Materials Handbook

François Cardarelli

Materials Handbook

A Concise Desktop Reference

3rd Edition

Springer

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Dedication for the First Edition

The *Materials Handbook: A Concise Desktop Reference* is dedicated to my father, Antonio, and my mother, Claudine, to my sister, Elsa, and to my spouse Louise St Amour for their love and support. I want also to express my thanks to my two parents and my uncle Consalvo Cardarelli, which in close collaboration have provided valuable financial support when I was a teenager to contribute to my first fully equipped geological and chemical laboratory and to my personal comprehensive scientific library. This was the starting point of my strong and extensive interest in both science and technology, and excessive consumption of scientific and technical literature.

Dedication for the Third Edition

Materials Handbook: A Concise Desktop Reference is dedicated to my father, Antonio, and my mother, Claudine, to my sister, Elsa, to my two nieces, Chiara Lucia and Venezia Elena, and to my great friend Louise St-Amour for their love and support.

François Cardarelli

Introduction

Despite the wide availability of several comprehensive series in materials sciences and metallurgy, it is difficult to find grouped properties on metals and alloys, traditional and advanced ceramics, refractories, polymers and elastomers, composites, minerals and rocks, soils, woods, cement, and building materials in a single-volume source book.

The purpose of this practical and concise reference book is to provide materials scientists, metallurgists, engineers, chemists, and physicists as well as academic staff, technicians, and students working in a broad range of scientific and technical fields with key scientific and technical material properties and data.

The classes of materials described in this new edition of *Materials Handbook* are:

1. Metals and their alloys
2. Ferroalloys
3. Semiconductors
4. Superconductors
5. Magnetic materials
6. Dielectrics and insulators
7. Miscellaneous electrical materials (e.g., resistors, thermocouples, and industrial electrode materials)
8. Ceramics, refractories, and glasses
9. Polymers and elastomers
10. Minerals, ores, and gemstones
11. Rocks and meteorites
12. Soils and fertilizers
13. Timbers and woods
14. Cement and concrete
15. Building materials
16. Fuels, propellants, and explosives
17. Nuclear materials
18. Composites
19. Gases
20. Liquids
21. Food materials, resins, and oils

Particular emphasis is placed on the properties of the most common industrial materials in each class. The physical and chemical properties usually listed for each material are as follows:

1. Physical (e.g., density, viscosity, surface tension)
2. Mechanical (e.g., elastic moduli, Poisson ratio, yield and tensile strength, hardness, fracture toughness)
3. Thermal (e.g., melting point and boiling point, thermal conductivity, specific heat capacity, coefficients of thermal expansion, spectral emissivities)
4. Electrical (e.g., resistivity, relative permittivity, loss tangent factor)

5. Magnetic (e.g., magnetization, permeability, retentivity, coercivity, Hall constant)
6. Optical (e.g., refractive indices, reflective index, dispersion, transmittance)
7. Electrochemical (e.g., Nernst standard electrode potential, Tafel slopes, specific capacity, overpotential)
8. Miscellaneous (e.g., relative abundances, electron work function, thermal neutron cross section, Richardson constant, activity, corrosion rate, flammability limits)

This third edition also includes a new chapter dedicated entirely to occupational health and safety issues of materials.

Finally, detailed appendices provide additional information (e.g., properties of the chemical elements, figures for identification of metal cations, thermochemical data, crystal field theory, crystallographic calculations, corrosion resistance toward molten salts and liquid metals, high-temperature oxidation resistance tables, radioactivity calculations, and prices of metals, industrial minerals, and commodities), and an extensive bibliography completes this comprehensive guide. The comprehensive index and handy format of the book enable the reader to locate and extract relevant information quickly and easily. Figures and tables are all referenced, and tabs are used to denote the different sections of the book. It must be emphasized that the information presented here is taken from several scientific and technical sources and has been meticulously checked, and every care has been taken to select the most reliable data.

Author Biography

Dr. François Cardarelli

Born in Paris (France), February 17, 1966 Canadian and French citizen

Academic Background

- Ph.D., chemical engineering (Université Paul Sabatier, Toulouse, France, 1996)
- Postgraduate degree (*diplôme d'études approfondies*) in electrochemistry (Université Pierre et Marie Curie, Paris, 1992)
- M.Sc. (*maîtrise*), physical chemistry (Université Pierre et Marie Curie, Paris, France, 1991)
- B.Sc. (*licence*), physical chemistry (Université Pierre et Marie Curie, Paris, France, 1990)
- *Diplôme d'études supérieures techniques* credits in nuclear sciences and technologies (Conservatoire National des Arts et Métiers, Paris, France, 1988)
- Associate degree (*diplôme d'études universitaires générales* B) in geophysics and geology (Université Pierre et Marie Curie, Paris, France, 1987)
- Baccalaureate C (mathematics, physics, and chemistry) (CNED, Versailles, France, 1985)

Fields of Professional Activity

The author has worked in the following areas (in chronological order) since 1990:

1. Research scientist in the Laboratory of Electrochemistry (Université Pierre et Marie Curie, Paris, France) for the development of a nuclear detector device for electrochemical experiments involving radiolabeled compounds
2. Research scientist at the Institute of Marine Biogeochemistry (CNRS and École Normale Supérieure, Paris, France) for the environmental monitoring of heavy-metal pollution by electroanalytical techniques
3. Research scientist for the preparation by electrochemistry in molten salts of tantalum protective thin coatings for the chemical-process industries (sponsored by Electricité de France)
4. Research scientist for the preparation and characterization of iridium-based industrial electrodes for oxygen evolution in acidic media in the Laboratory of Electrochemical Engineering (Université Paul Sabatier, Toulouse, France)
5. Registered consultant in chemical and electrochemical engineering (Toulouse, France)
6. Battery product leader in the technology department of ARGOTECH Productions, Boucherville (Quebec), Canada, in charge of electric-vehicle, stationary, and oil-drilling applications of lithium polymer batteries
7. Materials expert and industrial electrochemist in the lithium department of ARGOTECH Productions, involved in both the metallurgy and processing of lithium metal anodes and the recycling of spent lithium polymer batteries

8. Materials expert and industrial electrochemist in the technology department of AVESTOR, Boucherville (Quebec), Canada, in charge of all strategic raw materials used the fabrication of lithium polymer batteries and in charge of the recycling process for spent lithium batteries
9. Principal chemist (materials) in the technology department of Rio Tinto Iron and Titanium, Sorel–Tracy (Quebec), Canada, working on the electrowinning of titanium metal from titania-rich slags and on other novel electrochemical processes
10. Principal electrochemist at Materials and Electrochemical Research, Tuscon (Arizona, USA), working on the electrowinning of titanium metal powder from composite anodes and other materials-related projects
11. Recycling Manager, 5N Plus, Ville Saint-Laurent (Quebec), Canada, in charge of the recycling of end-of-life thin-film photovoltaic solar panels and the hydrometallurgical recovery of tellurium and cadmium values.
12. Since 2010, President and owner of the company Electrochem Technologies & Materials Inc., based in Montreal (Quebec), Canada, manufacturing mixed metal oxide industrial electrodes and producing tantalum, niobium, tungsten and rare earth fine chemicals and inventing, developing, and commercializing novel electrochemical and chemical technologies for electrowinning iron and iron-rich alloys and recovering sulfuric acid from industrial wastes and effluents containing ferrous sulfate, for the pyrometallurgical and hydrometallurgical production of tantalum and niobium oxides from ores and concentrates, and for the recycling of rare earth oxides from spent fluorescent lamps.

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Dr. Stuart Evans copy editor who performed a thorough reading of the manuscript bringing legitimate comments.

Units Policy

In this book the only units of measure used for describing physical quantities and properties of materials are those recommended by the *Système International d'Unités* (SI). For accurate conversion factors between these units and non-SI units (e.g., cgs, fps, imperial, and US customary), please refer to the reference book by the same author:

Cardarelli, F. (2005) *Encyclopaedia of Scientific Units, Weights, and Measures. Their SI Equivalences and Origins*. Springer, London. ISBN 978-1-85233-682-1.

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