ORNL/TM-2000/272

Oak Ridge National Laboratory Document Preparation Guide

January 2001

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ORNL/TM-2000/272

Computing, Information, and Networking Division

OAK RIDGE NATIONAL LABORATORY DOCUMENT PREPARATION GUIDE

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1. DOCUMENT FORMAT

The following guidance describes a default format for Oak Ridge National Laboratory (ORNL) technical reports. The results published in these reports represent much of the return that the U.S. taxpayers receive on their investment in ORNL. The purpose of providing this guidance is to encourage the publication of a uniform product that will be available and understandable for years to come.

Given the temper of the times, however, this guidance should be regarded as flexible. Type style and page layout can vary from one document to another for a number of reasons. For example, the authors of nonce publications, such as those used for publicity or marketing rather than as a record of research, will no doubt hasten to depart from this format. Also, each professional journal has its own house style, which may or may not agree with the guidance in this document. In addition, the World Wide Web is developing its own aesthetic, which may be described as situational rather than formal and which may or may not be well served by the conventions that have evolved for paper documents. The one guiding principle that should not be forgotten is that consistency is the key to producing an effective publication, whatever the medium.

1.1 COVERS

The following information, which should be taken verbatim from the title page, should appear on the cover of an ORNL report:

- the report number;
- the report title; and
- the names of the authors, compilers, or editors.

A document availability notice and a U.S. government disclaimer are printed on the inside front covers of external, unclassified ORNL reports. (See Exhibit 1.)

Typically, both sides of the back cover are left blank.

Covers for all ORNL reports are to be reproduced on preprinted UT-Battelle, LLC, cover stock by an approved reproduction facility (as designated by U.S. Government Printing Office). If loose-leaf binders are used, they should be the cover-insert type so that standard ORNL report covers can be inserted into them. A template for cover text is available from ORNL Creative Media Solutions.

Because hard-copy covers are reproduced on preprinted stock, a separate cover is needed for the portable-document-format (pdf) version required for registration in the ORNL Comprehensive Publications and Presentations Registry (CPPR). A pdf version of a blank ORNL report cover, as well as the notices belonging on the inside front cover, can be found at the following universal resource locator (URL):

http://www-internal.ornl.gov/~webworks/ORNL/ORNL-27.pdf.

1.1.1 Special Notices and Disclaimers

Special notices and disclaimers are sometimes required on the covers of ORNL reports. If that is the case, then the same information should appear on the title page. Refer any questions about the proper use of notices and disclaimers to the ORNL technical information officer. (Contact David Hamrin: H26@ornl.gov; 574-6752.)

1.1.1.1 Unclassified Internal Report

All unclassified internal reports and drafts meant for internal review and revision must bear the following notice on the cover. The notice, which may be expanded to include additional information, should be aligned below names of the authors.

CAUTION

This document has not been given final patent clearance and is for internal use only. If this document is to be given public release, it must be registered through the site Technical Information Office, which will see that the proper patent and technical information reviews are completed in accordance with UT-Battelle policy.

1.1.1.2 Applied Technology Report

The term "Applied Technology" is specific to the field of nuclear energy and has limited use at ORNL. If a report deals with Applied Technology, the following notice must appear on the report cover.

APPLIED TECHNOLOGY

Any further distribution by any holder of this document or data therein to third parties representing foreign interests, foreign governments, foreign companies, and foreign subsidiaries or foreign divisions of U.S. companies shall be approved by the Associate Deputy Assistant Secretary for Reactor Systems, Development and Technology, U.S. Department of Energy. Further, foreign party release may require DOE approval pursuant to Federal Regulation 10 CFR Part 810 and/or may be subject to Section 127 of the Atomic Energy Act.

1.1.1.3 Citations to Internal Data

The basic premise in citing references is that a cited document be as available to the reader as the document in which the citation appears. Therefore, documents (even though unclassified) that are not available to the public must not be cited in documents that are to be released to the public. For example, a report or letter having only internal distribution must not be referenced in a report receiving external distribution. Where extenuating circumstances necessitate an exception to the rules, the cover of the document should bear the following notice.

CAUTION

This report contains preliminary information and was prepared primarily for use by participants in the _____ program. Because the information is subject to revision, it should not be disseminated beyond the recipient organization. Also, documents prepared for public availability should not reference this report.

1.2 FRONT MATTER

The front matter of a report includes all of the pages between the front cover and the body text. Format the front matter according to the following guidelines.

- Arrange the front-matter elements according to the sequence of Sects. 1.2.1 through 1.2.12.
- Match the type and page layout in the front matter to that used in the body text of the report.
- Begin each element on a right-hand page.
- Use roman numerals centered in the footer to number the pages.
- Count the title page as page *i*, but do not print the page number on it.
- Count all blank pages, but do not print the page numbers on them.

1.2.1 Title Page

The title page normally appears as the first right-hand page following the front cover. (See Exhibit 2.) Any special notices that appear on the title page should also appear on the cover. A title page presents the following information:

- the report number;
- the title and, if any, the subtitle;
- the type of report (such as a quarterly progress report) and period covered (if applicable);
- the names of the authors, editors, or compilers;
- the publication date (month and year);
- the name and complete address of the reporting organization;
- a credit line;
- the contract number; and
- any special notices (as needed).

1.2.2 Dedication

A dedication page, which is optional, would appear on the first right page following the title page.

1.2.3 Table of Contents

The table of contents should list front matter, all subheadings through third-order levels, and back matter and their corresponding page numbers. The headings and page numbers in the contents should duplicate those in the text.

1.2.4 List of Figures

A list of figures is recommended for any report that has more than five figures in it. The list should contain the captions of all figures and their corresponding page numbers, listed in the sequence in which they appear in the report. Use only the first sentence of a multiple-sentence caption in the list of figures.
.

1.2.5 List of Tables

A list of tables is recommended for any report that has more than five tables in it. The list should contain the titles of all tables and their corresponding page numbers, listed in the sequence in which they appear in the report. Use only the first sentence of a multiple-sentence table title in the list.

1.2.6 List of Abbreviated Terms

The list of abbreviated terms is recommended for any report that has more than five abbreviated terms in it. It contains all of the abbreviated terms used in the report, listed in alphabetical order, along with their full spellings. The list either reiterates the terms defined in the report or defines the terms if they are not fully spelled out otherwise. Common units of measure and chemical compounds are not included in the list of abbreviated terms. Typically included are

- abbreviations, composed of shortened words: military specification (Mil Spec);
- acronyms, composed of selected letters: cardiopulmonary resuscitation (CPR); and
- initialisms, acronyms that use the first letters of words: U.S. Department of Energy (DOE).

1.2.7 Foreword

A foreword, which is optional, is usually written by someone other than the author after the report has been completed, and the writer's name appears at the end. The foreword may consist of

- comments on the quality or background of the study,
- the author's success or professional skill,
- the reason the work was undertaken,
- the period during which it was done, and
- the funding for the report.

Information contained in the body of the report is generally not included.

1.2.8 Preface

The preface, which is optional, is usually written by the author after the report has been completed. Information contained in the body of the report is generally not included in the preface. If the preface is written by someone other than the author, the writer's name should appear at the end.

A preface may explain

- the purpose of the report,
- the approach to any research,
- the intended audience, or
- the way the report relates to other reports (published or to be published).

It could also include

- dates during which the work was performed;
- task assignment identification, project number, or funding information;
- permissions granted for use of previously published material; and
- acknowledgments (if not included as a separate section).

1.2.9 Acknowledgments

An acknowledgments section, which is optional, may be (1) a separate part of the front matter, (2) included in the preface, or (3) placed in the back matter, immediately following the body text (before the references or bibliography and appendixes). Acknowledgments should be reserved to identify individuals who made substantial contributions to the work but who are not authors.

For anyone to carry out a significant piece of scientific study without assistance from others is almost impossible. If the author received major help or guidance from others, they should be credited as coauthors. If the contributions were simply a part of the others' normal job responsibilities, special acknowledgment need not be expressed. However, an exception might be made if the contributor is located at another site.

1.2.10 Summary

A summary, which is optional, is a self-contained condensation of the entire document. It includes

- information on the manner in which the work was done,
- the nature and purpose of the investigation,
- the equipment or processes used,
- a brief discussion of the results, and
- the primary conclusions or recommendations.

1.2.11 Executive Summary

The executive summary may be (1) part of the front matter, (2) the first section in the body of the document, or (3) a separate publication. An executive summary may be distinguished from a summary by its perceived value as an aid to short-term decision making. A short executive summary may satisfy the requirement for each report to have an abstract.

1.2.12 Abstract

Each report must have an abstract for indexing purposes; a short executive summary may satisfy that requirement. An abstract should contain no more than 250 words. It may be part of the front matter, or it may appear on page 1 of an unclassified report, in which case it should be preceded by the title and author of the report and followed immediately by the introduction, or followed by the introduction beginning on the next right page.

An abstract written in conjunction with the main body of a document should be informative (rather than indicative or descriptive) unless the nature of the document precludes the preparation of an informative abstract (e.g., a bibliography or some open-literature publications).

- An *informative* abstract includes the primary conclusions, a brief account of the purpose and nature of an investigation, a short description of the procedure, a concise statement of results, and some significant numerical data.

- An *indicative* abstract presents only general information on the contents of the document and excludes specific information on procedures and numerical data. An abstract of this type is useful in reducing a very long and greatly detailed document to a few lines.

- A *descriptive* abstract is generally written for conference proceedings or similar types of publications and contains the results and conclusions; a declaration of purpose; a statement about all the subjects for which new information is given; and a description of the methods, variables, or conditions under which the work was done.

Note: When an abstract is published separately from the document, it should be reviewed for classification as an independent document.

1.3 BODY TEXT

Begin the body text of a report on the first right-hand page following the front matter. The classic outline for a scientific report, which should govern the organization of the body text, or sections within the body text, addresses the following topics in the following order:

- introduction,
- materials and methods,
- results, and
- discussion.

1.4 BACK MATTER

The back matter of a technical report can consist of some or all of the items described in Sects. 1.4.1 to 1.4.7 and should be arranged in the order in which they are given. The type and page layout should match that used in the body text. Each section of the back matter begins on a right-hand page. The pages may be numbered one of two ways: either continuing the numbering of the body text or by sections keyed to the first-order headings (A-1, B-1). All of the back-matter elements may be treated as appendixes if doing so adds to the clarity of the document. (See Sect. 1.4.5.)

1.4.1 Acknowledgments

If you have decided to place the acknowledgments in the back matter, set it on the first right-hand page after the last page of body text.

1.4.2 References

See Sect. 1.8.3.

1.4.3 Selected Bibliography

See Sect. 1.8.2.

1.4.4 Glossary

A glossary entry should start at the left margin. The definition should begin with a lowercase letter if the first word is not a proper noun, and there should be no period at the end unless the definition consists of more than one sentence. Turnover lines are indented one paragraph indent. Set glossary entries according to the following example.

Carbon cycle—the cycle of carbon in living beings in which carbon dioxide is fixed by photosynthesis to form organic nutrients and is ultimately restored to the inorganic state by respiration and protoplasmic decay

1.4.5 Appendixes

Appendixes contain detailed information that is not essential to a basic understanding of the work and the results obtained but that may be helpful to readers. Detailed test data, engineering drawings of

component parts, graphs, information on a long series of tests, lengthy mathematical derivations, or detailed analytical procedures would be appropriate material for an appendix.

If two or more distinct sets of information are to be provided, each set should be designated separately (e.g., Appendix A, Appendix B, and so on). Because an appendix is a section of the report, its title should be considered a first-order heading. Tables, figures, and equations carry the prefix letter of the appendix; (e.g., Table F.11 or Fig. A.2). Appendixes are often divided by half-title pages, which should be counted in the pagination but not visibly numbered (e.g., the content of Appendix A would begin on the first right-hand page following its half-title, and would be numbered A-3.)

1.4.6 References

Typically, ORNL technical reports contain references to previously published documents that relate to the work being reported. Each reference must be fully cited in the report and called out with in-text indicators, either author-date identifiers or superscript numbers. Either method is acceptable so long as it is consistently applied throughout a given document. References may be listed under a heading at the end of each section of a report or at the end of the report in a separate section. If the references are listed in a separate section, it precedes the index if one is present. (See Sect. 1.8.)

1.4.7 Index

An index records the pages or sections in which a reader may find information relating to a specific word, group of words, name, or subject area. Proper names and subject entries may be presented together or in separate indexes. An entry consists of a heading (a noun, with or without modifiers) and numbers of all pages on which the reader can find information about that topic. Turnover lines are always indented. Subentries may be either run in or indented. Indented style is preferred if subsubentries are included.

1.4.8 Distribution List

The distribution list is the final section in ORNL reports. (See Exhibit 3 page 25.) The distribution list contains the names of the internal recipients of the report as well as the names and addresses of any external recipients. The report number should appear in the upper right-hand corner of the first page. Its pages are not numbered, and it is not listed in the table of contents. The following recipients should always be listed in the internal distribution of ORNL reports, and care should be taken to ensure that they are not duplicated in the external distribution:

- one copy to the Central Research Library;
- one copy to Laboratory Records, record copy (RC); and
- two copies to the DOE Office of Scientific and Technical Information (OSTI).

1.5 TEXT FORMAT

1.5.1 Body Text

Set body text in 11 point Times New Roman in a single column, ragged right (left justified). Either indent the first line of each paragraph and leave no extra space between paragraphs, or do not indent the first line and leave a space between paragraphs. Generally follow a “down style” of capitalization (capitalize only proper nouns and the first words in sentences), and avoid excessive variations in typography (e.g., avoid the use of italics or underscores or color or differing type sizes for emphasis).

1.5.2 Headings

Headings, the titles given to the various divisions of the report, represent the organization of the report and allow the author to present the narrative in a clear and logical sequence. Headings are designed to make it easier for the reader to grasp the nature of the material, its organization, and the relationship among its various parts.

Two major styles of headings prevail in technical and scientific documents: the typography-position method (see Exhibit 4) and the Arabic-decimal method (see Exhibit 5). The style for typeset headings may be varied as appropriate to the specific requirements of the document.

1.5.3 Figure Captions

Set figure captions in 10 point Times New Roman boldface. (See Sect. 1.6.5.) If the caption is composed of more than one sentence, set only the first sentence in boldface. Center the caption beneath its figure if the caption is equal to or less than the width of the figure; paragraph indent the caption if it wraps beneath the figure.

Figures are typically numbered in ascending order as they appear in the report. They may be numbered consecutively throughout the document (Fig. 1, Fig. 2) or by section (Fig. 2.1, Fig. 2.2). Captions for numbered figures begin with the abbreviation “Fig.” followed by the figure number and a period.

1.5.4 Table Titles

Set table titles in 10 point Times New Roman boldface, centered over the table. (See Sect. 1.7.5.) Titles that are longer than the table is wide should wrap while remaining centered. Center a headnote if one appears between the title and the table. Leave one line space between the title and the headnote. Do not set the headnote in boldface.

1.5.5 Pagination

Use arabic numbers to number the pages, either continuously (1, 2, 3) or by section (1-1, 1-2, 1-3). The position of the page number may vary and may be combined with text in the headers or footers.

Typically, documents are oriented “profile” (8½ × 11 in.). Sometimes, because of its proportions, a large figure or table must be oriented “landscape” (11 × 8½ in.). If so, place the page number in the same location as it appears on the profile pages. Also, some large drawings and tables require a “foldout” page (e.g., 8½ × 22 in.). Typically, a foldout page is folded in half to 8½ × 11 in., and then the right side is folded back on itself. Place the page number on a foldout page so that, when folded, the page number appears in the same location as it does on the profile pages.

1.5.6 Displayed Lists

Displayed lists are common in ORNL reports. Text passages are often composed of series (and series within series) that are easier to comprehend when displayed in a list. Each list needs to be internally consistent; however, one may vary stylistically from another because of its context and content.

Apply the following rules when formatting displayed lists.

- Do not combine bullets with a lettering or numbering scheme.
- Number the listed items if their order is critical to the meaning (e.g., if they describe the steps in a procedure) or if cross references are later made to them. Otherwise, use bullets.
- Apply the standard rules of punctuation, just as you would for displayed equations.

- Use down-style capitalization.
- Edit the listed items so that they are grammatically parallel with each other.
- Use indented dashes to set off a list of second-order items beneath an individual bullet.
- Exercise restraint; three or fewer short items in a series probably do not need to be displayed.

1.6 ILLUSTRATIONS

The following guidance applies generally to figures that appear in ORNL reports; however, document designs can vary, and design integrity and internal consistency should take precedence over these guidelines.

1.6.1 General Considerations

Assess the availability and quality of all graphic art as early into a project as possible. Graphics work can proceed in tandem with other publishing tasks, and an early start may avoid problems that would cause a bottleneck later on in the schedule. Be sure to acknowledge the use or modification of any previously published artwork.

At the current time, paper documents are still common at ORNL. However, demand is growing for documents published on other media, such as compact disks, and for documents prepared for the World Wide Web. Knowing the final output may affect the way that you manage the artwork. Therefore, these possibilities must be considered early on.

Graphic arts is a dynamic field. Therefore, it is likely that any specific information about software, file management, or file compatibility would soon be obsolete. Refer any questions related to graphic arts to Creative Media Solutions (peg@ornl.gov, 574-6695). Also, you can visit the group's Web site to obtain the latest available information: http://www.ornl.gov/cind/.

1.6.2 Callouts

Figures used in technical documents should add information to the document. They should be keyed to the text by means of a callout, usually at the end of a complete sentence, but in any case near a statement whose relationship to the figure is obvious. Style the callout in one of the following ways:

- The test gave unexpected results (Fig. 1).
- The test gave unexpected results (see Fig. 1).
- The test gave unexpected results. (See Fig. 1.)
- The test results are shown in Fig. 1.
- Figure 1 illustrates the test results.

The callouts contain the abbreviation "Fig." followed by the figure number unless the callout begins a sentence, in which case the word "Figure" is spelled out.

1.6.3 Position on the Page

Position each illustration as closely as is possible to its callout in the text. Ideally, it should follow its callout; however, the layout may demand that the callout follow the figure, an acceptable practice so long as they are set on the same page.

1.6.4 Size

Generally, size illustrations as small as possible while retaining legibility; needlessly large figures may force subsequent figures away from their callouts. The author (subject-matter expert) should make decisions on sizing and cropping any technical graphics to ensure that salient details are not lost and that proper scale and proportion are retained. In particular, be sure to retain scale references in photomicrographs.

1.6.5 Captions

See Sect. 1.5.3 and Exhibit 6.

- Set captions in 10 point boldface Times New Roman.
- If a caption contains more than one sentence, set only the first sentence in boldface.
- Position captions directly beneath their figures.
- Wrap the caption so that it does not exceed the width of its figure.
- If the caption fits on a single line, center it beneath the figure.
- If the caption is two or more lines long, use a paragraph indent.
- Begin each numbered caption with the abbreviation “Fig.” followed by the number and a period.

1.6.6 Archiving

Most of the artwork created at ORNL is in the public domain and should be easily available to anyone who can make use of it. The best way for authors who create their own graphics to ensure that their artwork is safe and available for future use is to seek the help of ORNL Creative Media Solutions (574-6695). Each image that the Creative Media Solutions group obtains or creates is labeled with an identifying number and is stored in the Image Retrieval Information System (IRIS). The identifying number, which appears in the upper right-hand corner of each graphic, should be visible when the graphic is reproduced in a document.

1.7 TABLES

1.7.1 Introduction

Tables should be self-contained, self-explanatory, and as simple as possible. A table should display one subject distinctly and should not be cluttered with unnecessary details. The following sections describe table formats for ORNL. For a detailed discussion of table theory and design, see *The Chicago Manual of Style*.

1.7.2 Table Types

Two types of tables are commonly recognized: integral and spot. Integral tables must be numbered and must have titles. Spot tables are less formal and set in the text after an introductory sentence, much like a displayed list. They have no title or number, and are usually referred to only once. Spot tables do not require a callout and are not included in the list of tables. Set integral tables in 10 point Times New Roman; set spot tables to match the body text. (The point size of text in integral tables is often reduced to suit copyfitting constraints.) The following spot table summarizes these distinctions:

Feature	Table type	
	Integral	Spot
Numbered	Yes	No
Has a title	Yes	No
Callout required	Yes	No
Cross-referred	Possibly	No
In list of tables	Yes	No
Type size	10 point	11 point

1.7.3 Integrated Table Placement

Tables are usually integrated with text and are placed as near as possible to their first point of reference. However, if the document has little text and many tables, the tables may appear at the ends of chapters or at the end of the document. It may also be useful to place tables side by side for comparison. Tables should be oriented in the same direction as the text when possible. If a table needs to be oriented broadside (landscape) in a document in which the text is set on portrait (profile) pages, the page number and any headers and footers should remain portrait and should conform to those of the surrounding pages.

1.7.4 Integrated Table Numbering

Integral tables may be numbered consecutively throughout a document (e.g., Table 1, Table 2); in sequence by section (e.g., Table 5.1, Table 5.2); or by subsection (e.g., Table 2.1-1, 2.1-2). Each integral table should be called out in the text by its number.

1.7.5 Integral Table Elements

See Exhibit 7 for examples of integral tables.

1.7.5.1 Table Title

Each table should have a brief but complete title. Place the table number (followed by a period) and the title on the same line above the table, centered and set in boldface type with no terminal punctuation. Multiple lines in the title should be set in centered, inverted-pyramid style. Any qualifying information following the title should be set as a headnote, centered beneath the title and set in medium type and with no terminal punctuation. An extra line is inserted between the title and the headnote.

1.7.5.2 Body

The body of a table is composed of information (data or text passages or both) arranged in columns and rows. The other elements of the table (headings, stub entries, and footnotes) define and qualify the information in the body. The information may be arranged in parallel lists labeled by headings, in rows labeled by stub entries, or in a cartesian arrangement in which each data position (cell) is defined by both its stub entry and its column heading.

The following distinctions should always be maintained with regard to data in a table body.

- Use a zero only as a measured quantity and never as a place holder for missing data or an irrelevant position.
- Use a centered en dash to indicate that no value is available for the defined position.
- Leave the cell blank if no relevant information exists for it.

No final punctuation is used in the text that appears in the body of a table, even with complete sentences, unless there is more than one sentence. If there are two or more sentences, a period is used after each sentence except the last one in each entry.

Any column or row that repeats the same entry throughout should be deleted from the body of a table; the information can best be given in a headnote or a footnote. Any column or row having almost all its entries the same can be deleted from the body by making the common information into a headnote and giving the exceptions as footnotes. Likewise, repetitive units of measure or other labels should be stated once in the stub or column heading rather than being repeated in each cell in the corresponding row or column.

1.7.5.3 Heads

Column Heads. Column heads should specify or classify data. They should be

- grammatically parallel and logically sequenced so that a table can be read and understood easily,
- set in boldface and in down style (only the first letter of the first word and those of proper nouns capitalized), and
- labeled with respective units of measure enclosed in parentheses and centered under the head.

Decking and Spanners. "Decking" of heads in a table is analogous to assigning levels to headings in body text. Typically, a generic head will be centered over several specific heads to indicate a shared trait. A rule called a "spanner" is set between the head and its subheads.

Cut-In Heads. Excessive decking of the headings can be avoided by the use of a cut-in head, which is a head that cuts across the body of the table and applies to the matter lying below it. Cut-in heads are set in boldface type.

1.7.5.4 Stub Entries

Stub entries, if present, label the rows of the tables. They should be set in boldface type, and only the first word should be capitalized. If they are longer than a single line, stubs should be hang-indented. Units of measure should follow the stub and be set off by a comma or enclosed in parentheses. A major stub entry, set flush left, may have any number of subentries indented beneath it.

1.7.5.5 Footnotes

The Chicago Manual of Style recognizes four types of table footnotes. If they appear together in the same table, they should be arranged at the foot of the table in the following order (for more details, see Sects. 12.46–52 in *The Chicago Manual of Style*):

- source notes, introduced by "*Source:*";
- other general notes, introduced by "*Note:*";

- notes on specific parts of the table, called out with letters and noted in the table in ascending alphabetical order as the table is read from the top (left to right, row by row); and
- notes on the level of probability, arranged in ascending order of probability and called out with increasing numbers of asterisks. Because they are short, probability footnotes may be run together on a single line.

Footnotes, used both to cite references and to qualify information, are common in tables. Lowercase italic letters are used as footnote indicators. Alphabetical order is followed, reading left to right, first across the column headings and then across each horizontal line of the body. The footnote indicators are superscripts unless they occur alone; if the footnote indicator constitutes the complete entry, it is set in the same point size as the table type. Reference footnotes must be complete and are handled independently of those in the text. A footnote is generally punctuated as a sentence and is set in paragraph style. Footnotes are always placed below the table cutoff rule; thus, if a table covers several pages, the footnotes are given on the last page.

If a table is taken from another publication and is to appear essentially unaltered, the table must include a source line below the baseline rule that acknowledges the originator of the material, even if the table is restyled or retyped. Under the Fair Use Provision of the Copyright Act, it is no longer necessary to have written permission from the originator of the material. Copyrighted material in source lines should be preceded by one of the following terms:

- "Reprinted from . . ." (if taken directly from another work), or
- "Adapted from . . ." (if the original table served as a basis for a new table with some change).

1.7.6 Vertical Spacing

If the title, headnote, column head, or stub entry requires more than one line, single-space each additional line. Leave a space between a table title and its headnote. Use single or double spacing for the table text, depending on the type style, but treat all tables in the same context consistently. Because the proportions of tables vary, use the spacing that will produce the most readable table. Tables consisting entirely of numbers can be made more readable by inserting an extra line of space at equal intervals (e.g., every five or ten entries).

1.7.7 Alignment of Entries

Align table entries according to the following guidelines.

- Data in columns should be aligned horizontally and vertically.
- Each column entry should be in horizontal alignment with the applicable stub entry. If the entry occupies fewer lines than the stub entry, align on the first line.
- Vertical alignment varies with the content:
  - If all values are in the same unit of measure, align on the decimal point or comma.
  - If most values in a column are given in the same unit unless otherwise indicated, align on the decimal point or comma.
  - If the values are given in assortment of dissimilar units, align on the left.
  - If signs of operation are present, align them on each other.
  - If the largest value in a table has four digits to the left of the decimal, do not use commas; if a table contains values that have five or more digits to the left of the decimal, add commas to all values in the table having four digits or more.
  - Footnote indicators within a column should follow the alignment pattern of the other entries in the column.

1.7.8 Rules

Uniformly spaced horizontal rules are used in a table to separate the main elements and to improve readability. The rules are precisely the width of the table, which is determined by the width of the longest entries (either in the column head or the entry under it in the body) plus the space allowed between the columns. Spacing above and below the rules should be uniform. Rules used to separate multiple-level column heads are called spanners.

The use of vertical rules between columns is rare but can be useful. For example, to better fit on the page, a long, narrow table may be divided into two or more columns that are separated by a double vertical rule. The heads would be repeated at the top of each new column. The title is centered over the columns (as is the headnote, if any).

1.7.9 Continued Tables

Tables that require more than one page must carry a "continued" title line on the second and subsequent pages. The word *Table*, its number, and the word *continued*, which is enclosed in parentheses, are centered above the repeated column heads. The continued line is set in the same typeface as the original title. The cutoff rule for the table is given only on the final page of the table.

One exception to the rule is a broadside table that begins on a left page; the head matter on the facing right page should be omitted. Should such a table continue to the next left page, the head matter would be repeated there.

1.7.10 Artwork in Tables

Some tables may require artwork (e.g., small maps or structural formulas of chemicals). The client should always include copies of the original artwork if a table containing graphics is being submitted to an electronic publisher (EP) or a graphic artist.

1.7.11 Chemical Notation in Tables

If there is a mixture of elements and compounds or elements with atomic numbers or ionic charges, symbols should be used for all. If the list is made up exclusively of elements or a mixture of elements and general classes of compounds (sulfates, carbonates, chlorides), they should be spelled out. If space is a critical factor, symbols may be used exclusively; for example, if spelling out the list would cause a vertical table to have to be positioned broadside, use symbols.

1.8 FOOTNOTES, ENDNOTES, REFERENCES, AND BIBLIOGRAPHIES

1.8.1 Footnotes and Endnotes

1.8.1.1 Footnotes

In typical ORNL reports, the use of footnotes is limited to identifying information that is indirectly related to the main line of discussion but distinct from the cited references. For example, a footnote may contain a passage of text that illuminates the discussion but does not fit well in the body of the report. It may also contain affiliations; credit lines; unpublished data; personal communications; and trade names, suppliers, or manufacturers. Footnotes for trade names, manufacturers, or suppliers that are referred to in the text of unclassified reports intended for external distribution must give the complete name. If

reference is made in a footnote to a published document, it should appear as a complete citation, not as a callout to a citation in the list of references.

Footnotes are placed at the bottom of the page on which they are called out. They may be called out by either superscript Arabic numbers or superscript symbols. The following symbols are used for footnotes and should be used in the following order: *, †, ‡, **, ††, ‡‡. It is important to choose a footnoting scheme that will not become confused with the method of citing references.

1.8.1.2 Endnotes

In typical ORNL reports, references to published documents appear as endnotes, either in the section in which they are called out (under a separate heading) or in a major section at the end of the body text. (See Sect. 1.8.2.)

1.8.2 References

Documents often contain information from other sources. When this is the case, the document should include a bibliographic citation for each supporting source. This information should be accurate and sufficient to allow the reader to locate the cited documents and should include, at a minimum, the author, title, publisher, location, and date of publication. This section gives the basic rules for styling references, along with some representative examples.

References for documents prepared at ORNL should be styled according to these guidelines. References for open-literature publications or for documents funded by other agencies will be styled according to the requirements of the publisher or sponsor (if specified).

1.8.2.1 Location of Reference Lists

In a typical ORNL technical report, references are listed in a separate section, entitled “References” or “Literature Cited.” The reference list should be the last section of a document unless the document also contains an index, in which case it should precede the index. References may be listed under a separate heading at the end of the section in which they are called out if doing so better suits the document; for example, an annual progress report containing sections that are not closely related to each other may benefit from having a separate list of references for each section.

1.8.2.2 Style

Two reference styles are recommended for ORNL reports: (1) the author-date style detailed in *The Chicago Manual of Style* (14th edition, Chap. 16) and (2) a modified version of the numerical style developed by the American National Standards Institute (ANSI Z39.29-1977). Comparative examples are given in Sect. 1.8.4.

Both styles offer some latitude among the particulars of citation. For example, journal titles can be spelled out fully (the preferred technique) or abbreviated according to standard guidelines [*Bibliographic Guide for Editors and Authors* (American Chemical Society, Washington, D.C., 1974), the *Chemical Abstracts Service Source Inde*x (CASSI) American Chemical Society, Columbus, Ohio, 1985, and yearly supplements, or the International Standard IS0-833].

1.8.2.3 Location of In-Text Indicators

In-text indicators should only be used in the main body of a report. Some sections of a report, such as the abstract and executive summary, the are meant to “stand alone,” which is to say that they should make sense outside the context of the report in which they appear. Therefore, they should not contain in-

text indicators. Likewise, tables and figures should be complete enough to stand alone. If needed, full references should be given as footnotes to a table or as parts of the figure caption.

For both the author-date and numerical reference styles, in-text indicators should follow as closely as possible the text to which they refer, typically at the end of a sentence. For the sake of clarity, in-text indicators may also be placed at other locations within the sentence. (For example, each clause of a sentence may require a separate reference.) In the following examples, the author-date style appears first.

> Hirst et al. 1997 reported on the residential energy-use model.
>
> Hirst et al. reported on the residential energy-use model.[3]
>
> The details of the plasma generator and the indirectly heated cathode have been published elsewhere (Smith 1997; Jones 1998).
>
> The details of the plasma generator and the indirectly heated cathode have been published elsewhere.[5,6]

We describe here extensions of the studies beyond those previously published (Smith 1997; Smith and Jones 1998; Howard, Fine, and Howard 1999).

> We describe here extensions of the studies beyond those previously published.[11–13]

The characteristics of the author-date and numerical styles are compared in the following lists. For detailed information, see *The Chicago Manual of Style*, 14th ed., Chaps. 15 and 16.

- Author-date In-text indicators
  - They precede the punctuation at the end of the sentence or clause.
  - They are composed of the last name of the primary author or authors (up to three; for more than three authors, use “et al.”) separated by commas and the date of publication in parentheses.
  - No punctuation is required between the author and the date.
  - Multiple references are all listed and are separated by semicolons.
- Author-date references
  - The first author’s name is inverted; subsequent author’s names are not.
  - The publication date follows immediately after the authors.
  - Main components of the references are separated by periods.
  - The references are arranged alphabetically.
- Numerical style indicators
  - They follow the punctuation at the end of the sentence or clause. ***Exception:*** They precede dashes.
  - They are set as superscript Arabic numbers. ***Exception:*** If a numerical indicator follows a symbol, another number, or an abbreviation, the following form is used: “The diameter of the tank was 6 m (ref. 3).”
  - Sequential pairs are separated by a comma (no spaces); multiple references are indicated by inclusive numbers separated by an en dash.
- Numerical style references
  - The first author’s name is not inverted.
  - The publication date falls in different places, depending on the type of publication being cited.
  - Main components of the references are separated by commas.
  - The references are arranged in ascending numerical order, according to order in which they are called out.

1.8.2.4 Capitalization

For English titles, the first letter of the first word and those of all principal words (nouns, pronouns, verbs, adverbs, adjectives, gerunds, and participles) are capitalized; conjunctions, articles, and abbreviations are not. Prepositions of five letters or more are capitalized. Prepositions having fewer than five letters and other short words are capitalized only if they are stressed or if they are an indispensable part of a verb form (e.g., the word "to," called the stem of the infinitive).

For foreign titles, either retain the capitalization used in the original or consult a good English translation dictionary. For French, Russian, and Italian titles, only the first word, proper nouns, and ordinary abbreviations are capitalized. For German titles, all nouns are capitalized; all else is lowercased except symbols normally used in uppercase form (e.g., pH).

1.8.2.5 Examples of References

The author-date style is given first.

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9. R. S. Booth, *Advanced Neutron Source Plant Design Requirements*, ORNL/TM-11265, Oak Ridge National Laboratory, Oak Ridge, Tenn., August 1994.

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33. The Spallation Neutron Source Collaboration, "Introducing the SNS: SNS Brochure," 1998, http://www.sns.gov/brochures/newSNSBrochure.pdf (February 1998).

1.8.3 Bibliographies

A bibliography is a list of literature on the subject covered by the publication. If both cited references and a bibliography are listed, the bibliographic entries are placed after the list of references and before any appendixes in a section titled "Selected Bibliography." The listed entries are printed in the same element sequence and in the same format as numbered references [i.e., paragraph form with Arabic numerals (no parentheses), positioned on the line, and followed by a period]. Bibliographic entries in an appendix are numbered separately and placed at the end of the appendix. As an in-text indicator for a bibliographic entry, an italic number in parentheses positioned on the text line is used. Example: Jones and Smith support this view (*12*). If a specific page number is cited, the following form is used: Jones and Smith also support this view [(*12*), p. 25].

DOCUMENT AVAILABILITY

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Exhibit 1. Inside front cover for ORNL reports.

ORNL/TM-2000/XXX

Division or Program

TITLE

Author

Date published—[Month] [Year]

Prepared for
(Applicable DOE Funding Office)
(Applicable DOE Budget Activity Number)

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
UT-BATTELLE, LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

Exhibit 2. Example of a title page for unclassified documents.

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1. T. B. Allen
2. G. E. Anderson
3. S. Baloga
4. J. H. Barker
5. K. J. Carroll
6–10. K. W. Cook
11. N. S. Dailey
12. C. T. Garten
13. T. W. Joseph
14. J. M. Loar
15. L. W. Long
16. J. P. Mason
17–18. L. W. McMahon
19. C. A. Strizak
20. L. O. Vaughan
21. J. L. Webb
22. Central Research Library
23. DOE Y-12 Site Office
24. ESD Library
25. ETTP Site Office
26. ETTP CEP Document Center
27–28. ORNL Laboratory Records—OSTI
29. ORNL Laboratory Records-RC

EXTERNAL DISTRIBUTION

30. John Aber, Complex Systems Research Center, Room 445, Morse Hall, University of New Hampshire, Durham, NH 03824
31. Mike Apps, Forestry Canada, 5320-122 Street, Edmonton, Canada T6H 3S5
32–41. Dennis Baldocchi, University of California, Ecosystem Science Division, Department of Environmental Science, Policy, and Management, 151 Hilgard Hall, Berkeley, CA 94720
42. Carol Barford, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138
43. Alan Barr, Atmospheric Environmental Services, National Hydrologic Research Center, 11 Innovation Boulevard, Saskatoon, SK, Canada S7N 3H5
44. Mercedes Berterretche, Forest Science Department, Oregon State University, Corvallis, OR 97331
45. John Blair, Department of Biology, Kansas State University, Manhattan, KS 66506
46. John Briggs, Division of Biology, Kansas State University , Manhattan, KS 66506-4901
47. Sean Burrows, Department of Forestry, University of Wisconsin, Madison, WI 53706
48–49. John Campbell, Department of Forestry, University of Wisconsin, Madison, WI 53706
50. Jing Chen, Canada Centre for Remote Sensing, Energy Mines & Resources Canada, 588 Booth Street, 4th Floor, Ottawa, Canada K1A 0Y7
51. Josef Cihlar, Canada Centre for Remote Sensing, Energy Mines & Resources Canada, 588 Booth Street, 4th Floor, Ottawa, Canada K1A 0Y7
52. Office of Assistant Manager for Energy Research and Development, U.S. Department of Energy Oak Ridge Operations, P.O. Box 2001, Oak Ridge, TN 37831-8600.

Exhibit 3. Example of a distribution list for unclassified documents.

FIRST-ORDER HEADING (11 point)

First-order headings are used for all major sections of the report. Major sections include front matter (e.g., contents, abstract), main text divisions (chapters or sections), and back matter (e.g., references, bibliography, appendixes). First-order headings are typed in bold capital letters and are centered between left and right margins. The narrative starts two blank lines below the heading and at the paragraph indent. Subsequent first-order headings are centered two blank lines below the text. In some reports, the author or editor may choose to begin every first-order heading on a new page. If this is done, the page should be a sink page (i.e., one that starts below the level of the top line of the full text page).

SECOND-ORDER HEADING (11 point)

Second-order headings are used to identify major divisions within a chapter or section. They are typed in bold capital letters and start at the left margin. Two blank lines precede and one blank line follows a second-order heading.

Third-Order Heading (11 point)

Third-order headings are used to separate the principal topics within a report division. The first letter of each principal word in the heading is capitalized. The heading starts at the left margin, and the heading is bold. One blank line precedes and one blank line follows a third-order heading.

Fourth-Order Heading (11 point). Fourth-order headings are used to subdivide the principal topics further if such subdivisions will enhance the report presentation. They are sometimes called paragraph headings and are similar to the third-order headings except that the heading begins with a paragraph indent, a period follows the heading, and the narrative follows the period on the same line. The first letter of each principal word in the heading is capitalized; the entire heading is bold. One blank line precedes the heading.

Use of further subdivisions in the typography-position method is not recommended.

Exhibit 4. Typography-position heading style.

1. FIRST-ORDER HEADING (11 point)

First-order headings are used for all the major sections of the report. First-order headings are typed in bold capital letters, have a one-digit numerical prefix followed by a period and two spaces, and are centered between the left and right margins. Two blank lines precede and follow a first-order heading.

1.1 SECOND ORDER HEADING (11 point)

Second-order headings are used to identify major divisions within a section. A two-digit decimal numerical prefix begins at the left margin, followed by the heading typed in capital letters. Both the prefix and the heading are bold. The second-order heading is preceded by two blank lines. The narrative is preceded by one blank line and begins with a paragraph indent.

1.1.1 Third-Order Heading (11 point)

Third-order headings are used to separate the principal topics within a report division. A three-digit decimal numerical prefix begins at the left margin and is followed by the heading, which has the first letter of each principal word capitalized; the numerical prefix and all words are bold. One blank line precedes and one blank line follows a third-order heading. The narrative begins with a paragraph indent.

1.1.1.1 Fourth-Order Heading (11 point)

Fourth-order headings are used to subdivide the principal topics further. They are similar to third-order headings except that they have a four-digit decimal numerical prefix. One blank line precedes and one blank line follows a fourth-order heading. The narrative begins with a paragraph indent.

Fifth-order heading (11 point)

If further subdivision is desirable, a fifth-order heading may be used. This heading begins at the left margin, has no numerical prefix, has only the initial letter capitalized, and is bold. One blank line precedes and one blank line follows a fifth-order heading. The narrative begins with a paragraph indent.

Sixth-order heading (11 point). This heading is similar to a fifth-order heading except that the heading is paragraph indented, a period follows the heading, and the narrative follows the period on the same line. One blank line precedes the heading.

Exhibit 5. Arabic-decimal heading style.

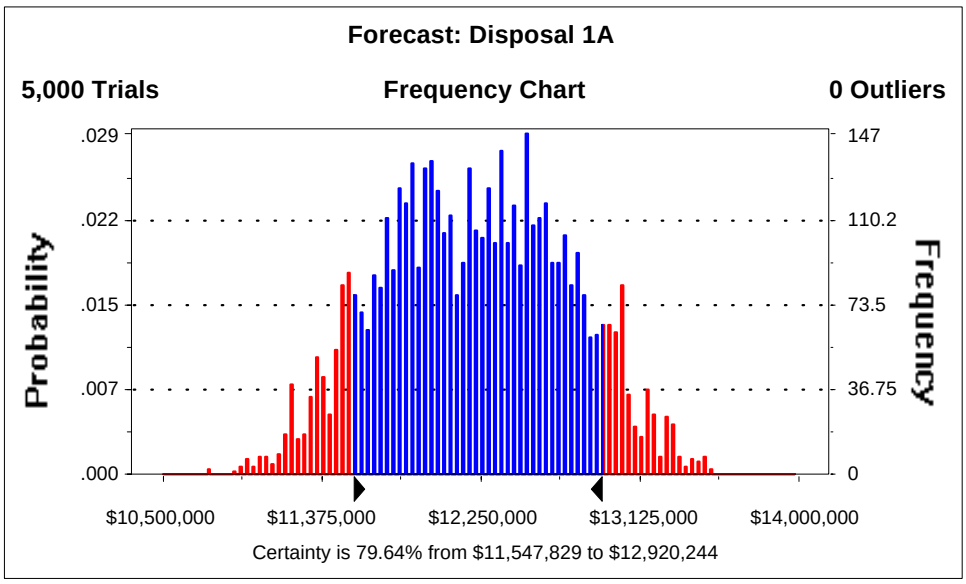

Fig. 2.5. A frequency chart representing all possible outcomes for a disposal alternative. At an 80% confidence level, the cost of disposal is expected to be between $11.5 million and $12.9 million.

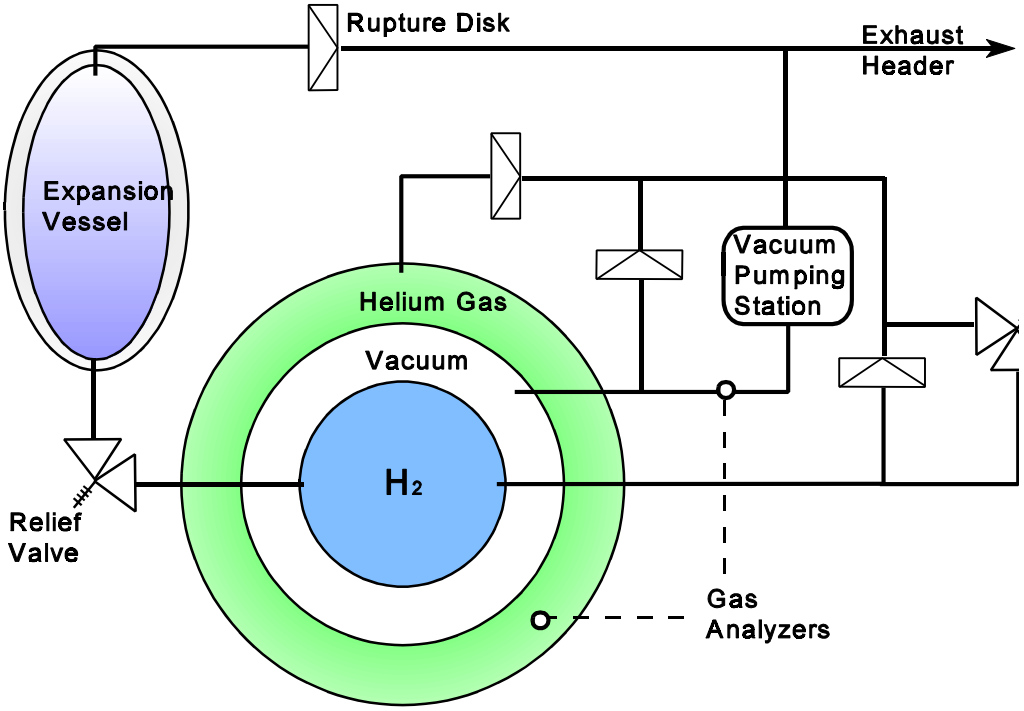

Fig. 2.6. Hydrogen containment and pressure relief concept.

Exhibit 6. Figures with captions. Single lines are centered; multiple lines are paragraph indented.

Table 4.3. Gamma radiation levels in maintenance cell[a]

Location	Highest reading on monitor (C/kg)	Radiation levels (C/kg)[b]			
		At 5 MW		After shutdown	
		Run 14	Run 16	3.6 h	6 d
After one month of operation[c]					
Fuel pump[d]	651[e]	68,000	42,000	2,900	350
After one year of operation					
Fuel pump	1,219	150,000	65,000	6,900	
Dump tank	963	100,000		4,700	2,400

[a]Table title, centered and set in boldface type.
[b]Headings and spanners, centered over their columns, indicate three levels of detail.
[c]Cut-in head, centered and set in boldface type.
[d] Stub entry, left-justified.
[e]Data points given in the same unit of measure are aligned on the decimal.

Table 4.4. Analytical results for two chemical compounds[a]
Based on samples collected during the calendar year[b]

	Compound A	Compound B
Voltage, MV[c]	1.66	1.66
Current, mA	50	55
Water content, %	0.75	0.76

[a]Multiple-line table title centered above table.
[b]Headnote set in medium type beneath the table title and preceded by a space.
[c]Stub entries labeled with different units of measure; data aligned left.

Exhibit 7. Examples of integral tables from an ORNL report. Footnotes identify the table parts.

2. USAGE

2.1 INTRODUCTION

The rules and examples given in this section deal primarily with the expression of quantitative information and abbreviated terms. This section is meant as a complement to the standard language references in use at ORNL, namely, *The Chicago Manual of Style* (currently in its 14th edition) and *Webster's New International Dictionary*. The practical considerations of a writer in a given situation, such as the motive for writing, the perceived audience, and the formal demands of the publisher, make it impossible to assemble one set of rules adequate for all the various needs of our writers. Therefore, the guidance in this section, like that of any other source, is useful to a writer to the extent that it does not conflict with other constraints or instructions.

ORNL Creative Media Solutions is a valuable resource for writers at ORNL. Creative Media Solutions staff are always ready to answer questions and to help researchers with writing, editing, and printing. They have experience with both paper and Web-based documents (http://www-internal.ornl.gov/ cind/pub_home/).

The staff in the Central Research Library have assembled a wide variety of Web-based resources. It is well worth the effort for writers to familiarize themselves with the contents of the library's Web pages and equally well worth it to discover the expertise of the library staff. (http://www-internal.ornl.gov/Library/library-home.html).

The following references can also be recommended for general reference and for the use of scientific and technical terms.

- *Merriam Webster's Collegiate Dictionary*
- *Hodge's Harbrace College Handbook*
- *Words into Type*
- *United States Government Printing Office Style Manual*
- *Thomas Register of American Manufacturers*
- *Merck Index*
- *McGraw-Hill Dictionary of Scientific and Technical Terms*

2.2 MATHEMATICAL EXPRESSIONS

This section contains guidelines for setting mathematical expressions in technical documents. Like text, mathematical expressions should follow rules of punctuation and should conform to uniform spacing conventions. Unlike text, however, mathematical expressions can grow both vertically and horizontally as they increase in complexity. For that reason, it is sometimes necessary to display equations on a separate line rather than run them into the lines of text.

The following three guidelines will help to compose pages that contain both text and mathematical expressions.

- Display built-up or lengthy equations if necessary for clarity or to improve page layout.
- Always display equations that are numbered for cross-reference.
- Otherwise, to the extent possible, incorporate mathematical expressions into text.

Note: Mathematical expressions can be set in a variety of ways and can therefore be restated accurately to suit formatting constraints. However, it is also easy to change the meaning of an equation

by trying to restate it. Therefore, any changes to the original expression that were made to fit it into the copy must be approved by the author.

2.2.1 Terminology, Symbols, and Abbreviations

2.2.1.1 Terminology

When used with reference to mathematical expressions, the following terms bring with them specialized formatting considerations. The terms are listed alphabetically.

Arrays

Arrays are mathematical terms arranged in rows and columns and enclosed in fences. The two types, *determinants* or *matrices*, differ from each other typographically.

Note: Keep arrays intact. Do not split them from one page to another.

A *determinant* has vertical lines as fences.

$$\begin{vmatrix} x_{11} & x_{12} & \dots & x_{1j} \\ x_{21} & x_{22} & \dots & x_{2j} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ x_{i1} & x_{i2} & \dots & x_{ij} \end{vmatrix} \quad , \qquad i = j \quad .$$

A *matrix* has square brackets as fences. Set abbreviations used to cross-refer to a matrix in boldface roman. The following example is an equation that has matrices **A** and **B** in a “where” list.

$$\mathbf{A} + \mathbf{B} = \mathbf{C} \quad ,$$

where

$$\mathrm{A} = \begin{bmatrix} a & x \\ b & y \\ c & z \end{bmatrix} \quad ,$$

$$\mathrm{B} = \begin{bmatrix} b & y \\ c & z \\ d & a \end{bmatrix} \quad .$$

Decimals

In mathematical expressions, always set a zero preceding a decimal fraction for a value less than 1.

$$3 \div 4 = 0.75 \quad .$$

Exponents

Generally, an *exponent* is a superscript value or variable placed to the right of a number or variable, which is called a *base*. The exponent indicates the number of times that the base is to be multiplied by itself.

$$a^3 = a \times a \times a \quad .$$

Note: In the case of the exponential function [$f(x) = e^x$], term "e^x" may be rewritten as "exp x" if needed.

$$\alpha\, e^{\frac{a+b}{c+d}} \quad = \quad \alpha \ \exp\left(\frac{a+b}{c+d}\right)$$

Fractions

A *fraction* expresses a ratio, denoting that one number (called the *numerator*) is to be divided by another (called the *denominator*). Fractions can be set in type three different ways to best suit formatting requirements or a specific usage.

built-up or stacked	The numerator and the denominator are superimposed and separated by a rule. Because of vertical spacing constraints, built-up fractions are primarily used in displayed expressions.	$\frac{a + b}{c + d}$
slashed	A built-up fraction can be restated as a slashed fraction to fit in text by setting the numerator and denominator side by side and by separating them with a slash rather than a rule.	$(a + b)/(c + d)$
case	Case fractions are special characters available in word-processing programs. They conform to the type of a given size and are meant to be set in line with text. Their use in technical documents is generally limited to expressing traditional English dimensions.	½-in. plywood ¾-in.-diam bolt

Note: Do not use case fractions in equations because they will not match the look of other built-up expressions.

In text, slash fractions (a/b) for ease in typing and appearance of the page. In displayed equations, slash equations to prevent a double built-up equation. Do not slash a fractional expression if other components of the displayed equation already require two lines or if slashing causes the equation to be more difficult to read.

Note: Use of a negative power often avoids the problem entirely.

$$\frac{3m}{(n+p)^2} = 3m/(n+p)^2 = 3m(n+p)^{-2}$$

Index numbers

Set index numbers (the "*i*" in the following example) in italics.

$$\sum_{i=1}^{n} x_i$$

Integrals

Set subscripts and superscripts beside integral symbols.

$$\int_0^1$$

Products, sums, and unions

In text, set superscripts and subscripts beside product, sum, and union symbols.

$$\prod_{k=1}^{\infty} \qquad \sum_{k=1}^{\infty} \qquad \bigcup_{k=1}^{\infty}$$

In displays, set superscripts above the symbols and subscripts beneath them.

$$\prod_{k=1}^{\infty} \qquad \sum_{k=1}^{\infty} \qquad \bigcup_{k=1}^{\infty}$$

Superscripts and subscripts

Set all subscript and superscript numbers, letters, and symbols the same point size. Italicize variables. Avoid double embellishments over variables, for example $\dot{\bar{a}}$. Use a different notation; for example, indexes (a_i) or primes (a').

Use a fractional exponent rather than a radical sign if necessary.

$$\sqrt{xyz} = (xyz)^{1/2}$$

Set superscripts outside fences at a height level with the highest superscript within the fences.

Vectors

Use an arrow over an italicized letter or a boldface italic letter to indicate a vector.

$$\vec{a} \qquad \text{or} \qquad \boldsymbol{a}$$

"Where" lists

If a displayed equation is followed by a "where" list, the list may be run into the text that follows or displayed. Run the list into the following text if it is short and simple. If the list is run into the following text, format it as a series.

$$x_k(\beta) = E_0 \sum_{n=k}^{\infty} \frac{\beta}{n^3} \left(1 - \frac{\beta}{n^2} e \right) \frac{\beta}{n^2} \quad ,$$

where E_0 is the kinetic energy of translation of a molecule at 0 °C, n is the number of gas molecules per cubic centimeter at 0 °C, and e is the potential energy.

Display a complex "where" list. If the list is displayed, set the word "where" on the left margin, and indent each line the same depth as a paragraph indent. Do not use "and" before the last entry in a displayed "where" list.

$$\mathrm{COP}_{\mathrm{AVG}} = \frac{\sum_{i=1}^{N} \left(QH_{F_i} \right) \tau_i}{\sum_{i=1}^{N} \left(W_{F_i} \right) \tau_i} = \mathrm{COP}_{\mathrm{SS}} \left(1 - m_2 / 100 \right) \quad ,$$

where

$\mathrm{COP}_{\mathrm{AVG}}$ = average COP calculated over given frosting period,
QH_{F_i} = average heating capacity under frosting conditions for time τ_i,
W_{F_i} = average power usage of heat pump under frosting conditions for time τ_i,
$\mathrm{COP}_{\mathrm{SS}}$ = steady-state COP,
N = integral number of time increments,
m_2 = coefficient expressing the percentage loss in steady-state COP.

2.2.1.2 Symbols

Fences, or symbols of inclusion

braces	{ }	absolute value	$\lvert\ \rvert$
brackets	[ ]	norm	$\lVert\ \rVert$
parentheses	( )	bar	$\bar{\ }$
angle brackets	$\langle\ \rangle$		

Signs of operation

Conjunctions

+	*plus*	×	*multiplied by*
–	*minus*	·	*multiplied by*
±	*plus or minus*	÷	*divided by*

Verbs

=	*is equal to, equals*	<	*is less than*
≠	*is not equal to, does not equal*	≤	*is less than or equal to*
≡	*identically equals by definition,* or *is congruent to*	«	*is very much less than*
~	*is equivalent (or similar or asymptotically equal) to*	⊂	*is contained in*
≅	*approximately equals*	⊃	*contains*
–	*approaches, implies, yields*, or *tends to*	∈	*is an element of*
>	is greater than	∝	*varies directly, is directly proportional to*
		:	*is to, the ratio of*

Symbols of collection

∑	*summation*	∩	*intersection*
∏	*product*	∫	*integral*
∪	*union*		

Other common symbols

!	*factorial*	∂	*partial differential*
\	*set difference*	∞	*infinity*
Δ	*delta*	⊥	*perpendicular*
π	*pi (approximately 3.1416)*	∠	*angle*
d	*differential*	∅	*empty set*
e	*base of natural logarithms (approximately 2.7183)*	∥	*parallel*
√	*radical sign, "square root of"*	∇	*gradient*
		…	*elisions*

Exceptions

Spell out the following terms in technical reports.

Note: They may be abbreviated in presentation materials (view graphs and slides).

$\forall$	*for every*
$\exists$	*there exists*
$\ni$	*such that*
$\therefore$	*therefore*

Define the following terms the first time they are used in a report.

σ or S	*standard deviation*
C.V.	*coefficient of variation*
χ^2	*Chi-square*
D.F.	*degrees of freedom*
S.E.	*standard error*

Frequently confused terms

capital *K*, lowercase *k*, and Greek κ
lowercase Roman letter l and numeral 1
capital letter *O*, lowercase *o*, Greek o, zero (0), and degree sign ($^\circ$)
prime ($'$), single quote (’), superscript 1 (^{1}), and accent mark ($\acute{}$)
comma (,) and subscript 1 ($_1$)
the letters *r* and *n* and Greek γ and η
capital letter *S*, lowercase *s*, and numeral 5
capital letter *Z*, lowercase *z*, and numeral 2
capital letter *X*, lowercase *x*, Greek ψ, Greek χ, numeral 4, and multiplication sign ($\times$)
capital letters *V* and *U* and symbols $\vee$ and $\cup$
Greek ε and symbol for “is an element of” ($\in$)
italic letter *a* and Greek α and proportion symbol ($\propto$)
italic letter *u*, Greek μ, and Greek υ
italic letter *v*, Greek ν, and Greek υ
italic capital letter *B* and Greek β
symbol for “empty set” ($\varnothing$) and Greek φ
symbol for “is less than” (<), angle bracket ($\langle$), and angle symbol ($\angle$)
tilde symbol (~) and the symbol for equivalency ($\sim$)

2.2.1.3 Abbreviations

Set abbreviations in mathematical expressions according to the following list. Conform to the capitalization in the examples. Do not italicize them, and do not add punctuation.

arg	*argument*	cosh	*hyperbolic cosine*
av	*average*	cot	*cotangent*
Cl	*closure*	coth	*hyperbolic cotangent*
conj	*conjugate*	cov	*covariance*
cos	*cosine*	csc	*cosecant*

csch	*hyperbolic cosecant*
det	*determinant*
diag	*diagonal*
dim	*dimension*
erf	*error function*
exp	*exponential function*
GCD	*greatest common divisor*
GLB	*greatest lower bound* (also *glb*)
grad	*gradient*
hom	*homology*
Im	*imaginary*
inf	*inferior* or *infimum*
int	*interior*
inv	*inverse*
ker	*kernel*
LCD	*least common denominator*
lim	*limit*
log	*common logarithm*
ln	*natural logarithm*
LUB	*least upper bound* (also *lub*)
max	*maximum*
min	*minimum*
mod	*modulus*
sec	*secant*
Prob	*probability*
Prop	*Property* (also *P*)
Re	*Real*
sech	*hyperbolic secant*
sin	*sine*
sinh	*hyperbolic sine*
sup	*superior or supremum*
tan	*tangent*
tanh	*hyperbolic tangent*
tr	*trace*
var	*variance*

2.2.2 Spacing

2.2.2.1 Vertical and Horizontal Spacing

Vertical spacing

- Double space above and below a displayed equation.
- Double space above and below the word “where” that introduces a “where” list.
- Do not double space between the entries of a “where” list whose entries are mainly text.
- Do not double space between short, simple equations displayed in a list.
- Set the equation number to the right of the last line of a numbered displayed equation that consists of multiple lines.
- Center the equation number vertically flush right of an array of displayed equations if they are represented by a single identifying number.

Horizontal spacing

- Center displayed equations.
- Align the “where” that introduces a “where” list flush left.
- Indent “where” lists five spaces (one paragraph indent).
- If the equation is numbered, set the number flush with the right margin.

2.2.2.2 Character Spacing

No space

The following examples demonstrate where no spaces are needed between characters.

- between quantities multiplied together when no multiplication sign is used

$$2ab \qquad\qquad (p^{ab})(m_{xyz})$$

- between a symbol or abbreviation of a function and its subscript, superscript, or limit or between the elements of a subscript, superscript, or limit

$$\alpha^{x+y-z} \qquad\qquad \sin^{-1}\theta \qquad\qquad \lim_{x\to 0}$$

- between the sign and the quantity in signed quantities, when signs of operation are used as adjectives

$$\pm 0.5\% \qquad\qquad -3$$

- before and after fences

$$f(x) \qquad\qquad [a(b)](m/x^{\lambda})$$

One space

The following examples demonstrate where one space is needed between characters.

- on either side of mathematical signs of operation used as verbs

$$a = b \qquad\qquad a \geq b$$

- on either side of mathematical signs of operation used as binary operators

$$a + b = c\ .$$

- before and after abbreviations of functions set in Roman type and not preceded by or followed by fences

$$2 \sin \omega t \qquad\qquad \log a$$

- between fractions multiplied by other fractions or quantities

$$\frac{1}{2}\ \frac{2}{3}$$

- before and after summation, product, union, intersection, and integral symbols.

Note: When these symbols (and abbreviations such as km, sup, or max) carry limits extending to the right or left, the limit (rather than the symbol) is used as the starting point for counting the one space

$$3N \lim_{x \to \infty} \rho_n(x) \qquad \int_0^1 \left(x^2 - 2tx\right) dt \qquad \sum_{1=1,\ldots,n} x_i y^{i-1}$$

- to separate differentials, derivatives, and like symbols from other expressions by which they are multiplied

$$2x \frac{dy}{dx} \qquad t^2 \frac{\partial^2 R}{\partial t^2} \qquad x \Delta x$$

- after the commas in sets of symbols, sequences of fractions, and coordinates of points

$$\{p_1, p_2, \ldots, p_n\} \qquad x = (2, 3)$$

- before and after vertical rules when they appear singly rather than in pairs and before and after a colon that is used as a mathematical symbol rather than as a mark of punctuation

$$ma / b \; x : x \; \varepsilon \; \mathrm{Re}$$

- between a displayed equation and its end punctuation

$$\int e^x = f(u^n) \; .$$

Two spaces (displayed expressions only)

Typically at ORNL, two spaces are left between a displayed equation and its terminal punctuation.

Three spaces (displayed expression only)

The following examples demonstrate where three spaces are needed between characters.

- between two separate equations on the same line

$$x^2 - y^2 = a^2 \; 2x = y$$

- between a statement and a condition on the statement

$$x^a - y^a = 36 \; (a = 1, 2, 3, \ldots, n)$$

- between an equation and parenthetical units-of-measure notation

$$V = s/t \; (m/s)$$

- between an equation and a verbal expression (limit)

$$E_n(f)^3 \to e^{-t} \text{ as } t \to \infty$$

2.2.3 Preferred Breaks

The following guidelines for breaking mathematical expressions, either in lines of text that wrap or in displays, are given in order of preference.

- at any “three-space” break;
- at an operator that is a verb and that does not occur within symbols of inclusion;
- at an operator that is used as a binary operator and that does not occur within symbols of inclusion;
  - for in-text breaks, set the operator (i.e., the verb or sign of operation) on either the first or second line of type, and
  - for displayed equations, always set the operator on the second line;
- between two adjacent sets of fences unless a symbol of collection precedes the fences. (a times sign must be inserted on the second line before the second set of fences);
- at an operator (verb or symbol of operation) within symbols of inclusion unless no other break is possible;
- never after a symbol of collection until an operator occurs outside of fences. For an integral sign, do not break until after a *d*;
- never between fences in expressions in mathematical logic; and
- never at a slash (/).

In the following example,

- the best break is before “for,”
- the next best break is before “=,” and
- the third choice is before first “–.”

$$\sum_{j=1}^{n} a_j^2 \sum_{k=1}^{n} b_k^2 - \left(\sum_{k=1}^{n} |a_k b_k| \right)^2 = \frac{1}{2} \sum_{j=1}^{n} \sum_{k=1}^{n} \left(|a_j b_k| - |a_k b_j|^2 \right) \qquad \text{for } j,\ k \ \varepsilon\ 1,2,\ldots, \quad .$$

2.2.4 Grammar

Mathematical expressions, either embedded within text or displayed, should read either as complete sentences or as clauses within sentences. For that reason, they should conform to standard rules of grammar. The following guidelines address common problems when mathematics is mingled with text.

- Do not begin a sentence with a mathematical symbol or a number.
- Do not omit the word *then* in “If, then” constructions:

If $a = b$, then $b = c$.

- Avoid dangling participles in text used to introduce mathematical expressions, just as you would elsewhere (e.g., “Using . . .” and “Substituting . . .” constructions) .

2.2.5 Punctuation

Read mathematical expressions in the context of their surrounding text, and punctuate them so that they conform to the context in which they are expressed.

Fences are used in matched pairs in the following order: {[( )]}, and this order may be repeated as necessary.

Note: Make fences large enough to cover the expression that is being enclosed.

Exceptions

Combinations of fences, such as ( ] can occur in set notation. For example, (0, 1] means "the interval between 0 and 1 and including 1. The symbol | may be used alone to mean "such that" (also defined by ":") or "divides."

Use the special word-processing character when setting ellipsis dots (elisions) in mathematical expressions.

$$1,2, \dots , .$$

2.2.6 Cross References

2.2.6.1 Reference Callouts

Do not place callouts to footnotes or references on a mathematical expression.

2.2.6.2 Numbered Equations

If displayed equations are numbered, number them either sequentially throughout an entire report (1, 2, 3, . . .), or by chapter (1.1, 1.2, 1.3, . . .). At the beginning of a sentence, use the spelled-out word "Equation" when cross-referring to a numbered equation. Otherwise, use the abbreviation "Eq." Set the number in parentheses.

Equation (1)
Eq. (3)
Eq. (2.2)
Eqs. (6) and (7)
Eqs. (4.1)–(4.15)

2.3 NUMERICAL TERMS

The following guidelines address most of the conditions under which quantities are expressed as either numerals or words in a technical document. Most of the guidelines are accompanied by examples. The guidelines are divided into four parts: (1) counting numbers, which do not carry with them units of measure; (2) measurements, which include linear and angular dimensions, quantities (volume and mass), and time; (3) situations in which guidelines for counting numbers and measurements overlap; and (4) numbers used within documents for reference.

2.3.1 Counting Numbers

2.3.1.1 Cardinal Numbers

If a sentence contains only one number, and that number is not used with a unit of measurement, quantity, or time, use a numeral if the number is more than ten; spell out the number if it is ten or less.

We tested ten samples.
We tested 11 samples.

If a sentence contains two or more numbers (none of which are measurements), and if at least one of the numbers is greater than ten, use numerals for all of them. Otherwise, spell them all out.

Note: Apply this guideline separately to each sentence.

Each of 15 major commodities (5 metal and 4 nonmetal) was available.
Each of nine major commodities (five metal and four nonmetal) was available.

Spell out rounded and approximate numbers.

a chance in a million

Note: Numbers in round amounts of a thousand or more may be expressed partially in words rather than with zeros. Repeat the unit (thousand, million, billion) with each number to avoid misunderstanding.

10 billion galaxies
between 20 thousand and 30 thousand employees

Spell out fractions that do not express measured amounts. Hyphenate spelled-out fractions.

three-fourths of the research team
one-tenth of the sample

2.3.1.2 Ordinal Numbers

Spell out ordinal numbers that represent quantities of 100 or less.

first, second, . . . ninety-ninth

Use a combination of digits and suffixes to express ordinal numbers that represent quantities greater than 100:

101st, 102nd, 103rd, 104th

If two or more ordinal numbers appear in one sentence, and if one of them refers to a quantity of more than 100, set all of them with digits and suffixes.

Results were identical for both the 1st and 200th trial.

2.3.2 Measurement, Quantity, and Time

2.3.2.1 General Considerations

Always express units of measurement, quantity, and time in numerals accompanied by the corresponding labels.

7 m 1.5 kg 2.5 h

Keep a value and its unit of measure together; never split a value from its label from one line of text to the next or from one page to the next.

2.3.2.2 Decimals

Write decimals in numerals. Put a zero before the decimal point in numbers less than one, and omit zeros after the decimal point unless they are significant digits.

1.25 cm
0.25 cm

Exceptions

Do not set a zero before the decimal point on the approximate dimensions that are used to identify firearms and their projectiles.

We helped to develop a frangible .223-caliber bullet.

Do not set a zero between values less than one dollar and the dollar sign.

The value of a quarter is $.25

2.3.2.3 Percentages

Express percentage in numerals and use the percent symbol (%) after the numeral. Do not set a space between the percent symbol and its quantity.

15%, (40 ± 2)%
50 g ± 2% (*not* 50 ± 2% g)

In the cases of atomic percent, volume percent, and weight percent, add spaces around the percent sign, its quantity, and the intervening modifier:

25 at. %
10 vol %
15 wt %

2.3.2.4 Ratios and Proportions

Always write ratios and proportions in numerals. *Note:* Set spaces on both sides of the colons in these expressions.

a 4-to-1 ratio or a 4 : 1 ratio
a proportion of 5 to 1
7 parts of benzene to 3 parts of water
1 : 3 : 5 of powder : alcohol : water

2.3.2.5 Degrees: Temperatures and Angular Measurements

Temperatures

To express Fahrenheit or Celsius temperatures, set the value, followed by the degree symbol, followed by the appropriate uppercase letter (F or C). Do not space between the three elements.

0°C = 32°F

To express kelvin temperatures, set the value followed by a space and the uppercase letter K.

0°C = 273.15 K

Spell out the word “degree” in general references to temperature.

The reaction raised the temperature of the solution by several degrees.

Angular measurements

To express an angular (arc) dimension, set the value followed by the degree symbol. Do not space between the two elements. If the value is given in the finer tolerances of minutes (′) or seconds (″) or both, display them following the degree symbol with no spaces between them. *Note:* Use the appropriate characters for minutes and seconds; do not use single and double quotation marks.

10°30′5″

Spell out the word “degree” in general references to arc measurements.

The angle of incidence had shifted by a degree or two.

Express latitude and longitude in the same way as other arc dimensions, but add labels that specify latitude or longitude and a compass direction. Set the label for latitude (lat.) or longitude (long.) and a space first, followed by the measurement and a space, followed by the compass direction (N, S, E, W).

lat. 8°38′5″ N
long. 83°11′1″ W

2.3.2.6 Periods of Time

General considerations

Use numerals to express specific periods of time.

45 s
8 min
6 h
90 d
7 weeks
2 years

Express general references to time and references to decades and centuries in words.

in a year or two
three decades
four centuries

Use an en dash to separate ranges that describe a fiscal year, consecutive years, or a continuous period of 2 years or more. Shorten the year following the dash to two digits if it does not introduce ambiguity.

FY 1998–99
1900–1901
1895–1914

Note: Do not use a dash if the preposition "from" precedes the range or if the word "inclusive" follows it; replace the dash with the word "to" and do not shorten the second year.

from 1933 to 1936
1980 to 1985, inclusive

Clock time

If time is recorded with reference to a 12-h clock,

- use numerals followed by A.M., M., or P.M.,
- set A.M., M., and P.M. consistently, either in small capitals or lowercase letters, and
- separate hours and minutes with a colon (no spaces).

9:30 A.M.
12 M. (noon)
12:01 P.M. (1 min past noon)
12 A.M. (midnight)

If time is recorded with reference to a 24-h clock, use a four-digit sequence with no punctuation:

0800 (equivalent to 8:00 A.M.), 1400 (equivalent to 2:00 P.M.)

Note: Do not combine the term "o'clock" with terms expressed according to the preceding guidelines. Spell out general references to time.

The meeting was held at six o'clock on Thursday evening.

Dates

When formatting dates within a document, consistently apply one of the following formats:

May 31, 1999
31 May 1999
5/31/99

If only the month and year are given, do not separate them with a comma.

July 1999

Spell out general references to the time of year.

the first of May.

2.3.2.7 Currency

Use numerals and the dollar sign to express U.S. currency.

$175.37

Do not set a zero in front of the decimal in amounts less than one dollar.

$.37

Note: If amounts less than a dollar are labeled with a cent sign (¢), express the amount as a whole number (unless the amount is less than one cent).

$.37 = 37¢

Currency in round amounts of a thousand or more may be expressed by a dollar sign followed by numerals followed by K (thousands) or M (millions). Do not space between the elements that compose these expressions.

$4K
$360M

2.3.3 Numbers Used for Reference

Style text callouts according to the following examples. Spell out abbreviated terms if they are the first word of a sentence. (See Chap. 2 for further guidance with numbered references and their in-text callouts.)

Fig. 14
Table 4
Sect. 1.2
Eq. (1.2)
Chap. 1.2
page 170
drawing 26
experiment 1
paragraph 4

2.3.4 Combined Numbers

Different types of numbers (counting numbers, measured amounts, mathematical expressions, and cross references) often appear together in technical writing. Consistent expression of numbers is not a

matter of making them all look alike; it is a matter of consistently applying the rules unique to each type of number. Consider each sentence individually and apply the rules to each number within the context of the sentence in which it appears.

2.3.4.1 General Considerations

If a sentence contains a combination of different kinds of numbers (measured amounts and counting numbers) treat each type according to its own rules, independently of the others.

Five of the ten samples tested on June 3, 1998, weighed 2 g each.

Never begin a sentence or a title with a numeral. Spell the number or recast the sentence.

Eleven samples were tested.
We tested 11 samples.

Spell out numbers greater than ten that precede a compound modifier containing a numeral.

We tested twelve 2-kg samples.

2.3.4.2 Mathematical Expressions

Use numerals to represent numbers in mathematical expressions, whether they be abstract numbers or quantities.

multiplied by 3
a factor of 5
integrated from 0 to 1
$2\ \text{ft} \times 3\ \text{ft} = 6\ \text{ft}^2$

2.3.4.3 Punctuation

Commas

Do not add commas to four-digit values in text. However, add a comma to values that have five or more digits to the left of the decimal.

1234 kg 11,427 kg

Do not add commas to four-digit values in tables that do not contain values that exceed four digits. In a table that contains both four-digit and five-digit numbers, add commas to all of them so that they align with each other and so that the table is consistent internally.

En dashes

Use an en dash to denote a range of measurements unless the values are preceded by a preposition. If the range is preceded by a preposition use the word “to” or “and” instead of the en dash. ***Note:*** Label the second value only with the unit of measure.

10–20%, in a range of 10 to 20%
90–100°C, from 90 to 100°C
between 15 and 30 samples

Hyphens

Hyphenate numbers and words that combine to form a unit modifier preceding the word that is modified. *Note:* Remember to distinguish between counting numbers and units of measure.

10-mm-diam rod (*but* a rod 10 mm in diameter)
6-m-long board (*but* a board 6 m long)
five-member panel
20-fold increase (*but* threefold, . . . ninefold)

Exception

Do not hyphenate a modifier consisting of a number followed by a possessive noun.

2 months' layoff
1 day's pay

When two or more dimensions that have the same unit of measure precede the item being measured, omit the label from all but the last dimension. Use suspensive hyphens to separate the dimensions. (Note the spacing in the examples). Do not hyphenate dimensions that follow the item being measured

2- to 5-m-thick sheets
2- or 3-mm tubing
2- by 4-in. boards, *but* boards 2 by 4 in. in cross section

In lists, when unit modifiers follow the item modified and refer back to it, hyphenate and use in the singular form of the unit of measure.

motor: ac, three-phase, 60-Hz, 115-V

Use a math font times sign "×" when more than two dimensions occur. Do not use hyphens in this type of expression.

2 × 4 × 8 m block

Hyphenate elements of spelled-out compound numbers from 21 to 99, a situation that may occur if the number starts a sentence. Also apply this guideline when one of these numbers appears as part of a number larger than 99.

twenty-one, . . . ninety-nine
one hundred forty-four

Set a hyphen between the numerator and denominator of a spelled-out fraction, except when one or the other already contains a hyphen.

one-half
two one-thousandths *or* two-thousandths

Set a hyphen between a telephone number and its prefix. If an area code, country code, or other dialing prefix is given (e.g., the “1” that precedes a toll-free number) hyphenate them as well.

555-0000
423-555-0000
1-800-555-1212

2.4 THE METRIC SYSTEM AND THE INTERNATIONAL SYSTEM OF UNITS

The metric system is based on the linear unit of one meter, from which were derived volumes (cubic meters and liters); from the volumes were derived mass values (kilograms), based on the amount of the water that would occupy those volumes. The metric system was subsequently refined into the International System of Units (originally, *Le Système International d’Unités* or SI), which formalized and expanded the conventions associated with metric use. The International System is widely used, but it is not a universally accepted standard. For that reason, a convention has developed so that technical documents meet the needs of an individual discipline while making the information easily understood by a wider audience; measurements recorded in English units are often accompanied by their equivalents in the International System, and vice versa.

Table 2.1 contains metric prefixes, their abbreviations, and the quantities they represent.

Table 2.1. Metric prefixes

Prefix	Abbreviation	Amount	Prefix	Abbreviation	Amount
exe	E	10^{18}	deci	d	10^{-1}
peta	P	10^{15}	centi	c	10^{-2}
tera	T	10^{12}	milli	m	10^{-3}
giga	G	10^{9}	micro	μ	10^{-6}
mega	M	10^{6}	nano	n	10^{-9}
kilo	k	10^{3}	pico	p	10^{-12}
hecto	h	10^{2}	femto	f	10^{-15}
deka	da	10^{1}	atto	a	10^{-18}

2.4.1 Unit Conversion

If unit conversion is required for a document, treat units of measure and their respective equivalents according to the following guidelines.

- State all measurements in the units in which they were taken.
- Convert the measurements into their equivalents.
- Set the converted values in parentheses after the original measurements.

In the following example, a measured inch is followed by its metric equivalent.

The disk measured 1 in. (2.54 cm) in diameter.

Note: Pitfalls exist for the editor in the seemingly simple task of unit conversion. For example, Fahrenheit temperatures are often restated as Celsius temperatures, such as for the freezing point of water: 32°F (0°C); however, if the temperature drops 32°F overnight, that does not mean that it has dropped 0°C. In this case a distinction must be made between measured temperatures and observed changes in temperatures, and that distinction may not be easily determined from the context. Therefore, the authors always need to verify that all converted values are correct.

2.4.2 Reference Sources

The American Society for Testing and Materials (ASTM) publication, *Standard for Metric Practice* (E 380), is a handy guide for applying the International System. The most recent edition of this booklet is available from ASTM; to obtain a copy, e-mail *service@astm.org* and request stock No. METRIC97.

See also the Web page maintained by the National Institute of Standards and Technology: http://physics.nist.gov/cuu/index.html.

2.4.3 Exceptions Followed at ORNL

The following guidelines, currently followed at ORNL, are either exceptions to ASTM E 380 guidelines or are chosen preferences in cases in which ASTM E 380 offers latitude.

- Use “eV,” “barn,” “rad,” “rem,” “curie,” and “roentgen.”
- Use “meter” and “liter” (not “metre” and “litre”).
- Use kW(e) and kW(t) as the way of further specifying power.
- Use commas instead of spaces in numbers with five or more digits.

Note: Four-digit numbers have neither commas nor spaces except as needed to align values in tables containing both four- and five-digit numbers.

2.5 CHEMICAL NOTATION

The purpose of this section is to help the writer express some of the more common forms of chemical notation accurately and consistently. The most frequently used types of notation (e.g., ionic charge, isotopes, oxidation state) are described. No attempt has been made to cover the entire subject. *The Merck Index: An Encyclopedia of Chemicals, Drugs and Biologicals* (now available on CD-ROM with text and structure search features) and the *ACS Style Guide* (published by the American Chemical Society) are recommended to those who frequently edit text containing chemical nomenclature.

2.5.1 Formulas

The compositions of simple compounds in terms of atoms of their elementary constituents are denoted by the familiar formulas:

WF_6 U_3O_8 UAl_3 UC ZrH_4 $Ca_{12}Be_{17}O_{29}$

In complex compounds, parentheses and brackets are used, as in mathematics, to enclose groupings taken as an entity:

$$Th(NO_3)_4 \qquad (n\text{-}C_4H_9)_4PI \qquad Zn_3[Fe(CN)_6]_2$$

Formulas for addition compounds (especially solvates), loosely bound to other compounds by weak electrostatic forces, are denoted by vertically centered dots and numerical coefficients, written with no spaces:

$$UO_2(NO_3)_2{\cdot}6H_2O$$

This notation means a combination of definite composition and must not be used to denote a mixture of substances.

In nuclear technology, often one encounters substances with the nature of compounds but of varying atomic composition. These are often described by formulas with nonintegral subscripts:

$$UO_{2+x} \qquad Eu_{5+x}MoO_{10.5+y} \qquad UN_{1.87} \qquad UO_{2.04}$$

One element can often partially substitute for another in a "solid solution." The substitution in the formula is indicated by a grouping in parentheses:

$$(Th,U)O_2 \qquad U(C,N) \qquad (Th–5\%\ U)O_2$$

Note that spaces are not used before or after commas or parentheses.

When a particular isotope is designated in a formula, the customary left superscript is inserted at the proper place:

$$^{242}PuO_2 \qquad {}^{10}B_4C \qquad (Th–3\%\ {}^{233}U)O_2 \qquad (U,Pu)^{15}N$$

2.5.2 The Written Word and the Chemical Formula

The full chemical name of a complex substance (particularly an organic compound) should be spelled out the first time the substance is mentioned, unless the generic name is well known or understood. Many abbreviations for long or complex names of compounds are acceptable, such as NADP for nicotinamide adenine dinucleotide phosphate.

Elements are generally spelled out when used in text. However, element symbols are used when three or more elements are mentioned together. For example:

> The major components in the material were found to be Al, Fe, Cu, and Ni.
> An element symbol should never be used to begin a sentence.

2.5.3 Ionic Charge, Number of Atoms, Atomic Number, and Atomic Weight

Four indices placed around the element symbol represent the following:

- atomic weight, left upper index;
- atomic number, left lower index;
- ionic charge, right upper index; and
- number of atoms, right lower index.

An individual isotope of an element is represented by the chemical symbol and a left superscript giving the mass number:

$$^{233}U \qquad ^{14}N \qquad ^{99}Tc \qquad ^{242}Pu$$

If the atomic number is to be emphasized, it is given by a left subscript:

$$^{235}_{92}U \qquad ^{238}_{94}Pu \qquad ^{4}_{2}He$$

Ionic charge, as a right superscript, should always be expressed by the number of the charge (if greater than one) followed by the plus or the minus sign (not a hyphen).

$$Na^{+} \qquad Cl^{-} \qquad Bi^{3+} \qquad O^{2-}$$

In formulas, the number of atoms is indicated as a right subscript:

$$Cl_2 \qquad H_2SO_4$$

If the formula of an ion is complicated (i.e., contains parentheses), it is often enclosed in square brackets and the charge indicated outside the right bracket to show that it applies to the whole formula:

$$[Fe(CN)_6]^{4-}$$

2.5.4 Oxidation States

Roman numerals are used in parentheses immediately after the name of an element to indicate its oxidation number (or state). For example:

iron(II) chloride ($FeCl_2$)	manganese(IV) oxide (MnO_2)
uranium(V) fluoride (UF_5)	cesium tetraiodonickelate(II) (Cs_2NiI_4)

2.5.5 Molarity, Normality, and Molality

Concentrations of liquid solutions, particularly aqueous solutions, are often described as molar, normal, and molal—designated respectively by *M*, *N*, and *m*—after a numerical value. The italic letter is preceded and followed by a space:

15.6 *M* HNO_3 5 *M* HNO_3–0.1 *M* HF 0.01 *m* H_2SO_4 0.1 *N* NaOH

2.5.6 Molecular Configuration

Configurational descriptors set in italics are used to designate the following:

1. The element in a heteroatomic chain or ring at which there is substitution:

   O-benzylhydroxylamine *N*-methylaniline

2. The prefixes *cis*- and *trans*-, as well as the structural prefixes *o*-, *m*-, and *p*- (representing *ortho*, *meta*, and *para* positions), used to designate isomers and disubstitutions:

   cis-$[Co(NH_3)_4CO_3]NO_3$ *trans*-decalin

   o-xylene *p*-bromophenol *m*-itroaniline

3. Cyclic structures distinguished from straight-chain structures by the prefixes *cyclo* or *n*-:

   cyclo-C_5H_{10} *n*-pentane

   Arabic numbers are used to indicate position when two or more substituents are present:

   1,3,5-trichlorobenzene 2,4,6-trinitrotoluene

2.5.7 Percent Composition

Compositions of solids, without any indication of combination or structure, are given by percentages:

Nb–1% Zr Mo–0.5% Ti–0.08% Zr ThO_2–0.5% CaO

Unconventional subscript notation such as the following should be avoided because it does not convey the intended meaning:

$Pt_{90}Rh_{10}$ for Pt–10% Rh $W_{74}Re_{26}$ for W–26% Re

The nontechnical reader would interpret it as an unusual chemical formula; technical readers may mistake it for atomic composition.

2.5.8 Superscripts and Subscripts

Superscripts and subscripts used in chemical notation may be numerals, single letters, Greek characters, mathematical symbols, or groups of scripts. Superscripts that appear to the *right* of a chemical compound or element containing a *right* subscript should immediately follow the subscript, as shown. In this instance, placing the superscript immediately above the subscript (i.e., “stacking” the two) is not recommended.

$$NO_3^- \qquad CO_3^{2-} \qquad SO_4^{2-} \qquad C_2H_3O_2^-$$

$$3Ca^{2+} + 2PO_4^{3-} \rightarrow Ca_3(PO_4)_2$$

However, superscripts that appear to the *left* of an element that also contains a *left* subscript (expressing atomic weight and atomic number) should appear directly above the subscript. In this case, stacking is required.

$$^{3}_{2}He \qquad ^{235}_{92}U$$

2.5.9 Nuclear Reactions

Nuclear reactions can be described by "equations" resembling chemical equations:

$$^{16}O + n \rightarrow {}^{16}N + p$$

Because most nuclear reactions involve the change of a nucleus by entry of a nuclear particle and departure of one or a small number of particles or a quantum of gamma radiation, a simple symbolic notation is most often used to describe these reactions. The target nucleus is followed by symbols in parentheses representing the entering and leaving particles and then by the product nucleus. The example shown above becomes $^{16}O(n,p)^{16}N$. Note that no spaces are left before or after either parenthesis or the comma. Symbols often used are *n* for neutron, *p* for proton, α for alpha particle, and γ for a quantum of gamma radiation.

Further examples:

$$^{232}Th(n,\gamma)^{233}Th \qquad ^{238}U(n,2n)^{237}U \qquad ^{6}Li(n,\alpha)^{3}H \qquad ^{10}B(n,\alpha)^{7}Li$$

2.5.10 Thermocouple Notation

No widely adopted practice exists for representing thermocouples. A thermocouple is a junction between two metals or alloys, individually called "thermoelements," arranged in a suitable circuit to produce an electrical signal that is a measure of the temperature of the junction. Although established conventions exist for designating the alloys, none exist for the junction between the alloys.

Use the abbreviation "vs" to separate the two thermoelements:

Chromel-P vs Alumel W–5% Re vs W–26% Re

Spell out the name of a chemical element if the other thermoelement is a chemical element or a spelled-out trade or common name:

rhodium vs platinum copper vs constantan

However, use the symbol for an element when it is joined to an alloy designated by symbols:

Mo vs W–26% Re Pt–10% Rh vs Pt

Standard practice is to name the positive element first. Because the editor cannot easily make this determination, the author's order should not be changed. Thus, in the last pair of examples given, neither should be reversed to match the other.

2.5.11 Chemical Equations

The chemical equation is a statement of what occurs in a chemical reaction. Ordinary chemical equations must be "balanced" so that equal numbers of atoms of each element appear on each side of the equation.

$$UF_6 + 3H_2 \rightarrow U + 6HF$$

$$UC_2 + CO_2 \rightarrow UO_2 + 3C$$

Some formulas bear numerical coefficients, which are not followed by a space. Also note that an arrow is used rather than an equals sign.

A double arrow, $\rightleftharpoons$, is used to indicate that an incomplete reaction reaches a state of "equilibrium," a balance in which the forward and reverse reactions are proceeding at equal rates:

$$Zr + H_2 \rightleftharpoons ZrH_2$$

$$3UO_2 + O_2 \rightleftharpoons U_3O_8$$

Equations are often modified to include other information. The physical state of a reactant or product is indicated in parentheses after the formula by "s" for solid, "l" for liquid, "g" for gas, "aq" for aqueous solution, and other abbreviations and words:

$$UC(s) + C(graphite) \rightleftharpoons UC_2(s)$$

$$UF_6(g) + 2H_2O(g) + H_2(g) \rightarrow UO_2(s) + 6HF(g)$$

Note that there is no space between the formula and the state designation. Frequently, information describing reaction conditions, such as temperature, pressure, and catalysts, is written above and/or below the arrow. This requires an arrow of appropriate length.

$$UO_2 + CCl_4(g) \xrightarrow{450\,^\circ C} UCl_4(s) + CO_2(g)$$

$$WF_6(g) + 3H_2(g) \xrightarrow[\text{Excess } H_2]{\text{Heat}} W(s) + 6HF(g)$$

In most cases, nonintegral coefficients are closed up to the formula:

$$UO_{2.23}(s) \rightarrow 0.885UO_{2.0}(s) + 0.115UO_4(g)$$

$$SO_2 + ½O_2 \rightarrow SO_3$$

Vertical arrows are used occasionally to indicate precipitation (↓) or gas evolution (↑). The arrow follows the formula of a reaction product, separated by one space:

$$UAl_2 + 6F_2 \rightarrow UF_6 \uparrow + 2AlF_3$$

Sometimes expressions that are not chemical designations are used in chemical equations to convey information:

$$UC_2 + 2H_2O \rightarrow UO_2 + \text{mixed hydrocarbons (e.g., } CH_4, C_2H_4)$$

2.5.12 Isotopes

There are two accepted ways to designate an isotope. When the name of the element is spelled out, the isotope mass number follows the name in the same size and typeface (not as a superscript or subscript). The number is preceded by a hyphen. This form *must* be used at the beginning of a sentence.

The preferred form is the use of the chemical symbol. When the chemical symbol for the element is used, the isotope number precedes the symbol as a superscript. This form may not be used at the beginning of a sentence. For example:

Who discovered ^{235}U?

Uranium-235 was used in this study.

2.5.13 List of Elements and Symbols

Table 2.2 contains a list of the elements and their symbols.

2.6 ABBREVIATIONS, ACRONYMS, AND INITIALISMS

2.6.1 Definitions

- Abbreviation: a shortened form of a word or phrase: Doctor of Philosophy (Ph.D.)
- Acronym: an abbreviation formed from the initial letter or letters of successive parts or major parts of a compound term: U.S. Army Development and Readiness Command (DARCOM)
- Initialism: an acronym formed from initial letters only: Oak Ridge National Laboratory (ORNL)
- Unit of measure: a label for quantitative information, usually given in an abbreviated form when matched with a quantity: kilometer (10 km), British thermal unit (10,000 Btu)

2.6.2 General Guidelines

Generally, define abbreviated terms where they first appear in the body text; place the abbreviation in parentheses immediately after the spelled-out term: Oak Ridge National Laboratory (ORNL).

Table 2.2. List of elements and symbols

actinium	Ac	hafnium	Hf	promethium	Pm
aluminum	Al	helium	He	protactinium	Pa
americium	Am	holmium	Ho	radium	Ra
antimony	Sb	hydrogen	H	radon	Rn
argon	Ar	indium	In	rhenium	Re
arsenic	As	iodine	I	rhodium	Rh
astatine	At	iridium	Ir	rubidium	Rb
barium	Ba	iron	Fe	ruthenium	Ru
berkelium	Bk	krypton	Kr	samarium	Sm
beryllium	Be	lanthanum	La	scandium	Sc
bismuth	Bi	lawrencium	Lr	selenium	Se
boron	B	lead	Pb	silicon	Si
bromine	Br	lithium	Li	silver	Ag
cadmium	Cd	lutetium	Lu	sodium	Na
calcium	Ca	magnesium	Mg	strontium	Sr
californium	Cf	manganese	Mn	sulfur	S
carbon	C	mendelevium	Md	tantalum	Ta
cerium	Ce	mercury	Hg	technetium	Tc
cesium	Cs	molybdenum	Mo	tellurium	Te
chlorine	Cl	neodymium	Nd	terbium	Tb
chromium	Cr	neon	Ne	thallium	Tl
cobalt	Co	neptunium	Np	thorium	Th
copper	Cu	nickel	Ni	thulium	Tm
curium	Cm	niobium	Nb	tin	Sn
dysprosium	Dy	nitrogen	N	titanium	Ti
einsteinium	Es	nobelium	No	tungsten	W[a]
erbium	Er	osmium	Os	uranium	U
europium	Eu	oxygen	O	vanadium	V
fermium	Fm	palladium	Pd	wolfram	W[a]
fluorine	F	phosphorus	P	xenon	Xe
francium	Fr	platinum	Pt	ytterbium	Yb
gadolinium	Gd	plutonium	Pu	yttrium	Y
gallium	Ga	polonium	Po	zinc	Zn
germanium	Ge	potassium	K	zirconium	Zr
gold	Au	praseodymium	Pr		

[a]Two names for the same element; *tungsten is* used primarily in the United States, and *wolfram* is used primarily in Europe.

Exceptions

- Redefine the abbreviated terms in each chapter of a large report if doing so benefits the reader.
- If a report contains many abbreviated terms, list them and their definitions in a separate section of the report front matter. In this case, you would not need to define the abbreviated terms in the body text.
- Use an abbreviated term in headings, if necessary, before its first occurrence in the body text; spell the term at its first occurrence in the text that follows the heading.
- Do not define abbreviations that have become familiar, particularly shorthand terms for foreign phrases: e.g., i.e., vs, Ph.D., et al., etc.
- Use the Latin term "i.e."(meaning "that is") to introduce a clause that restates and clarifies an idea. Use "e.g." (meaning "for example") to introduce a specific example that illustrates the point being made. In current usage, the English terms may be preferable. Clauses introduced by "i.e." or "e.g." typically appear either in parentheses or set off by a semicolon.

  Samples of various media (e.g., flora, soil, and water) were collected.

  Samples were collected according to the predetermined schedule; i.e., weekly and quarterly samples were collected.

- Begin a sentence with an abbreviated term if necessary.
- Set abbreviated terms in all capital letters and do not punctuate them unless conventional practice dictates otherwise: doctor of philosophy (Ph.D.); cash on delivery (c.o.d.).

2.6.3 Formation of Plurals and Possessives

- Form the plurals of most acronyms and abbreviations by adding " s " to the singular: depts., Nos., YMCAs, BWRs
- Form the plurals of single letters and abbreviations with periods by adding " 's ": the three R's, several M.D.'s.
- Form the plurals of single or multiple letters considered as a word by adding " 's ": U's, and's, if's.
- Form the possessives of acronyms and abbreviations by adding " 's " : DOE's travel plans, NRC's travel plans.

2.6.4 Choice of Article

Choose indefinite articles (a, an) to go with abbreviated terms to suit the pronunciation (not the spelling) of the term: a NASA report, a HFIR experiment, an FPS, an ORNL document.

Note: Often, an article is not needed when the abbreviated term is used as a noun: Most activities at ORNL are performed directly for DOE.

Use an article with an abbreviated term that is used as an adjective if it makes your meaning clear: The ORGDP powerhouse was built by a DOE subcontractor.

2.6.5 Guidelines for Units of Measure

Do not define a unit of measure unless it is likely that your readers will not recognize it. Generally, leave a space between a quantity and its label: 1 in., 10 L.

Exceptions

- Currency: $100.00
- Percentage: 10%
- Temperature, Fahrenheit, Centigrade (no spaces): 10°F, 10°C
- Map coordinates (no space between the number and the degree symbol): lat. 30° N, long. 90° W

Hyphenate a measurement if it is used as a compound modifier: 10-mL syringe, 1-in.-diam bolt.

If a unit conversion is required (such as from English to metric units), place the conversion in parentheses immediately following the measurement: 1 in. (2.54 cm). See the the following URL, posted by the National Institute of Standards and Technology, for a discussion of Système International (SI) units, on-line conversion tools, and the appendix of Special Publication 811, which contains a list of official conversion factors: http://physics.nist.gov/cuu/Units/index.html.

Use the singular abbreviation of units of measure for both the singular and plural.

Spell out units of measure if they are discussed in text without numbers: The speed limit signs are being changed from “miles per hour” to “kilometers per hour.”

Abbreviate units of measure when they are used with specific quantities: The speed limit is 20 km/h.

Use the solidus (/) to indicate division when necessary to show the quotient of two abbreviated units of measure; e.g, meter per second (10 m/s), kilogram meter per second (10 kg·m/s) .

Note: Do not use the solidus (/) as a shorthand for per if more than one occurs in a measurement: abbreviate 1.5 picocuries per square kilometer per year as either 1.5 pCi·km^2·year^{-1} or 1.5 pCi/(km^2·year), but not as 1.5 pCi/km^2/year.

2.6.6 Abbreviations List

absolute	abs	bar	spell out
acceleration due to gravity	g	barn	b
acoustic emission	AE	barrel	bbl
acre	spell out	becquerel	Bq
acre-foot	acre-ft	before Christ	BC
air horsepower	air hp	binary-coded decimal	BCD
alternating current	ac	board-foot	bd-ft
altitude	alt	body-centered cubic	bcc
American wire gage	AWG	boiling point	bp
ampere	A	brake horsepower	bhp
ampere-hour	A-h	British thermal unit	Btu
amplitude modulation	AM	bushel	bu
angstrom	Å	byte	B
anno Domini	AD	calendar year	CY
ante meridiem	a.m.	calorie	cal
antilogarithm	antilog	candela	cd
atmosphere	atm	candlepower	cp
atomic mass unit	amu	capacitance	C
atomic percent	at. %	cash on delivery	c.o.d.
atomic weight	at. wt	cathode-ray tube	CRT
audio frequency	af	cent (unit of nuclear reactivity)	spell out
average	av	centerline	℄
bachelor of arts	B.A. or A.B.	center of gravity	c.g.
		center of mass	c.m.
Bachelor of science	B.S.	centigram	cg

centimeter	cm
centimeter-gram-second	cgs
centimeters per second	cm/s
chapter(s)	Chap(s).
chemically pure	cp
chi-square	χ^2
circa (used with dates only)	ca.
circular mil	cir mil
coefficient	coeff
coefficient of variation	C.V.
cologarithm	colog
compare	cf
constant	const
continuous wave	cw
coulomb	C
counts per minute	spell out
counts per second	spell out
cubic feet per hour	ft^3/h
cubic feet per minute	ft^3/min
cubic feet per second	ft^3/s
cubic foot	ft^3
cubic inch	$in.^3$
cubic meter	m^3
cubic millimeter	mm^3
cubic yard	yd^3
curie (convert to becquerel)	Ci
cycle	spell out
cycles per minute	cycles/min
cycles per second (use hertz)	cycles/s
day	d
debye	D
decibel	dB
decigram	dg
decimeter	dm
degree	°
degrees Baume	°B
degrees Celsius (or Centigrade)	°C
degrees Fahrenheit	°F
degrees kelvin	K
degrees of freedom	D.F.
degrees Rankine	°R
degrees Reaumur	°Re
diameter	diam
diamond-pyramid hardness	dph
direct current	dc
doctor of jurisprudence	J.D.
doctor of medicine	M.D.
doctor of philosophy	Ph.D.
doctor of science	D.S.
dollar	$
dollars—million	$M
dollars—thousand	$K
dozen	doz
dyne	dyn
east	E
electromagnetic unit	EMU
electromotive force	emf
electron spin resonance	ESR
electron volt (use joule)	eV
electrostatic unit	ESU
entropy unit	eu
equation(s)	Eq(s).
equivalent	equiv
error function	erf
error function complement	erfc
estimated	estd
et alii (and others)	et al.
exempli gratis (for example)	e.g.
exponential	exp
face-centered cubic	fcc
farad	F
feet per hour	ft/h
feet per minute	ft/min
feet per second	ft/s
figure(s)	Fig(s).
fiscal year	FY
fissions per second	spell out
foot	ft
foot-candle	ft-c
foot-lambert	ft-L
foot-pound	ft-lb
foot-pound-second (system)	fps
free on board	f.o.b.
freezing point	fp
frequency	
high	hf
intermediate	i.f.
low	lf
medium	mf
radio	rf
superhigh	shf
ultrahigh	uhf
very high	vhf
very low	vlf
video	vdf
frequency modulation	FM
full width at half maximum	FWHM
functions (trigonometric)	
cosecant	csc
cosine	cos

cotangent	cot
secant	sec
sine	sin
tangent	tan
coversed sine	covers
versed sine	vers
functions (hyperbolic)	
cosecant	csch
cosine	cosh
cotangent	coth
secant	sech
sine	sinh
tangent	tanh
gallon	gal
gallons per hour	gal/h
gallons per minute	gal/min
gallons per second	gal/s
gastrointestinal	GI
Geiger-Müller	G-M
gigacycle (use gigahertz)	spell out
gigahertz	GHz
gigawatt	GW
Gilbert	Gi
grain	spell out
gram	g
gray	Gy
greatest common divisor	gcd
greatest lower bound	GLB (also glb)
hectare	ha
henry	H
hertz (singular and plural)	Hz
hexagonal close-packed	hcp
high voltage	hv
horsepower	hp
horsepower hour	hp·h
hour	h
hundredweight	cwt
hyperfine structure	hfs
id est (that is)	i.e.
inch	in.
inches of mercury	in. Hg
inches of water	in. H_2O
inch-pound	in.-lb
infrared	ir
inhour	spell out
inside diameter	ID
intelligence quotient	IQ
intermediate frequency	i.f.
intravenous	IV
iron pipe size	IPS
joule	J
kelvin	K
kiloampere	kA
kilobyte	kB
kilocalorie	kcal
kilocurie (convert to becquerel)	kCi
kiloelectron volt (convert to joule)	keV
kilogram	kg
kilogram meter	kg·m
kilograms per cubic meter	kg/m^3
kilogram-weight	kg-wt
kilohm	kΩ
kilojoule	kJ
kilometer	km
kilopound	kip
kiloton	kt
kilovolt	kV
kilovolt-ampere	kVA
kilovolts peak	kVp
kilowatt	kW
kilowatt-hour	kWh
kilowatt-hour (electrical)	kWh(e)
kilowatt-hour (thermal)	kWh(t)
kinetic energy	KE
kip (1000-lb unit of deadweight)	kip
kips per square inch	ksi
knot	spell out
lambert	L
latitude	lat
least common denominator	LCD
least common multiple	lcm
limit (mathematics)	lim
linear energy transfer	LET
linear foot	lin ft
liter	L
logarithm (common)	log
logarithm (natural)	ln
longitude	long.
Loss-of-coolant accident	LOCA
lumen	lm
lux (singular and plural)	lx
magnetohydrodynamic	MHD
magnetomotive force	mmf
mass median diameter	MMD
master of arts	M.A. or A.M.
master of science	M.S.
maximum	max
maximum credible accident	MCA

maximum permissible concentration	MPC
maximum permissible dose	MPD
mean free path	mfp
mean sea level	MSL
mega (prefix)	M
megabyte	MB
megapascal	MPa
megasecond	Ms
megaton	Mt
megavolt	MV
megavolt-ampere	MVA
megawatt	MW
megawatt-day	MWd
megawatt (electrical)	MW(e)
megawatt-hour	MWh
megawatt-second	MWs
megawatt (thermal)	MW(t)
megawatt-year	MW-year
megohm	MΩ
melting point	mp
meter	m
meter kilogram	m·kg
meter-kilogram-second (system)	mks
meters per second	m/s
mho (use siemens)	spell out
microampere	µA
microampere-hour	µA·h
microcoulomb	µC
microcurie	µCi
microequivalent	spell out
microfarad	µF
microgram	µg
microhenry	µH
microhm	µΩ
microinch	µin.
microliter	µL
micromolar	µM
micromole	µmol
micron/micrometer	µm
microsecond	µs
microvolt	µV
microwatt	µW
mil	spell out
mile	spell out
miles per hour	mph
mill	spell out
milliampere	mA
millicurie (convert to becquerel)	mCi
milliequivalent	meq
millifarad	mF
milligram	mg
millihenry	mH
milliliter	mL
milli-mass-units	mmu
millimeter	mm
millimeters of mercury	convert to Pascals
millimole	mmol
milliohm	mΩ
million	M
million electron volts	MeV
million gallons per day	Mgd
millirad	mrad
millirem	mrem
milliroentgen	mR
millisecond	ms
millivolt	mV
milliwatt	mW
mils per year	spell out
minimum	min
minute	min
molal	m
molar	M
mole	mol
molecular weight	mol. wt
mole percent	mol %
month	spell out
nanogram	ng
nanometer	nm
nanosecond	ns
neper	Np
neutron	spell out
newton	N
normal (concentration)	N
north	N
nuclear magnetic resonance	nmr
nuclear magneton	µN
number(s)	No(s).
ohm	Ω
ohm-centimeter	Ω-cm
ohm-foot	Ω-ft
ounce	oz.
outside diameter	OD
page(s)	p. (pp.)
parts per billion	ppb
parts per million	ppm
pascal	Pa
percent	%
per thousand	‰