Worldwide Guide to Equivalent Nonferrous Metals and Alloys

Second Edition

Worldwide Guide to Equivalent Nonferrous Metals and Alloys

Second Edition

Paul M. Unterweiser
Editor of First Edition
(Deceased)

Harold M. Cobb
Consulting Editor

ASM INTERNATIONAL
Metals Park, Ohio 44073

Library of Congress Catalog Card Number: 87-072576
ISBN: 0-87170-306-8

Printed in the United States of America

ASM INTERNATIONAL
Metals Park, OH 44073
Tel: (216) 338-5151

ACKNOWLEDGEMENTS

The editors of this volume want to extend sincere thanks to the following listed individuals and organizations who generously donated their time and effort to the *Worldwide Guide* revision project.

Australia: D.A. Black, Standards Association of Australia (SAA); Dr. L.E. Samuels. Austria: Ing Alfons F. Donko, Osterreichisches Normungsinstitut (ON). Belgium: P. Rigaux, Institut Belge de Normalisation (IBN). Brazil: Paulo Mauricio Pereira, Associacao Brasileira de Normas Technicas (ABNT). Canada: Dr. John O. Edwards, Dr. Alan Dove. Czechoslovakia: Dr. Ivo Prokop, Urad pro Normalizacia Mereni. Denmark: Lillian Holmgaard, Dansk Standardiseringsraad (DS). Europe: Pascal Gigot, AECMA; E. Previdi, Commission of the European Communities (EURONORM); H. Plissart, European Committee for Iron and Steel Standardization (ECISS). Federal Republic of Germany: A.J. Fischer (DIN); Dr. Emin Arpaci, Deutsches-Institut Kupfer-Institut (DKI); F. Klaus, Normenausschuss Eisen und Stahl im DIN; Dr. Dirk Springorum, Verein Deutscher Eisenhuttenleute. Finland: Susanna Vahtila, Suomen Standardisomisliitto (SFS); Jorma Kemppainen, Ilpo Koppinen, Yrjo Lemmetty, Outokumpu Oy. France: Phillip Bretionniere, AFNOR; Dr. Claude Leymonie, Alsthom. Hungary: S. Vass, Magyar Szabvanyugyi Hivatal (MSZH). India: Dr. Dara P. Antia, The Indian Institute of Metals; K. Raghavendran, Indian Standards Institution (ISI); Dr. L.R. Vaidyanath, Indian Copper Development Center. Netherlands: J.J.A.M. Simons, Library of Eindhoven University of Technology; J.S. Smit, Nederlands Normalisatie-Instituut (NNI). Norway: Odd Solheim, Statens teknologiske instituut (NSF). Pan America: Enrique Garcia, COPANT. Union of South Africa: N. Herbert, South African Bureau of Standards (SABS). Spain: Dr. F. Molleda and Dr. Calvo, Universidad Complutense de Madrid. Sweden: Lennart Ryden, Metallnormcentralen; Ulla-Britt Mittag, Standardiseringskommissionen i Sverige (SIS). United Kingdom: V.S. Wright, IRD Derby. United States: J.A. Overman and staff, Office of Product Standards Policy, National Bureau of Standards (NBS); Jean J. Piety, Science and Technology Dep., Cleveland Public Library; Eleanor M. Baldwin and staff, ASM INTERNATIONAL library. Yugoslavia: Savezni zavodza Standardizeciju (SZS).

PREFACE

Phrases such as spaceship earth, global village, Pacific basin trading partners, real-time networking, and EECM along with detente, emerging third-world country, and IMF all should suggest to individuals involved in the metals industry a fundamental and essential need for a comprehensive international reference volume of nonferrous metals' equivalencies. The first edition of *Worldwide Guide to Equivalent Nonferrous Metals and Alloys,* published seven years ago, provided the technical community with a workhorse reference book for this ongoing effort to correlate a given metal with some similar or identical metal. The nature of contemporary global commerce, however, warrants an updated, expanded, reorganized, and reformatted second edition. This current volume is specifically designed to support the task of identifying, relating, and on the most superficial level, at least, selecting nonferrous material from a variety of national origins.

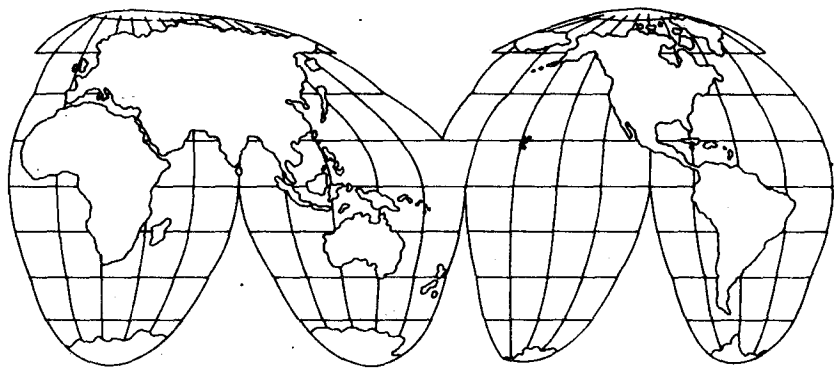
Approximately 28 national standards and standards-issuing organizations are included here. The cited products are initially organized into ten major groupings, as detailed later. The next organizational division is based on an alphabetized listing of countries or, in some instances, standards organizations. Thereafter, individual materials, placed under a given country subdivision, appear in line item fashion, arranged alphanumerically according to the agency-issued designation.

This simplified, three-tier organizational plan gives the reader a quick-access method for locating an individual designation. Moreover, rear-of-book indexes aid with the location of a designation.

The first edition's Introduction ended with a cautionary statement that is no less true now than it was at that earlier time. It was—and still is—that the ultimate selection of a given material rests with the reader. Keep in mind that individual requirements relating to product form, heat treatment or temper, cost, fabrication, and end use may, and often do, vary considerably even when an apparently identical alloy composition is selected. The word equivalency, as used here, suggests similarity, but not necessarily identicality. For reasons of national history, geographical and geological differences, or level of technological advancement, many metals cannot be absolutely equated with any other. In fact some alloys exist uniquely by themselves. The Unified Numbering System, therefore, acts primarily as a guideline for establishing an approximate equivalency.

TABLE OF CONTENTS

Section 1



INTRODUCTION

INTRODUCTION

MetSel/2 Database. The *Worldwide Guide to Equivalent Nonferrous Metals and Alloys* in this second edition, is far more than a simple correction and expansion of the earlier first edition. It is a completely revised, greatly expanded, and fundamentally reorganized reworking of the original data. The means chosen to realize this new volume are of some interest, since they involve a similar ASM INTERNATIONAL computer-based product that may also be of use to users involved with a wide variety of metals applications.

Historically, the original *Worldwide Guide,* in electronic data form, was imported into ASM INTERNATIONAL's MetSel/2 database software package and associated pre-compiled materials data disks. The package is a menu-driven database manager, and the supplemental disks provide the technical information on individual types of nonferrous metals and alloys (and of irons and steels). Together, they support metals-selection, specification, and customized database-building activities. Additionally, users may add their own data records according to their own needs.

MetSel/2, along with subsequent releases, represent an ongoing develop-ment by ASM INTERNATIONAL that is aimed at providing, in electronic format, the most complete and up-to-date metals database possible. Even after its initial releases, the database has continued to be expanded and refined in an ongoing effort by ASM INTERNATIONAL.

The *Worldwide Guide,* in this second edition, is a restructured version of the nonferrous items included in MetSel/2 plus the additions made after the package's release. However, only those items of overall data that are required to establish equivalency have been extracted and listed in the *Worldwide Guide.* (Approximately 85% of the data items appears.) As may be expected, the format of the book is entirely different from the electronic display screens produced by MetSel/2.

It is anticipated that, as the MetSel/2 database evolves, the *Worldwide Guide* will, as a consequence, be expanded and reissued in new editions. While serving different purposes, the two products share a common origin, and their developments will continue in tandem.

Content Structure. The content of the *Worldwide Guide* to *Equivalent Nonferrous Metals and Alloys* is indicated in its title. (A companion volume, *Worldwide Guide to Equivalent Irons and Steels* is also available in its second edition.) This *Nonferrous Metals and Alloys* volume is divided into eleven sections, as follows:

1. Introduction
2. Wrought aluminum
3. Cast aluminum
4. Wrought copper
5. Cast copper
6. Wrought and cast lead
7. Wrought and cast magnesium

8 Wrought and cast nickel

9 Wrought and cast tin

10 Wrought and cast titanium

11 Wrought and cast zinc

These sections serve as the *first level* of organization for the volume. To aid the user with locating a nonferrous material, one of these categories appears on the upper corner of each page within a particular section. (See figure 1.)

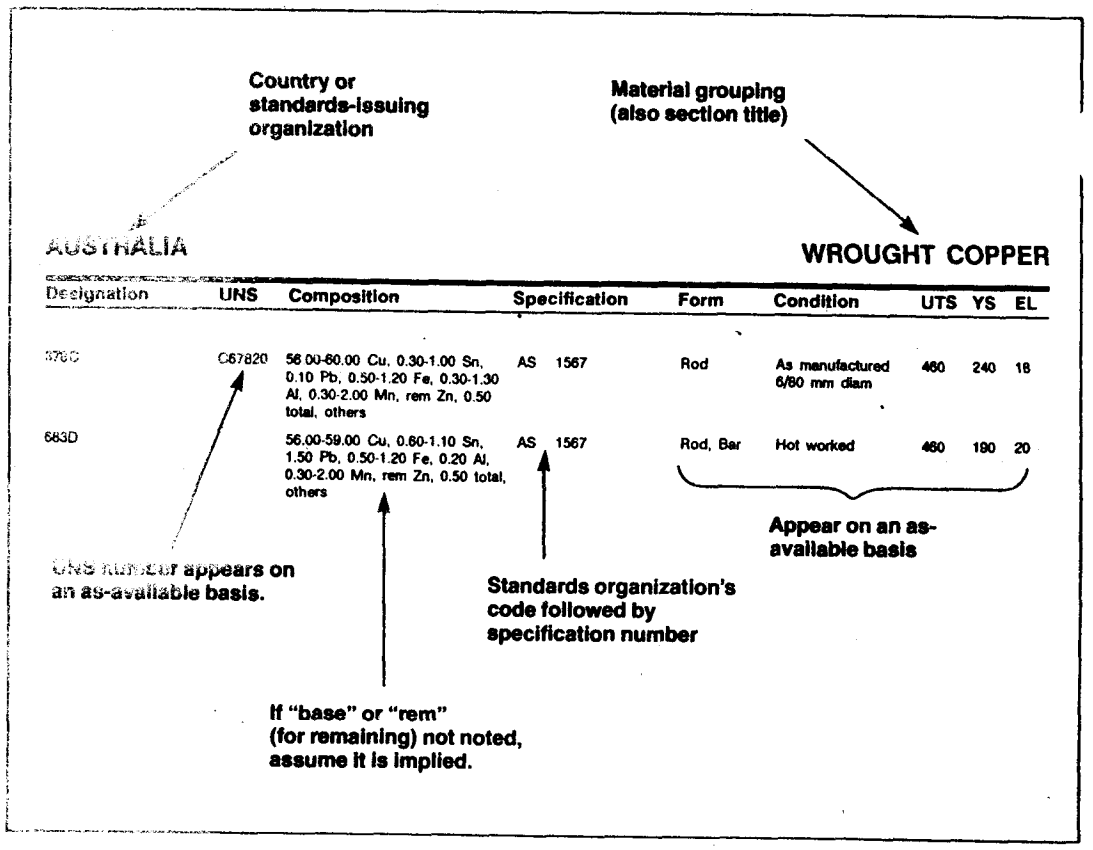


Figure 1 - Typical page format

Pages within a given section are numbered first with the section number and then with a sequentially incrementing number beginning with 1. For example, 1-3, 4-21.

The *second level* of structuring involves either a country name or a standards-issuing organization. This name or organization also appears at the upper corner of each page, opposite the section's title. Within a given category of metal or alloy (which is to say a section) all the included designations originating in a given country are listed *only* under that country's division. (See Figure 1.) For example, all Australian designations for wrought aluminum appear only under Australia.

The *third level* of structuring centers on the designation given by a standards-issuing organization to a specific nonferrous metal or alloy. Designations appear in the leftmost column of each page. They are ordered alphanumerically; all letters are listed before numbers begin.

There may be instances of a country having more than one standards organization: this results in two or more designations for the same materials. In such cases organizations are grouped alphabetically under the Specification column. (See Figure 1.) The similar or identical materials would then be separated according to the organization.

With reference to the Specification column, it plays only a minor role in the structuring of the volume. At the same time it is a particularly important unit of information. Within it, standards organizations are identified in abbreviated form. Also, the particular standard or specification containing a given designation is indicated, usually with alphanumeric groups. (See Figure 1.) In the majority of cases the specifications and designations are completely different. In some instances they are either similar or identical, as explained later in this introduction.

Locating a Metal or Alloy. A specific nonferrous metal or alloy may be located by a user in one of two ways. First, find the section in this volume corresponding to the material in question. Use the table of contents to do this. Next, within a section (or metal category) find the country involved. Lastly, run down the alphanumerically ordered Designation column (the leftmost) until the searched-for metal or alloy is found.

Alternatively, a user can refer to any of the three kinds of indexes. These are arranged numerically by UNS number and alphanumerically by designation and specification.

Difficulties with Designations. The majority of organizations tend to issue specifications, or documents, with some sort of alphanumeric individualizing code. Within a given specification one or more designations appear to identify one or more metals or alloys. Thus the *Worldwide Guide* has both a Specification and a Designation column.

At times, however, this generality does not apply. In some instances the specification also may be the designation, and so the same information will appear in both columns. In other cases the agency may issue only designations, not specification document references. Here, only the agency abbreviation appears under Specification, and the designation is placed in the leftmost column.

Page Format. In addition to the already-discussed Designation and Specification columns, the *Worldwide Guide* page format includes the following elements of information:

- Chemical composition
- Form of product
- Condition
- Mechanical properties
- UNS number

This kind of information supports a user's efforts to determine application and selection factors. Each of these elements is discussed separately in following paragraphs.

Composition. Chemical composition is given in conventional weight percent for each of the chemical elements cited in the specification. Weight percent of each element, either a number or range, precedes the chemical symbol for the element to which it applies. Thus, 2.0-3.0 Si, 0.7-1.3Cu, 0.10 Mn, 0.10 Mg describe the range of weight percentages of the four elements—silicon, copper, manganese, and magnesium—listed in the specification for the alloy described. The alloy is an aluminum alloy, and thus the notation "rem Al" (for remainder aluminum) also appears. The remainder may at times be implied.

Unspecified elements may be referred to in generalized terms such as 0.30 "others, total," or abbreviated as OT. At other times they may be cited specifically.

At times the compositions may be nominal or actual, maximum or minimum. Indication is given at appropriate places to guide the reader.

Form. The Form column lists the product forms in which a given designation, insofar as it is specified, appears. These citations are neither definitive nor exhaustive. A user's sales representative must be consulted in any given case to determine if a cited designation is in fact provided in a specific product form.

Condition. The Condition column contains the metal or alloy's specified condition: as manufactured (that is, not tempered), tempered, solution treated, etc. Again, there is no assurance that these citations are definitive. Users must always consult individual suppliers for the product form's available conditioning.

In some cases the condition may be arrived at by mutual agreement between supplier and purchaser. When done this way, the conditions is described "as agreed."

The values noted next to a given Specification correlate with the stated conditions.

Mechanical Properties. Three of the most significant mechanical properties are noted in the columns at the rightmost side of each page. These are: ultimate tensile strength (UTS), yield strength (YS), and elongation (EL). The first two are cited as MPa; the third is a percent.

It should be noted that specifications which in their published form commonly use English units have all been converted to metric. A rounding process has taken place to arrive at the stated value. Appendix A includes a metric-to-English units conversion table.

Equivalencies and UNS. When possible, SAE/ASTM's Unified Numbering System (UNS) has been applied to the designations appearing in the *Worldwide Guide*. Correlations, however, are not absolute, nor was it always possible to relate a UNS number to each designation. The existing UNS numbers are not inclusive; currently the numbering system totals about 3000 individual designations. Moreover, the UNS system has its roots in the United States, and, so far, has not had widespread influence beyond these national borders.

The function the UNS system performs is nonetheless important since many equivalencies among the designations can be established at a glance.

In cases where a UNS number does not exist for one of two seemingly equivalent designations, or in which a designation has no corresponding UNS number stated, users may refer to the chemical composition column to establish equivalency. Thus similarities may be quickly perceived.

An extended explanation of the UNS Numbering System follows.

UNIFIED NUMBERING SYSTEM

Introduction. In an attempt to create a single, comprehensive system for designating metals and alloys, the Society of Automotive Engineers (SAE) and the American Society of Testing Materials (ASTM), in 1967, began planning an orderly numbering system to replace, or at least to supplement, the vast array of existing standards-issuing organizations' numbering schemes and manufacturers' trade names then—and even now—in existence. A group of trade associations, government agencies, and independent companies participated in these early feasibility studies.

In 1974 the *SAE and ASTM Recommended Practice* document for the numbering of metals and alloys was issued. Subsequently, the establishment of specific designations for over 1000 steel, stainless steel, superalloys, aluminum, etc. were issued. These early designations were compiled and first published as *Metals and Alloys in the Unified Numbering System.* As of the publication date noted at the beginning of this edition of the *Worldwide Guide,* the *UNS Handbook,* as it is frequently called in conversation, is in its fourth edition (1986) and contains more than 3000 entries. Future editions are anticipated.

The format of the *UNS Handbook* contains cross-references to other standards, specifications, and trade designations, when available. However, these cross-references are representative only, and are in no way a complete, exhaustive listing for any given UNS designation. Furthermore, the cited chemical compositions are for identification purposes *only;* they should not be used in preference to the compositions appearing in the cross-referenced specifications.

UNS Numbering of Metals and Alloys. The *SAE and ASTM Recommended Practice* (SAE publication J1086 and/or ASTM E527) is a document that describes the UNS method of the numbering of metals and alloys which have commercial standing or are in production usage. It also describes how a company can apply for a UNS number. Among the many explanations and descriptions in the document, the following main ideas are the most important.

First, the UNS system is designed to aid a user only to correlate a wide variety of numbering systems. Although there is an assumption that confusion may be avoided by means of a single identifying number relating to an individual material, the UNS scheme cannot at this time be seen as a universal conversion tool. (Given time, the system will be applicable on an exceptionally widespread basis.)

Second, it must be kept in mind that the UNS designation is not, in and of itself, a specification, since it establishes no requirements regarding form, condition, or quality. Rather, it aims at a unified identification of metals and alloys "for which controlling limits have been established in specifications elsewhere," as the document phrases it.

System Description. The UNS system establishes a series of 18 number groupings for all metals and alloy types. (See Table 1.) The basic designation scheme uses a single alphabetical prefix followed by a 5-digit group. When possible, there is a conscious similarity between a newly assigned UNS number and an existing designation. For example: a carbon steel identified as CDA C52400 is designated by UNS as C52400. At times, of course, the similarity extends to only a few digits.

A more detailed breakdown of the numbering system in relation to specific metals and alloys is given in Table 2.

UNS Equivalencies. Insofar as possible the Unified Numbering System has been used throughout the *Worldwide Guide* in order to establish equivalency among the thousands of individual material designations contained in it. It is obvious that not all of the cited designations as yet have UNS equivalents. This situation flows directly from the basically United States perspective of the system, together with the currently limited quantity of assigned UNS numbers. It may be expected that, as time passes, more companies will formally apply for a UNS number related to each of its metal products. Similarly, it may be assumed that the traditional standards-issuing organizations will provide additional cross-referencing information, if not outright adoptions of the UNS scheme.

Perhaps of equal importance are the simple facts that non-United States producers of metals and alloys have differing alloying philosophies, distinct alloying needs, and, perhaps, limited amounts and kinds of native raw materials. Thus thousands of designations considered in this country as foreign simply may have no existing UNS equivalent.

A knowledge of a lack of equivalency, however, has value since it may suggest the singularity of the specified product. Additionally, the compositional listings in the *Worldwide Guide* for almost all designations are invaluable for establishing a "likeness," which may support an approximate selection, assuming a noncritical application.

Table 1. General UNS Scheme

Type (number group)	Description
	Nonferrous metals and alloys
A00001-A99999	Aluminum and aluminum alloys
C00001-C99999	Copper and copper alloys
E00001-E99999	Rare earth and rare earth-like metals alloys (18 items; see Table 2)
L00001-L99999	Low melting metals and alloys (14 items; see Table 2)
M00001-M99999	Miscellaneous nonferrous metals and alloys (12 items; see Table 2)
N00001-N99999	Nickel and nickel alloys
P00001-P99999	Precious metals and alloys (8 items; see Table B)
R00001-R99999	Reactive and refractory metals and alloys (14 items; see Table 2)
Z00001-Z99999	Zinc and zinc alloys
	Ferrous metals and alloys
D00001-D99999	Specified mechanical properties steels
F00001-F99999	Cast irons
G00001-G99999	AISI and SAE carbon and alloy steels (except tool steels)
H00001-H99999	AISI H-steels
J00001-J99999	Cast steels (except tool steels)
K00001-K99999	Miscellaneous steels and ferrous alloys
S00001-S99999	Heat- and corrosion-resistant (stainless) steels
T00001-T99999	Tool steels
	Welding filler metals
W00001-W99999	Welding filler metals, covered and tubular electrodes, classified by weld and deposit composition (see Table 2)

From SAE/ASTM

Table 2. Detailed UNS Scheme

Type/number group	Metal
Rare earth and rare earth-like metals and alloys	
E00000-E00999	Actinium
E01000-E20999	Cerium
E21000-E45999	Mixed rare earths
E46000-E47999	Dysposium
E48000-E49999	Erbium
E50000-E51999	Europium
E52000-E55999	Gaddinium
E56000-E57999	Holmium
E58000-E67999	Lanthanum
E68000-E68999	Lutetium
E69000-E73999	Neodymium
E74000-E77999	Praseodymium
E78000-E78999	Promethium
E79000-E82999	Samarium
E83000-E84999	Scandium
E85000-E86999	Terbium
E87000-E87999	Thulium
E88000-E89999	Ytterbium
E90000-E99999	Yttrium
Cast irons	
F00001-F99999	Gray, malleable, pearlitic malleable, and ductile (nodular) cast irons
Miscellaneous steels and ferrous alloys	
K00001-K99999	Miscellaneous
Low-melting metals and alloys	
L00001-L00999	Bismuth
L01001-L01999	Cadmium
L02001-L02999	Cesium
L03001-L03999	Gallium
L04001-L04999	Indium
L50000-L59999	Lead
L06001-L06999	Lithium
L07001-L07999	Mercury
L08001-L08999	Potassium
L09001-L09999	Rubidium
L10001-L10999	Selenium
L11001-L11999	Sodium
L12001-L12999	Thallium
L13001-L13999	Tin

Miscellaneous nonferrous metals and alloys

M00001-M00999	Antimony
M01001-M01999	Arsenic
M02001-M02999	Barium
M03001-M03999	Calcium
M04001-M04999	Germanium
M05001-M05999	Plutonium
M06001-M06999	Strontium
M07001-M07999	Tellurium
M08001-M08999	Uranium
M10001-M19999	Magnesium
M20001-M29999	Manganese
M30001-M39999	Silicon

Precious metals and alloys

P00001-P00999	Gold
P01001-P01999	Iridium
P02001-P02999	Osmium
P03001-P03999	Palladium
P04001-P04999	Platinum
P05001-P05999	Rhodium
P06001-P06999	Ruthenium
P07001-P07999	Silver

Reactive and refractory metals and alloys

R01001-R01999	Boron
R02001-R02999	Hafnium
R03001-R03999	Molybdenum
R04001-R04999	Niobium (Columbium)
R05001-R05999	Tantalum
R06001-R06999	Thorium
R07001-R07999	Tungsten
R08001-R08999	Vanadium
R10001-R19999	Beryllium
R20001-R29999	Chromium
R30001-R39999	Cobalt
R40001-R49999	Rhenium
R50001-R59999	Titanium
R60001-R69999	Zirconium

Welding filler metals
(Classified by weld deposit composition.)

W00001-W09999	Carbon steel with no significant alloying elements
W10000-W19999	Manganese-molybdenum low alloy steels
W20000-W29999	Nickel low alloy steels
W30000-W39999	Austenitic stainless steels
W40000-W49999	Ferritic stainless steels
W50000-W59999	Chromium low alloy steels