boilers*

Current Edition:	2007 (128 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	These guidelines apply to the boiler proper and to pipe connections up to and including the valve or valves as required by the code. Superheaters, reheaters, economizers or other pressure parts connected directly to the boiler without intervening valves should be considered as part of the boiler. Guidelines are also provided for operation of auxiliary equipment and appliances that affect the safe and reliable operation of power boilers. With respect to the application of these guidelines, a power boiler is a pressure vessel constructed in compliance with Section 1 in which steam is generated for use external to the boiler at a pressure exceeding 15 psig (100 kPa) due to the application of heat. This heat may be derived from the combustion of fuel (solids, liquids or gases), from hot waste gases or other chemical reactions or from the application of electrical energy.
Application:	The purpose of these recommended guidelines is to promote safety in the use of power boilers. These guidelines are intended for use by those directly responsible for operating, maintaining, and inspecting power boilers. The difficulty in formulating a set of guidelines that may be applied to all sites and types of plants is recognized; therefore, it may be advisable to depart from them in specific cases. Manufacturer's operating instructions should always be followed. Other recommended procedures such as National Fire Protection Association codes covering prevention of furnace explosions are suggested for additional guidance.
Comments:	The main topics covered by this section are fundamentals; boiler operation; boiler auxiliaries; appurtenances; instrumentation, controls and interlocks; inspection; repairs, alterations and maintenance; control of internal chemical conditions; and preventing boiler failures. It also includes maintenance and operation checklists for watertube and firetube boilers.
User:	Contractor: [ ] Manufacturer: [ ] Owner: P Inspector: P Regulator: [ ] P – Primary User S – Secondary User

A-97 BPVC Section VIII - Division 1 *Rules for Construction of Pressure Vessels*

Current Edition:	2007 (671 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	For the scope of this division, pressure vessels are containers for the containment of pressure, either internal or external exceeding 15 psig. This pressure may be obtained from an external source, by the application of heat by a direct or indirect source or through any combination thereof. This division contains mandatory requirements, specific prohibitions and nonmandatory guidance for pressure vessel materials, design, fabrication, examination, inspection, testing, certification and pressure relief. The code does not address all aspects of these activities, and those aspects which are not specifically addressed should not be considered prohibited. This division is divided into three subsections, mandatory appendices and non-mandatory appendices. Subsection A covers the general requirements applicable to all pressure vessels. Subsection B covers specific requirements that are applicable to the various methods used in the fabrication of pressure vessels. It deals with welded, forged and brazed methods. Subsection C covers specific requirements applicable to the several classes of materials used in pressure vessel construction. It deals with carbon and low alloy steels, nonferrous metals, high alloy steels, cast iron, clad and lined material, cast ductile iron and ferritic steels, with properties enhanced by heat treatment, layered construction and low temperature materials, respectively. Section II, Part D contains tables of maximum allowable stress values for these classes of materials. The mandatory appendices address specific subjects not covered elsewhere in this division, and their requirements are mandatory when the subject covered is included in construction under this division. The non-mandatory appendices provide information and suggested good practices.
Application:	This division can be used by persons knowledgeable in the design, fabrication, testing and repair of pressure vessels.
Comments:	This division is based on “Design by Rule” procedures. It is less rigorous than Division 2 but uses lower allowable stress values.
User:	Purchaser: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **P** P – Primary User S – Secondary User

A-98 BPVC Section VIII - Division 2 *Rules for Construction of Pressure Vessels – Alternative Rules*

<table>
<tr><td>Current Edition:</td><td>2007 (931 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>In the scope of this division, pressure vessels are containers for the containment of pressure, either internal or external, exceeding 15 psig. This pressure may be obtained from an external source or by the application of heat from a direct or indirect source as a result of a process or through any combination thereof.

The rules of this division may be used for the construction of the following pressure vessels.
Vessels to be installed at a fixed (stationary) location for a specific service where operation and maintenance control is retained during the useful life of the vessel by the user and is in conformance with the user’s design specification
Pressure vessels installed in ocean-going ships, barges and other floating craft or used for motor vehicle or rail freight
Pressure vessels or parts subject to direct firing from the combustion of fuel (solid, liquid or gaseous) that are not within the scope of Sections I, III or IV may be constructed in accordance with the rules of this division
The following pressure vessels in which steam is generated shall be constructed in accordance with the rules of Section VIII, Division 1 of this division
Vessels known as evaporators or heat exchangers
Vessels in which steam is generated by the use of heat resulting from operation of a processing system containing a number of pressure vessels such as used in the manufacture of chemical and petroleum products, and
Vessels in which steam is generated but not withdrawn for external use.
Unfired steam boilers shall be constructed in accordance with the rules of Section I or Section VIII, Division 1.
This division is divided into nine parts: general requirements, responsibilities and duties, materials requirements, design by rule requirements, design by analysis requirements, fabrication requirements, examination and inspection requirements, pressure testing requirements and pressure vessel overpressure protection. Technical information previously placed in mandatory and non-mandatory appendices at the back of the document have been re-deployed as annexes to the nine parts in the 2007 edition.</td></tr>
<tr><td>Application:</td><td>This division can be used by persons knowledgeable in the design, fabrication, testing, repair and approval of pressure vessels.</td></tr>
<tr><td>Comments:</td><td>This division is based on both “Design by Rule” and “Design by Analysis” procedures. It is more rigorous than Division 1, and uses higher allowable stress values. This division covers cyclic fatigue analysis.</td></tr>
<tr><td>User:</td><td><table><tr><td>Purchaser</td><td>Manufacturer</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr><tr><td>**P**</td><td>**P**</td><td>**P**</td><td>**P**</td><td>**P**</td></tr></table>P – Primary User
S – Secondary User</td></tr>
</table>

A-99 BPVC Section VIII - Division 3 *Rules for Construction of Pressure Vessels - Alternative Rules for Construction of High Pressure Vessels*

Current Edition:	2007 (277 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	The rules of this division constitute requirements for the design, construction, inspection and overpressure protection of metallic pressure vessels with design pressures generally above 10 ksi (70 MPa). However, it is not the intent of this division to establish maximum pressure limits for Section VIII, Division 1 or 2, nor minimum pressure limits for this division. Specific pressure limitations for vessels constructed to the rules of this division may be imposed elsewhere in this division for various types of fabrication. Pressure vessels within the scope of this division are pressure containers for the retainment of fluids, gaseous or liquid, under either internal or external pressure. This pressure may be generated by an external source, the application of heat from a direct or indirect source, a process reaction or through any combination thereof. This division is divided into eight parts and mandatory and nonmandatory appendices. The eight parts cover general requirements; material requirements; design requirements; fabrication requirements; pressure relief devices; examination requirements; testing requirements; and marking, stamping, reports and records.
Application:	This division can be used by persons knowledgeable in the design, fabrication, testing, repair and approval of high pressure vessels.
User:	Designer: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Regulator: **P** P – Primary User S – Secondary User

A-100 BPVC Section IX *Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operations*

Current Edition:	2007 (276 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This section of the ASME Boiler and Pressure Vessel Code relates to the qualifications of welders, welding operators, brazers and brazing operators, and the procedures that they employ in welding and brazing according to the ASME Boiler and Pressure Vessel Code and the ASME B31 Code for Pressure Piping. It is divided into two parts: Part QW gives requirements for welding and Part QB contains requirements for brazing. Others sections of the code may specify different requirements than those specified by this section. Such requirements take precedence over those of this section, and the manufacturer or contractor shall comply with them. The main topics in the welding Part QW are welding general requirements; welding procedure qualification; welding performance qualifications; welding data; and standard welding procedure specifications (SWPSs). The main topics in brazing Part QB are brazing general requirements; brazing procedure qualifications; brazing performance qualifications; and brazing data.
Application:	Purchasers can reference this section in purchase specification for new equipment or repairs and modifications to existing equipment. Manufacturers and field contractors need it to comply with the purchase specification when the section is cited therein.
Comments:	This section provides detailed procedures to qualify welders and brazers (operate manual or semi-automatic equipment) and welding and brazing operators (operate machine or automatic equipment) and also the procedures employed. It also contains acceptance standards.
User:	Purchaser: **P**; Manufacturer: **P**; Field Contractor: **P**; Inspector: ; Regulator: P – Primary User S – Secondary User

A-101 BPVC Section X *Fiber-Reinforced Plastic Pressure Vessels*

<table>
<tr><td>Current Edition:</td><td>2007 (212 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>This section established the requirements for the fabrication of fiber-reinforced thermosetting plastic pressure vessels for general service, sets limitations on the permissible service conditions and defines the types of vessels to which these rules are not applicable.
To assure that vessels fabricated according to these rules will be capable of safely withstanding the operating conditions specified by the design specification, this section:
Gives minimum requirements for the materials of fabrication
Specifies test procedures for determining laminate mechanical properties
Defines two methods of design qualification:
Class I Design – qualification of a vessel design through the destructive test of a prototype
Class II Design – mandatory design rules and acceptance testing by nondestructive methods.
Suggests nonmandatory design procedures for Class I vessels
Provides mandatory design procedures and acceptance testing for Class II vessels
Defines the general methods of fabrications which may be used
Limits the types of end closures, connections and attachments which may be employed and the means used to join them to the vessels
Stipulates the procedures to be used in proving that prototype vessels will withstand specified operating and test conditions
Establishes rules under which fabricating procedures used for fabricating Class I prototype and production vessels are qualified, and defines what deviations from such procedures necessitate requalification
Sets forth requirements to assure that no essential variation in qualified fabrication procedures has occurred
Establishes rules for acceptance testing, inspection and reporting
Gives requirements for stamping and marking.
For vessels fabricated in accordance with these rules, the provisions of Section X shall apply over any other sections of the code. When metallic components are part of fiber-reinforced plastic vessels, they shall meet the provisions of Section VIII, Division 1.
This section is divided into nine main parts and mandatory and nonmandatory appendices. The main parts are general requirements; material requirements; fabrication requirements; qualification requirements; pressure relief devices; rules governing testing; inspection requirements; and marking, stampin, and reports.</td></tr>
<tr><td>Application:</td><td>This section can be used by persons knowledgeable in the design, fabrication, testing, repair and approval of fiber-reinforced plastic pressure vessels.</td></tr>
</table>

Comments:	The use of fiber-reinforced plastics for the manufacture of pressure vessels presents unique materials considerations in the design, fabrication and testing of these vessels. Metallic vessels, being made from materials which are normally isotropic and ductile, are designed by using well-established allowable stresses based on measured tensile and ductility properties. In contrast, fiber-reinforced plastics are usually anisotropic and the physical properties are dependent upon the fabrication process, the placement and orientation of the reinforcement and the resin matrix. Adequacy of specific designs shall be qualified by one of two basic methods: • Class I Design – qualification of a vessel design through the pressure testing of a prototype • Class II Design – mandatory design rules and acceptance testing by nondestructive methods. These two methods shall not be intermixed. These vessels are not permitted to store, handle or process lethal fluids. Vessel fabrication is limited to the following processes: bag-molding, centrifugal casting and filament-winding and contract molding. General specifications for the glass and resin materials and minimum physical properties for the composite materials are given.
User:	Designer: **P** · Consultant: **P** · Owner: **P** · Inspector: **S** · Regulator: P – Primary User S – Secondary User

A-102 BPVC Code Cases *Boilers and Pressure Vessels*

Current Edition:	2007 (No. of pages changes when periodic supplements are issued.)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This document contains provisions which have been adopted by the Boiler and Pressure Vessel Committee that cover all the sections of the code other than Section III, Divisions 1, 2 and 3 and Section XI. Code cases provide rules that permit the use of materials and alternative methods of construction that are not covered by existing B&PVC rules. A Code case comes into existence when there is an inquiry to the ASME Boiler and Pressure Vessel Standards Committee on some aspect of design and/or construction that is not covered by the current code rules. The written response from the committee is assigned a number and it is published, along with the inquiry, in this document.
Application:	The initial user of a code case is typically the party that made the inquiry to the ASME Standards Committee. Once the committee responds, it is available for use by anyone involved in the use, design and construction of boilers and pressure vessels.
Comments:	The code cases are indexed according to the: 1) ASME code section, 2) material specification, 3) AWS specifications, 4) international specifications designer and 5) charts for vessels under external pressure. There is also a numerical index that shows the approval date and annulled date, if applicable. The ASME Boiler and Pressure Vessel Standards Committee took action to eliminate code c ase expiration dates effective March 11, 2005. This means that all code cases listed after this date will remain available for use until annulled by the ASME Boiler and Pressure Vessel Standards Committee.
User:	Purchaser: (blank); Maunfacturer: **P**; Owner: **P**; Designer: **P**; Fabricator: **S** P – Primary User S – Secondary User

A-103 RTP-1 *Reinforced Thermoset Plastic Corrosion-Resistant Equipment*

<table>
<tr><td>Current Edition:</td><td>2007 (322 Pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>

This standard applies to stationary vessels used for the storage, accumulation or processing of corrosive or other substances at pressures not exceeding 15 psig external and/or 15 psig internal above any hydrostatic head.
In relation to the geometry of vessels, the scope of this standard shall include the following.

Where external piping is to be connected to the vessel

The first threaded joint for screwed connections
The face of the first flange for bolted connections
The vessel side sealing surface for proprietary connections or fittings.

The vessel attachment joint when an attachment is made to either the external or internal surface of the vessel
Covers for vessel openings, such as manhole and handhole covers
The vessel side sealing surface for proprietary fittings attached to vessels for which rules are not provided by this standard, such as gages and instruments.

The following types of reinforced thermoset plastic equipment are excluded from the rules of the standard:

Vessels with internal operating pressure in excess of 15 psig
Hoods, ducts and stacks
Fans and blowers
Vessel internals such as entrainment separators, chevron blades, packing support plates and liquid distribution plates
Pumps
Pipe or piping (see ASME B31.3)
Fully buried underground closed vessels.

This standard is divided into eight main parts and mandatory and non-mandatory appendices. The main parts are: general requirements; materials; design; fabrication; over-pressure protection; inspection and testing; shop qualification; and certification.
</td></tr>
<tr><td>Application:</td><td>This standard can be used by persons knowledgeable in the design, fabrication, testing, repair and approval of reinforced thermoset plastic low pressure vessels.</td></tr>
</table>

<table>
<tr><td>Comments:</td><td>
Design by formulas and by stress analysis are both included in this standard. Consideration is given both to ultimate strength and to limiting strain. Time and temperature dependence of RTP laminate properties is recognized.

The ultimate stress consideration is required to assure safety against catastrophic failure over a reasonably long term. The strain considerations are required to assure long-term operation under cyclic stress (fatigue) without cracking the resin matrix of the composite laminate, thus maintaining maximum corrosion resistance.

Vessels conforming to this standard shall be limited to the following pressure and temperature limits.

Maximum internal pressure

With Proof Test. The internal operating pressure, measured at the top of the vessel, shall not be greater than 15 psig.
Without Proof Test. The internal operating pressure, measured at the top of the vessel, shall not be greater than 2 psig.

Maximum external pressure

With Proof Test. The limit on external operating pressure is 15 psig.
Without Proof Test. The limit on external operating pressure is 2 psig.

Temperature limits. The operating temperature shall be limited to a value for which mechanical properties have been determined and the chemical resistance has been established.

</td></tr>
<tr><td>User:</td><td>
<table>
<tr><th>Designer</th><th>Consultant</th><th>Owner</th><th>Inspector</th><th>Regulator</th></tr>
<tr><td>P</td><td>P</td><td>P</td><td>P</td><td>P</td></tr>
</table>
P – Primary User
S – Secondary User
</td></tr>
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A-104 PCC-1 *Guidelines for Pressure Boundary Bolted Flange Joint Assembly*

<table>
<tr><td>Current Edition:</td><td>2000 (44 pages)</td></tr>
<tr><td>Alt. Number:</td><td>None</td></tr>
<tr><td>ANSI Approved?</td><td>Yes</td></tr>
<tr><td>Scope:</td><td>The guidelines may be used to develop effective joint assembly procedures for flanged joints with ring type gaskets covering a broad range of sizing and service conditions.</td></tr>
<tr><td>Application:</td><td>Owners, users, and manufacturers of pressure equipment can use the methods in this guideline to optimize the assembly procedures for bolted flanged joints in order to minimize leaks.</td></tr>
<tr><td>Comments:</td><td>Detailed rules are provided for:

Examination of “working” surfaces
Alignment of mating surfaces
Installation of gaskets
Lubrication of “working” surfaces
Installation of bolts
Number of bolts and tightening sequence
Bolt tightening/tensioning methods and determination of the load achieved
Tables of torque to achieve target bolt stress levels.

As of this publication, a major update to this guideline is under development to provide rules for qualification of bolted flange joint assembly personnel.</td></tr>
<tr><td>User:</td><td>
<table>
<tr><td>Purchaser</td><td>Manufacturer</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr>
<tr><td></td><td>P</td><td>P</td><td></td><td></td></tr>
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P – Primary User
S – Secondary User</td></tr>
</table>

A-105 PCC-2 *Repair of Pressure Equipment and Piping*

Current Edition:	2008 (206 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Provides methods for repairing pressure equipment after it has been placed into service. The methods include relevant design, fabrication, examination and testing of repairs, which may be temporary or permanent.
Application:	Owners and users of pressure equipment can use the methods in this standard to make repairs using the "best practices" provided in the document.
Comments:	Detailed rules are provided for the following general types of repairs. • Weld repairs, including insert plates, weld overlay, seal welds, leak boxes, flaw evacuation and weld repair, full encirclement reinforcing sleeves and lap patches reinforcing plug welds, preheat alternatives, PWHT alternatives, weld buildup, fillet weld patches, plug repairs • Mechanical repairs, including replacement of components, freeze plugs, damaged threads, flange refinishing, mechanical leak clamps, pipe straightening and alignment, concrete anchors, bolting removal, repair of heat exchangers • Nonmetallic and bonded repairs • Examination and testing.
User:	Purchaser: – ; Contractor: **P** ; Owner: **P** ; Inspector: **P** ; Regulator: – P – Primary User S – Secondary User

A-106 PCC-3 *Inspection Planning Using Risk-Based Methods*

Current Edition:	2007 (88 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Provides guidance for developing and implementing an inspection program for fixed pressure-containing equipment and components. The approach emphasizes safe and reliable operation through cost-effective inspection.
Application:	Owners and users of pressure equipment can use the guidance in this standard to develop an in-service (post-construction) inspection program for their equipment. The guidance applies broadly to boilers, pressure vessels, piping, pipelines and storage tanks. However, other standards that are specific to one or more of these equipment types should also be consulted in developing inspection plans. These include: • API RP 580 "Risk-based Inspection." This document is very similar to ASME PCC-3 but is focused on the hydrocarbon and chemical process industries • API RP 581 "Base Resource Document – Risk Based Inspection." This document provides specific, detailed guidance for risk-based inspection • NB-23 – "National Board Inspection Code" for boilers and pressure vessels that are not in refining and chemical process services • API 510 – "Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair, and Alteration" for pressure vessels in refining and chemical process services • API 570 – "Inspection, Repair, Alteration, and Rerating of in-service Piping Systems" for piping systems. Although developed for the refining and chemical process industries, it may be used, where practical, for any piping system.
Comments:	PCC-3 should be used to help the owner or user of pressure equipment determine what areas of the equipment to inspect, what inspection techniques to use and how frequently to do the inspection. Although basic guidance on these topics is provided in NB-23, API 510 and API 570 (described above), PCC-3 provides for a more detailed analysis of inspection needs. This typically results in a reduction in the overall inspection effort, with increases in some areas offset by reductions in others. Most importantly, it provides for a systematic analysis to identify damage mechanisms that may affect particular material/process environment combinations to ensure that inspection/examination activities are focused on the areas that are important to pressure equipment integrity PCC-3 provides an overall methodology that can be used to develop an inspection plan using risk-base methods. It provides guidance and detailed tables to assist in defining the damage mechanisms that can affect pressure equipment, as well as inspection and monitoring methods to detect the damage. It provides methods for establishing RBI teams to determine the probability and consequence of failure and to calculate the risk of continued operation. The result of applying the process is an optimized, cost-effective inspection plan.
User:	Purchaser: — ; Consultant: **P** ; Owner: **P** ; Inspector: **P** ; Regulator: — P – Primary User S – Secondary User

A-107 PTC 25 *Pressure Relief Devices (Performance Test Codes)*

Current Edition:	2001 (74 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This code provides standards for conducting and reporting tests on reclosing and nonreclosing pressure relief devices normally used to terminate an abnormal internal or external rise in pressure above a predetermined design value in boilers, pressure vessels and related piping equipment. This code covers the methods and procedures to determine relieving capacity and additional operating characteristics which may be required for certification or other purposes by other codes. This is accomplished by dividing the code into two parts following Sections 1 and 2: Part 1, "Flowing Capacity Testing," and Part 2, "In-Service and Bench Testing." This code provides instructions in Part 1 for flow capacity testing and in Part 2 for in-service and bench testing. Testing of reclosing and nonreclosing pressure relief devices is conducted under various inlet and outlet conditions using steam, gases and liquids for which valid physical properties are known. The object of the test is to determine the performance of pressure-relief devices. These tests determine one or more of the following: a) dimensional, operational and mechanical characteristics; b) relieving pressure; c) relieving flow capacity at test pressure; and d) individual flow resistance. Procedures for conducting the tests, calculating the results and making corrections are defined. This code does not necessarily cover the methods and procedures to satisfy operating and other conditions as may be required by other codes. Establishment of pressure-relief device ratings and rules of safe construction do not fall within the province of this code.
Application:	This code is intended for use by pressure-relief device manufacturers and testing facilities for conducting and reporting tests on reclosing and non reclosing pressure-relief devices. This code can also be used by owners as a reference for in-service and bench testing.
Comments:	This code is applicable to the following types of reclosing and non reclosing pressure-relief devices: (A) Pressure relief valves, (B) Rupture disk devices (part 1 only), (C) Breaking/shear pin devices (part 1 only), and (D) Fusible plug devices (part 1 only). Other pressure relief devices may be tested provided all parties to the test agree to accept the provisions of this code.
User:	Test Facility: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **S**; Regulator: (blank) P – Primary User S – Secondary User

AMERICAN SOCIETY OF NONDESTRUCTIVE TESTING STANDARDS

A-108 CP-189 *ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*

Current Edition:	2006 (14 pages)
Alt. Number:	None
ANSI Approved?	Yes
Scope:	This standard specifies the procedures, essential factors, and minimum requirements for qualifying and certifying NDT personnel. The standard: • Establishes the minimum requirements for the qualification and certification of nondestructive testing (NDT) and Predictive Maintenance (PdM) personnel • Details the minimum training, education and experience requirements for NDT personnel and provides criteria for documenting qualifications and certification • Requires the employer to establish a procedure for the certification of NDT personnel • Requires that the employer incorporate any unique or additional requirements in the certification procedure.
Application:	This standard is intended for use by persons who are in charge of the training, qualification and certification of the personnel who are responsible for, and perform, nondestructive testing.
Comments:	A complementary standard to ANSI/ASNT CP189-2006 is ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (Document No. ANSI/ASNT CP-105-2006). This standard specifies the body of knowledge to be used as part of a training program qualifying and certifying NDT personnel. The scope of ANSI/ASNT CP-105-2006: • Establishes the minimum topical outline requirements for the qualifications of nondestructive testing (NDT) personnel • Details the minimum training course content for NDT personnel • Specifies that the amount of time spent on each topic in each method should be determined by the NDT Level III and the applicable certification document • These topical outlines are progressive; i.e., consideration as Level I is based on satisfactory completion of Level I training course; consideration as Level II is based on satisfactory completion of both Level I and Level II training courses • Topics in the outlines may be deleted or expanded to meet the employer's specific applications or for limited certification, unless stated otherwise by the applicable certification procedure or written practice. Note: While ANSI/ANST CP-189-2006 refers to NDT Level III, it does not cover certification for Level III.
User:	Company: **P**; Instructor: **P**; Owner: **P**; Inspector: **S**; Regulator: P – Primary User S – Secondary User

A-109 RP SNT-TC-1A *Personnel Qualification and Certification in Nondestructive Testing*

Current Edition:	2006 (31 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This recommended practice establishes the general framework for a qualification and certification program for nondestructive testing. In addition, the document provides recommended educational experience and training requirements for the different test methods. Supplementary documents include question and answer lists, which may be used in composing examinations for nondestructive testing personnel. The following apply to this recommended practice. • It is recognized that the effectiveness of nondestructive testing (NDT) applications depends upon the capabilities of the personnel who are responsible for, and perform, NDT. This recommended practice has been prepared to establish guidelines for the qualification and certification of NDT personnel whose specific jobs require appropriate knowledge of the technical principles underlying the nondestructive tests they perform, witness, monitor or evaluate. • This document provides guidelines for the establishment of a qualification and certification program. • These guidelines have been developed by The American Society for Nondestructive Testing Inc., to aid employers in recognizing the essential factors to be considered in qualifying personnel engaged in any of the NDT methods listed in Section 3 (Acoustic Emission Testing, Electromagnetic Testing, Laser Testing Methods, Leak Testing, Liquid Penetrant Testing, Magnetic Flux Testing, Neutron Radiographic Testing, Radiographic Testing, Thermal/Infrared Testing, Ultrasonic Testing, Vibration Analysis, Visual Testing). • It is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or application. In developing a written practice as required in Section 5, the employer should review the detailed recommendations presented herein and modify them, as necessary, to meet particular needs.
Application:	This recommended practice is intended for use by persons who are in charge of the training, qualification and certification of personnel who are responsible for and perform nondestructive testing.

<table>
<tr><td>Comments:</td><td>A complementary standard to RP SNT-TC-1A is ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (Document No. ANSI/ASNT CP-105-2006). This standard specifies the body of knowledge to be used as part of a training program qualifying and certifying NDT personnel.
The scope of ANSI/ASNT CP-105-2006:
Establishes the minimum topical outline requirements for the qualifications of nondestructive testing (NDT) personnel
Details the minimum training course content for NDT personnel
Specifies that the amount of time spent on each topic in each method should be determined by the NDT Level III and the applicable certification document
These topical outlines are progressive; i.e., consideration as Level I is based on satisfactory completion of Level I training course; consideration as Level II is based on satisfactory completion of both Level I and Level II training courses
Topics in the outlines may be deleted or expanded to meet the employer’s specific applications or for limited certification, unless stated otherwise by the applicable certification procedure or written practice.
Note: While ASNT RP SNT-TC-1A refers to NDT Level III, it does not cover certification for Level III.</td></tr>
<tr><td>User:</td><td><table><tr><td>Company</td><td>Instructor</td><td>Owner</td><td>Inspector</td><td>Regulator</td></tr><tr><td>P</td><td>P</td><td>P</td><td>S</td><td>S</td></tr></table>P – Primary User
S – Secondary User</td></tr>
</table>

ELECTRIC POWER RESEARCH INSTITUTE (EPRI) STANDARDS

A-110 EPRI CS-4774 *Guidelines for the Evaluation of Seam-Welded High-Energy Piping*

Current Edition:	Fourth Edition, December 2003 (392 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	The guidelines offer remaining life estimation procedures that provide the engineering basis for making inspection or maintenance decisions. Seam weldment damage mechanisms and the influence of numerous operational and structural variables on performance are not currently understood quantitatively enough for developing a rigorous mechanistic-based evaluation procedure. Nevertheless, a significant body of laboratory and field experience acquired since the 1980s has been reviewed, consolidated and incorporated into developing an alternative empirical procedure that is an effective piping integrity assurance tool. The main sections in these Guidelines are: 1) Industry Experience and Observations; 2) Technical Bases for Guidelines; 3) Overview of Approach to Pipe Evaluation; 4) Inspection Decision; 5) Inspection Methodology; 6) Serviceability Assessment; 7) Conclusions; and 8) References. The following supporting appendices are also included in the Guidelines: A) Cracking and Failure Experience; B) Ultrasonic Examination Procedure; C) Time-of-Flight Diffraction Examination Procedure; D) Automated Phased Array Examination Procedure; E) Ultrasonic Flaw Sizing Procedure; F) Bid Specification for Examination of Seam-Welded Steam Piping; G) Crack Growth Calculation Procedure; and H) Stress Rupture Testing.
Application:	These guidelines can be used by plant owners and operators to assess the remaining life of seam-welded high-energy piping. They can also be used by inspectors as guidance on inspection procedures for obtaining information for a remaining life assessment. They can also be used by consultants and regulators in assessing the adequacy of a plant's inspection/remaining life assessment program.
Comments:	This fourth edition of the Guidelines for Evaluation of Seam-Welded High-Energy Piping, updates the third edition by incorporating new cracking and failure data, observations of industry trends and information on inspection and evaluation methods. Data on cracking and failure incidents reported since the third edition of the guidelines – and recent EPRI reports on advances in applicable nondestructive evaluation methods – were reviewed to prepare the 2003 update (fourth edition) of the guidelines. The guidelines feature an easy-to-use stepwise format with inspection and evaluation procedure details. EPRI's pipe integrity evaluation approach is based on a flaw or damage tolerance evaluation method in which the flaw or damage zone is detected by inspection. A reinspection interval is set on the basis of current flaw size (in the through-wall dimension) and the estimated rate of crack growth. The flaw size is the inspection-estimated value or an appropriately selected default size when inspection data show no indication of damage.
User:	Purchaser: (blank); Consultant: **S**; Owner/Operator: **P**; Inspector: **P**; Regulator: **S** P – Primary User S – Secondary User

A-111 EPRI CS-5208 *Life Extension and Assessment of Fossil Power Plants (Conference Proceedings)*

Current Edition:	1987 (1265 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This document consolidated the proceedings of a conference, which was held in Washington, DC, June 2-4, 1986, to review, document and transfer technology on all aspects of life extension for fossil-fuel-firing power plants. It provided a unique opportunity for personnel involved with the development of life extension strategies to interface directly with personnel in the development and application of residual life assessment methodologies for major pieces of plant equipment. Participation was truly international, with over four hundred people in attendance representing 14 countries. Utility experience reports were presented from Australia, Canada, England, Germany, Japan, Italy, Holland and the United States. In recognition of the fact that life extension is not only a technical issue but has broader implications with respect to economic, environmental and regulatory issues, a comprehensive agenda was organized that included: • Programs and strategies for plant life extension • Residual life estimation for boilers, turbines and steam pipes • Nondestructive examination techniques • Environmental and regulatory issues.
Application:	These conference proceedings can be used as a reference by power plant owners and operators, and their engineering contractors and consultants, to develop and implement life extension methods as a possible way of retaining units in service for 50 to 60 years or longer. They can also be used by the power plant component suppliers of boilers and turbines.
Comments:	The conference was sponsored by Edison Electric Institute, the American Society of Mechanical Engineers and the American Society of Metals. The presentations and discussions supplemented ongoing EPRI work on life extension and assessment and contributed to the development of the Generic Life Extension Guidelines (EPRI report CS-4778, out of print). Since many of the residual life techniques have usefulness above and beyond life extension, the information consolidated in these proceedings is expected to be of long-range value and even applicable to newer plants. In addition to the papers and presentations by individual authors, an overview of each subject area was presented by a recognized expert in the field. These experts included the following. David Foster – Environmental Protection Agency William McDearman – Combustion Engineering, Inc. Scott Patulski – Wisconsin Electric Power Co. David Roberts – GA Technologies, Inc. Stephen Salay – Cincinnati Gas & Electric Co. Duncan Sidey – Ontario Hydro Robert Stone – J.A. Jones Applied Research Clifford Wells – Failure Analysis Associates

User:	Contractor/ Consultant	Boiler Manufacturer	Owner/ Operator	Inspector	Turbine Manufacturer
	P	**S**	**P**	**S**	**S**
	P – Primary User S – Secondary User				

A-112 EPRI CS-5235 *Recommended Practices for Operating and Maintaining Steam Surface Condensers*

Current Edition:	July 1987 (248 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This document is a guideline for the operation and maintenance of steam surface condensers. It was developed for the Electric Power Research Institute by Heat Exchange Systems, Inc. The guideline includes a primer on the theory of operation of steam surface condensers. Also included is a brief description of typical condenser problems. These introductory sections lay the groundwork for assisting operators and engineers in troubleshooting to maximize condenser performance and availability. The remaining sections concentrate on specific topics such as performance monitoring, lay-up and corrective action. Corrosion monitoring and maintenance methods including cleaning, plugging, corrosion countermeasures and other corrective actions are also addressed.
Application:	The guideline is intended to assist plant engineers, operators and maintenance personnel in improving the availability and performance of the steam surface condenser.
Comments:	This guideline describes the theory of operation, related heat transfer principals and a description of the steam surface condenser designs typically used in the electric utility industry. A section is also included that identifies condenser performance, structural designs, and materials of construction related problems and their causes. This section also contains a table which cross references the reader to other report sections and other Electric Power Research Institute reports for guidance in problem resolution. The guideline also identified methods of performance and condition monitoring. In addition, technologies for improving condenser performance and availability are also identified. Since there are many technologies and monitoring practices which apply to specific condenser problems, the report addresses all which were identified by the principal investigators and which are proven by past utility experience. The guideline identifies the advantages and disadvantages of the technologies and methods presented. This is done in a manner that will assist a utility's operation and maintenance personnel in selecting the best solution for a specific application.
User:	Purchaser: — ; Manufacturer: — ; Owner/Operator: **P** ; Inspector: **S** ; Regulator: — P – Primary User S – Secondary User

NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE) STANDARDS

A-113 NACE SP0106-2006 *Control of Internal Corrosion in Steel Pipelines and Piping Systems*

Current Edition:	December 2006 (14 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard presents recommended practices for the control of internal corrosion in steel pipelines and piping systems used to gather, transport or distribute crude oil, petroleum products or gas. This standard serves as a guide for establishing minimum requirements for control of internal corrosion in the following systems: (a) crude oil gather and flow lines; (b) crude oil transmission; (c) hydrocarbon products; (d) gas gathering and flow lines; (e) gas transmission; (f) gas distribution; and (g) storage systems.
Application:	This standard presents general practices and preferences in regard to control of internal corrosion in steel piping systems. This standard is intended for use by pipeline operators, pipeline service providers, government agencies and any other persons or companies involved in planning, designing or managing pipeline integrity.
Comments:	Because of the complex nature and interaction between constituents that are found in gas and liquid (e.g., oxygen, carbon dioxide, hydrogen sulfide, chloride, bacteria, etc.), certain combinations of these impurities being transported in the pipeline may affect whether a corrosive condition exists. Identification of corrosive gas and liquid in a pipeline can only be achieved by analysis of operating conditions, impurity content, physical monitoring or other considerations. Therefore, gas, liquids and operating conditions must be monitored and evaluated on an individual basis in order to accurately assess the effects of their presence or absence in the pipeline.
User:	Engineering Contractor: **P**; Field Contractor: **P**; Owner/ Operator: **P**; Inspector: **P**; Consultatnt: **P** P – Primary User S – Secondary User

A-114 NACE SP0169-2007 *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*

Current Edition:	April 1992, Reaffirmed 2007 (29 pages)
Alt. Number:	Formerly RP0169-2002
ANSI Approved?	No
Scope:	This standard practice presents procedures and practices for achieving effective control of external corrosion on buried or submerged metallic piping systems. These recommendations are also applicable to many other buried or submerged metallic structures. This standard describes the use of electrically insulating coatings, electrical isolation and cathodic protection (CP) as external corrosion control methods. It contains specific provisions for the application of CP to existing bare, existing coated and new piping systems. Also included are procedures for control of interference currents on pipelines.
Application:	This standard practice is intended for use by corrosion control personnel concerned with the corrosion of buried or submerged piping systems, including oil, gas, water and similar structures. It can also be used as a reference by field inspectors.
Comments:	This standard should be used in conjunction with the practices described in the following NACE standards and publications, when appropriate (use latest revisions): SP0572, RP0177, RP0285, SP0186, SP0286, SP0387, SP0188, TPC11, TM0497
User:	Construction Contractor: **P**; Engineering Contractor: **P**; Owner: **P**; Inspector: **P**; Consultant: **P** P – Primary User S – Secondary User

A-115 NACE RP0288-2004 *Inspection of Linings on Steel and Concrete*

Current Edition:	October 1994, Reaffirmed March 2004 (4 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	The intent of this NACE standard recommended practice is to provide appropriate inspection requirements to verify compliance to the lining/coating specification. It is not intended to address the selection of a lining/coating or to specify surface preparation and application requirements.
Application:	This standard is intended for use by owners and their representatives, coating contractors, coating suppliers and coating inspectors involved with the inspection of linings/coatings on steel and concrete.
Comments:	For further information on coatings for concrete users of this standard should refer to NACE No. 6/SSPC-SP 13 and NACE Publication 02203/ICRI Technical Guideline 03741/SSPC-TR 5. For further information about selecting and specifying surface preparation methods for concrete before application of linings, users of this standard should refer to ICRI Technical Guideline 03732. For further information on the design, installation and inspection of linings, users of this standard should refer to NACE No. 10/SSPC-PA 6 and NACE No. 11/SSPC-PA8.
User:	Field Contractor: **P**; Coating Supplier: **P**; Owner: **P**; Inspector: **P**; Engineering Contractor: **S** P – Primary User S – Secondary User

A-116 NACE SP0472-2007 *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*

Current Edition:	November 2008 (27 pages)
Alt. Number:	Formerly RP0472
ANSI Approved?	No
Scope:	This standard establishes guidelines to prevent most forms of environmental cracking of weldments in carbon steel refinery equipment, including pressure vessels, heat exchangers, storage tanks, piping, valve bodies and pump and compressor cases. Weldments are defined to include the weld deposit, base metal HAZ and adjacent base metal zones subject to residual stresses from welding. This standard covers only carbon steels classified as P-No. 1, Group 1 or 2. These classifications can be found in the ASME Boiler and Pressure Vessel Code, Section IX for pressure vessels, ASME B31.3 for process piping or API Standards 620 and 650 for tanks. It excludes steels with greater than 480 MPa (70,000 psi) minimum specified tensile strength. Other materials may be vulnerable to cracking, but these materials are outside the scope of this standard. All pressure-containing weldments or internal attachment weldments to the pressure boundary are included. In addition, weldments in some non-pressure-containing equipment, such as storage tanks, are included. External attachment weldments are sometimes included as discussed in paragraph 3.5.1. Both new fabrication and repair welds are within the scope of this standard. The practices included are intended to prevent in-service cracking and are not intended to address cracking that can occur during fabrication, such as delayed hydrogen cracking. In most cases, however, these practices are also helpful in minimizing these fabrication problems.
Application:	This standard is intended for use by persons involved in the design and repair of equipment that is susceptible to environmental cracking in corrosive petroleum refinery services. It can also be used as a reference by field and shop inspectors.
Comments:	Corrosive refinery process environments covered by this standard can be divided into two general categories: services that could cause cracking as a result of hydrogen charging and services that could cause alkaline stress corrosion cracking (ASCC). However, identification of the specific environments to which the guidelines set forth in this standard are to be applied to prevent various forms of in-service environmental cracking is the responsibility of the user.
User:	Egnineering Contractor: **P**; Manufacturer: **P**; Owner: **P**; Inspector: **P**; Construction Contractor: **P** P – Primary User S – Secondary User

A-117 NACE SP0590-20007 *Prevention, Detection, and Correction of Deaerator Cracking*

Current Edition:	March 2007 (19 pages)
Alt. Number:	Formerly RP0590-96
ANSI Approved?	No
Scope:	This standard practice addresses: 1) procedures for inspection of deaerator heater and water storage vessel welds, including reinspection criteria and qualification of personnel; 2) factors influencing boiler feedwater deaerator cracking based on literature references and case history analyses; 3) standardized nomenclature of deaerator vessel welds and cracking; 4) guidelines for materials, design, fabrication, inspection and acceptance criteria for new deaerator vessels and for repair of existing deaerator vessels; and 5) operational and water chemistry parameters that may influence deaerator deterioration.
Application:	This standard is intended to be the primary source of information on deaerator cracking and is directed toward owners, operators and designers of deaerator equipment used in steam generation. It can also be used as a reference by field inspectors.
Comments:	Information presented in this standard reflects the work of the many individuals involved in documenting the deaerator cracking problem and is based on studies of carbon steel units. Similar cracking has been found in blowdown flash tanks, sedimentation tanks, hot water storage/disengaging vessels and steam and feedwater piping.
User:	Purchaser: — ; Designer: **P** ; Owner/Operator: **P** ; Inspector: **S** ; Regulator: — P – Primary User S – Secondary User

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBPVI) STANDARDS

A-118 NB-18 *National Board Pressure Relief Device Certifications*

Current Edition:	February 4, 2009 (747 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This National Board program provides for the certification of pressure-relief designs and the accreditation of organizations that manufacture or assemble these devices. Accredited organizations are issued a certificate of authorization to apply the National Board "NB" symbol to devices of certified designs. Technical requirements applied by this program to pressure-relief devices are contained in standards called "construction codes." These codes are: <u>Code Section</u> — <u>Construction Code</u> I — ASME Boiler & Pressure Vessel Code (B&PVC) Section I III — ASME B&PVC Section III IV — ASME B&PVC Section IV VIII — ASME B&PVC Section VIII. Organizations which have met the program requirements and have paid the proper administrative fees will be granted permission to use the National Board "NB" mark on devices to denote certification by the National Board of the pressure relieving device design.
Application:	Manufacturers and assemblers of pressure relief devices can use this document to learn what is required to obtain National Board (NB) accreditation for the devices they manufacture or assemble. Owners, users and designers of pressure vessels can reference this document to locate manufacturers and assemblers of National Board accredited pressure-relief devices. Owners and users of pressure vessels can also use it to locate repair firms who hold a National Board certificate of authorization to repair pressure relief valves.
Comments:	The steps presented in this document required for accreditation of pressure-relief devices are: a) administrative rules; b) quality system requirements; c) design review; d) initial testing; e) production testing for permission to apply the "NB" mark; f) 5 year repeat testing for "NB" mark permission extension; g) device marking requirements; h) permission to transfer the certification results of initial/production testing to a different/relocated facility; and i) test facility and test procedure requirements. This document presents two methods (coefficient and slope) to determine the relieving capacity which should appear on a valve set between the maximum and minimum listed set pressures. These methods are presented separately for the four ASME Codes (I, III, IV and VIII) to which this document applies. Although this document lists the repair firms who hold a National Board certificate of authorization to repair pressure relief valves, it does not address how that authorization is obtained (refer to the National Board Inspection Code, Part 3, Section 1). This document is updated frequently and can be downloaded free of charge from the National Board web site: www.nationalboard.org

User:	Purchaser	Designer	Owner/User	Manufacturer/ Assembler	Regulator
		P	**P**	**P**	
	P – Primary User S – Secondary User				

A-119 NB-23 *National Board Inspection Code*

Current Edition:	2007
Alt. Number:	None
ANSI Approved?	Yes
Scope:	Provides basic rules that are required in many jurisdictions (see NB-370 for specific jurisdictional requirements) for installation, in-service inspection, repair and alteration of boilers, pressure vessels, piping and pressure-relief devices. For pressure vessels, API 510, “Inspection of Refinery Equipment,” and for piping, API 570, “Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems,” are typically used in lieu of NB-23 in the petroleum and chemical process industries. Legal requirements for the use of these documents are determined by each jurisdiction. The three primary parts of NB-23 are: • Part 1 – Installation • Part 2 – Inspection • Part 3 – Repairs/Alterations.
Application:	Owners and users of pressure equipment can use NB-23 to develop an in-service (post-construction) inspection program for their equipment. Although not specifically recognized by NB-23, other inspection planning documents as listed below can be used for inspection planning if permitted by local jurisdictional authorities: • ASME PCC-3 “Inspection Planning Using Risk-Based Methods” • API RP 580 “Risk-based Inspection.” This document is very similar to ASME PCC-3, but is focused on the hydrocarbon and chemical process industries. • API RP 581 “Base Resource Document – Risk Based Inspection.” This document provides specific, detailed guidance for risk-based inspection. Owners and users of pressure equipment can use NB-23, in combination with other documents as listed below, to plan for repairs and alterations to pressure equipment. Other documents include: • ASME PCC-2 “Repair of Pressure Equipment and Piping.”
Comments:	NB-23 provides administrative requirements for accreditation of repair organizations and owner-user inspection organizations. Accredited organizations receive a Certificate of Authorization and can apply an “R” stamp to pressure equipment that they have repaired as an indication that the repairs conform to the requirements of NB-23. NB-23 also provides: • Installation requirements that impose requirements for new construction such as accessibility for inspection • Precautions for conducting inspections (e.g., vessel entry requirements) • General guidance on examination techniques and pressure testing • Descriptions of a limited number of damage (deterioration) mechanisms • Specific inspection requirements for boilers by boiler type • General requirements for inspection of pressure vessels and piping • Requirements for inspection and repair of overpressure protection devices • Methods for determining inspection intervals • General requirements for repairs and alterations and re-rating • Repair, alteration and inspection of fiber-reinforced plastic equipment.

User:	Field Contractor	Consultant	Owner	Inspector	Regulator
	P	**S**	**P**	**P**	

P – Primary User
S – Secondary User

A-120 NB-370 *National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations*

Current Edition:	4/29/2008 (301 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	Provides a compilation of laws, rules and regulations relating to boilers and pressure vessels in the 50 states in the US, 13 provinces and territories of Canada and 17 US cities. Also provides a directory of code enforcement officials.
Application:	Owners and users of pressure equipment in the United States and Canada can use the guidance in this document to determine what state, provincial and local laws and regulations apply to their boilers and pressure vessels for both new construction (e.g., code stamping requirements) and in-service inspection, alteration and repair. It does not cover federal requirements, such as those of the Occupational Safety and Health Administration (OSHA).
Comments:	This document is updated frequently and can be downloaded free of charge from the National Board web site: www.nationalboard.org
User:	Purchaser: (blank); Consultant: **S**; Owner: **P**; Inspector: **P**; Regulator: **P** P – Primary User S – Secondary User

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION (TEMA) STANDARDS

A-121 *Standards of the Tubular Exchanger Manufacturers Association*

Current Edition:	Ninth Edition, 2007 (296 pages)
Alt. Number:	None
ANSI Approved?	No
Scope:	This standard covers the mechanical design, fabrication and testing for shell and tube type heat exchangers. The main sections are: fabrication tolerances; general fabrication and performance information; installation, operation and maintenance; mechanical standard TEMA Class RCB heat exchangers; flow induced vibration; thermal relations; physical properties of fluids; and general information. There is also a recommended practice section that covers: horizontal vessel supports; vertical vessel supports; lifting lugs; wind and seismic design; plugging tubes in tube bundles; entrance and exit areas; tubesheets; nozzles; end flanges and bolting; finite element analysis guidelines; and fouling. The TEMA mechanical standards are applicable to shell and tube heat exchangers which do not exceed any of the following criteria. • Inside diameters of 100 in. • The product of nominal diameter, in., multiplied by design pressure, psi, of 100,000 • A design pressure of 3,000 psi. The intent of these parameters is to limit the maximum shell wall thickness to approximately 3 in., and the maximum stud diameter to approximately 4 in. Criteria contained in these standards may be applied to units which exceed the above parameters.
Application:	This standard is intended to be used by persons knowledgeable in the design, fabrication, operation, testing and repair of shell and tube heat exchangers. This standard can be cited in a purchase specification.
Comments:	Three classes of mechanical standards, R, C and B, reflecting acceptable designs for various service applications, are presented in this standard: • Class "R" covers unfired shell and tube heat exchangers for the generally severe requirements of petroleum and related processing applications • Class "C" covers unfired shell and tube heat exchangers for the generally moderate requirements of commercial and general process applications • Class "B" covers unfired shell and tube heat exchangers for chemical process service. Heat exchangers built to this standard shall comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
User:	Purchaser: **P** Manufacturer: **P** Owner: **P** Inspector: **P** Regulator: P – Primary User S – Secondary User

APPENDIX B ADDITIONAL READING

B-1 *Companion Guide to the ASME Boiler & Pressure Vessel Code, Third Edition - Volumes 1, 2 & 3*

This third edition of the Companion Guide of ASME Boiler & Pressure Vessel and Piping Codes has been updated to the current (2007) Code Edition. Since the first edition, a total of 140 authors have contributed to this publication, and in this edition there are 107 contributors of which 51 are new authors. Several of the new contributors are from countries around the world that use ASME B&PV Codes, with knowledge of ASME Codes, in addition to expertise of their own countries' B&PV Codes. All of these authors who contributed to this third edition considerably updated, revised or added to the content matter covered in the second edition to address current and future trends as well as dramatic changes in the industry.

The first two volumes covering Code Sections I through XI address organizational changes of B&PV Code Committees and special topics relating to the application of the Code. Volume 1 covers ASME Code Sections I through VII, B31.1 and B31.3 Piping Codes. Volume 2 has chapters addressing Code Sections VIII through XI, refurbished with additional code material consistent with the current 2007 Code edition. ASME Code Section VIII Division 2 was completely rewritten, and that effort has been captured in this publication. Notable updates included in this Volume relate to maintenance rules, accreditation, dynamic loads, functionality, operability criteria, fluids, pipe vibration analysis, code design and evaluation for cyclic loading for Code Sections III and VIII.

Volume 3 addresses Code Section XII and issues for the success of current and the next generation of nuclear reactors and internals, license renewal, public safety, PRA and spent fuel pool-related issues. The impact of globalization and inter-dependency of ASME B&PV Codes is recognized in this volume, by inclusion of several countries that own and operate nuclear reactors or have nuclear steam supply vendors and fabricators that use ASME B&PV Code Sections I through XII. This information is meant to benefit international users of ASME Codes with authors covering East and West European countries, Africa, Asia, in addition to the USA and Canada.

A unique feature of this publication is the inclusion of all author biographies and an introduction that synthesizes every chapter, along with an alphabetical listing of indexed terms.

B-2 *ASME Section VIII - Division 2, Criteria and Commentary*

This document provides the technical criteria and additional information typically found in a companion guide for the new ASME Section VIII, Division 2 Pressure Vessel Code.

In 1998 the ASME Boiler and Pressure Vessel Standards Committee authorized a project to rewrite the Section VIII, Division 2 pressure vessel code. This decision was made shortly after the design margin on specified minimum tensile strength was lowered from 4.0 to 3.5 in Section I and Section VIII, Division 1. ASME saw the need to update Section VIII, Division 2 to incorporate the latest technologies and to be more competitive.

A list of some of the new technology produced for Section VIII, Division 2 rewrite includes:

- *(a)* Adoption of a design margin on specified minimum tensile strength of 2.4
- *(b)* Toughness requirements
- *(c)* Design-by-rule for the creep range
- *(d)* Conical transition reinforcement requirements
- *(e)* Opening reinforcement rules
- *(f)* Local strain criteria for design-by-analysis using elastic-plastic analysis
- *(g)* Limit load and plastic collapse analysis for multiple loading conditions
- *(h)* Fatigue design for welded joints based on structural stress method and
- *(i)* Ultrasonic examination in lieu of radiographic examination.

Users of Section VIII, Division 2 (manufacturers and owner/operators) were surveyed at the beginning of the project to identify enhancements that they felt the industry wanted, and would lead to increased use of the standard. Some of the enhancements included:

- *(a)* Alternatives provided for US and Canadian Registered Professional Engineer (RPE) certification of the User Design Specification (UDS) and Manufacturers Design Report (MDR)
- *(b)* Consolidation of weld joint details and design requirements
- *(c)* Introduction of a weld joint efficiency and the use of partial radiographic and ultrasonic examination
- *(d)* Introduction of the concept of a Maximum Allowable Working pressure (MAWP) identical to VIII-1
- *(e)* Significant upgrade to the design-by-rule and design-by-analysis procedures
- *(f)* Extension of the time-independent range for low chrome alloys used in heavy wall vessels
- *(g)* Extension of fatigue rules to 900°F (400°C) for low-chrome alloys used in heavy wall vessels
- *(h)* Adoption of new examination requirements and simplification of presentation of the rules
- *(i)* User-friendly; extensive use of equations, tables and figures to define rules and procedures and
- *(j)* ISO format; logical paragraph numbering system and single column format.

Many of these enhancements identified by users were accomplished in the new Section VIII, Division 2.

B-3 WRC 488 *Damage Mechanisms Affecting Fixed Equipment in the Pulp and Paper Industry*

Introduction

The ASME and API design codes and standards for pressurized equipment provide rules for the design, fabrication, inspection and testing of new pressure vessels, piping systems and storage tanks. These codes do not address equipment deterioration while in service. Deficiencies due to degradation or from original fabrication may be found during subsequent inspections. Fitness-For-Service (FFS) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage. The first step in a fitness-for-service assessment performed in accordance with API RP 579 is to identify the flaw type and the cause of damage. Proper identification of damage mechanisms for components containing flaws or other forms of deterioration is also the first step in performing a Risk-Based Inspection (RBI) in accordance with API RP 580. When conducting an FFS assessment or RBI study, it is important to determine the cause(s) of the damage or deterioration observed or anticipated and the likelihood and degree of further damage that might occur in the future. Flaws and damage discovered during an in-service inspection can be the result of a pre-existing condition before the component entered service or could be service-induced. The root causes of deterioration could be due to inadequate design considerations including materials selection and design details, or the interaction with aggressive environments/conditions that the equipment is subjected to during normal service or during transient periods.

One factor that complicates an FFS assessment or RBI study for pulp and paper plant equipment is that material/environmental condition interactions are extremely varied. Pulp and paper plants contain many different processing units, each having its own combination of aggressive process streams and temperature/pressure conditions. In general, the following types of damage are encountered in pulp and paper plant equipment.

(a) General and local metal loss due to corrosion and/or erosion

(b) Surface connected cracking

(c) Subsurface cracking

(d) Microfissuring/microvoid formation

(e) Metallurgical changes.

Each of these general types of damage may be caused by a single, or multiple, damage mechanism. In addition, each of the damage mechanisms occurs under very specific combinations of materials, process environments and operating conditions.

Scope

General guidance as to the most likely damage mechanisms for common alloys used in the pulp and paper industry is provided in this bulletin. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage, and are intended to introduce the concepts of service-induced deterioration and failure modes.

The summary provided for each damage mechanism provides the fundamental information required for an FFS assessment performed in accordance with API RP 579 or an RBI study performed in accordance with API RP 580.

The damage mechanisms in this bulletin cover situations encountered in the pulp and paper industry in pressure vessels, piping and tankage. The damage mechanism descriptions are not intended to provide a definitive guideline for every possible situation that may be encountered, and the reader may need to consult with an engineer familiar with applicable degradation modes and failure mechanisms, particularly those that apply in special cases.

Organization and Use

The information for each damage mechanism is provided in a set format as shown below. This bulletin format facilitates use of the information in the development of inspection programs, FFS assessment and RBI applications.

(a) Description of Damage – a basic description of the damage mechanism

(b) Affected Materials – a list of the materials prone to the damage mechanism

(c) Critical Factors – a list of factors that affect the damage mechanism (i.e., rate of damage)

(d) Affected Units or Equipment – a list of the affected equipment and/or units where the damage mechanism commonly occurs is provided. This information is also shown on process flow diagrams for typical pulp and paper processing schemes.

(e) Appearance or Morphology of Damage – a description of the damage mechanism, with pictures, in some cases, to assist with recognition of the damage

(f) Prevention/Mitigation – methods to prevent and/or mitigate damage

(g) Inspection and Monitoring – recommendations for NDE for detecting and sizing the flaw types associated with the damage mechanism

(h) Related Mechanisms – a discussion of related damage mechanisms

(i) References – a list of references that provide background and other pertinent information.

Damage mechanisms that are common to a variety of industries including refining and petrochemical, pulp and paper and fossil utility are covered in Section 4.0.

Damage mechanisms that are specific to the pulp and paper industry are covered in Section 5. In addition, process flow diagrams are provided in 5.2 to assist the user in determining primary locations where some of the significant damage mechanisms are commonly found.

B-4 WRC 489 *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

Introduction

The ASME and API design codes and standards for pressurized equipment provide rules for the design, fabrication, inspection and testing of new pressure vessels, piping systems and storage tanks. These codes do not address equipment deterioration while in service. Deficiencies due to degradation or from original fabrication may be found during subsequent inspections. Fitness-For-Service (FFS) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage. The first step in a fitness-for-service assessment performed in accordance with API RP 579 is to identify the flaw type and the cause of damage.

Proper identification of damage mechanisms for components containing flaws or other forms of deterioration is also the first step in performing a Risk-Based Inspection (RBI) in accordance with API RP 580. When conducting an FFS assessment or RBI study, it is important to determine the cause(s) of the damage or deterioration observed or anticipated and the likelihood and degree of further damage that might occur in the future. Flaws and damage that are discovered during an in-service inspection can be the result of a pre-existing condition before the component entered service or could be service-induced. The root causes of deterioration could be due to inadequate design considerations including materials selection and design details, or the interaction with aggressive environments/conditions that the equipment is subjected to during normal service or during transient periods.

One factor that complicates an FFS assessment or RBI study for refining and petrochemical equipment is that material/environmental condition interactions are extremely varied. Refineries and chemical plants contain many different processing units, each having its own combination of aggressive process streams and temperature/pressure conditions. In general, the following types of damage are encountered in petrochemical equipment:

(a) General and local metal loss due to corrosion and/or erosion

(b) Surface connected cracking

(c) Subsurface cracking

(d) Microfissuring/microvoid formation

(e) Metallurgical changes.

Each of these general types of damage may be caused by a single, or multiple, damage mechanism. In addition, each of the damage mechanisms occurs under very specific combinations of materials, process environments and operating conditions.

Scope

General guidance as to the most likely damage mechanisms for common alloys used in the refining and petrochemical industry is provided in this bulletin. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage, and are intended to introduce the concepts of service-induced deterioration and failure modes.

The summary provided for each damage mechanism provides the fundamental information required for an FFS assessment performed in accordance with API RP 579 or an RBI study performed in accordance with API RP 580.

The damage mechanisms in this bulletin cover situations encountered in the refining and petrochemical industry in pressure vessels, piping and tankage. The damage mechanism descriptions are not intended to provide a definitive guideline for every possible situation that may be encountered, and the reader may need to consult with an engineer familiar with applicable degradation modes and failure mechanisms, particularly those that apply in special cases.

Organization and Use

The information for each damage mechanism is provided in a set format as shown below. This bulletin format facilitates use of the information in the development of inspection programs, FFS assessment and RBI applications.

(a) Description of Damage – a basic description of the damage mechanism

(b) Affected Materials – a list of the materials prone to the damage mechanism

(c) Critical Factors – a list of factors that affect the damage mechanism (i.e., rate of damage)

(d) Affected Units or Equipment – a list of the affected equipment and/or units where the damage mechanism commonly occurs is provided. This information is also shown on process flow diagrams for typical process units.

(e) Appearance or Morphology of Damage – a description of the damage mechanism, with pictures, in some cases, to assist with recognition of the damage

(f) Prevention/Mitigation – methods to prevent and/or mitigate damage

(g) Inspection and Monitoring – recommendations for NDE for detecting and sizing the flaw types associated with the damage mechanism

(h) Related Mechanisms – a discussion of related damage mechanisms

(i) References – a list of references that provide background and other pertinent information.

Damage mechanisms that are common to a variety of industries including refining and petrochemical, pulp and paper and fossil utility are covered in Section 4.0. Damage mechanisms that are specific to the refining and petrochemical industries are covered in Section 5. In addition, process flow diagrams are provided in 5.2 to assist the user in determining primary locations where some of the significant damage mechanisms are commonly found.

B-5 WRC 490 *Damage Mechanisms Affecting Fixed Equipment in the Fossil Electric Power Industry*

Introduction

The ASME and API design codes and standards for pressurized equipment provide rules for the design, fabrication, inspection and testing of new pressure vessels, piping systems and storage tanks. These codes do not address equipment deterioration while in service. Deficiencies due to degradation or from original fabrication may be found during subsequent inspections. Fitness-For-Service (FFS) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage. The first step in a fitness-for-service assessment performed in accordance with API RP 579 is to identify the flaw type and the cause of damage.

Proper identification of damage mechanisms for components containing flaws or other forms of deterioration is also the first step in performing a Risk-Based Inspection (RBI) in accordance with API RP 580. When conducting an FFS assessment or RBI study, it is important to determine the cause(s) of the damage or deterioration observed or anticipate, and the likelihood and degree of further damage that might occur in the future. Flaws and damage that are discovered during an in-service inspection can be the result of a pre-existing condition before the component entered service or could be service induced. The root causes of deterioration could be due to inadequate design considerations including materials selection and design details, or the interaction with aggressive environments/conditions to which the equipment is subjected during normal service or during transient periods.

One factor that complicates an FFS assessment or RBI study is that material/environmental condition interactions are extremely varied. In general, the following types of damage are encountered in fossil utility plant equipment.

(a) General and local metal loss due to corrosion and/or erosion

(b) Surface connected cracking

(c) Subsurface cracking

(d) Microfissuring/microvoid formation

(e) Metallurgical changes.

Each of these general types of damage may be caused by a single or multiple damage mechanisms. In addition, each of the damage mechanisms occurs under very specific combinations of materials, process environments and operating conditions.

Scope

General guidance as to the most likely damage mechanisms for common alloys used in the fossil utility industry is provided in this bulletin. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage, and are intended to introduce the concepts of service-induced deterioration and failure modes.

The summary provided for each damage mechanism provides the fundamental information required for an FFS assessment performed in accordance with API RP 579 or an RBI study performed in accordance with API RP 580.

The damage mechanisms in this bulletin cover situations encountered in the fossil utility industry. The damage mechanism descriptions are not intended to provide a definitive guideline for every possible situation that may be encountered, and the reader may need to consult with an engineer familiar with applicable degradation modes and failure mechanisms, particularly those that apply in special cases.

Organization and Use

The information for each damage mechanism is provided in a set format as shown below. This bulletin format facilitates use of the information in the development of inspection programs, FFS assessment and RBI applications.

(a) Description of Damage – a basic description of the damage mechanism

(b) Affected Materials – a list of the materials prone to the damage mechanism

(c) Critical Factors – a list of factors that affect the damage mechanism (i.e., rate of damage)

(d) Affected Units or Equipment – a list of the affected equipment and/or units where the damage mechanism commonly occurs is provided. This information is also shown on process flow diagrams for typical fossil utility plants.

(e) Appearance or Morphology of Damage – a description of the damage mechanism, with pictures, in some cases to assist with recognition of the damage.

(f) Prevention / Mitigation – methods to prevent and/or mitigate damage

(g) Inspection and Monitoring – recommendations for NDE for detecting and sizing the flaw types associated with the damage mechanism

(h) Related Mechanisms – a discussion of related damage mechanisms

(i) References – a list of references that provide background and other pertinent information.

Damage mechanisms that are common to a variety of industries including refining and petrochemical, pulp and paper and fossil utility are covered in Section 4.0.

Damage mechanisms that are specific to the fossil utility industry are covered in Section 5. In addition, a process flow diagram is provided in 5.2 to assist the user in determining primary locations where some of the significant damage mechanisms are commonly found.

B-6 WRC 409 *Fundamental Studies of the Metallurgical Causes and Mitigation of Reheat Cracking in 1¼Cr-½Mo and 2¼Cr-1Mo Steels*

This work provides an enhanced understanding of the fundamentals of reheat cracking in the 1¼Cr-½Mo and 2¼Cr-1Mo steels widely used in the pressure vessel and petrochemical industries. The techniques employed to examine reheat cracks were essentially developed in this work to avoid the examination of cracks not related to the true reheat cracking mechanism (cracked samples used in earlier studies to determine the grain boundary segregating elements were produced by means not in concert with the reheat cracking mechanism). The examination of true and "pristine" reheat cracks was coupled with an extensive study of the carbide evolutionary sequences during PWHT. This information was interrelated to develop a more precise understanding of the reheat cracking mechanism in the Cr-Mo materials.

The results show a distinct difference in carbide evolution and segregation pattern for reheat crack susceptible and non-susceptible heats. Although the relation between the carbide evolution kinetics and the trace element segregation in affecting the reheat cracking susceptibility was not fully defined, it was obvious that the two were interlinked. The activation energy calculations revealed that diffusion of P was the rate controlling step for reheat cracking. Thus, all the results point to P as the element responsible for reheat cracking.

B-7 WRC 411 *An Experimental Study of Causes and Repair of Cracking of 1¼Cr-½Mo Steel Equipment*

A multitask experimental study was conducted to provide the petroleum industry with solutions to recurring incidents of cracking in the application of welded 1¼Cr-½Mo steel for hydrogen processing equipment. The principal objective was to develop recommendations for the elimination of cracking that occurred during fabrication or early in operating life, was associated with repairs or was found after extended service exposure at elevated temperature.

Vessel and equipment experience has shown that the majority of weld cracking problems have occurred at temperatures in excess of 850°F. Further, few or no problems have been found for operation at temperatures below 800°F. Thus, a cutoff temperature of 825°F has been suggested for invoking the precautions, considerations and recommendations regarding the potential for coarse grained weld HAZ (CGHAZ) cracking in 1¼Cr-½Mo steels.

The objectives of this research report were to: determine what compositional and other material issues influence cracking; evaluate controlled deposition repair techniques; determine the suitability of low carbon filler materials; and understand the role of fabrication and welding practices on susceptibility to cracking.

B-8 WRC 412 *Challenges and Solutions in Repair Welding for Power and Processing Plants – Proceedings of a Workshop*

Over the last 10 years oil, gas, petrochemical and power generation companies have placed increasing emphasis on developing cost effective, practical and reliable repair and maintenance strategies to prolong plant life. Those efforts have led to the development of comprehensive guidelines for repairing welding pressure vessel and piping systems and associated equipment. Procedures selected incorporate the results of major research programs conducted by the Pressure Vessel Research Council (PVRC), Edison Welding Institute (EWI) and others to develop and evaluate repair techniques, suitable with or without PWHT. Optimized methods for pressure vessels and piping systems have now been used in petrochemical and power generation service. This publication focuses on the repair of creep resistant steels, e.g., Cr-Mo and Cr-Mo-V steels, and reports practical experiences. The information reported from these projects has resulted in the development and validation of repair techniques for specific applications and changes in national codes, standards and recommended practices. The following papers were presented at a workshop co-sponsored by PVRC and EWI on January 31-February 1, 1996 in San Diego, CA

B-9 WRC 452 *Recommended Practices for Local Heating of Welds in Pressure Vessels*

The framework for this document is based upon the American Welding Society ANSI/AWS D10.10-90, Recommended Practices for Local Heating of Welds in Piping and Tubing. During the process of revising this AWS document, it was recognized that it might be more appropriate to prepare a separate document pertaining to recommended practices for local heating of welds in pressure vessels. At the same time, a request was received to prepare a guideline regarding postweld heat treatment of repairs for heavy wall hydroprocessing reactors. This request was made by a joint industry project on aging hydroprocessing reactors. Additionally, for the last several years, an ASME Boiler & Pressure Vessel Code Ad Hoc Task Group on Local PWHT, operating under the Section VIII Subgroup Fabrication and Inspection, has been developing requirements for local PWHT. The confluence of these three activities is responsible for the development of this document.

The document in draft form has been circulated for review and commenting by various communities since May 1997. They are the Pressure Vessel Research Council, ASME Board of Pressure Technology Codes and Standards Task Group on local PWHT, AWS Subcommittee D10P on local heat treating of pipework and IIW Commission XI on pressure vessels, boilers and pipelines. During the review and commenting period, a new revision on the requirements (paragraphs UW-40 and AF-410, see Appendices A and B) for local PWHT in Section VIII of ASME Boiler and Pressure Vessel Code was issued in July 1998. A summary of the changes in ASME Section VIII pertaining to local PWHT are summarized below:

- *(a)* The term soak band has been added, defined and its width revised
- *(b)* The use of non-uniform width or temperature 360-degree band PWHT for attachments has been added
- *(c)* The use of local circular spot PWHT for attachments on spherical shells/heads has been added
- *(d)* The use of other local spot PWHT based upon sufficiently similar, documented experience evaluations are allowed.

In view of the fact that most of these issues were already discussed in the draft document (although not in terms of ASME Section VIII Code) and that incorporation of these changes will significantly delay the publication of this document, it is decided by the Pressure Vessel Research Council that this document should be published in the present form. In addition, detailed guidelines for Items (c) and (d) above (Item 4 in particular) are not available at the present time. A joint industry project by the Pressure Vessel Research Council has recently been initiated to support these code changes and to establish a complete standard for local PWHT.

B-10 WRC 435 *Evaluation of Design Margins for Section VIII, Div. 1 And 2 of the ASME Boiler and Pressure Vessel Code*

This bulletin contains two reports, which provide information regarding the design margin on ultimate stress used in Section VIII, Division 1 and Division 2 of the ASME Boiler and Pressure Vessel Code. The first report specifically deals with the background and technical justification involved with changing the design margin in Division 1 from 4.0 to 3.5. This report provides the basis for reducing the margin to 3.5 and recommendations to ASME for implementing the reduction for Division 1, which has occurred through two ASME Code Cases and then in Division 1, itself, as of July 1, 1999. Section I of the code also used information in this report to supplement its justification for changing its design margin from 4.0 to 3.5. The first report discusses the effects of the change on the overall construction requirements in Division 1 regarding the many improvements to it since the design margin of 4.0 was instituted in the 1950s.

The second report deals with the considerations necessary to reduce design margins even lower than 3.5 in Division 1 and lower than 3.0 in Division 2. Discussions in both reports include review of burst tests, failure data, failure modes—particularly fatigue and fracture and related toughness requirements, fabrication practices, improved materials, advances in welding, examination and testing and comparison with other international codes and other important aspects. Results from the second report have been used to develop proposals to restructure Division 2 to include multiple levels of design margins in stages from 3.0 to as low as 1.8, with attendant changes in design and construction requirements.

B-11 WRC 447 *Evaluation of Operating Margins for In-Service Pressure Equipment*

In the design of structures, including pressure vessels and piping systems, consideration must be given to uncertainties in material properties, loading conditions, fabrication and welding, geometric shape and the design approach. Although probabilistic or risk-based approaches are becoming more common, the traditional approach of applying a margin (sometimes called a “safety factor”) to one or more of the design parameters is still the predominant method for dealing with these uncertainties in the construction of new pressure equipment. Many new construction codes and standards apply a margin to one or more material strength parameters. For example, the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 limits the primary membrane stress in materials operating below the creep regime to 2/3 of the yield strength or 1/3.5 times the tensile strength, whichever is lower. This overall margin accounts for uncertainties in all of the parameters listed above, except that an additional margin is applied to certain weld seams that are not fully examined. As the science of the evaluation of flaws in in-service pressure equipment advances, it is likely that probabilistic or risk-based approaches will be used extensively. These approaches may be implemented through the use of partial margins (partial safety factors) applied to the individual variables which are used in the design or analysis of the equipment. Appropriate values for partial margins can be determined mathematically, based on the uncertainty in the individual variables, as expressed by statistical parameters such as mean and standard deviation, and a target probability of failure.

However, the concept of an overall margin, as used by new construction codes, will probably continue to be useful for the evaluation of in-service equipment in many cases. This study has been done to provide guidance in establishing appropriate margins on material parameters when this approach is selected. In many cases, the guidance in this document will result in margins that are lower than new construction margins if the level of uncertainty in one or more of the design parameters can be reduced. The recommendations in this study can be used by organizations performing flaw evaluations or re-rating equipment. It is also anticipated that they will be considered by the ASME, API and other organizations that are developing standards in this area.

B-12 WRC 430 *Review of Existing Fitness-For-Service Criteria for Crack-Like Flaws*

The scope of the work described in this report mainly involved a review of the current practices for making an assessment of the acceptability of a flaw, at one snapshot in time. In ASME Section XI terminology, this is analogous to making a flaw-specific end of evaluation assessment using the flaw size. Aspects related to flaw growth, whether period creep, or some other mechanism, are not rigorously covered in this document.

The main conclusion drawn as a result of this effort is that, for the most part, the existing flaw evaluation criteria are conservative when compared with experimental data. Even so, there are a number of limitations associated with the application of these criteria which must be considered. These include:

(a) High R/t Ratio components

(b) Undermatching welds

(c) Questionable choice of material data

(d) Poorly defined flaw size.

The following recommendations are made as a result of this effort.

(a) It is recommended that any new FFS criteria that evolve as a result of the ASME Post Construction Committee activities should be based on the failure assessment diagram (FAD) approach.

(b) To use such an FAD-based approach, a stress intensity factor (K) solution and limit-load solution must be available for the geometry of interest.

(c) It is recommended that FFS assessment procedures allow assessments at multiple levels of complexity and accuracy.

(d) It is recommended that the FFS assessment procedures that evolve allow flaw assessments to be performed either deterministically or probabilistically.

B-13 WRC 465 *Technologies for the Evaluation of Non-Crack-Like Flaws in Pressurized Components—Erosion/Corrosion, Pitting, Blisters, Shell Out-Of-Roundness, Weld Misalignment, Bulges and Dents*

An overview, comparison and evaluation of assessment methods for non-crack-like flaws in pressurized components such as straight piping and cylindrical and spherical vessels are provided in this report. The non-crack-like flaws include: flaws include local thin areas; pitting damage; hydrogen blisters and laminations; geometric irregularities such as weld misalignment, shell out-of-roundness and bulges; and external force damage that typically results in dents or dent-gouge combinations.

The vast majority of this work was performed by a Joint Industry Program on Fitness-For-Service administered by the Materials Properties Council working in conjunction with the API Committee on Refinery Equipment's Task Group on Fitness-For-Service. The work performed by these groups forms the technical basis for API 579, and, as is shown in this report, a significant amount of the fitness-for-service technology for non-crack-like flaws that is available in the literature.

B-14 WRC 465 *Analysis of the Effects of Temperature on Bolted Joints*

Thermal events and transient thermal effects are known to play a major role in pressurized flanged joint leakage. When a leak occurs, the engineering challenge is to understand and properly diagnose the role temperature and thermal transients in that failure and thereby specify measures necessary avoid future leaks. Also, since most pressure vessel codes require the consideration of thermal effects without providing the methodology, perhaps the greater engineering challenge is to the flanged joint designer. This is not only to determine temperature effects on flanged joint designs to comply with code requirements but also an evaluation of the design to assure leak free operation considering anticipated thermal events. This bulletin provides a set of analytical tools and guidelines for addressing these challenges. The purpose of PVRC Project 01-BFC-05 was to summarize the findings of the author’s doctoral project on the effects of temperature loads on bolted flange joints and publish a summary document providing design guidelines to deal with temperature effects and the relative magnitude of these effects. Reporting on this work, the bulletin provides users with simplified thermal calculation methods that enable the flanged joint designer or field troubleshooter to determine the effect of steady state or transient temperatures on flanged joints, including an evaluation of leakage possibilities.

This is accomplished by the author in a readable step by step process that provides the tools to answer along the way questions such as: What increase in assembly bolt load would be sufficient to overcome anticipated thermal events? Is flange deflection caused by joint component thermal interaction sufficient to cause a leak from loss of gasket load? Could radial shearing of the gasket from differential radial expansion of the flanges or tube-sheet caused either by differences in mating flange temperatures or material properties result in failure? Is gasket crushing a possibility due to increased load caused by joint component thermal interaction? How much bolt and gasket load could be lost because of a process thermal transient, or a sudden cool-down, without failure? If insulation is applied to an operating uninsulated flanged joint, how much hotter than the flange ring might the bolts be? Is this transient sufficient cause a leak?

Following an overview of bolted flanged joint response to thermal loads, causes of failure and a background description of mechanical and thermal analysis, a detailed calculation procedure is presented. For simplicity, axisymmetric and generally identical mating flanges are assumed by the calculation method. Detailed guidance is then provided on extending this approach to non-identical flange pairs, joints with a tube-sheet (Heat exchanger girth joints) and coverplates. The method first provides steady state thermal and deformation results followed by means to calculate the steady state bolt load using component compliance. An evaluation of transient of these findings and the use of a series of graphs providing the time effects by extension to reach 95% and 5% the steady state temperature for each component completes the process. Appendices A through D provide additional information on the details of the calculation methodology. Appendices E and F illustrate the calculation method via an available Excel spreadsheet.

B-15 WRC 470 *Recommendations for Design of Vessels for Elevated Temperature Service*

This bulletin provides guidelines for the design of pressure vessels for operation at temperatures where the long term creep properties govern design. The ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 has a long and successful service history, including elevated temperature service, however experience has shown that in-service cracking problems can develop in pressure vessels at elevated temperature. The experience indicates that the cracking has occurred at locations of high local discontinuity stresses, high local thermal gradients and weld joints. The work behind this bulletin is based on industry experience with specified practices and guidelines and screen out those design practices that have had problems from those that have been successful. The result is development of design rules, guidelines and mechanical design details that are recommended for pressure vessels operating in the creep regime. The focus is on practical design guidelines and not on complex analytical methods. The report is general in scope, however the focus is on carbon and low alloy steels. It is anticipated that many of the recommendations made will become standard practice in the industry through updates to the ASME Boiler and Pressure Vessel Code, Section VIII.

B-16 WRC 517 *Examination of Mechanical Properties and Corrosion of High Temperature Alloys after Long Term Service Under Advanced Power Plant Boiler Conditions: The Eddystone Studies*

For many years heat resistant austenitic steels have been successfully used in power plants. TP304H, TP321H and TP347H have been employed in the superheater and reheater sections of power boilers. However, these steels were originally developed for use in chemical plants and the compositions were optimized for corrosive environments. In order to use austenitic steels for more advanced fossil-fired power plants, microstructures and creep resistance recently have been substantially improved as compared to the earlier stainless steels. Some of the steels developed for creep resistance have already been used in modern ultra supercritical pressure power plants. The service temperatures and pressures of these power plants are presently just under 1112°F (600°C) and 3500 psig (25 MPa). In the future, advanced steam conditions up to 1292°F (700°C) and higher pressures are expected in power plants. Newer high-strength and high-temperature corrosion resistant steels are required. WRC Bulletin 517 reports the results of a cooperative, international investigation of these superior alloys. The program participants were the Materials Properties Council, Inc (MPC) in the USA, an American utility (the owners of the Eddystone plant, Exelon Generation), Tenaris NKK Tubes, Sumitomo Metal Industries, Ltd., Mitsubishi Heavy Industries, Ltd., Kyushu Institute of Technology and Nippon Steel Corp. The long-term field exposure test of austenitic stainless steels was conducted at Eddystone Power Station Unit No.1, which has highest steam parameters worldwide to date. The experimental tubes used were of service-exposed in the final superheater operated at steam conditions of 1170°F (632°C) and 4550 psig (31 MPa) for about ten years. The new austenitic stainless steel tubes included SUPER304H®, TP347HFG, NF709®, TEMPALOY A-3®, HR3C®(TP310HCbN) and TEMPALOY CR30A®. Additionally, corrosion studies were conducted to evaluate various protection schemes applicable to these alloys. Finally, an exploratory study of a life assessment tool developed by MPC, the Omega Method, was conducted using circumferentially oriented specimens extracted from the thick-wall, small diameter tubes. This document should serve as a valuable road map to the information required for the introduction of new alloys into advanced plant and other critical service.

B-17 WRC 517 *Half-Bead Temper-Bead Controlled Deposition Techniques for Improvement of Fabrication and Service Performance of Cr-Mo Steels*

The half-bead/temper-bead/controlled deposition repair welding techniques, which utilize the thermal cycles of the second and later weld layers to temper and refine the HAZ of the first layer, have been applied in accordance with ASME Boiler and Pressure Vessel Nuclear Code Section III for new construction since the late 1960s and Section XI for in-service repair welding of nuclear power plant components. Thus, Post Weld Heat Treatment (PWHT) may be omitted without causing degraded properties of the component; especially the base metal HAZ. The extensive ASME Nuclear Code studies of SA533 and SA508 materials clearly show the efficacy of non-PWHT technique on the C-Mn and C-Mo steels. The University of Tennessee, Knoxville (UTK) joined hands with the Ontario Hydro Co. to conduct research on the Temper-Bead welding techniques employed primarily in Cr-Mo and also a low alloy steel with the Shielded Metal Arc Welding (SMAW) process. Two layer temper-bead refining techniques were applied in this study. Different temper-bead welding parameters were utilized for obtaining complete CGHAZ refinement, in terms of the energy input of first buttering layers and fill layers. The energy ratio between the second butter layer to the first layer is the controlling entity. Conventional stringer bead welds with and without PWHT were made for the purpose of comparison. This program was sponsored by the Pressure Vessel Research Council (PVRC) and spanned a total of 4 years. The materials used in study were SA387-11 (1 1/4Cr-1/2Mo), SA387-22 (2 1/4Cr-1Mo) and A516-70. Ontario Hydro supplied the weld coupons and the examination and testing were conducted at the University of Tennessee, Knoxville. The goals of the program lay in the evaluation of the temper-bead welding techniques and thus the determination of the welding procedures pertinent to the refinement of the base metal HAZ. To evaluate the weldments, a series of tests were conducted. Hardness traverses across the weld metal through HAZ to base metal were taken; Macrostructural and microstructural examination was conducted using optical light microscopy. The reheat cracking tendency of the weld HAZ for each of the three heats of material was evaluated using spiral notched transverse weld specimens with both small (0.125 in. dia.) and large (0.350 in. dia.) diameter samples. Gleeble thermal simulation was applied for evaluation of the HAZ refining procedures. HAZ Charpy V-notched impact tests were conducted for the temper-bead, conventional with/without PWHT welds, as well as for Gleeble simulated and UTK fabricated welds. Creep rupture testing of cross weld HAZ specimens was also carried out for the different procedure conditions, in which both small and large diameter samples were utilized for testing. Ontario Hydro temper-bead and conventional, UTK weave bead and conventional welds in the as-welded and PWHT conditions were tested for sensitivity to hydrogen cracking by a hydrogen charging-bend test method. Stress rupture testing of longitudinal smooth bar specimens, a new test method for the evaluation of the creep ductility in different weld regions, was developed during this investigation. A singular and straight CGHAZ produced by a weave bead welding technique and the overlapped CGHAZ induced by conventional deposition sequences made at UTK were also evaluated and compared to the Ontario Hydro weld coupons in terms of Charpy V-notched impact, large diameter creep rupture, spiral notched stress rupture and hydrogen sensitivity tests. The results showed a general superiority for the temper-bead welds over the conventional and weave bead welds, as regard to the tests conducted in the program. The Ontario Hydro welding procedures were found to achieve a high degree of CGHAZ refinement. Gleeble simulated samples showed lower properties than the actual welds. The temper-bead welding procedures can be used in practice if more attention is paid to root passes and the final layer of fill passes.

B-18 WRC 175 *PVRC Recommendations on Toughness Requirements for Ferritic Materials*

One objective of the Pressure Vessel Research Committee (PVRC) of the Welding Research Council is to review and present the results of pressure-vessel research in a useful form for designers and code-making bodies. Many such reviews with recommendations have been presented. In January 1971, PVRC formed a task group, under the Evaluation and Planning Committee, to review current knowledge and prepare recommendations on toughness requirements for ferritic materials in nuclear power plant components. The recommendations were requested from PVRC by the ASME Boiler and Pressure Vessel Committee for its use in considering any revisions to the requirements of Section 111-Nuclear Power Plant Components.

B-19 WRC 265 *Interpretive Report on Small Scale Test Correlations with K_{IC} Data*

Correlations between fracture toughness and small-scale test results are useful in pressure vessel applications due to cost, availability of material and ease of testing. The material parameter, fracture toughness, can be used directly in design analysis. The small-scale test results, which are not designed to provide the information necessary to predict a failure load or critical flaw size, may provide this information through correlation with the fracture toughness. Possible small-scale tests for this type of relationship include the Charpy test, the nil-ductility transition temperature test and the dynamic tear test. Correlations of Charpy test results for the upper shelf region and three types of transition region correlations are evaluated. When evaluating the proposed correlations, it is important to consider the effects of notch acuity and strain rate. The effects of plate position and scatter of the experimental results are also noted. Due to the empirical nature of the correlations, no one correlation can be shown to be more accurate for all materials. The materials reviewed are steels with yield strengths between 250 and 760 MPa (36 and 110 ksi). A correlation developed for a material under consideration is obviously preferred. When such a correlation is not available, the authors have recommended correlations likely to give conservative results.

B-20 Additional Publications

In addition to the publications described in B-1 through B-19, the following publications from the Materials Technology Institute (MTI) should be considered.

(a) 9230-34 *Guidelines for Mothballing Process Plants 1989 and 1998.*

(b) 9240-30 *Guidelines for Assessing Fire & Explosion Damage 1st – 1990 2nd - 1996*

(c) 9360-40 *Inspection Guidelines for Pressure Vessels & Piping – Vol 1: New Fabrication 1993and 1996.*

(d) 9490-49 *Inspection Guidelines for Pressure Vessels & Piping – Volume 2 1996.*

(e) 9494 *Pressure Vessels & Piping Inspection Checklists on Computer Disk CD 1996.*

(f) 9380-45 *Corrosion Control in the Chemical Process Industries –2nd Edition 1994 and 1997.*

(g) 9410-43 *Materials of Construction for Once-Through Water Systems 1995 and 1998.*

(h) 9440-44 *Materials Engineering & Risk Management in Chemical Plant Operations 1995.*

(i) 9495 50 *User's Guide to ASME Standards for Fiberglass Tanks & Vessels 1996.*

(j) 9501-R3 *Surface Preparation of Carbon & Stainless Steels for Non-Destructive Detection of Surface Cracks 1997.*

(k) 9511-R10 *Flaw Detection & Characterization in Heat Exchanger Tubing 1999.*

(l) 9515 129 *A Practical Guide to Field Inspection of FRP Equipment & Piping CD 2001.*

(m) 9519 *Materials Selection for the Chemical Process Industries 2004.*

(n) 9520 *Guidelines for Troubleshooting Water Cooled Heat Exchangers 2004.*

(o) 9526 56 *Implementing & Evergreening RBI in Process Plants 2005.*

(p) 9528-R19 *Nondestructive Test Methods for Furnaces 2004.*

(q) 9533-R14 *Selection & Use of Flux Cored & Gas Metal Arc Welding Processes in the Chemical Process Industry 2004.*

(r) 9534-R15 *Procedures for Qualifying Personnel in Flange Joint Assembly 2005.*

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