CASTI Guidebook

ASME Section II

2000 Materials Index

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Table of Contents

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Volume 1

ASME Section II
2000 Materials Index

(Covering the 1999 Addenda to 1998 Edition of ASME Section II)

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PREFACE

The ASME Boiler and Pressure Vessel Code is a large compilation of rules and guidance covering numerous types of construction. Those rules pertain to various issues within each construction type encompassing design, materials selection and procurement, fabrication, inspection and testing, overpressure protection, and stamping. There are numerous other subsets of these issues, each having its own degree of complexity. Then there are simply those precautions noted throughout that should be considered. To the novice first-time user of the Code, this is an awesome task, trying to find all the rules and guidelines that apply to a given application. Even to the veteran user of the Code, it is surprising what one finds in other parts of the Code that can be of general use elsewhere.

I was a "novice" first-time user of the Code in the late 1960s and, like all others, was overwhelmed by the complexity, strange terminology, and shear dimension of the Code. As a metallurgical engineer, my primary interest was in materials but in a broad sense ranging from selection and specification to properties and environmental effects. And like the typical well organized engineer, I started making my own checklists, indexes, and cross references to ensure that my work would be done in the most efficient and proficient ways possible.

In 1969, I started what became a long association with the committees that write the Code. Affiliations have included: Task Groups on Materials Behavior, Physical Properties, Inspection of Reactor Internal Structures, and Environmental Effects; Subgroups on Strength of Ferrous Alloys and Materials, Fabrication, and Examination (SC III); Subcommittees on Specifications, Materials, and Nuclear Power; and the Main Committee of the ASME Boiler and Pressure Vessel Code. In the mid 1970s, my first materials index found its way into Code committee work. Its primary use was in achieving consistency in the use of nominal composition designations throughout the Code. The format of that index led to numerous improvements over the years. During this time, peers started to recognize the usefulness of the index, and it was during this time that they encouraged me to publish it so others might also benefit from its many useful features.

The first editions of *ASME Section II Practical Guide* concentrated primarily on the features of the original "Moen Index". Recognizing that materials support people for Code construction would benefit from additional guidance on materials issues, the 1998 Edition provides additional help in understanding broader aspects of the Code as well as focusing on the location of materials requirements and guidance within the various Code sections. It is my desire to make this the ultimate "primer" for anyone dealing with Code materials issues, benefiting everyone from the "novice" to the "veteran."

Richard A. Moen

TABLE OF CONTENTS

Chapter 1

INTRODUCTION

The Materials Index (Moen Index)

Historical Perspective

The "Moen Index" has evolved over a period of nearly twenty years, appearing in various forms. This latest format is keyed to Part D of Section II of the ASME Boiler and Pressure Vessel Code (B&PVC). As with earlier versions, the primary reason for developing such an index is to assist the infrequent user of the ASME Code with a better understanding of the identification of materials used in ASME Code construction.

In the mid 1970s, when the author was involved in ASME Code committee work associated with thermophysical properties, it was noted that the four principal sections of the ASME Code (I, III, VIII, and IX) on occasion referred to materials in their individual stress tables by different nominal composition designations. Since there was a necessity at that time to tie thermo-physical properties to nominal compositions, there was first a need to identify and resolve nominal composition designation differences within the Code. That exercise resulted in the first version of the Moen Index.

Once the merits of such a materials index were recognized as a tool for maintaining consistency in nominal composition designations, there were logical "next steps" that included the addition of corresponding common trade names, ASME Code section usage, minimum specified tensile properties, and Unified Numbering System (UNS) numbers.

These first few editions of the Moen Index were updated yearly, with significant changes every three to four years. Throughout these past few years, colleagues continuously encouraged the author to publish the Moen Index. Therefore this book was written. The latest version (this one) now covers material used in Section IV and Section VIII, Division 3 construction. This additional coverage was driven by a need for a more complete depiction of materials used in all boiler and pressure vessel construction.

A newer yet Materials Index, is now being developed for B31.1 and B31.3 materials. This new publication was inspired by the fact that the ASME B&PVC Subcommittee on Materials is now responsible for setting the stresses used by B31.1 and B31.3 and questions continued to surface concerning materials applications within those two Codes.

Materials Index Development

The first step in developing the Materials Index is to list all specifications contained in Section II, Part A - Ferrous Specifications and Part B - Nonferrous Specifications, showing material grades, types, and/or classes within each specification. Heat treatment, product form, and size limits are also included. In some cases for a given material, separate entries are made as a function of size or heat

treatment condition. Tensile strength requirements are also shown as ultimate tensile strength (UTS) or yield strength (YS). Values in ksi (1000 psi) are minimum values unless noted otherwise. This listing results in the inclusion of materials that are not yet approved for use in Code construction, but are materials simply included in ASTM specifications adopted by ASME.

The second step is to go through each of the stress tables found in Section II, Part D and place a check (√) under each column heading whenever a particular material is found within the stress tables.

Within the Materials Index, the Section II, Part D table headings are as follows:

Table 1A Section I; Section III, Classes 2 and 3; and Section VIII, Division 1 - Maximum Allowable Stress Values for Ferrous Materials.

Table 1B Section I; Section III, Classes 2 and 3; and Section VIII, Division 1 - Maximum Allowable Stress Values for Nonferrous Materials.

Table 2A Section III, Class 1 and Section VIII, Division 2 - Design Stress Intensity Values for Ferrous Materials.

Table 2B Section III, Class 1 and Section VIII, Division 2 - Design Stress Intensity Values for Nonferrous Materials.

Table 3 Section III, Classes 2 and 3 and Section VIII, Divisions 1 and 2 - Maximum Allowable Stress Values for Bolting Materials.

Table 4 Section III, Class 1 and Section VIII, Division 2 - Design Stress Intensity Values for Bolting Materials.

The materials permitted for Section IV construction–Tables HF300 and HLW 300, and Section VIII, Division 3–Tables KCS-1, and KHA-1 and KNF-1 are also covered.

Section II, Part D contains tables of tensile strength, yield strength, thermal expansion, thermal conductivity, thermal diffusivity, and modulus of elasticity, but none of these are specific to particular ASME Code book sections, with the exception of Tables U-2 and Y-3 which are specific to Section VIII, Division 3. Thus, the Materials Index does not indicate ASME Code usage for these tables–only what is reflected within the stress tables of Section II, Part D, the stress tables of Section IV, and the three tables of permitted materials from Section VIII, Division 3.

The third step is to go through Table QW/QB-422 of Section IX, checking whether the materials are assigned welding P-Numbers. If so, the welding P-Numbers are listed under the column heading Weld No./P-Gr.

The fourth step is to review every current Code Case, for both non-nuclear and nuclear construction, to define which materials are covered by these cases. When a case references a new material, that Code case is identified in the appropriate “Code Case Coverage” column. The goal of the Code is to incorporate the provisions of these cases into the body of the Code as soon as the materials are adequately covered by ASME specifications and adequate use experience is achieved.

The last step is to ensure that nominal compositions are properly identified and uniformly applied throughout the specification listing. For those materials not yet described by Unified Numbering System numbers within the specifications, ASTM DS56G (Eighth Edition with 1999 update) is used

to supplement and correct, if necessary, the ASME Code. Trade names are included whenever they are known and when the grade or type designation gives little clue as to the real identity. This is all collectively portrayed in Chapters 9 and 10 of this guide for ferrous and nonferrous materials, respectively. Issues surrounding assignment of nominal composition and UNS numbers will be discussed in more detail in the next subsection of this chapter and in Chapter 3 under Alloy Designation/UNS No.

The second part of the Materials Index serves those who have a nominal composition and simply need to know all of the specifications associated with that composition. The first portion of Chapter 6 is limited to ferrous materials, primarily because these materials are better known by nominal composition than by UNS number. The second portion lists nonferrous alloys by their UNS number and then lists the corresponding specifications for those unique materials. For the nonferrous materials, most users are more familiar with UNS designations than with nominal compositions. Also included in Chapter 6 are general requirements specifications applicable to products covered by specifications listed in Chapters 9 and 10.

Chapter 5 of the Materials Index contains an abbreviated cross index, primarily associating UNS numbers for 10 classes of alloys with their common designation (if it exists). Where specific names for steels do not exist, the Materials Index simply provides the applicable specifications.

Chapter 11 of the Materials Index lists the ASME Code material specification titles and designations found in ASME Section II Parts A and B. This information is first divided into ferrous and nonferrous materials, then is listed by product form, alloy group, and finally by specification number sequence. Sometimes, knowing the title of a specified material designation can provide the user with valuable information to deal with the issue at hand.

Nominal Composition Designation

Since the original motivation for the Materials Index was to achieve some consistency in the nominal composition of ASME Code materials, it is appropriate at this point to explain how those compositions are derived. For ferrous alloys, usually the principal alloying ingredients other than iron are listed. Note that "usually" is underlined; that means there are cases where alloys have had a particular nominal composition for twenty-five years or more, which is not totally indicative of the actual composition. With the long term recognition of a material by that nominal composition, there is now no compelling reason to change. Cast versions of a given wrought product may be assigned the same nominal composition as the wrought product, even though particular elements may differ by one to two percent from the nominal composition of the wrought product. This has caused some concern, but it was done with a good purpose in mind, namely there was a desire to tie thermophysical data to both the wrought and cast materials, thus a single composition was usually selected and it was typically that of the wrought product materials.

In the nickel base system of alloys, nominal compositions can be long and detailed due to the complexity of these alloys. Thus, liberty is taken in showing percentages of only the principle alloying elements, generally not for more than four elements. Throughout the Materials Index, it should be obvious that there is no absolute system for developing nominal compositions. It is mostly a case of following in the footsteps of those who initially came upon the idea and not deviating very far from that "system."

Development of nominal compositions has never been "standardized" and several committees and/or individuals within ASTM or ASME committee structures may develop such an identifier. This may explain why there may appear to be different approaches for this task. Until there are rules for developing nominal composition designations, there will inevitably be differences. The Materials

Chapter 2

ORGANIZATION OF THE ASME BOILER & PRESSURE VESSEL CODE FROM A MATERIALS STANDPOINT

The "heart" of the *CASTI Guidebook to ASME Section II - Materials Index* is the tabulation of ferrous and nonferrous materials specifications by Code section use. However, this Index is only part of the story with respect to Section II and Code materials in general. The focus of this guide is also on how Section II relates to the rest of the ASME Boiler and Pressure Vessel Code, how Section II - Part D is organized, and on some of the common metallurgical issues and terms encountered in the specifications conveyed in Section II, Parts A and B.

The word *Code* in this guide refers to the ASME Boiler and Pressure Vessel Code (see General Overview of the Code for a list of the Code Sections.) *Construction book committees* refers to SC I, SC III, SC IV, SC VIII, and SC X (where SC is the abbreviation for Subcommittee). *Service book committees* refers to SC II, SC V, and SC IX who provide service to all construction book committees. All of these Subcommittees are responsible for Code books (or Code Sections) covering the specific subject areas.

Scope

Section II is an integral part of the 11 section ASME Boiler and Pressure Vessel Code, hereafter referred to simply as the Code. This chapter focuses on how Section II interacts with the rest of the Code, and other related Codes. Important features common to all or most Code sections are discussed. Presentations focus on the "materials person" who should be an integral part of any engineering task. This *materials person* may be an experienced metallurgical or materials engineer whose role is to provide expert guidance on materials issues, or it may simply be an engineer of another discipline who assumes the broader role of a materials specialist, along with his/her other areas of expertise. The current trends within industry, and practice of engineering in particular, have underscored the need to broaden the skill base and become even more versatile. This Materials Index is evolving with this trend in mind.

A Brief History of the Code

A series of tragedies in the late 1800s and early 1900s precipitated what would become the first set of steam boiler construction rules. During a 14 year period between 1889 and 1903, approximately 1,200 people were killed in 1,600 boiler explosions in the United States. First recognizing a way to halt this tragic loss of life was the Commonwealth of Massachusetts. In 1907, it enacted the first set of steam boiler construction rules, all of which were conveyed in just three pages. Four years later in 1911, New York and Ohio published similar boiler construction laws. By 1920, nine other states had followed suit.

Each state had developed slightly different rules, however. For a manufacturer who desired to market a standard boiler in all states, this presented a severe hardship. Recognizing this unfavorable situation in 1911, the American Society for Mechanical Engineers Council appointed a committee to formulate standard specifications for the construction of steam boilers and other pressure vessels. The Council was also concerned about the care of boilers in service. The first published version of the ASME Code appeared in 1914, covering power and heating boilers. By 1937, nine sections had been issued covering procedures for all phases of fabrication, materials selection, maintenance, and inspection of pressure vessels.

The late 1940s brought about newer design methods and advances in materials technology. In the early 1950s, the Code committee completed a comprehensive review of stress tables. Later in that decade, demands for higher temperatures and pressures pushed the envelope into the regime where creep considerations became significant. Within a few years, particularly in the case of Grade 321 stainless steel, failures began to appear, indicating a need to reevaluate the bases for setting stresses. These events led to a renewed emphasis on materials testing. An important step was taken in 1966 with formation of the Metals Properties Council. This organization worked closely with the Code committee to improve the databases and the analytical processes used to set Code allowable stresses. As the Code takes on a more international "flavor", a major step was taken in 1998 to reduce the factor on tensile strength used in deriving allowable stresses for Sections I, III (Classes 2 and 3) and VIII – Div. 1 vessels. This step aligns the ASME B & PV Code with comparable European codes.

The problem of state-specific boiler codes was gradually rectified as states began to adopt the ASME Boiler and Pressure Vessel Code. Today, the Code has been adopted by nearly every state in America and all 10 provinces in Canada, and is now well on the way to become a truly international Code.

A more complete history of the development of rules for construction of boilers appears in a three part article in *Power Engineering*, Vol. 100, No. 2, February 1996 (pp 15 - 30). These articles provide further insight into the involvement of the American Boiler Manufacturers Association (ABMA), ASME, and the National Board of Boiler and Pressure Vessel Inspectors (NBBI).

Content of the 1998 Code Edition

Today's Code (the 1998 Edition) is made up of the following sections:

Section	Title	No. Pages
I	Rules for Construction of Power Boilers	283
II	Part A - Ferrous Materials Specifications	1447
	Part B - Nonferrous Materials Specifications	1015
	Part C - Specifications for Welding Rods, Electrodes and Filler Metals	652
	Part D - Properties	717
III	Division 1 - Rules for Construction of Nuclear Power Plant Components	
	Division 2 - Code for Concrete Reactor Vessels and Containments	2187
	Division 3 - Containment Systems and Transport Packagings for Spent	255
	Nuclear Fuel and High Level Radioactive Waste	207
IV	Rules for Construction of Heating Boilers	298
V	Nondestructive Examination	736
VI	Recommended Rules for the Care and Operation of Heating Boilers	102
VII	Recommended Guidelines for the Care of Power Boilers	161

Section	Title (Continued)	No. Pages
VIII	Division 1 - Rules for Construction of Pressure Vessels	689
	Division 2 - Alternative Rules for Construction of Pressure Vessels	530
	Division 3 - Alternative Rules for Construction of High Pressure Vessels	338
IX	Welding and Brazing Qualifications	267
X	Fiber-Reinforced Plastic Pressure Vessels	253
XI	Rules for Inservice Inspection of Nuclear Power Plant Components	785
	Code Cases for Boilers and Pressure Vessels (Nonnuclear)	615
	Code Cases for Nuclear Components	1054
	Total Pages:	**12,591**

No attempt will be made to update this page tally for each new addenda–it is shown here to simply illustrate the general magnitude of the Code. This is quite a change from the three page Code that first appeared in 1914! This phenomenal growth has been driven mostly by technological advances in materials, testing, inspection, design and analysis methodology, fabrication, and overpressure protection as well as demands for rules covering new service conditions.

Sections II, V, and IX are "service sections" providing rules and guidance for both nonnuclear and nuclear construction. These sections constitute 4,834 pages or 38% of the 12,591 total pages in the Code. Rules for nonnuclear components (Sections I, IV, VI, VII, VIII, X, and their Code cases) involve 3,269 pages or 26%. The remainder of the Code covers nuclear construction (Sections III, XI, and Code cases) with a total of 4,488 pages or about 36% of the Code. Section II alone, with 3,831 pages, represents 30% of the entire Code.

Constructing a component in accordance with Code rules requires, first, a basic decision on which category of rules apply.

General categories are:
- power boilers (fired),
- heating boilers,
- unfired pressure vessels,
- nuclear systems, or
- fiber-reinforced plastic pressure vessels.

One important issue to understand is that each category has unique materials requirements for that type of construction. Within each of the governing Code books are additional factors that must be addressed as the design, fabrication, testing, inspection, and installation processes progress. The following outlines show the organization of the various Code sections with particular emphasis on materials requirements. These outlines may serve as checklists or quick references for the materials specialist in Code construction.

Section I - Power Boilers

Part PG - General Requirements for Power Boilers and High Pressure, High Temperature Water Boilers
- General
- Materials
  - PG-5 General
  - PG-6 Plate
  - PG-7 Forgings
  - PG-8 Castings
  - PG-9 Pipes, Tubes and Pressure Containing Parts
  - PG-10 Material Identified with or Produced to a Specification Not Permitted by This Section, and Material Not Fully Identified

Chapter 3

ORGANIZATION AND THE USE OF SECTION II, PART D

There is a near-symbiotic association between the "heart" of this *CASTI Guidebook to ASME Section II* and Section II, Part D. Each has influenced the other as they progressed to their current forms. The evolution of both spanned a time period of nearly 20 years, which lends support to the adage that "good things take time." Unfortunately, the publication of Section II, Part D represented a somewhat controversial departure from an older, well established way of conveying allowable stresses and properties of Code materials. Some of the confusion surrounding use of this "new" approach is addressed by this chapter, and many of the questions will be answered and misunderstandings dispelled.

Scope

Section II, Part D is now the focal point for allowable stresses and properties for those materials permitted in Section I, III and VIII (Divisions 1 and 2) construction. This chapter delves into the development of Section II, Part D, its organization, use of the many stress and property tables, external pressure charts, associated appendices, and current efforts to adopt non-ASTM (foreign) specifications. It also provides additional useful information on materials behavior. As frequently suggested in Chapter 1, much of this information in Section II, Part D may be valuable in other engineering assignments. So, becoming comfortable with its organization and use is a MUST.

A Brief History of the Development of Section II, Part D

This author wrote a letter on October 5, 1979 to the Chairman of Subcommittee on Properties (as it was called at that time, before it was combined with the Subcommittee on Specifications to become the current Subcommittee on Materials), proposing that there be an "attempt to combine stress tables within a separate Code book." It was further suggested at that time that other minimum and nominal properties and other materials characteristics, that are independent of Code application, be included as well. The arguments cited were that it would be a "quality control system to ensure consistency" and that it would eliminate a lot of duplicate pages, common to numerous Code sections. This letter also recognized "how this approach could uncover minor (and perhaps major) discrepancies in stress listings." The gestation period for this idea was about five years, culminating in early 1985 with a move to resurrect a Task Group on Tabulation of Allowable Stresses and Materials Properties. The ambitious goal of publishing a new document in the 1986 Edition of the Code was obviously not met, but the wheels of motion were moving forward.

Michael Gold, current chairman of the Subcommittee on Materials, presented a paper at the 1995 ASME Pressure Vessel and Piping meeting, in Honolulu, Hawaii in June 1995, entitled "Section II, Part D and Adoption of Foreign Materials." The balance of this historical recap uses portions of

Mr. Gold's paper and is updated to cover the time since that paper was authored. Section II, Part D first appeared in the 1992 Edition of the Code, combining into one book, as suggested earlier, design stress values and materials property values previously published in Sections I, III, and VIII (Divisions 1 and 2). The stated purpose for publishing the information in a single volume for use with the respective sections was to ensure consistency of design values. This was essential since criteria used to develop the values and the data bases upon which values were based were identical.

The first version of Section II, Part D was nothing more than an editorial reformatting of information that existed in the four targeted Code sections. No attempts were made at that time to correct discrepancies that would now be painfully obvious. Over the next three years, concerted efforts were expended to eliminate the many inconsistencies that became evident not only in stress values, but in notes, nomenclature, and use temperatures. Corrections then allowed the merging of many stress lines, and that reduced the size of Section II, Part D.

The 1995 Edition of Section II, Part D was a "slimmed down" version with a new note system, further simplifying the stress tables. Also making the stress tables more user friendly was the numbering of lines to follow stress lines and associated information from one page to the next one, two, or three pages. Efforts will continue to further improve the quality of stresses and material properties as better data become available.

Structure of Section II, Part D

The Michael Gold paper cited earlier also provided an excellent description of the organizational structure of Section II, Part D. This write-up was based on "A Users Guide to BPV Section II Materials, Part D Properties: 1992 Addenda", written by G. M. Eisenberg, at that time Secretary for the B&PVC Main Committee. The following was taken verbatim from Mr. Gold's paper, with permission from ASME.

BASIC ORGANIZATION

The organization and structure of Section II, Part D, has been described thoroughly by G. M. Eisenberg (1992), in the *User Guide to BPV Section II, Materials, Part D Properties: 1992 Edition*, which was published as part of the 1992 Addenda update to Section II, Part D. Because that User Guide did not have page numbers, even current users of the Code may have lost track of it by now, so much of the information developed by Eisenberg has also been included here.

Section II, Part D, is divided into Subparts, followed by Appendices. These are described below.

Subpart 1: Stress Tables

Grouping by Criteria

The individual tables in Subpart 1 include values for materials, based on common stress criteria. For materials other than bolting, *Tables 1A (Ferrous) and Table 1B (Non-Ferrous)* contain maximum allowable stress values, based on the criteria that have been adopted for use in: Section I; Section III, Class 2 and 3; and Section VIII, Division 1. *Tables 2A (Ferrous) and 2B (Non-Ferrous)* contain design stress intensity values based on the criteria used for Section III, Class 1, and Section VIII, Division 2.

For bolting materials, *Table 3* contains allowable stress values based on the criteria used in: Section VIII, Division 1; Section VIII, Division 2, according to the rules of Appendix 3 of Division 2; and Section III, Class 2 and 3. *Table 4* contains design stress intensity values for bolting based on the criteria used for: Section VIII, Division 2; according to the rules of Appendices 4, 5, and 6, of Division 2; and those constructed according to the rules of Section III, Class 1. *Table U* contains tensile strength values for ferrous and nonferrous materials, previously contained only in Section III. *Table Y-1* contains the yield strength values for ferrous and nonferrous materials previously contained in Sections I, III, and VIII, Division 2. *Table Y-2* contains factors for limiting permanent strain for nickel, high nickel alloys, and high alloy steels from data previously contained in Sections III, and VIII, Division 2. *Tables U-2 and Y-3* contain ultimate tensile strength and yield strength values respectively for additional materials used in Section VIII, Division 3 construction.

Ordering of Listing

The sorting order for materials, as they are listed in the tables, differs between Tables 1A and 1B. This difference persists in the other tables, as well, for ferrous and nonferrous materials, respectively. In Tables 1A and 2A, and the portions of Tables 3, 4, U, and Y-1 containing ferrous materials, the underlying sorting sequence in order of priority, is: nominal composition, tensile strength S_T, yield strength S_Y, specification number, and grade or type. Two variables to this ordering are worth mentioning: There is no distinction made among the carbon steels on the basis of nominal compositions shown as C, C-Si, C-Mn, and C-Mn-Si. These were all treated as being identical carbon steels, with regard to nominal compositions, and were placed at the beginning of the table. In fact, those distinctions in Nominal Composition for carbon steels will soon be eliminated from Code stress tables and those materials will <u>all</u> be described simply as "C Steels." This is already reflected in this version of the Materials Index. Micro-alloyed carbon steels will still retain their original distinction even though the reported thermophysical properties for carbon steels also are appropriate for these micro-alloyed carbon steels. The ordering of the carbon steels in stress tables begins with the tensile strength as the primary discriminator. Further, the austenitic stainless steels, those with chromium contents between 16 and 25, were separated from the ferritic steels and placed after them.

In Tables 1B, 2B, and the portions of Tables 3, 4, U, and Y-1 containing the nonferrous materials, the sorting priority is somewhat different: alloy/UNS number (alpha-numeric), tensile strength S_T, yield strength S_Y, class/condition/temper, and specification number. Nominal compositions are not included as a sorting priority for the nonferrous materials. In fact, nominal compositions are not listed for the aluminum and copper alloys, because of all of the many different variations of nominal compositions available in different systems for these materials. For all nonferrous materials, the primary ordering sequence is based on the more unique UNS numbers that have been assigned to each grade.

Other Information in Tables

In addition to providing columns for the materials and the criteria by which they are sorted, and, of course, the design values, other information is provided in the stress tables: This includes nominal composition (for the other nonferrous materials), product form (e.g. tube, pipe, plate, etc.), specification number, type or grade, alloy designation or UNS number, class/condition/ temper, size/thickness, welding

P-number and group number, minimum tensile strength in ksi, minimum yield strength in ksi, and most importantly, the maximum temperature and applicability for each material in the Construction Codes appropriate for each table.

Applicability-Temperature Limit Columns

An example of the applicability/temperature limit column heading, is as follows.

NP = (Not Permitted)		
I	III	VIII-1
800	NP	1500

This entry indicates that, for this particular stress line, the values shown are appropriate for use in Section I construction, up to a maximum temperature of 800°F, and are appropriate for use in Section VIII, Division 1 construction, up to a maximum temperature of 1,500°F. The NP entry indicates that this stress line is not permitted for Section III construction. The difference in temperatures of applicability between Section I and Section VIII, may have no technical basis. It is possible that no inquirer ever requested use of this material in Section I construction, above 800°F. Many of these types of inconsistencies have been, and will continue to be eliminated in future Addenda. Further, the NP doesn't necessarily mean that this particular material would never be permitted in Section III construction; it might mean that either no one has ever requested this material for use in Section III construction, or that there is another stress line, with some differences, that has previously been approved for Section III construction, and it would normally be found immediately above or below this particular line. Subcommittee II is working to eliminate such inconsistencies, and the 1995 Edition went a long way in that direction.

External Pressure Charts and Notes

Other information included in the stress tables are the external pressure chart numbers, and their references. Many inconsistencies in the referenced external pressure charts existed in the initial publication of Section II, Part D, but these have since been addressed and resolved.

The 1992 Edition and its three Addenda contained separate tables for notes, essentially as they originally appeared in the construction Codes. The 1995 Edition merged all of those notes into a single set of notes applicable to each stress table. Unfortunately, those who became familiar with a particular identification number for certain notes will have to learn new numbers. The new system is much more understandable and combines many similarly worded notes that had exactly the same meaning into single notes.

Subpart 2: Physical Properties Tables

There are four sets of physical properties tables. Those in the first set are the nominal coefficients of thermal expansion, numbered *TE-1* through *TE-5*. These combined existing values from the 1989 Editions of Section III and Section VIII, Division 2. The five tables cover ferrous materials, aluminum alloys, copper and copper alloys, high nickel alloys, and titanium and titanium alloys, respectively. The next table is *Table TCD*, which includes nominal coefficients of thermal conductivity and thermal diffusivity. The values in this table were also extracted from tables that existed in the

Chapter 4

EVOLUTION, ORGANIZATION AND USE OF ASME MATERIALS SPECIFICATIONS

This chapter is intended for users who are new to materials specifications or to comprehensive collections such Section II, Parts A, B, and C of the *ASME Boiler and Pressure Vessel Code.* It includes basic information on how the Code specifications were developed and how they should be used.

Scope

ASME Code specifications cover ferrous, nonferrous, and weld filler materials. This chapter concentrates on the ferrous and nonferrous materials covered by specifications in Parts A and B, respectively, of Section II. Welding filler metals are already covered in a companion book, *CASTI Metals Blue Book - Welding Filler Metals*, and to a lesser extent in the recently published *CASTI Guidebook to ASME Section IX - Welding Qualifications*, both published by *CASTI* Publishing Inc.

Evolution of ASME Specifications

ASME materials specifications are currently based on ASTM materials specifications that have been reviewed and approved by the various Code committees as being suitable for Code construction. Suitability is generally determined by a set of chemical composition requirements and well defined mechanical property requirements. When such specifications are not suitable, there is obvious pressure for ASTM to make the necessary changes to make their standards more acceptable. This close association between ASTM and the ASME Code has been going on since the 1920s or about 75 years. An article by Michael Gold in the January 1996 issue of *ASTM Standardization News*, entitled "ASTM and ASME: Partners in Materials Specifications" expounds on the role of ASTM standards for metals in the ASME Boiler and Pressure Vessel Code. The article covers very clearly the exhaustive review and approval process required by both organizations.

The Foreword to the various Code sections also contains information relative to the evolution of ASME materials specifications. Excerpts follow:

> "Revisions to material specifications are originated by the American Society for Testing and Materials (ASTM) and other recognized national or international organizations, and are usually adopted by ASME. However, those revisions may or may not have any effect on the suitability of material, produced to earlier editions of specifications, for use in ASME construction. ASME material specifications approved for use in each construction Code are listed in the Appendices of Section II, Parts A and B. These Appendices list, for each specification, the latest edition adopted by ASME, and earlier and later editions considered by ASME to be identical for ASME construction."

The words "other recognized national or international organizations" (in the context of standards that might be adopted as ASME specifications) in the above excerpt are recent additions to the Foreword. They reflect a recent policy decision by the ASME Code Committee to remove impediments to greater use of the ASME Code overseas. Appearing at the end of the Chapter 9 table are the first non-ASTM Standards adopted for Code construction.

Organization of Parts A and B of Section II

The organization of Parts A and B of Section II has already been defined in Chapter 2. Listings of specifications found within these two books are found in Chapter 11 of this Guidebook. Each of these specifications covers one or more product forms and anything from one to 90 or more different material grades. This will become obvious in Chapters 9 and 10 for ferrous and nonferrous materials. Parts A and B also contain numerous general requirement specifications listed at the beginning of Chapter 6.

Organization of Typical Specifications

In dealing with a well established set of national standards, the first expectation would be that a common, consistent format would be used in all material specifications. Unfortunately, that is not the case. Nearly every ASME specification (which is based on an ASTM specification) has a slightly different format. So, rather than attempt to describe some hypothetical ideal common specification format, discussions will center around the more common features. Since almost all start with a scope statement, reference documents, and ordering information, the ensuing discussion covers those subjects first and then touches on other subjects, not necessarily in the order they appear in any particular specification. A review of both Parts A and B of Section II suggest that this approach will apply equally to both ferrous and nonferrous material specifications.

Scope

The scope statement contains very important information, generally dealing with application intentions or limits not fully conveyed in the title of the specification. ASME SA-620 provides a good example.

> Title: Specification for Steel, Sheet, Carbon, Drawing Quality, Special Killed, Cold-Rolled
>
> Scope: This specification covers cold-rolled carbon steel sheet of drawing quality, special killed, in coils or cut lengths.
>
> This material is intended for fabricating identified parts where particularly severe drawing or forming may be involved or essential freedom from aging is required.

The second sentence of this scope statement defines quite clearly where material of this type should be used.

One more example is SA-540, a bolting specification:

Title: Specification for Alloy - Steel Bolting Materials for Special Applications

Scope: Para 1.1 - This specification covers regular and special quality alloy steel bolting materials which may be used for nuclear and other special applications.
Bolting materials as used in this specification cover rolled or forged bars, rotary pierced or extruded seamless tubes, forged bars, or forged hollows from forged or rolled bar segments to be manufactured into bolts, studs, washers, and nuts.

Para. 1.2 - Several grades of steel are covered. The grade and class shall be specified by the purchaser.

Para. 1.3 - Supplementary requirements of an optional nature are provided for use when special quality is desired. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order, together with the acceptance limits required.

There are two more paragraphs (1.4 and 1.5) with units (SI); in other specifications, such information might be found as footnotes. Paragraphs 1.2 and 1.3, in other specifications, might be found under Ordering Information (which will be discussed later). Paragraph 1.1 is the real "meat" of the scope statement, defining further where such material is typically used and how it can be manufactured. In this particular specification, there is paragraph 4, Manufacture, but that only defines the steel-making process.

In summary, there is a tremendous amount of application information in these scope statements and they should be read carefully and often until the serious materials person has the more frequently used ones almost memorized.

Reference Documents

"Reference Documents", almost without exception, is the second paragraph heading of any ferrous or nonferrous material specification. The first documents generally listed are the ASTM standards, including ones for the material from which this product form might be made, the general requirements specifications that apply (in addition to the requirements within the subject specification), and any applicable testing method specifications.

There may be other standards listed from ASME, ANSI, SAE, ASNT, MSS, AWS, API, AIAG, etc. When there are general requirements specifications listed in the Reference Documents paragraph, there is generally specific reference to the specification one or more times in other paragraphs.

General Requirements and Ordering Information

Some specifications cover this information in a single paragraph while others separate the information into two paragraphs, with some variation in which is presented first.

The General Requirements mostly emphasize that material furnished shall conform to applicable requirements of the appropriate general requirements specification. In many specifications for nonferrous materials, this paragraph will be missing and may be replaced by a paragraph on Terminology (which will be discussed later).

Chapter 5

CODE ALLOYS BY UNS NUMBERS

Alloys used in ASME Code construction are divided into 10 groupings of alloy types, as depicted below:

- AXXXXX Aluminum-base alloys
- CXXXXX Copper-base alloys
- FXXXXX Cast iron alloys
- GXXXXX AISI and SAE carbon and alloys steels
- HXXXXX AISI and SAE H-steels
- JXXXXX Cast steels
- KXXXXX Misc. steel and ferrous alloys
- NXXXXX Nickel-base alloys
- RXXXXX Special metals and alloys
- SXXXXX Heat and corrosion resistant steels

The following pages are arranged by UNS sections and by increasing number. This portion matches UNS numbers with nominal composition and alloy grade or specification. Materials shown in this chapter appear in ASME "SA" or "SB" specifications, but they may not have been assigned stresses that allow their use in Code construction. Indications of assigned stresses will be found in Chapters 9 and 10 for ferrous and nonferrous materials, respectively.

Groupings of UNS numbers beginning with F, G, H, J, and K contain a more complete listing of actual specifications/grades/classes that are associated with each UNS number. The balance of the UNS number groupings, beginning with A, C, N, R, and S show only the grade designation and generally the common name or trade name. As was discussed back in Chapter 3, assignment of UNS numbers is an ongoing process and there will most likely be some changes in the future to these UNS numbers.

ALUMINUM-BASE ALLOYS BY UNS No.		
UNS No.	**Nominal Composition**	**Grade**
A02040	Al – Cu – Mg	Alloy 204
A03560	Al – Si – Mg	Alloy 356; old SG70A
A03570	Al – Si – Mg	---
A13560	Al – Si – Mg – Cu	
A24430	Al – Si	Alloy 443; old S5A
A83003	---	Alclad 3003
A83004	---	Alclad 3004
A86061	---	Alclad 6061
A91060	99.60 Al	1060
A91100	99.0 Al – Cu	1100
A92014	Al – 4 Cu – Si – Mn	2014
A92024	Al – 4 Cu – Mg	2024
A93003	Al – Mn – Cu	3003
A93004	Al – Mn – Mg	3004
A95052	Al – 2.5 Mg	5052
A95083	Al – 4.4 Mg – Mn	5083
A95086	Al – 4.0 Mg – Mn	5086
A95154	Al – 3.5 Mg	5154
A95254	Al – 3.5 Mg	5254
A95454	Al – 2.7 Mg – Mn	5454
A95456	Al – 5.1 Mg – Mn	5456
A95652	Al – 2.5 Mg	5652
A96061	Al – Mg – Si – Cu	6061
A96063	Al – Mg – Si	6063

COPPER-BASE ALLOYS BY UNS No.		
UNS No.	**Nominal Composition**	**Grade**
C10200	99.95 Cu	OF Cu
C10400	99.95 Cu + Ag	OFS Cu
C10500	99.95 Cu + Ag	OFS Cu
C10700	99.95 Cu + Ag	OFS Cu
C11000	99.90 Cu	ETP Cu
C12000	99.90 Cu + P	DLP Cu
C12200	99.9 Cu + P	DHP Cu
C12300	99.90 Cu + Ag & P	DPS Cu
C12500	99.88 Cu	FRTP Cu
C14200	99.40 Cu + As & P	DPA Cu
C19200	98.7 Cu + Fe + P	Phosphorized 1% Fe
C19400	97.4 Cu + Fe	Cu-Fe alloy
C23000	85 Cu – 15 Zn	Red brass
C28000	60 Cu – 40 Zn	Muntz metal
C36500	60 Cu – 39 Zn – Pb	Leaded Muntz metal, uninhibited
C37700	60 Cu – 37 Zn – 2 Pb	Forging brass
C44300	71 Cu – 28 Zn – Sn – As	Admiralty metal B (arsenical)
C44400	71 Cu – 28 Zn – Sn – Sb	Admiralty metal C (antimonial)
C44500	71 Cu – 28 Zn – Sn – P	Admiralty metal D (phosphorized)
C46400	60 Cu – 39 Zn – Sn	Naval brass, uninhibited
C46500	60 Cu – 39 Zn – Sn – As	Naval brass, arsenical

COPPER-BASE ALLOYS BY UNS No. (Continued)		
UNS No.	**Nominal Composition**	**Grade**
C60800	95 Cu – 5 Al	Aluminum bronze
C61300	90 Cu – 7 Al – 3 Fe – Sn	Aluminum bronze
C61400	90 Cu – 7 Al – 3 Fe	Aluminum bronze D or 3
C62300	88 Cu – 9 Al – 3 Fe	Aluminum bronze 2
C63000	81 Cu – 10 Al – 3 Fe – Ni	Aluminum-nickel bronze 2
C64200	91 Cu – 7 Al – 2 Si	Aluminum bronze 1
C65100	98.5 Cu – 1.5 Si	Copper silicon alloy B
C65500	97 Cu – 3 Si	High silicon bronze alloy A
C66100	94 Cu – 3 Si – P	Copper-silicon alloy D
C68700	78 Cu – 20 Zn – 2 Al	Aluminum brass B
C70400	95 Cu – 5 Ni	95 – 5 copper nickel
C70600	90 Cu – 10 Ni	90 – 10 copper nickel
C71000	80 Cu – 20 Ni	80 – 20 copper nickel
C71500	70 Cu – 30 Ni	70 – 30 copper nickel
C71640	66 Cu – 30 Ni – 2 Fe – 2 Mn	Copper-nickel
C72200	80 Cu – 16 Ni – Mn – Zn – Cr	Copper-nickel
C74500	65 Cu – 10 Ni – Zn	Nickel silver 65 – 10
C75200	65 Cu – 18 Ni – Zn	Nickel silver 65 – 18
C75700	65 Cu – 12 Ni – Zn	Nickel silver 65 – 12
C76400	60 Cu – 18 Ni – Zn	Nickel silver 60 – 18
C77000	55 Cu – 18 Ni – Zn	Nickel silver 55 – 18
C79200	63 Cu – 12 Ni – Zn - Pb	Leaded nickel silver
C83600	85 Cu – 5 Sn – 5 Zn – 5 Pb	Alloy 85 or 85-5-5-5
C84400	81 Cu – 9 Zn – 7 Pb – 3 Sn	Leaded, semi-red brass
C90300	87 Cu – 8 Sn – 4 Zn	Tin bronze
C92200	88 Cu – 6 Sn – 4.5 Zn – Pb	Alloy 2A or valve bronze
C93700	80 Cu – 10 Sn – 9 Pb	Cast high leaded tin bronze
C95200	88 Cu – 9 Al – 3 Fe	Aluminum bronze 9A
C95400	85 Cu – 11 Al – 4 Fe	Aluminum bronze 9C
C95820	77.5 Cu – 9 Al – 5 Ni – Fe	Nickel-aluminum bronze
C96200	87.5 Cu – 10 Ni – Fe – Mn	Alloy A
C96400	66 Cu – 30 Ni – Fe – Mn	Alloy B
C97600	65 Cu – 20 Ni – 8 Zn – Pb	Leaded nickel-silver

CAST IRONS BY UNS No.		
UNS No.	**Nominal Composition**	**Specification - Grade/Class**
F11401	Cast iron	SA-278 Class 20
F11701	Cast iron	SA-278 Class 25
F12101	Cast iron	SA-278 Class 30
F12401	Cast iron	SA-278 Class 35
F12803	Cast iron	SA-278 Class 40
F13102	Cast iron	SA-278 Class 45
F13502	Cast iron	SA-278 Class 50
F13802	Cast iron	SA-278 Class 55
F14102	Cast iron	SA-278 Class 60
F22200	Malleable iron	SA-47 Grade 32510
F32800	Nodular iron	SA-395
F34100	Nodular iron	SA-476

AISI AND SAE CARBON AND ALLOY STEELS BY UNS No.		
UNS No.	**Nominal Composition**	**Specification - Grade/Class**
G10180	C steel	SA-311, Grade 1018
G10350	C steel	SA-311, Grade 1035
G10450	C steel	SA-311, Grade 1045
G10500	C steel	SA-311, Grade 1050
G11170	C steel	SA-311, Grade 1117
G11370	C steel	SA-311, Grade 1137
G11410	C steel	SA-311, Grade 1141
G11440	C steel	SA-311, Grade 1144
G15410	C steel	SA-311, Grade 1541
G40370	C - ¼ Mo	SA-320 Grades L7A, L71, SA-574 Grade 4037
G40420	C - ¼ Mo	SA-194 Grade 7, SA-574 Grade 4042
G41350	1 Cr - ⅕ Mo	SA-372 Grade F
G41370	1 Cr - ⅕ Mo	SA-320 Grades L7B, L72 SA-574 Grade 4137, SA-372 Grade J
G41400	1 Cr - ⅕ Mo	SA-193 Grades B7, B7M, SA-194 Grades 7, 7M, SA-320 Grades L7, L7M, SA-574 Grade 4140
G41420	1 Cr - ⅕ Mo	SA-574 Grade 4142
G41450	1 Cr - ⅕ Mo	SA-574 Grade 4145
G43400	1 ¾ Ni - ¾ Cr - ¼ Mo	SA-574 Grade 4340, SA-320 Grade L43
G61500	1 Cr - 0.15 V	SA-232
G87400	½ Ni - ½ Cr - ¼ Mo	SA-320 Grades L7C and L73, SA-574 Grade 8740

AISI AND SAE H-STEELS BY UNS No.		
UNS No.	**Nominal Composition**	**Specification - Grade/Class**
H15211	Low C - Boron steel	SA-320 Grade L1
H41420	1 Cr - 1 Mn - ¼ Mo	SA-540 Grade B22
H43400	2 Ni - ¾ Cr - ¼ Mo	SA-540 Grade B23

CAST STEELS BY UNS No.		
UNS No.	**Nominal Composition**	**Specification - Grade/Class**
J02502	C steel	SA-216 Grade WCA
J02503	C steel	SA-216 Grade WCC
J02504	C steel	SA-352 Grade LCA, SA-660 Grade WCA
J02505	C steel	SA-352 Grade LCC, SA-660 Grade WCC
J03002	C steel	SA-216 Grade WCB
J03003	C steel	SA-352 Grade LCB, SA-660 Grade WCB
J11522	C - ½ Mo - Si	SA-426 Grade CP15
J11547	½ Cr - ½ Mo	SA-426 Grade CP2
J11562	1 Cr - ½ Mo	SA-426 Grade CP12
J11872	1 ¼ Cr - ½ Mo	SA-217 Grade WC11
J12072	1 ¼ Cr - ½ Mo	SA-217 Grade WC6, SA-426 Grade CP11
J12082	1 Ni - ½ Cr - ½ Mo	SA-217 Grade WC4, SA-487 Grades 11A and 11B
J12084	Ni - Cr - Mo - V	SA-487 Grade 7A
J12521	C - ½ Mo	SA-426 Grade CP-1
J12522	C - ½ Mo	SA-352 Grade LC1
J12524	C - ½ Mo	SA-217 Grade WC1
J13002	Mn - V	SA-487 Grades 1A, 1B and 1C
J13005	Mn - ¼ Mo - V	SA-487 Grades 2A, 2B and 2C

CAST STEELS BY UNS No. (Continued)		
UNS No.	**Nominal Composition**	**Specification - Grade/Class**
J13047	½ Ni - ½ Cr - ¼ Mo - V	SA-487 Grades 4A, 4B, 4C, 4D and 4E
J13080	Ni - Mo	SA-487 Grades 13A and 13B
J13345	1 Cr - ½ Mo	SA-487 Grades 9A, 9B, 9C, 9D and 9E
J13855	Mn - Ni - Cr - Mo	SA-487 Grades 6A and 6B
J15580	Ni - Mo	SA-487 Grade 14A
J21890	2 ¼ Cr - 1Mo	SA-217 Grade WC9, SA-426 Grade CP22
J22000	¾ Ni - 1 Mo - ¾ Cr	SA-217 Grade WC5, SA-487 Grades 12A and 12B
J22091	2 ¼ Cr - 1 Mo	SA-487 Grades 8A, 8B and 8C
J22500	2 ½ Ni	SA-352 Grade LC2
J23015	1 ½ Ni - ¾ Cr - ¼ Mo	SA-487 Grades 10A and 10B
J31200	Low C Mn-Ni	SA-487 Grade 16A
J31300	9 Ni	SA-352 Grade LC9
J31545	3 Cr - 1 Mo	SA-426 Grade CP21
J31550	3 ½ Ni	SA-352 Grade LC3
J41500	4 ½ Ni	SA-352 Grade LC4
J42045	5 Cr - ½ Mo	SA-217 Grade C5, SA-426 Grade CP5
J42215	Ni - Cr - Mo	SA-352 Grade LC2-1
J51545	5 Cr - ½ Mo - Si	SA-426 Grade CP5b
J82090	9 Cr - 1 Mo	SA-217 Grade C12, SA-426 Grade CP9
J91150	13 Cr	SA-217 Grade CA15, SA-426 Grade CPCA15, SA487 Grades CA15A and CA15B
J91151	13 Cr - Mo	SA-487 Grade CA15M-A
J91171	13 Cr	SA-487 Grades CA15C and CA15D
J91540	13 Cr - 4 Ni - .7 Mo	SA-352 Grade CA6NM, SA-487 Grade CA6NM-A/-B
J92110	15 Cr - 5 Ni - 3 Cu	SA-747 Grade CB7Cu-2
J92180	16 Cr - 4 Ni - 3 Cu	SA-747 Grade CB7Cu-1
J92500	18 Cr - 8 Ni	SA-351 Grades CF3 and CF3A, SA-451 Grades CPF3 and CPF3A
J92590	19 Cr - 9 Ni - ½ Mo	SA-351 Grade CF10
J92600	18 Cr - 8 Ni	SA-351 Grades CF8 and CF8A, SA-451 Grades CPF8 and CPF8A
J92700	16 Cr - 12 Ni - 2 Mo - N	SA-351 Grade CF3MN
J92710	18 Cr - 10 Ni - Cb	SA-351 Grade CF8C, SA-451 Grade CPF8C
J92800	16 Cr - 12 Ni - 2 Mo	SA-351 Grades CF3M and CF3MA, SA-451 Grade CPF3M
J92802	24 Cr - 9 Ni - Mo - N	SA-351 Grade CE20N, SA-451 Grade CPE20N
J92900	16 Cr - 12 Ni - 2 Mo	SA-351 Grade CF8M, SA-451 Grade CPF8M
J92901	19 Cr - 9 Ni - 2 Mo	SA-351 Grade CF10M
J92971	16 Cr - 14 Ni - 2 Mo	SA-351 Grade CF10MC, SA-451 Grade CPF 10 MC
J92972	18 Cr - 8 Ni - 4 Si - N	SA-351 Grade CF10SMnN
J92999	19 Cr - 11 Ni - 3 Mo	SA-351 Grade CG3M
J93000	19 Cr - 10 Ni - 3 Mo	SA-351 Grade CG8M
J93254	20 Cr - 18 Ni - 6 Mo-Cu-N	SA-351 Grade CK3MCuN
J93345	24 Cr - 10 Ni - 3 Mo - N	SA-351 Grade CE8MN
J93370	25 Cr - 5 Ni - 3 Cu - 2 Mo	SA-351 Grade CD4MCu
J93380	25 Cr - 7 ½ Ni - 3 ½ Mo-N-Cu-W	SA-351 Grade CD3MWCuN
J93400	25 Cr - 12 Ni	SA-351 Grade CH8, SA-451 Grade CPH8
J93401	24 Cr - 13 Ni - ½ Mo	SA-351 Grade CH10, SA-451 Grade CPH10
J93402	25 Cr - 12 Ni	SA-351 Grade CH20, SA-451 Grade CPH20
J93790	22 Cr - 13 Ni - 5 Mn	SA-351 Grade CG6MMN
J94202	25 Cr - 20 Ni	SA-351 Grade Grade CK20, SA-451 Grade CPK20

Chapter 6

CODE SPECIFICATIONS BY NOMINAL COMPOSITION & BY COMMON NAME

The assigned nominal composition for a given type of material, particularly for ferrous materials, determines its location in the various stress tables of the Code. The following tables in this Chapter were developed to help locate other product forms for a given composition or to find materials with similar compositions. The following is a listing of the various categories of materials covered by tables within this Chapter. Their order does not quite parallel the system used within Section II, Part D stress tables. Also listed in this Chapter are the General Requirements specifications and Methods (testing and exmination) specifications. In all of the materials tables within this Chapter, an attempt was made to list all correponding common names or trade names.

ASME General Requirements Specifications

- Carbon Steels
- Clad Steels
- Cast Irons
- Low Alloy Steels
  - C - Mo steels
  - ½ Cr - 1 ¾ Cr steels
  - 1 ¾ Cr - 3 Cr steels
  - 5 Cr - 9 Cr steels
  - Mn, Mn - Mo, and Si steels
  - Nickel steels
- High Alloy Steels
  - By increasing chromium content
  - Ni - Cr steels
- Aluminum Alloys (by changes in nominal composition designation)
- Copper Alloys (by increasing alloying element/decreasing copper contact)
- Nickel Alloys (by increasing alloying element/decreasing nickel content)
- Special Alloys (typically the higher cobalt-containing alloys)
- Titanium Alloys (by increasing alloying element content)
- Zirconium Alloys (by increasing UNS number)

Abbreviation Note: ASME Material Specifications that are enclosed in brackets and are followed by the letters CC indicate a Code Case material, e.g. (SA-387 CC).

UNS Numbers with round brackets, e.g. (R53400), infers that the particular alloy is not listed in the Metals & Alloys in the Unified Numbering System, but rather the nominal composition of this alloy most closely resembles the UNS Number within the bracket, and is given only for convenience.

CARBON STEELS BY NOMINAL COMPOSITION					
Nominal Composition	**Specification No.**	**Grade Designation**	**UNS No.**	**Common Name or Trade Name**	**Product Form**
C steel	SA-36	---	K02600	---	Structural
C steel	SA-53	Type S Grade A	K02504	---	Pipe, welded and seamless
C steel	SA-53	Type E Grade A	K02504	---	Pipe, welded and seamless
C steel	SA-53	Type F Grade A	K02504	---	Pipe, welded and seamless
C steel	SA-53	Type S, Grade B	K03005	---	Pipe, welded and seamless
C steel	SA-53	Type E, Grade B	K03005	---	Pipe, welded and seamless
C steel	SA-105	---	K03504	---	Flanges, fittings, etc.
C steel	SA-106	A	K02501	---	Pipe, seamless
C steel	SA-106	B	K03006	---	Pipe, seamless
C steel	SA-106	C	K03501	---	Pipe, seamless
C steel	SA-134	---	---	uses ASME SA-36, SA-283, and SA-285 plus ASTM A570	Pipe, welded
C steel	SA-135	A	---	---	Pipe, welded
C steel	SA-135	B	---	---	Pipe, welded
C steel	SA-178	A	K01200	---	Tubes, welded
C steel	SA-178	C	K03503	---	Tubes, welded
C steel	SA-178	D	---	---	Tubes, welded
C steel	SA-179	---	K01200	---	Tubes, seamless
C steel	SA-181	60 and 70	K03502	---	Flanges, fittings, etc.
C steel	SA-192	---	K01201	---	Tubes, seamless
C steel	SA-194	1	K01503	---	Nuts
C steel	SA-194	2, 2H, 2HM	K04002	---	Nuts
C steel	SA-210	A-1	K02707	---	Tubes, seamless
C steel	SA-210	C	K03501	---	Tubes, seamless
C steel	SA-214	---	K01807	---	Tubes, welded
C steel	SA-216	WCA	J02502	---	Castings
C steel	SA-216	WCB	J03002	---	Castings
C steel	SA-216	WCC	J02503	---	Castings
C steel	SA-226	---	K01201	---	Tubes, welded
C steel	SA-234	WCB	K03006	---	Fittings
C steel	SA-234	WPC	K03501	---	Fittings
C steel	SA-266	1 and 2	K03506	---	Forgings
C steel	SA-266	3	K05001	---	Forgings
C steel	SA-266	Grade 4	K03017	---	Forgings
C steel	SA-283	A, B, C	K02401	---	Plates

CARBON STEELS BY NOMINAL COMPOSITION (Continued)					
Nominal Composition	**Specification No.**	**Grade Designation**	**UNS No.**	**Common Name or Trade Name**	**Product Form**
C steel	SA-283	D	K02702	---	Plates
C steel	SA-285	A	K01700	---	Plates
C steel	SA-285	B	K02200	---	Plates
C steel	SA-285	C	K02801	---	Plates
C steel	SA-299	---	K02803	---	Plates
C steel	SA-307	A, B and C	K03002	---	Threaded fasteners
C steel	SA-311	1018, Cl. A	G10180	1018 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1035, Cl. A	G10350	1035 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1045, Cl. A & B	G10450	1045 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1050, Cl. A & B	G10500	1050 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1117, Cl. A	G11170	1117 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1137, Cl. A	G11370	1137 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1141, Cl. A & B	G11410	1141 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1144, Cl. A & B	G11440	1144 steel	Bars, stress-relieved, cold drawn
C steel	SA-311	1541, Cl. A & B	G15410	1541 steel	Bars, stress-relieved, cold drawn
C steel	SA-325	Type 1	K02706	---	Bolting
C steel	SA-333	1	K03008	---	Pipe, seamless and welded
C steel	SA-333	6	K03006	---	Pipe, seamless and welded
C steel	SA-334	1	K03008	---	Tubes, welded
C steel	SA-334	6	K03006	---	Tubes, welded
C steel	SA-350	LF1	K03009	---	Forgings
C steel	SA-350	LF2	K03011	---	Forgings
C steel	SA-352	LCA	J02504	---	Castings
C steel	SA-352	LCB	J03003	---	Castings
C steel	SA-352	LCC	J02505	---	Castings
C steel	SA-354	BC and BD	K04100	---	Bolting
C steel	SA-369	FPA	K02501	---	Pipe, forged/bored
C steel	SA-369	FPB	K03006	---	Pipe, forged/bored
C steel	SA-372	A	K03002	---	Forgings
C steel	SA-372	B	K04001	---	Forgings
C steel	SA-372	C	K04801	---	Forgings
C steel	SA-414	A	K01501	---	Sheet
C steel	SA-414	B	K02201	---	Sheet
C steel	SA-414	C	K02503	---	Sheet
C steel	SA-414	D	K02505	---	Sheet

CARBON STEELS BY NOMINAL COMPOSITION (Continued)					
Nominal Composition	**Specification No.**	**Grade Designation**	**UNS No.**	**Common Name or Trade Name**	**Product Form**
C steel	SA-414	E	K02704	---	Sheet
C steel	SA-414	F	K03102	---	Sheet
C steel	SA-414	G	K03103	---	Sheet
C steel	SA-420	WPL6	K03006	---	Fittings, welded
C steel	SA-449	---	K04200	---	Bolts and studs
C steel	SA-455	---	K03300	---	Plates
C steel	SA-508	1	K13502	---	Forgings
C steel	SA-508	Grade 1A	K13502	---	Forgings
C steel	SA-515	60	K02401	---	Plates
C steel	SA-515	65	K02800	---	Plates
C steel	SA-515	70	K03101	---	Plates
C steel	SA-516	55	K01800	---	Plates
C steel	SA-516	60	K02100	---	Plates
C steel	SA-516	65	K02403	---	Plates
C steel	SA-516	70	K02700	---	Plates
C steel	SA-524	I and II	K02104	---	Pipe, seamless
C steel	SA-537	1, 2 and 3	K12437	---	Plates
C steel	SA-541	1A	---	---	Forgings
C steel	SA-541	1	K03506	---	Forgings
C steel	SA-556	A2	K01807	---	Tubes, seamless
C steel	SA-556	B2	K02707	---	Tubes, seamless
C steel	SA-556	C2	K03006	---	Tubes, seamless
C steel	SA-557	A2	K01807	---	Tubes, welded
C steel	SA-557	B2	K03007	---	Tubes, welded
C steel	SA-557	C2	K03505	---	Tubes, welded
C steel	SA-563	O, A, B, C	K05802	---	Nuts
C steel	SA-563	D	K05801	---	Nuts
C steel	SA-563	DH	K03800	---	Nuts
C steel	SA-587	---	K11500	---	Pipe, welded
C steel	SA-612	---	K02900	---	Plates
C steel	SA-620	---	K00040	---	Sheet, CR for drawing
C steel	SA-649	2	K05001	---	Forged rolls
C steel	SA-649	4	---	---	Forged rolls
C steel	SA-660	WCA	J02504	---	Pipe, centrifugal cast
C steel	SA-660	WCB	J03003	---	Pipe, centrifugal cast

LOW ALLOY STEELS BY NOMINAL COMPOSITION (C - Mo) (Continued)					
Nominal Composition	**Specification No.**	**Grade Designation**	**UNS No.**	**Common Name or Trade Name**	**Product Form**
C - ½ Mo	SA-250	T1a	K12023	---	Tubes, welded
C - ½ Mo	SA-250	T1b	K11422	---	Tubes, welded
C - ½ Mo	SA-335	P1	K11522	---	Pipe, seamless
C - ½ Mo	SA-336	F1	K12520	---	Forgings
C - ½ Mo	SA-352	LC1	J12522	---	Castings
C - ½ Mo	SA-369	FP1	K11522	---	Pipe, forged/bored
C - ½ Mo	SA-426	CP1	J12521	---	Pipe, centrifugal cast
C - ½ Mo	SA-672	L65	K11820	---	Pipe, welded
C - ½ Mo	SA-672	L70	K12020	---	Pipe, welded
C - ½ Mo	SA-672	L75	K12320	---	Pipe, welded
C - ½ Mo	SA-691	CM65	K11820	---	Pipe, welded
C - ½ Mo	SA-691	CM70	K12020	---	Pipe, welded
C - ½ Mo	SA-691	CM75	K12320	---	Pipe, welded
C - ½ Mo - B	SA-517	J	K11625	---	Plates
C - ½ Mo - B	SA-671	CJ109	K11625	---	Pipe, welded
C - ½ Mo - Si	SA-426	CP15	J11522	---	Pipe, centrifugal cast

LOW ALLOY STEELS BY NOMINAL COMPOSITION (½ Cr - 1 ¼ Cr)					
Nominal Composition	**Specification No.**	**Grade Designation**	**UNS No.**	**Common Name or Trade Name**	**Product Form**
½ Cr - ⅕ Mo	SA-372	Grade G	K13049	---	Forgings
½ Cr - ⅕ Mo	SA-372	Grade H	K13547	---	Forgings
½ Cr - ⅕ Mo - V - B	SA-517	B	K11630	---	Plates
½ Cr - ⅕ Mo - V - B	SA-671	CJ102	K11630	---	Pipe, welded
½ Cr - ¼ Mo - Si	SA-517	A	K11856	---	Plates
½ Cr - ¼ Mo - Si	SA-592	A	K11856	---	Fittings
½ Cr - ¼ Mo - Si	SA-671	CJ101	K11856	---	Pipe, welded
½ Cr - ½ Mo	SA-182	F2	K12122	---	Flanges, fittings, etc.
½ Cr - ½ Mo	SA-213	T2	K11547	---	Tubes, seamless
½ Cr - ½ Mo	SA-250	T2	---	---	Tubes, welded
½ Cr - ½ Mo	SA-335	P2	K11547	---	Pipe, seamless
½ Cr - ½ Mo	SA-369	FP2	K11547	---	Pipe, forged/bored
½ Cr - ½ Mo	SA-387	2	K12143	---	Plates
½ Cr - ½ Mo	SA-426	CP2	J11547	---	Pipe, centrifugal cast

Chapter 7

FERROUS SPECIFICATIONS BY COMMON NAME

This Chapter provides yet another cross index–this one is based first on the common name or trade name. In many cases, these designations will correspond with the grade designation within a given specification. The first part of this cross index listing is by material's numerical designations. Within this portion of the cross index, one needs to closely examine the "system" used. Numbers such as "2304" come before 253MA, because the second digit from the left determines its placement within those numerical designations beginning with "2".

The second portion of this cross index for ferrous materials is an alphabetical listing of common or trade names. These cover most of the materials shown later in Table 9, even if they are not yet approved for use in any specific Code construction.

CODE FERROUS ALLOYS BY COMMON NAME OR TRADE NAME					
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Spec. No.**	**Grade Designation**	**UNS No.**
1018 Steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1018, Cl. A	G10180
1035 Steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1035, Cl. A	G10350
1045 Steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1045, Cl. A & B	G10450
1050 Steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1050, Cl. A & B	G10500
1117 steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1117, Cl. A	G11170
1137 steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1137, Cl. A	G11370
1141 steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1141, Cl. A & B	G11410
1144 steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1144, Cl. A & B	G11440
13-8 Mo PH or XM-13	Bars and shapes	13 Cr - 8 Ni - 2 Mo	SA-564	XM-13	S13800
13-8 Mo PH or XM-13	Plate, sheet, strip	13 Cr - 8 Ni - 2 Mo	SA-693	XM-13	S13800
13-8 Mo PH or XM-13	Forgings	13 Cr - 8 Ni - 2 Mo	SA-705	XM-13	S13800
153 MA	Plate, sheet, strip	18 Cr - 9 Ni - N - Ce	SA-240	---	S30415
153 MA	Tubes, welded	18 Cr - 9 Ni - N - Ce	SA-249	---	S30415
153 MA	Pipe, seamless and welded	18 Cr - 9 Ni - N - Ce	SA-312	---	S30415
153 MA	Pipe, welded	18 Cr - 9 Ni - N - Ce	SA-358	---	S30415
1541 steel	Bars, stress-relieved, cold drawn	C steel	SA-311	1541, Cl. A & B	G15410
15-5 PH or XM-12	Bars and shapes	15 Cr - 5 Ni - 3 Cu	SA-564	Type XM-12	S15500
15-5 PH or XM-12	Plate, sheet, strip	15 Cr - 5 Ni - 3 Cu	SA-693	Type XM-12	S15500
15-5 PH or XM-12	Forgings	15 Cr - 5 Ni - 3 Cu	SA-705	Type XM-12	S15500
15-7 Mo PH	Bars and shapes	15 Cr - 7 Ni - 2½ Mo - 1 Al	SA-564	Type 632	S15700
15-7 Mo PH	Plate, sheet, strip	15 Cr - 7 Ni - 2½ Mo - 1 Al	SA-693	Type 632	S15700
15-7 Mo PH	Forgings	15 Cr - 7 Ni - 2½ Mo - 1 Al	SA-705	Type 632	S15700
17-4 PH	Bars and shapes	17 Cr - 4 Ni - 4 Cu	SA-564	Type 630	S17400
17-4 PH	Plate, sheet, strip	17 Cr - 4 Ni - 4 Cu	SA-693	Type 630	S17400
17-4 PH	Forgings	17 Cr - 4 Ni - 4 Cu	SA-705	Type 630	S17400
17-7 PH	Bars and shapes	17 Cr - 7 Ni - 1 Al	SA-564	Type 631	S17700
17-7 PH	Plate, sheet, strip	17 Cr - 7 Ni - 1 Al	SA-693	Type 631	S17700
17-7 PH	Forgings	17 Cr - 7 Ni - 1 Al	SA-705	Type 631	S17700
18-15 LC Si	Forgings	18 Cr - 15 Ni - 4 Si	SA-182	F46	S30600
18-15 LC Si	Tubes, seamless	18 Cr - 15 Ni - 4 Si	(SA-213 CC)	---	S30600
18-15 LC Si	Plate, sheet, strip	18 Cr - 15 Ni - 4 Si	SA-240	---	S30600
18-15 LC Si	Tubes, welded	18 Cr - 15 Ni - 4 Si	(SA-249 CC)	---	S30600
18-15 LC Si	Pipe, seamless and welded	18 Cr - 15 Ni - 4 Si	SA-312	---	S30600
18-15 LC Si	Forgings	18 Cr - 15 Ni - 4 Si	SA-336	F46	S30600
18-15 LC Si	Pipe, welded	18 Cr - 15 Ni - 4 Si	SA-358	---	S30600

CODE FERROUS ALLOYS BY COMMON NAME OR TRADE NAME (Continued)					
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Spec. No.**	**Grade Designation**	**UNS No.**
18-15 LC Si	Bars and shapes	18 Cr - 15 Ni - 4 Si	SA-479	---	S30600
18-17 LC	Forgings	18 Cr - 17 Ni - 5.3 Si	(SA-182 CC)	---	S30601
18-17 LC	Tubes, seamless	18 Cr - 17 Ni - 5.3 Si	(SA-213 CC)	---	S30601
18-17 LC	Plate, sheet, strip	18 Cr - 17 Ni - 5.3 Si	SA-240	---	S30601
18-17 LC	Tubes, welded	18 Cr - 17 Ni - 5.3 Si	(SA-249 CC)	---	S30601
18-17 LC	Tubes, seamless and welded	18 Cr - 17 Ni - 5.3 Si	(SA-268 CC)	---	S30601
18-17 LC	Pipe, seamless and welded	18 Cr - 17 Ni - 5.3 Si	(SA-312 CC)	---	S30601
18-17 LC	Bars and shapes	18 Cr - 17 Ni - 5.3 Si	(SA-479 CC)	---	S30601
18-18-2	Tubes, seamless	18 Cr - 18 Ni - 2 Si	SA-213	TP XM-15	S38100
18-18-2	Plate, sheet, strip	18 Cr - 18 Ni - 2 Si	SA-240	Type XM-15	S38100
18-18-2	Tubes, welded	18 Cr - 18 Ni - 2 Si	SA-249	TPXM-15	S38100
18-18-2	Pipe, seamless and welded	18 Cr - 18 Ni - 2 Si	SA-312	TPXM-15	S38100
18-18-2	Pipe, welded	18 Cr - 18 Ni - 2 Si	SA-813	TPXM-15	S38100
18-18-2	Pipe, welded	18 Cr - 18 Ni - 2 Si	SA-814	TPXM-15	S38100
18-2	Tubes, seamless	18 Cr - 2 Mo	SA-213	18 Cr - 2 Mo	S44400
18-2	Plate, sheet, strip	18 Cr - 2 Mo	SA-240	Type 18 Cr - 2 Mo	S44400
18-2	Tubes, seamless and welded	18 Cr - 2 Mo	SA-268	18 Cr - 2 Mo	S44400
18-2	Bars and shapes	18 Cr - 2 Mo	SA-479	18 Cr - 2 Mo	S44400
18-2	Pipe, seamless and welded	18 Cr - 2 Mo	SA-731	18 Cr - 2 Mo	S44400
18-2	Tubes, welded	18 Cr - 2 Mo	SA-803	18 Cr - 2 Mo	S44400
18-3 Mn	Plate, sheet, strip	18 Cr - 3 Ni - 12 Mn	SA-240	Type XM-29	S24000
18-3 Mn	Tubes, welded	18 Cr - 3 Ni - 12 Mn	SA-249	TPXM-29	S24000
18-3 Mn	Pipe, seamless and welded	18 Cr - 3 Ni - 12 Mn	SA-312	TPXM-29	S24000
18-3 Mn	Pipe, welded	18 Cr - 3 Ni - 12 Mn	SA-358	XM-29	S24000
18-3 Mn	Bars and shapes	18 Cr - 3 Ni - 12 Mn	SA-479	Type XM-29	S24000
18-3 Mn	Tubes, welded	18 Cr - 3 Ni - 12 Mn	SA-688	TPXM-29	S24000
18-3 Mn	Pipe, welded	18 Cr - 3 Ni - 12 Mn	SA-813	TPXM-29	S24000
18-3 Mn	Pipe, welded	18 Cr - 3 Ni - 12 Mn	SA-814	TPXM-29	S24000
19-9DL	Bolting	19 Cr - 9 Ni - Mo - W	SA-453	651	S63198
201 SS	Tubes, seamless	17 Cr - 4 Ni - 6 Mn	SA-213	TP201	S20100
201 SS	Plate, sheet, strip	17 Cr - 4 Ni - 6 Mn	SA-240	Type 201 (-1 and -2)	S20100
201 SS	Tubes, welded	17 Cr - 4 Ni - 6 Mn	SA-249	TP201	S20100
201 SS	Plate, sheet, strip	17 Cr - 4 Ni - 6 Mn	SA-666	Type 201 (-1 and -2)	S20100
201L SS	Plate, sheet, strip	17 Cr - 4 Ni - 7 Mn	SA-240	Type 201L	S20103
201LN SS	Plate, sheet, strip	17 Cr - 4 Ni - 7 Mn - N	SA-240	Type 201LN	S20153

CODE FERROUS ALLOYS BY COMMON NAME OR TRADE NAME (Continued)					
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Spec. No.**	**Grade Designation**	**UNS No.**
202 SS	Tubes, seamless	18 Cr - 5 Ni - 9 Mn	SA-213	TP202	S20200
202 SS	Plate, sheet, strip	18 Cr - 5 Ni - 9 Mn	SA-240	Type 202	S20200
202 SS	Tubes, welded	18 Cr - 5 Ni - 9 Mn	SA-249	TP202	S20200
202 SS	Plate, sheet, strip	18 Cr - 5 Ni - 9 Mn	SA-666	Type 202	S20200
205 SS	Plate, sheet, strip	17 Cr - 1½ Ni - 15 Mn	SA-666	---	S20500
2205	Forgings	22 Cr - 5 Ni - 3 Mo - N	SA-182	F51	S31803
2205	Plate, sheet, strip	22 Cr - 5 Ni - 3 Mo - N	SA-240	S31803	S31803
2205	Bars and shapes	22 Cr - 5 Ni - 3 Mo - N	SA-479	S31803	S31803
2205	Tubes, seamless and welded	22 Cr - 5 Ni - 3 Mo - N	SA-789	S31803	S31803
2205	Pipe, seamless and welded	22 Cr - 5 Ni - 3 Mo - N	SA-790	S31803	S31803
2205	Fittings	22 Cr - 5 Ni - 3 Mo - N	SA-815	S31803	S31803
22V	Forgings	2¼ Cr - 1 Mo - ¼ V	SA-182	F22V	K31835
22V	Forgings	2¼ Cr - 1 Mo - ¼ V	SA-336	F22V	K31835
22V	Forgings	2¼ Cr - 1 Mo - ¼ V	SA-541	22V	K31835
22V	Plates	2¼ Cr - 1 Mo - ¼ V	SA-542	Type D	---
22V	Plates	2¼ Cr - 1 Mo - ¼ V	SA-832	22V	K31835
2304	Plate, sheet, strip	23 Cr - 4 Ni - Mo - Cu	SA-240	S32304	S32304
2304	Tubes, seamless and welded	23 Cr - 4 Ni - Mo - Cu	SA-789	S32304	S32304
2304	Pipe, seamless and welded	23 Cr - 4 Ni - Mo - Cu	SA-790	S32304	S32304
253 MA	Forgings	21 Cr - 11 Ni - N	SA-182	F45	S30815
253 MA	Tubes, seamless	21 Cr - 11 Ni - N	SA-213	S30815	S30815
253 MA	Plate, sheet, strip	21 Cr - 11 Ni - N	SA-240	S30815	S30815
253 MA	Tubes, welded	21 Cr - 11 Ni - N	SA-249	S30815	S30815
253 MA	Pipe, seamless and welded	21 Cr - 11 Ni - N	SA-312	S30815	S30815
253 MA	Pipe, welded	21 Cr - 11 Ni - N	SA-358	S30815	S30815
253 MA	Pipe, welded	21 Cr - 11 Ni - N	SA-409	S30815	S30815
253 MA	Bars and shapes	21 Cr - 11 Ni - N	SA-479	S30815	S30815
253 MA	Pipe, welded	21 Cr - 11 Ni - N	SA-813	S30815	S30815
253 MA	Pipe, welded	21 Cr - 11 Ni - N	SA-814	S30815	S30815
254 SMO	Forgings	20 Cr - 18 Ni - 6 Mo	SA-182	F44	S31254
254 SMO	Bolting	20 Cr - 18 Ni - 6 Mo	SA-193	B8MLCuN/B8MLCuNA	S31254
254 SMO	Nuts	20 Cr - 18 Ni - 6 Mo	SA-194	8MLCuN/8MLCuNA	S31254
254 SMO	Plate, sheet, strip	20 Cr - 18 Ni - 6 Mo	SA-240	S31254	S31254
254 SMO	Tubes, welded	20 Cr - 18 Ni - 6 Mo	SA-249	S31254	S31254
254 SMO	Pipe, seamless and welded	20 Cr - 18 Ni - 6 Mo	SA-312	S31254	S31254

Chapter 8

NONFERROUS SPECIFICATIONS BY COMMON NAME

This Chapter parallels Chapter 7, except covering nonferrous materials. Alloys are first listed numerically when their common name or trade name identifies them in such a manner. Likewise, the second portion of this index is an alphabetical listing of common or trade names associated with nonferrous alloys–with no particular attempt to segregate the various basic types of nonferrous alloys (e.g. Al, Cu, Ni, Ti and Zr).

CODE NONFERROUS ALLOYS BY COMMON NAME OR TRADE NAME				
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Specification No.**	**UNS No.**
20 - Cb 3	Fittings	35 Ni - 35 Fe - 20 Cr - Cb	SB-366	N08020
20 - Cb 3	Forgings	35 Ni - 35 Fe - 20 Cr - Cb	SB-462	N08020
20 - Cb 3	Plate, sheet, strip	35 Ni - 35 Fe - 20 Cr - Cb	SB-463	N08020
20 - Cb 3	Pipe, seamless and welded	35 Ni - 35 Fe - 20 Cr - Cb	SB-464	N08020
20 - Cb 3	Tubes, seamless and welded	35 Ni - 35 Fe - 20 Cr - Cb	SB-468	N08020
20 - Cb 3	Bar and wire	35 Ni - 35 Fe - 20 Cr - Cb	SB-473	N08020
20 - Cb 3	Pipe and tube, seamless	35 Ni - 35 Fe - 20 Cr - Cb	SB-729	N08020
20 - Mo 4	Forgings	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-462	N08024
20 - Mo 4	Plate, sheet, strip	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-463	N08024
20 - Mo 4	Pipe, seamless and welded	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-464	N08024
20 - Mo 4	Tubes, seamless and welded	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-468	N08024
20 - Mo 4	Bar and wire	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-473	N08024
20 - Mo 4	Pipe and tube, seamless	37 Ni - 33 Fe - 24 Cr - 4 Mo	SB-729	N08024
20 - Mo 6	Forgings	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-462	N08026
20 - Mo 6	Plate, sheet, strip	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-463	N08026
20 - Mo 6	Pipe, seamless and welded	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-464	N08026
20 - Mo 6	Tubes, seamless and welded	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-468	N08026
20 - Mo 6	Bar and wire	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-473	N08026
20 - Mo 6	Pipe and tube, seamless	35 Ni - 30 Fe - 24 Cr - 6 Mo - 3 Cu	SB-729	N08026
20 Mod.	Pipe, welded	26 Ni - 43 Fe - 22 Cr - 5 Mo	SB-619	N08320
20 Mod.	Plate, sheet, strip	26 Ni - 43 Fe - 22 Cr - 5 Mo	SB-620	N08320
20 Mod.	Rod	26 Ni - 43 Fe - 22 Cr - 5 Mo	SB-621	N08320
20 Mod.	Pipe and tube, seamless	26 Ni - 43 Fe - 22 Cr - 5 Mo	SB-622	N08320
20 Mod.	Tubes, welded	26 Ni - 43 Fe - 22 Cr - 5 Mo	SB-626	N08320
20 or Beta C	Plate, sheet, strip	Ti - 8 V - 6 Cr - Mo - Zr -Al -Pd	SB-265	R58645
2014	Bars, rod and wire	Al - 4 Cu - Si - Mn	SB-211	A92014
2014	Forgings	Al - 4 Cu - Si - Mn	SB-247	A92014
2024	Bars, rod and wire	Al - 4 Cu - Mg	SB-211	A92024
2024	Bars, rods and shapes	Al - 4 Cu - Mg	SB-221	A92024
204.0	Castings	Al - Cu - Mg	SB-26	A02040
204.0	Castings	Al - Cu - Mg	SB-108	A02040
21	Plate, sheet, strip	Ti - 15 Mo - 3 Al- Cb	SB-265	---
23	Plate, sheet, strip	Ti - 6 Al - 4V	SB-265	---
25-6 Mo	Plate, sheet, strip	28 Ni - 39 Fe - 16 Cr - 4 Cu	SA-240	N08926

CODE NONFERROUS ALLOYS BY COMMON NAME OR TRADE NAME (Continued)				
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Specification No.**	**UNS No.**
25-6 Mo	Forgings	28 Ni - 39 Fe - 16 Cr - 4 Cu	(SB-462 CC)	N08926
25-6 Mo	Plate, sheet, strip	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-625	N08926
25-6 Mo	Bar and wire	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-649	N08926
25-6 Mo	Pipe, welded	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-673	N08926
25-6 Mo	Tubes, welded	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-674	N08926
25-6 Mo	Pipe and tube, seamless	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-677	N08926
25-6 Mo	Pipe, welded	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-804	N08926
25-6 Mo/CR1925N/WP1925N	Fittings	28 Ni - 39 Fe - 16 Cr - 4 Cu	SB-366	N08926
Alloy 33	Fittings, welded	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	SB-366	R20033
Alloy 33	Forgings	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	SB-564	R20033
Alloy 33	Pipe, welded	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	SB-619	R20033
Alloy 33	Pipe and tube, seamless	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	SB-622	R20033
Alloy 33	Plate, sheet, strip	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	(SB-625 CC)	R20033
Alloy 33	Tubes, welded	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	SB-626	R20033
Alloy 33	Bar and wire	33 Cr - 31 Ni - 1.5 Mo - 0.6 Cu - N	(SB-649 CC)	R20033
Alloy 803	Forgings	35 Ni - 27 Cr - Al - Ti	(SA-182 CC)	S35045
Alloy 803	Plate, sheet, strip	35 Ni - 27 Cr - Al - Ti	(SA-240 CC)	S35045
Alloy 803	Tubes, seamless and welded	35 Ni - 27 Cr - Al - Ti	(SA-268 CC)	S35045
Alloy 803	Pipe, seamless and welded	35 Ni - 27 Cr - Al - Ti	(SA-312 CC)	S35045
Alloy 803	Fittings	35 Ni - 27 Cr - Al - Ti	(SA-403 CC)	S35045
Alloy 803	Bars and shapes	35 Ni - 27 Cr - Al - Ti	(SA-479 CC)	S35045
904L, AL4X	Plate, sheet, strip	44 Fe - 25 Ni - 21 Cr - Mo	SB-625	N08904
904L, AL4X	Bar and wire	44 Fe - 25 Ni - 21 Cr - Mo	SB-649	N08904
904L, AL4X	Pipe, welded	44 Fe - 25 Ni - 21 Cr - Mo	SB-673	N08904
904L, AL4X	Tubes, welded	44 Fe - 25 Ni - 21 Cr - Mo	SB-674	N08904
904L, AL4X	Pipe and tube, seamless	44 Fe - 25 Ni - 21 Cr - Mo	SB-677	N08904
925	Pipe and tube, seamless	42 Ni-22 Fe-21 Cr-Mo-Ti-Cu	(SB-423 CC)	N09925
925	Plate, sheet, strip	42 Ni-22 Fe-21 Cr-Mo-Ti-Cu	(SB-424 CC)	N09925
925	Rod and bar	42 Ni-22 Fe-21 Cr-Mo-Ti-Cu	(SB-425 CC)	N09925
925	Forgings	42 Ni-22 Fe-21 Cr-Mo-Ti-Cu	(SB-564 CC)	N09925
Admiralty metal, antimonial	Tubes, seamless	71 Cu - 28 Zn - Sn - Sb	SB-111	C44400
Admiralty metal, antimonial	Plates	71 Cu - 28 Zn - Sn - Sb	SB-171	C44400
Admiralty metal, antimonial	Tubes, seamless with fins	71 Cu - 28 Zn - Sn - Sb	SB-359	C44400
Admiralty metal, antimonial	Tubes, seamless - U	71 Cu - 28 Zn - Sn - Sb	SB-395	C44400

CODE NONFERROUS ALLOYS BY COMMON NAME OR TRADE NAME (Continued)				
Common Name or Trade Name	**Product Form**	**Nominal Composition**	**Specification No.**	**UNS No.**
Admiralty metal, antimonial	Tubes, welded	71 Cu - 28 Zn - Sn - Sb	SB-543	C44400
Admiralty metal, arsenical	Tubes, seamless	71 Cu - 28 Zn - Sn - As	SB-111	C44300
Admiralty metal, arsenical	Plates	71 Cu - 28 Zn - Sn - As	SB-171	C44300
Admiralty metal, arsenical	Tubes, seamless with fins	71 Cu - 28 Zn - Sn - As	SB-359	C44300
Admiralty metal, arsenical	Tubes, seamless - U	71 Cu - 28 Zn - Sn - As	SB-395	C44300
Admiralty metal, arsenical	Tubes, welded	71 Cu - 28 Zn - Sn - As	SB-543	C44300
Admiralty metal, phosphorized	Tubes, seamless	71 Cu - 28 Zn - Sn - P	SB-111	C44500
Admiralty metal, phosphorized	Plates	71 Cu - 28 Zn - Sn - P	SB-171	C44500
Admiralty metal, phosphorized	Tubes, seamless with fins	71 Cu - 28 Zn - Sn - P	SB-359	C44500
Admiralty metal, phosphorized	Tubes, seamless - U	71 Cu - 28 Zn - Sn - P	SB-395	C44500
Admiralty metal, phosphorized	Tubes, welded	71 Cu - 28 Zn - Sn - P	SB-543	C44500
AL-6X	Pipe, welded	46 Fe - 24 Ni - 21 Cr - 6 Mo	SB-675	N08366
AL-6X	Tubes, welded	46 Fe - 24 Ni - 21 Cr - 6 Mo	SB-676	N08366
AL-6X	Plate, sheet, strip	46 Fe - 24 Ni - 21 Cr - 6 Mo	SB-688	N08366
AL-6X	Pipe and tube, seamless	46 Fe - 24 Ni - 21 Cr - 6 Mo	SB-690	N08366
AL-6X	Rod, bar and wire	46 Fe - 24 Ni - 21 Cr - 6 Mo	SB-691	N08366
AL-6XN	Fittings	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-366	N08367
AL-6XN	Forgings	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-462	N08367
AL-6XN	Forgings	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-564	N08367
AL-6XN	Pipe, welded	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-675	N08367
AL-6XN	Tubes, welded	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-676	N08367
AL-6XN	Plate, sheet, strip	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-688	N08367
AL-6XN	Pipe and tube, seamless	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-690	N08367
AL-6XN	Rod, bar and wire	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-691	N08367
AL-6XN	Pipe, welded	46 Fe - 24 Ni - 21 Cr - 6 Mo - Cu - N	SB-804	N08367
Alclad 3003	Sheet and plate	---	SB-209	A83003
Alclad 3003	Tubes, seamless	---	SB-210	A83003
Alclad 3003	Tubes, seamless	---	SB-234	A83003
Alclad 3003	Pipe and tubes, seamless	---	SB-241	A83003
Alclad 3004	Sheet and plate	---	SB-209	A83004
Alclad 6061	Sheet and plate	---	SB-209	A86061
Allcor	Forgings	51 Ni - 31 Cr - 10 Mo - W	SB-564	N06110
Alloy 230	Welding fittings	53 Ni - 22 Cr - 14 W - Co - Fe - Mo	SB-366	N06230
Alloy 230	Sheet and plate	53 Ni - 22 Cr - 14 W - Co - Fe - Mo	SB-435	N06230

Chapter 9

FERROUS MATERIALS SPECIFICATIONS BY CODE SECTION USE

Chapters 9 and 10 are the "heart" of this Materials Index - they form the bases for development of all other cross indexes (e.g., Chapters 5 through 8). Development of Chapters 9 and 10 was decribed in Chapter 2 of this book. Listing all ASME specification materials and materials permitted by Code cases involved going through over 4000 pages in four Code books. Defining which materials are permitted for each type of Code construction then required review of 3500-4000 individual stress lines in Tables 1-4 of Section II, Part D and the two stress tables of Section IV. Next, Table QW-422, spawning over 50 pages in Section IX was reviewed line-by-line to verify proper use of welding P/Group numbers.

This latest version of the Materials Index now addresses those specific materials permitted in Section IV and Section VIII-3 construction. To facilitate this expansion in scope of the tables found in Chapters 9 and 10, two columns had to be eliminated, namely "IX QW-422" and "Notes". The first was considered to be redundant since it was only checked if a P/Group number had already been shown. The "Notes" column was found to be of little use and essential information was transferred to other parts of the Chapter 9/10 tables. When space in the following tables of Chapters 9 and 10 is limited, the following abbreviations may appear to describe "Product Form."

Abbreviation	Product Form	Abbreviation	Product Form
Ba	Bars	Pl Co	Plates for Coating
Bi	Bars and Billets	Ro	Rods
Bo	Bolting	RP	Rolled Products
Ca	Castings	Sa	Shapes
CC	Centrifugal Castings	Sd	Studs
CCP	Centrifugal Cast Pipe	Sh	Sheet
CR	Cold Rolled	SHS	Socket Head Screws
CR Sh Dr	CR Sheet for Drawing	Sm	Seamless
CWP	Cast/Worked Pipe	SP	Seamless Pipe
CWWP	Cold worked welded pipe	St	Structural
Fa	Fasteners	ST	Seamless Tube
FBP	Forged and Bored Pipe	Std	Standard
Fi	Fittings	Std Fa	Standard Fasteners
Fl	Flanges	Stl	Steel
Fo	Forgings	Str	Strip
Fo Cor Ro	Forged Corrugated Rolls	Va	Valves
Gen. Reqs.	General Requirements	W and SP	Welded and Seamless Pipe
Pa	Parts	W Fi	Welded Fittings
PF	Piping Fittings	WP	Welded Pipe
Pl	Plates	WT	Welded Tubes
		Wi	Wire

HEAT TREAT CONDITIONS & OTHER ABBREVIATIONS

Abbreviation	Term
Sol'n (Treated)	Solution (Treated)
ST	Solution Treated
Norm'd	Normalized
Q & T	Quench and Tempered
N & T	Nomalized and Tempered
Cond'n (Heat Treated)	Condition (Heat Treated)
CR	Cold Rolled
HR	Hot Rolled
IS	Intermediate Strength
HS	High Strength
incl.	inclusive

TESTING SPECIFICATIONS	
Spec. No.	**Title**
SA-275	Test Method for Magnetic Particle Examination of Steel Forgings
SA-370	Test Methods and Definitions for Mechanical Testing of Steel Products
SA-388	Practice for Ultrasonic Examination of Heavy Steel Forgings
SA-435	Specification for Straight-Beam Ultrasonic Examination of Steel Plates for Pressure Vessels
SA-450	Specification for General Requirements for Carbon, Ferritic Alloy, Austenitic Alloy Steel Tubes
SA-480	Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
SA-484	Specification for General Requirements for Stainless and Heat-Resisting Steel Bars, Billets, and Forgings
SA-530	Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe
SA-577	Specification for Ultrasonic Angle-Beam Examination of Steel Plates
SA-578	Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications
SA-609	Practice for Castings, Carbon, Low-Alloy, and Martensitic Stainless Steel, Ultrasonic Examination Thereof
SA-703	Specification for Steel Castings, General Requirements, for Pressure-Containing Parts
SA-745	Practice for Ultrasonic Examination of Austenitic Steel Forgings
SA-751	Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
SA-770	Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications
SA-781	Specification for Castings, Steel, and Alloy, Common Requirements for General Industrial Use
SA-788	Specification for Steel Forgings, General Requirements
SA-834	Specification for Common Requirements for Iron Castings for General Industrial Use

SPEC. NO.	GRADE - Gr CLASS - Cl TYPE - Ty	HT CONDI-TION	NOMINAL COMPOSITION DESIGNATION	PRODUCT FORM	SIZE LIMITS, IN.	WELD NO. P	WELD NO. Gr	UNS NO.	COMMON NAME OR TRADE NAME OR REF. SPEC.	STRENGTH LEVEL, ksi UTS	STRENGTH LEVEL, ksi YS	SECTION II, PART D COVERAGE: TABLE 1A I	TABLE 1A III 2/3	TABLE 1A VIII 1	TABLE 1B I	TABLE 1B III 2/3	TABLE 1B VIII 1	TABLE 2A III 1	TABLE 2A VIII 2	TABLE 2B III 1	TABLE 2B VIII 2	TABLE 3 III 2/3	TABLE 3 VIII 1	TABLE 3 VIII 2	TABLE 4 III 1	TABLE 4 VIII 2	SECTION IV TABLES HF 300	SECTION IV TABLES HLW 300	SECTION VIII-3 TABLES KCS-1 KHA-1 KNF-1	CODE CASE COVERAGE NON-NUCL	CODE CASE COVERAGE NUCL
SA-36			C Stl	Strl, Sa, Pl, Ba		1	1	K02600 (Note 1)		58-80	YP=36	√	√	√				√	√								√	√			N71, 249
SA-47	Gr 32510		Malleable iron	Castings				F22200		50	32.5																				
SA-53	Ty S - Gr A		C Stl	Pipe, S & W	NPS ⅛ to	1	1	K02504		48	30	√	√	√				√									√	√		2273	
	Ty S - Gr B		C Stl		NPS 26	1	1	K03005		60	35	√	√	√				√									√	√		2273	
	Ty E - Gr A		C Stl			1	1	K02504		48	30	√	√	√				√									√	√		2273	
	Ty E - Gr B		C Stl			1	1	K03005		60	35	√	√	√				√									√	√		2042, 2273	
	Ty F - Gr A		C Stl			1	1	K02504		48	30	√															√	√		2273	
SA-105			C Stl	Forgings		1	2	K03504		70	36	√	√	√				√	√								√	√		1876	N253
SA-106	Gr A		C Stl	Pipe, smls	NPS ⅛ to	1	1	K02501		48	30	√	√	√				√	√								√	√	√	2273	
	Gr B		C Stl		NPS 48	1	1	K03006		60	35	√	√	√				√	√								√	√	√	1876, 2273	N253
	Gr C		C Stl			1	2	K03501		70	40	√	√	√				√	√								√	√	√	1876, 2273	N253
SA-134 (Note 2)	(A283A)		C Stl	Pipe, wld	≥ NPS 16	1	1			45	24		√																		
	(A283B)		C Stl			1	1			50	27		√																		
	(A283C)		C Stl			1	1	K02401		55	30		√																		
	(A283D)		C Stl			1	1	K02702		60	33		√																		
SA-135	Gr A		C Stl	Pipe, wld	NPS 2 to	1	1			48	30			√													√	√			
	Gr B		C Stl		NPS 30	1	1			60	35			√													√	√			
SA-178	Gr A		C Stl	Tubes, wld	½ to 5, O.D.	1	1	K01200	Low carbon steel	(47)	(26)	√		√													√	√			
	Gr C		C Stl			1	1	K03503	Med. carbon steel	60	37	√	√	√				√	√								√	√			N253
	Gr D		C Stl			1	2		Carbon-manganese steel	70	40	√																			
SA-179	---		C Stl	Tubes, smls	⅛ to 3, O.D.	1	1	K01200	Low carbon steel	(47)	(26)			√																	
SA-181	Cl 60		C Stl	Forgings		1	1	K03502	Old Gr I	60	30	√	√	√				√	√								√	√		1876	N253
	Cl 70		C Stl			1	2	K03502	Old Gr II	70	36	√	√	√				√	√								√			1876	N253
SA-182	Gr F1		C-½ Mo	Forgings		3	2	K12822		70	40	√	√	√				√	√												N253
	Gr F2		½ Cr-½ Mo			3	2	K12122		70	40	√		√					√												
	Gr F3V		3 Cr-1 Mo-¼ V			5C	1	K31830		85-110	60			√					√											1961	

Note 1 - The UNS number may also be K02595-K02599 for plate, as a function of thickness; K02600 covers only shapes.
Note 2 - Steel from which piping is made may also conform to A285, A570 or A36.

SPEC. NO.	GRADE - Gr CLASS - Cl TYPE - Ty	HT CONDI-TION	NOMINAL COMPOSITION DESIGNATION	PRODUCT FORM	SIZE LIMITS, IN.	WELD NO. P	WELD NO. Gr	UNS NO.	COMMON NAME OR TRADE NAME OR REF. SPEC.	STRENGTH LEVEL, ksi UTS	STRENGTH LEVEL, ksi YS	SECTION II, PART D COVERAGE: TABLE 1A I	TABLE 1A III 2/3	TABLE 1A VIII 1	TABLE 1B I	TABLE 1B III 2/3	TABLE 1B VIII 1	TABLE 2A III 1	TABLE 2A VIII 2	TABLE 2B III 1	TABLE 2B VIII 2	TABLE 3 III 2/3	TABLE 3 VIII 1	TABLE 3 VIII 2	TABLE 4 III 1	TABLE 4 VIII 2	SECTION IV TABLES HF 300	SECTION IV TABLES HLW 300	SECTION VIII-3 TABLES KCS-1 KHA-1 KNF-1	CODE CASE COVERAGE NON-NUCL	CODE CASE COVERAGE NUCL
SA-182	Gr F3VCb		3 Cr-1 Mo-¼ V-Cb	Forgings						85-110	60																			
(Con't)	Gr F5		5 Cr-½ Mo	(Con't)		5B	1	K41545		70	40	√	√	√				√	√										2151	
	Gr F5a		5 Cr-½ Mo			5B	1	K42544		90	65	√		√					√											
	Gr F6a, Cl 1		13 Cr			6	1	S41000	(K91151)	70	40		√	√				√												
	Gr F6a, Cl 2		13 Cr			6	3	S41000	(K91151)	85	55		√	√				√	√											
	Gr F6a, Cl 3		13 Cr			(6)	(3)	S41000		110	85																			
	Gr F6a, Cl 4		13 Cr			(6)	(3)	S41000		130	110																			
	Gr F6b		13 Cr -½ Mo			6	3	S41026		110-135	90																			
	Gr F6NM		13 Cr -4½ Ni-Mo			6	4	S41500		115	90		√					√												
	Gr F9		9 Cr-1 Mo			5B	1	K90941		85	55	√		√					√											
	Gr F91		9 Cr-1 Mo-V			5B	2	K90901		85	60	√	√	√				√											1973	N253
	Gr F10		20 Ni-8 Cr			8	2	S33100		80	30																			
	Gr F11, Cl 1		1¼ Cr-½ Mo-Si			4	1	K11597	Old F11b	60	30	√		√					√											
	Gr F11, Cl 2		1¼ Cr-½ Mo-Si			4	1	K11572	Old F11	70	40	√	√	√				√	√										1876	N201
	Gr F11, Cl 3		1¼ Cr-½ Mo-Si			4	1	K11572	Old F11a	75	45																			
	Gr F12, Cl 1		1 Cr-½ Mo			4	1	K11562	Old F12a	60	32	√		√					√										2183	
	Gr F12, Cl 2		1 Cr-½ Mo			4	1	K11564	Old F12	70	40	√	√	√				√	√											N253
	Gr F21		3 Cr-1 Mo			5A	1	K31545		75	45	√	√	√				√	√											
	Gr F22, Cl 1		2¼ Cr-1 Mo			5A	1	K21590	Old F22a	60	30	√	√	√				√												N201
	Gr F22, Cl 3		2¼ Cr-1 Mo			5A	1	K21590	Old F22	75	45	√	√	√				√	√										1876	N253
	Gr F44		20Cr-18Ni-6Mo			8	4	S31254	254 SMO	94	44			√																N439
	Gr F45		21 Cr-11 Ni-N			8	2	S30815	253 MA	87	45			√															2033	
	Gr F46		18 Cr-15 Ni-4 Si			8	1	S30600	18-15 LC Si Old S01815	78	35																		1953	
	Gr F47		19 Cr-15 Ni-4 Mo					S31725	317LM	75	30																			N636
	Gr F48		19 Cr-15½ Ni-4 Mo					S31726	317L4	80	35																			N636
	Gr F50		25 Cr-6 Ni-Mo-N			10H	1	S31200	44LN	100-130	65																			
	Gr F51		22 Cr-5 Ni-3 Mo-N			10H	1	S31803	2205	90	65			√															2067	N635
	Gr F56		27 Cr-32 Ni-Cb					S33228	Nicrofer 3228 NbCe, Alloy AC66	73	27																			
	Gr FR		2 Ni-1 Cu			9A	1	K22035		63	46			√					√											
	Gr FXM-11		21 Cr-6 Ni-9 Mn			8	3	S21904	21-6-9 LC	90	50			√					√											

Chapter 10

NONFERROUS CODE MATERIALS SPECIFICATIONS BY SECTION USE

The first page of Chapter 9 decribes the evolution of this Chapter. When space permits, Product Form will be defined–if abbreviation must be used, the following will be used:

PRODUCT FORM ABBREVIATIONS

Abbreviation	Product Form	Abbreviation	Product Form
Ba	Bars	Sm	Seamless
Ca	Castings	Pipe, S & W	Seamless and Welded Pipe
CC	Centrifugal Castings	Tube, S & W	Seamless and Welded Tubes
Fo	Forgings	SP	Seamless Pipe
Hex(s)	Hexagonal(s) (shape)	Sq(s)	Square(s) (shape)
Pl	Plates	St	Structural
Oct(s)	Octagonal(s) (shape)	ST	Seamless Tube
Rect's	Rectagonals	Str	Strip
Ro	Rods	W Fi	Welded Fittings
Sa	Shapes	WP	Welded Pipe
SFT	Seamless/Finned Tubes	WT	Welded Tubes
Sh	Sheet		

HEAT TREAT CONDITIONS & OTHER ABBREVIATIONS

Abbreviation	Term
Cond'n (Treated)	Condition (Treated)
HT	Heat Treated
SHT	Solution Heat Treated
Stab	Stabilized
PH	Precipitation Hardened
HR	Hot Rolled
HF	Hot Finished
HW	Hot Worked
CD	Cold Drawn
CR	Cold Rolled
CW	Cold Worked
SR	Stress Relieved
WT	Wall Thickness
incl.	inclusive

SPEC. NO.	GRADE - Gr CLASS - Cl TYPE - Ty	HT CONDI-TION	NOMINAL COMPOSITION DESIGNATION	PRODUCT FORM	SIZE LIMITS, IN.	WELD NO. P	WELD NO. Gr	UNS NO.	COMMON NAME OR TRADE NAME OR REF. SPEC.	STRENGTH LEVEL, ksi UTS	STRENGTH LEVEL, ksi YS	SECTION II, PART D COVERAGE TABLE 1A I	TABLE 1A III 2/3	TABLE 1A VIII 1	TABLE 1B I	TABLE 1B III 2/3	TABLE 1B VIII 1	TABLE 2A III 1	TABLE 2A VIII 2	TABLE 2B III 1	TABLE 2B VIII 2	TABLE 3 III 2/3	TABLE 3 VIII 1	TABLE 3 VIII 2	TABLE 4 III 1	TABLE 4 VIII 2	SECTION IV TABLES HF 300	SECTION IV TABLES HLW 300	SECTION VIII-3 TABLES KCS-1 KHA-1 KNF-1	CODE CASE COVERAGE NON-NUCL	CODE CASE COVERAGE NUCL
SB-26	204.0	T4	Al-Cu-Mg	Castings				A02040		45	28						√													
	356.0	T6	Al-Si-Mg			(21)		A03560	Old SG 70A	30	20					√	√													
	356.0	T71	Al-Si-Mg			(21)		A03560	Old SG 70A	25	18					√	√													
	B443.0	F	Al-Si			(21)		A24430	Old S5A	17	6					√	√													
SB-42	C10200	061	99.95 Cu	Pipe, smls		31		C10200	OF Cu	30	9				√	√	√										√			
	C10200	H80	99.95 Cu		⅛ to 2	31		C10200	OF Cu	45	40				√	√	√										√			
	C10200	H55	99.95 Cu		2½ to 12	31		C10200	OF Cu	36	30				√	√	√										√			
	C12000	061	99.90 Cu + P			31		C12000	DLP Cu	30	9				√	√	√										√			
	C12000	H80	99.90 Cu + P		⅛ to 2	31		C12000	DLP Cu	45	40				√	√	√										√			
	C12000	H55	99.90 Cu + P		2½ to 12	31		C12000	DLP Cu	36	30				√	√	√										√			
	C12200	061	99.9 Cu + P			31		C12200	DHP Cu	30	9				√	√	√										√			
	C12200	H80	99.9 Cu + P		⅛ to 2	31		C12200	DHP Cu	45	40				√	√	√										√			
	C12200	H55	99.9 Cu + P		2½ to 12	31		C12200	DHP Cu	36	30				√	√	√										√			
SB-43	C23000	061	85 Cu-15 Zn	Pipe, smls		32		C23000	Red Brass	40	12				√	√	√										√			
	(Case only)	058	85 Cu-15 Zn					C23000	Red Brass	40	12																		2172	
SB-61	C92200	M01	88 Cu-6 Sn-4½ Zn-Pb	Castings		107		C92200	Alloy 2A Valve Bronze	34	16				√	√	√										√			
SB-62	C83600	M01	85 Cu-5 Sn-5 Zn-5 Pb	Castings		107		C83600	Alloy 85 or 85-5-5-5	30	14				√	√	√										√			
SB-75	C10200	050	99.95 Cu	Tubes, smls		31		C10200	OF Cu	30	9																√			
	C10200	060	99.95 Cu			31		C10200	OF Cu	30	9				√	√	√										√			
	C10200	H55	99.95 Cu			31		C10200	OF Cu	36-47	30				√	√	√										√			
	C10200	H58	99.95 Cu					C10200	OF Cu	36	30																			
	C10200	H80	99.95 Cu			31		C10200	OF Cu	45	40				√	√	√										√			
	C12000	050	99.90 Cu + P			31		C12000	DLP Cu	30	9					√											√			
	C12000	060	99.90 Cu + P			31		C12000	DLP Cu	30	9				√	√	√										√			
	C12000	H55	99.90 Cu + P			31		C12000	DLP Cu	36-47	30				√	√	√										√			
	C12000	H58	99.90 Cu + P					C12000	DLP Cu	36	30																			
	C12000	H80	99.90 Cu + P			31		C12000	DLP Cu	45	40				√	√	√										√			
	C12200	050	99.9 Cu + P			31		C12200	DHP Cu	30	9					√	√										√		2289	
	C12200	060	99.9 Cu + P			31		C12200	DHP Cu	30	9				√	√											√			
	C12200	H55	99.9 Cu + P			31		C12200	DHP Cu	36-47	30				√	√	√										√			
	C12200	H58	99.9 Cu + P					C12200	DHP Cu	36	30																			
	C12200	H80	99.9 Cu + P			31		C12200	DHP Cu	45	40				√	√	√										√			

SPEC. NO.	GRADE - Gr CLASS - Cl TYPE - Ty	HT CONDI-TION	NOMINAL COMPOSITION DESIGNATION	PRODUCT FORM	SIZE LIMITS, IN.	WELD NO. P	WELD NO. Gr	UNS NO.	COMMON NAME OR TRADE NAME OR REF. SPEC.	STRENGTH LEVEL, ksi UTS	STRENGTH LEVEL, ksi YS	SECTION II, PART D COVERAGE: TABLE 1A I	TABLE 1A III 2/3	TABLE 1A VIII 1	TABLE 1B I	TABLE 1B III 2/3	TABLE 1B VIII 1	TABLE 2A III 1	TABLE 2A VIII 2	TABLE 2B III 1	TABLE 2B VIII 2	TABLE 3 III 2/3	TABLE 3 VIII 1	TABLE 3 VIII 2	TABLE 4 III 1	TABLE 4 VIII 2	SECTION IV TABLES HF 300	SECTION IV TABLES HLW 300	SECTION VIII-3 TABLES KCS-1 KHA-1 KNF-1	CODE CASE COVERAGE NON-NUCL	CODE CASE COVERAGE NUCL
SB-96	C65500	061	97 Cu-3 Si	Pl, Sh, Str & Ba		33		C65500	Cu-Si Alloy A	50-67	18					√	√				√						√				
SB-98	C65100	060	98.5 Cu-1.5 Si	Ro, Ba & Sa		33		C65100	Cu-Si Alloy B	40	12					√	√					√	√	√			√				
	C65100	H02	98.5 Cu-1.5 Si			33		C65100	Cu-Si Alloy B	55	20					√	√										√				
	C65100	H06	98.5 Cu-1.5 Si		≤ ½	33		C65100	Cu-Si Alloy B	85	55											√	√	√							
	C65100	H06	98.5 Cu-1.5 Si		> ½ to 1, incl.	33		C65100	Cu-Si Alloy B	75	45											√	√	√							
	C65100	H06	98.5 Cu-1.5 Si		> 1 to 1½, incl.	33		C65100	Cu-Si Alloy B	75	40											√	√	√							
	C65500	060	97 Cu-3 Si			33		C65500	Cu-Si Alloy A	52	15					√	√					√	√	√			√				
	C65500	H01	97 Cu-3 Si			33		C65500	Cu-Si Alloy A	55	24											√		√			√				
	C65500	H02	97 Cu-3 Si			33		C65500	Cu-Si Alloy A	70	38					√	√					√		√							
	C66100	060	94 Cu-3 Si-Pb			33		C66100	Cu-Si Alloy D	52	15					√	√					√	√	√							
	C66100	H01	94 Cu-3 Si-Pb			33		C66100	Cu-Si Alloy D	55	24											√		√							
	C66100	H02	94 Cu-3 Si-Pb			33		C66100	Cu-Si Alloy D	70	38					√	√					√		√							
SB-108	204.0	T4	Al-Cu-Mg	Castings				A02040		48	29						√														
	356.0	T6	Al-Si-Mg					A03560	Old SG70A	33	22						√														
	(Case only)	Overaged	Al-Si-Mg					A03570		27	20																			2239	
	(Case only)	Overaged	Al-Si-Mg-Cu					A13560		26	19																			2239	
	(Case only)	T61	Al-Si-Mg					A03560	Old SG70A	37	26																			2153	
SB-111	C10200	H55	99.95 Cu	Tubes, smls		31		C10200	OF Cu	36	30					√	√										√				
	C10200	H80	99.95 Cu			31		C10200	OF Cu	45	40					√	√										√				
	C12000	H55	99.90 Cu			31		C12000	DLP Cu	36	30					√	√										√				
	C12000	H80	99.90 Cu			31		C12000	DLP Cu	45	40					√	√										√				
	C12200	H55	99.9 Cu + P			31		C12200	DHP Cu	36	30					√	√										√				
	C12200	H80	99.9 Cu + P			31		C12200	DHP Cu	45	40					√	√										√				
	C14200	H55	99.40 Cu + As + P			31		C14200	DPA Cu	36	30					√	√														
	C14200	H80	99.40 Cu + As + P			31		C14200	DPA Cu	45	40					√	√														
	C19200	061	98.7 Cu + Fe + P			31		C19200	Phosphorized 1% iron	38	12						√														
	C23000	061	85 Cu-15 Zn			32		C23000	Red brass	40	12					√	√										√				
	C28000	061	60 Cu-40 Zn			32		C28000	Muntz metal	50	20				√	√	√				√										
	C44300	061	71 Cu-28 Zn-Sn-As			32		C44300	Admiralty B or Arsenical	45	15				√	√	√				√										

Chapter 11

ASME SPECIFICATION DESIGNATIONS AND TITLES

ASME FERROUS SPECIFICATION DESIGNATIONS AND TITLES LISTED BY PRODUCT FORM

Steel Pipe	
SA-53	Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
SA-106	Seamless Carbon Steel Pipe for High-Temperature Service
SA-134	Pipe, Steel, Electric-Fusion (Arc)-Welded (Sizes NPS 16 and Over)
SA-135	Electric-Resistance-Welded Steel Pipe
SA-312/SA-312M	Seamless and Welded Austenitic Stainless Steel Pipe
SA-333/SA-333M	Seamless and Welded Steel Pipe for Low-Temperature Service
SA-335/SA-335M	Seamless Ferritic Alloy Steel Pipe for High-Temperature Service
SA-358/SA-358M	Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High Temperature Service
SA-369/SA-369M	Carbon and Ferritic Alloy Steel Forged and Bored Pipe for High-Temperature Service
SA-376/SA-376M	Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service
SA-409/SA-409M	Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service
SA-426	Centrifugally Cast Ferritic Alloy Steel Pipe for High-Temperature Service
SA-430/SA-430M	Austenitic Steel Forged and Bored Pipe for High-Temperature Service
SA-451	Centrifugally Cast Austenitic Steel Pipe for High-Temperature Service
SA-452	Centrifugally Cast Austenitic Steel Cold-Wrought Pipe for High-Temperature Service
SA-524	Seamless Carbon Steel Pipe for Atmospheric and Lower Temperatures
SA-530/SA-530M	General Requirements for Specialized Carbon and Alloy Steel Pipe
SA-587	Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry
SA-660	Centrifugally Cast Carbon Steel Pipe for High-Temperature Service
SA-671	Electric-Fusion-Welded Steel Pipe for Atmospheric and Lower Temperatures
SA-672	Electric-Fusion-Welded Steel Pipe for High-Pressure Service at Moderate Temperatures
SA-691	Carbon and Alloy Steel Pipe, Electric-Fusion-Welded for High-Pressure Service at High Temperatures
SA-727/SA-727M	Forgings, Carbon Steel, for Piping Components with Inherent Notch Toughness
SA-731/SA-731M	Seamless and Welded Ferritic, Martensitic Stainless Steel Pipe
SA-790/SA-790M	Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
SA-813/SA-813M	Single- or Double-Welded Austenitic Stainless Steel Pipe
SA-814/SA-814M	Cold-Worked Welded Austenitic Stainless Steel Pipe

Steel Tubes	
SA-178/SA-178M	Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes
SA-179/SA-179M	Seamless Cold-Drawn Low-Carbon Steel Heat Exchanger and Condenser Tubes
SA-192/SA-192M	Seamless Carbon Steel Boiler Tubes for High-Pressure Service
SA-199/SA-199M	Seamless Cold-Drawn Intermediate Alloy Steel Heat Exchanger and Condenser Tubes
SA-210/SA-210M	Seamless Medium-Carbon Steel Boiler and Superheater Tubes
SA-213/SA-213M	Seamless Ferritic and Austenitic Alloy Steel Boiler, Superheater, and Heat Exchanger Tubes
SA-209/SA-209M	Seamless Carbon-Molybdenum Alloy-Steel Boiler and Superheater Tubes
SA-214/SA-214M	Electric-Resistance-Welded Carbon Steel Heat-Exchanger and Condenser Tubes
SA-226/SA-226M	Electric-Resistance-Welded Carbon Steel Boiler and Superheater Tubes for High Pressure Service
SA-249/SA-249M	Welded Austenitic Steel Boiler, Superheater, Heat Exchanger, and Condenser Tubes
SA-250/SA-250M	Electric-Resistance-Welded Ferritic Alloy Steel Boiler and Superheater Tubes
SA-268/SA-268M	Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service
SA-334/SA-334M	Seamless and Welded Carbon and Alloy Steel Tubes for Low-Temperature Service
SA-423/SA-423M	Seamless and Electric-Welded Low-Alloy Steel Tubes
SA-450/SA-450M	General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
SA-556/SA-556M	Seamless Cold-Drawn Carbon Steel Feedwater Heater Tubes
SA-557/SA-557M	Electric-Resistance-Welded Carbon Steel Feedwater Heater Tubes
SA-688/SA-688M	Welded Austenitic Stainless Steel Feedwater Heater Tubes
SA-789/SA-789M	Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
SA-803/SA803M	Welded Ferritic Stainless Steel Feedwater Heater Tubes
Steel Flanges, Fittings, Valves, and Parts	
SA-105/SA-105M	Forgings, Carbon Steel, for Piping Applications
SA-181/SA-181M	Forgings, Carbon Steel, for General-Purpose Piping
SA-182/SA-182M	Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
SA-216/SA-216M	Steel Castings, Carbon, Suitable for Fusion Welding for High-Temperature Service
SA-217/SA-217M	Steel Castings, Martensitic Stainless and Alloy, for Pressure Containing Parts Suitable for High-Temperature Service
SA-232/SA-232M	Chromium-Vanadium Alloy Steel Valve Spring Quality Wire
SA-234/SA-234M	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
SA-350/SA-350M	Forgings, Carbon and Low-Alloy Steel, Requiring Notch Toughness Testing for Piping Components
SA-351/SA-351M	Castings, Austenitic, Austenitic-Ferritic (Duplex) for Pressure-Containing Parts
SA-352/SA-352M	Steel Castings, Ferritic and Martensitic, for Pressure Containing Parts Suitable for Low-Temperature Service
SA-403/SA-403M	Wrought Austenitic Stainless Steel Piping Fittings
SA-420/SA-420M	Piping Fittings of Wrought Carbon Steel and Alloy Steel for Low-Temperature Service
SA-522/SA-522M	Forged or Rolled 8 and 9% Nickel Alloy Steel Flanges, Fittings, Valves, and Parts for Low-Temperature Service
SA-592/SA-592M	High-Strength Quenched and Tempered Low-Alloy Steel Forged Fittings and Parts for Pressure Vessels
SA-815/SA-815M	Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings
SA-905	Steel Wire, Pressure Vessel Winding

Appendix

1

UNIT CONVERSION TABLES

To Convert From	To	Multiply By	To Convert From	To	Multiply By
Angle			**Mass per unit length**		
degree	rad	1.745 329 E -02	lb/ft	kg/m	1.488 164 E + 00
Area			lb/in.	kg/m	1.785 797 E + 01
$in.^2$	mm^2	6.451 600 E + 02	**Mass per unit time**		
$in.^2$	cm^2	6.451 600 E + 00	lb/h	kg/s	1.259 979 E - 04
$in.^2$	m^2	6.451 600 E - 04	lb/min	kg/s	7.559 873 E - 03
ft^2	m^2	9.290 304 E - 02	lb/s	kg/s	4.535 924 E - 01
Bending moment or torque			**Mass per unit volume (includes density)**		
lbf - in.	N - m	1.129 848 E - 01	g/cm^3	kg/m^3	1.000 000 E + 03
lbf - ft	N - m	1.355 818 E + 00	lb/ft^3	g/cm^3	1.601 846 E - 02
kgf - m	N - m	9.806 650 E + 00	lb/ft^3	kg/m^3	1.601 846 E + 01
ozf - in.	N - m	7.061 552 E - 03	$lb/in.^3$	g/cm^3	2.767 990 E + 01
Bending moment or torque per unit length			$lb/in.^3$	kg/m^3	2.767 990 E + 04
lbf - in./in.	N - m/m	4.448 222 E + 00	**Power**		
lbf - ft/in.	N - m/m	5.337 866 E + 01	Btu/s	kW	1.055 056 E + 00
Corrosion rate			Btu/min	kW	1.758 426 E - 02
mils/yr	mm/yr	2.540 000 E - 02	Btu/h	W	2.928 751 E - 01
mils/yr	μ/yr	2.540 000 E + 01	erg/s	W	1.000 000 E - 07
Current density			ft - lbf/s	W	1.355 818 E + 00
$A/in.^2$	A/cm^2	1.550 003 E - 01	ft - lbf/min	W	2.259 697 E - 02
$A/in.^2$	A/mm^2	1.550 003 E - 03	ft - lbf/h	W	3.766 161 E - 04
A/ft^2	A/m^2	1.076 400 E + 01	hp (550 ft - lbf/s)	kW	7.456 999 E - 01
Electricity and magnetism			hp (electric)	kW	7.460 000 E - 01
gauss	T	1.000 000 E - 04	$W/in.^2$	W/m^2	1.550 003 E + 03
maxwell	μWb	1.000 000 E - 02	**Pressure (fluid)**		
mho	S	1.000 000 E + 00	atm (standard)	Pa	1.013 250 E + 05
Oersted	A/m	7.957 700 E + 01	bar	Pa	1.000 000 E + 05
Ω - cm	Ω - m	1.000 000 E - 02	in. Hg (32 F)	Pa	3.386 380 E + 03
Ω circular - mil/ft	μΩ - m	1.662 426 E - 03	in. Hg (60 F)	Pa	3.376 850 E + 03
Energy (impact other)			$lbf/in.^2$ (psi)	Pa	6.894 757 E + 03
ft - lbf	J	1.355 818 E + 00	torr (mm Hg, 0 C)	Pa	1.333 220 E + 02
Btu (thermochemical)	J	1.054 350 E + 03	**Specific heat**		
cal (thermochemical)	J	4.184 000 E + 00	Btu/lb - F	J/kg - K	4.186 800 E + 03
kW - h	J	3.600 000 E + 06	cal/g - C	J/kg - K	4.186 800 E + 03
W - h	J	3.600 000 E + 03	**Stress (force per unit area)**		
Flow rate			$tonf/in.^2$ (tsi)	MPa	1.378 951 E + 01
ft^3/h	L/min	4.719 475 E - 01	kgf/mm^2	MPa	9.806 650 E + 00
ft^3/min	L/min	2.831 000 E + 01	ksi	MPa	6.894 757 E + 00
gal/h	L/min	6.309 020 E - 02	$lbf/in.^2$ (psi)	MPa	6.894 757 E - 03
gal/min	L/min	3.785 412 E + 00	MN/m^2	MPa	1.000 000 E + 00

Appendix
2

HARDNESS CONVERSION TABLES

APPROXIMATE HARDNESS CONVERSION NUMBERS FOR NONAUSTENITIC STEELS [a,b]								
Rockwell C 150 kgf Diamond HRC	Vickers HV	Brinell 3000 kgf 10mm ball[c] HB	Knoop 500 gf HK	Rockwell A 60 kgf Diamond HRA	Rockwell Superficial Hardness 15 kgf Diamond HR15N	30 kgf Diamond HR30N	45 kgf Diamond HR45N	Approx. Tensile Strength ksi (MPa)
68	940	---	920	85.6	93.2	84.4	75.4	---
67	900	---	895	85.0	92.9	83.6	74.2	---
66	865	---	870	84.5	92.5	82.8	73.3	---
65	832	739[d]	846	83.9	92.2	81.9	72.0	---
64	800	722[d]	822	83.4	91.8	81.1	71.0	---
63	772	706[d]	799	82.8	91.4	80.1	69.9	---
62	746	688[d]	776	82.3	91.1	79.3	68.8	---
61	720	670[d]	754	81.8	90.7	78.4	67.7	---
60	697	654[d]	732	81.2	90.2	77.5	66.6	---
59	674	634[d]	710	80.7	89.8	76.6	65.5	351 (2420)
58	653	615	690	80.1	89.3	75.7	64.3	338 (2330)
57	633	595	670	79.6	88.9	74.8	63.2	325 (2240)
56	613	577	650	79.0	88.3	73.9	62.0	313 (2160)
55	595	560	630	78.5	87.9	73.0	60.9	301 (2070)
54	577	543	612	78.0	87.4	72.0	59.8	292 (2010)
53	560	525	594	77.4	86.9	71.2	58.6	283 (1950)
52	544	512	576	76.8	86.4	70.2	57.4	273 (1880)
51	528	496	558	76.3	85.9	69.4	56.1	264 (1820)
50	513	482	542	75.9	85.5	68.5	55.0	255 (1760)
49	498	468	526	75.2	85.0	67.6	53.8	246 (1700)
48	484	455	510	74.7	84.5	66.7	52.5	238 (1640)
47	471	442	495	74.1	83.9	65.8	51.4	229 (1580)
46	458	432	480	73.6	83.5	64.8	50.3	221 (1520)
45	446	421	466	73.1	83.0	64.0	49.0	215 (1480)
44	434	409	452	72.5	82.5	63.1	47.8	208 (1430)
43	423	400	438	72.0	82.0	62.2	46.7	201 (1390)
42	412	390	426	71.5	81.5	61.3	45.5	194 (1340)
41	402	381	414	70.9	80.9	60.4	44.3	188 (1300)
40	392	371	402	70.4	80.4	59.5	43.1	182 (1250)
39	382	362	391	69.9	79.9	58.6	41.9	177 (1220)
38	372	353	380	69.4	79.4	57.7	40.8	171 (1180)
37	363	344	370	68.9	78.8	56.8	39.6	166 (1140)
36	354	336	360	68.4	78.3	55.9	38.4	161 (1110)
35	345	327	351	67.9	77.7	55.0	37.2	156 (1080)
34	336	319	342	67.4	77.2	54.2	36.1	152 (1050)
33	327	311	334	66.8	76.6	53.3	34.9	149 (1030)
32	318	301	326	66.3	76.1	52.1	33.7	146 (1010)
31	310	294	318	65.8	75.6	51.3	32.5	141 (970)
30	302	286	311	65.3	75.0	50.4	31.3	138 (950)
29	294	279	304	64.6	74.5	49.5	30.1	135 (930)
28	286	271	297	64.3	73.9	48.6	28.9	131 (900)
27	279	264	290	63.8	73.3	47.7	27.8	128 (880)
26	272	258	284	63.3	72.8	46.8	26.7	125 (860)
25	266	253	278	62.8	72.2	45.9	25.5	123 (850)

ABOUT THE AUTHOR

Richard A. Moen earned his Bachelor of Science degree in Metallurgical Engineering in 1962 from South Dakota School of Mines and Technology. He has over 33 years of experience in the development, selection, specification, and characterization of structural materials. These work experiences have spanned the entire spectrum from research and development to plant design, construction, operation, and maintenance. Most of the work was in support of nuclear energy, including light water, gas, and liquid cooled systems. Many of the materials applications required extensions of the bases of knowledge and engineering extrapolations. Some of these applications even required extension of ASME Code rules, which is what led the author to Code committee work.

Beginning in late 1969, Mr. Moen became involved with the ASME Boiler and Pressure Vessel Code in committees associated with design limits for materials used in elevated temperature nuclear construction. Over the years, his ASME Code involvement increased to the extent that he is now a member of the Main Committee, the Subcommittee on Materials, and the Subcommittee on Nuclear Power, Subgroup on Materials, Fabrication and Examination (SCIII), and the Subgroup on Strength of Ferrous Alloys, and the Special Working Group on Environmental Effects.

After 33 years of continuous employment in industry, Mr. Moen is now self-employed as President of Moen Technical Services, providing consultation, support, and training services on a wide range of materials issues. Prior training in business administration and experience in supervision and management, coupled with his organizational skills, provide additional dimensions to the services offered.