

# **2006 ASHRAE® HANDBOOK**

# **REFRIGERATION**

**Inch-Pound Edition**

**American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.**

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**DEDICATED TO THE ADVANCEMENT OF  
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TG1.EASB Exergy Analysis for Sustainable Buildings

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TG2.UVAS Ultraviolet Air and Surface Treatment

TRG Blast, Chemical and Biological Remediation

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## ASHRAE Research: Improving the Quality of Life

The American Society of Heating, Refrigerating and Air-Conditioning Engineers is the world's foremost technical society in the fields of heating, ventilation, air conditioning, and refrigeration. Its members worldwide are individuals who share ideas, identify needs, support research, and write the industry's standards for testing and practice. The result is that engineers are better able to keep indoor environments safe and productive while protecting and preserving the outdoors for generations to come.

One of the ways that ASHRAE supports its members' and industry's need for information is through ASHRAE Research. Thousands of individuals and companies support ASHRAE Research

annually, enabling ASHRAE to report new data about material properties and building physics and to promote the application of innovative technologies.

Chapters in the ASHRAE Handbook are updated through the experience of members of ASHRAE Technical Committees and through results of ASHRAE Research reported at ASHRAE meetings and published in ASHRAE special publications and in *ASHRAE Transactions*.

For information about ASHRAE Research or to become a member, contact ASHRAE, 1791 Tullie Circle, Atlanta, GA 30329; telephone: 404-636-8400; [www.ashrae.org](http://www.ashrae.org).

### Preface

The 2006 *ASHRAE Handbook—Refrigeration* covers the refrigeration equipment and systems for applications other than human comfort. This book includes information on cooling, freezing, and storing food; industrial applications of refrigeration; and low-temperature refrigeration. Primarily a reference for the practicing engineer, this volume is also useful for anyone involved in cooling and storage of food products.

This edition includes a new chapter (8), Refrigerant Containment, Recovery, Recycling, and Reclamation, reflecting this topic's importance. An accompanying CD-ROM contains all the volume's chapters (in both I-P and SI units) in searchable electronic format.

Some of the other revisions and additions are as follows:

- Chapter 2, System Practices for Halocarbon Refrigerants, has added information on safety considerations in using copper tubing for refrigerant lines.
- Chapter 3, System Practices for Ammonia and Carbon Dioxide Refrigerants, has a new title to reflect the addition of a new section on carbon dioxide as a refrigerant.
- Chapter 5, Refrigerant System Chemistry, has been reorganized and contains updated information on environmental acceptability.
- Chapter 7, Lubricants in Refrigerant Systems, has been thoroughly updated, with several new figures on various refrigerant/lubricant combinations, plus new information on considerations for carbon dioxide and CFC conversions.
- Chapter 9, Thermal Properties of Foods, contains updated surface heat transfer coefficients for food products.
- Chapter 10, Cooling and Freezing Times of Foods, has been extensively updated, with new geometric shape factors, and a new section comparing freezing time estimating methods.
- Chapter 11, Commodity Storage Requirements, has updated requirements for vegetables, fresh fruits, and melons.
- Chapter 13, Refrigeration Load, has new material on heat gain from cooler floors and coil defrosting.
- Chapter 14, Refrigerated Facility Design, has new discussion of design considerations for interstitial spaces.
- Chapter 15, Methods of Precooling Fruits, Vegetables, and Cut Flowers, contains new information on product requirements, loads, and time estimation methods, with new figures and tables on cooling methods.
- Chapter 16, Industrial Food-Freezing Systems, updated throughout, has added discussion of dehydration losses.
- Chapter 18, Poultry Products, has been updated, particularly on freezing effects on product quality, and control of texture and tenderness.
- Chapter 22, Deciduous Tree and Vine Fruit, contains new information on controlled-atmosphere storage and transport of some fruits.

- Chapter 27, Processed, Precooked, and Prepared Foods, has a revised section on potato products, and updates for regulatory changes.
- Chapter 38, Cryogenics, now includes low-temperature and integrated thermal and transport properties of cryogenics and cryogenic materials; revised text on using refrigerant mixtures in cryocoolers, including discussion of the Kleemenko cycle; and updates on pulse tube cryocoolers.
- Chapter 44, Refrigerant-Control Devices, has updates on float switches, condenser-pressure-regulating valves, and pressure-relief devices, and a new section on liquid level sensors.
- Chapter 45, Factory Dehydrating, Charging, and Testing, has a substantially revised section on testing with refrigerant.
- Chapter 46, Retail Food Store Refrigeration and Equipment, has been reorganized for clarity, and has new discussions on self-contained versus remote systems, energy efficiency opportunities, refrigerated storage rooms, and interaction with supermarket air-conditioning systems.
- Chapter 47, Food Service and General Commercial Refrigeration Equipment, largely revised, has an expanded section on refrigerated cabinets, and added discussion on refrigeration systems, vending machines, ice machines, preparation tables, and energy efficiency opportunities.
- Chapter 48, Household Refrigerators and Freezers, has been substantially updated and reorganized, including adding a new table showing energy consumption testing standards from around the world.

This volume is published, both as a bound print volume and in electronic format on a CD-ROM, in two editions: one using inch-pound (I-P) units of measurement, the other using the International System of Units (SI).

Corrections to the 2003, 2004, and 2005 Handbook volumes can be found on the ASHRAE Web site at <http://www.ashrae.org> and in the Additions and Corrections section of this volume. Corrections for this volume will be listed in subsequent volumes and on the ASHRAE Web site.

Reader comments are enthusiastically invited. To suggest improvements for a chapter, **please comment using the form on the ASHRAE Web site** or, using the cutout comment pages at the end of this volume's index, write to Handbook Editor, ASHRAE, 1791 Tullie Circle, Atlanta, GA 30329, or fax 678-539-2187, or e-mail [mowen@ashrae.org](mailto:mowen@ashrae.org).

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