

## DECLARATION

I, Wayne Strickland, based on my personal knowledge and information hereby declare:

1. I am the Acting Associate Director of the National Technical Information Service ("NTIS") of the U.S. Department of Commerce. NTIS is a clearinghouse for scientific technical information produced by or for federal agencies, which information, by law, must be reported to the NTIS where it is cataloged, organized, preserved and disseminated to the public. (15 USC § 3704b).
2. I have been employed at NTIS since 1999.
3. As part of my role as the Acting Associate Director of NTIS, I am familiar with the operation of NTIS and National Technical Reports Library ("NTRL"), including how technical reports and documents are recorded, cataloged or otherwise entered into the system, and how they become available to the public.
4. I make this declaration based on my personal knowledge and information contained in the records of the NTIS and NTRL.
5. NTIS makes publicly available documents dating back to at least 1964 with bibliographic data.
6. Exhibit A is a true and correct copy of the 2011 NTIS Search Guide stating that documents collected and published by the NTIS are available to the public via NTRL. The Search Guide also includes information about companies that provide bibliographic data. The Search Guide specifies that in the 1960s NTIS and other federal libraries adopted standard guidelines for cataloging technical reports. Documents published by NTIS are cataloged with bibliographic data that includes: author name, document title, document abstract, a unique ID number, and keywords, descriptors or identifiers related to document contents. Documents collected and published by NTIS since the cataloging guidelines were implemented in the 1960's were organized, cataloged, and made available to the public by NTIS through NTRL with the bibliographic information specified above.
7. Exhibit B is a signed copy of an NTIS letter confirming the approximate date that "A Cementation Process for Minerals Recovery from Salton Sea Geothermal Brines" by Maimoni, A., NTIS ID number DE82014954, was added to the NTIS Bibliographic Database.
8. Exhibit C is a true and correct copy of "A Cementation Process for Minerals Recovery from Salton Sea Geothermal Brines" by Maimoni, A., NTIS ID number DE82014954.

I declare that the foregoing is true and correct.

Sworn to this \_\_\_th day of \_\_\_\_\_, 20\_\_\_, in \_\_\_\_\_, \_\_\_\_\_

By: Wayne Strickland Digitally signed by Wayne Strickland  
Date: 2019.09.25 17:35:52 -04'00'



**UNITED STATES DEPARTMENT OF COMMERCE**  
**National Technical Information Service**  
5301 Shawnee Road  
Alexandria, VA 22312

September 25, 2019

To Whom It May Concern,

This is in response to your inquiry in which you requested a confirmation of the availability of information from the National Technical Information Service (NTIS).

NTIS announced the availability of the document "A Cementation Process for Minerals Recovery from Salton Sea Geothermal Brines" by Maimoni, A., NTIS ID number DE82014954, through the following means:

The bibliographic reference/abstract was added to the NTIS Bibliographic Database as part of issue 197601 available "on or about" January 1983.

"On or about" refers to the document being available in the NTIS Database within a month of the date provided above.

Best regards,

**Wayne Strickland** Digitally signed by Wayne Strickland  
Date: 2019.09.25 16:48:04 -04'00'

Wayne Strickland, Acting Associate Director  
Office of Program Management  
National Technical Information Service

# **NTIS<sup>®</sup> DATABASE**



**SEARCH**

# **GUIDE**

**National Technical Information Service**  
U.S. Department of Commerce  
5301 Shawnee Road  
Alexandria, VA 22312

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## Introduction

### Organization of the Search Guide

**Section I - Introduction:** Provides a basic introduction to the features of the NTIS Database, how it differs from other government and/or scientific and technical databases and how it supplements other government databases.

**Section II - NTIS Database Elements:** Each component field of the bibliographic record is defined with examples. Presents the record structure and composition of the NTIS Database. Changes in the use of a field are discussed. NTIS' names and labels for the fields in the bibliographic citation are identified.

**Section III – Online Searching Hints:** Includes online searching hints arranged alphabetically by topic and field. Points covered are: searching accession numbers and specially assigned information product type numbers; abbreviations, acronyms; biological species; chemical studies; and verbalization of scientific and mathematical symbols. Distinctions between sponsoring agencies and performing agencies in the corporate author field are shown.

The NTIS Subject Category Codes are interpreted with emphasis on health care and medicine, environment, and business-related information. Geographic features and locations are demonstrated as well as discussions of developing country, foreign language documents and translations. Searching for reprints, maps, patents, and environmental impact statements are also covered. The placement and meaning of sponsoring agency acronym codes are also noted.

**Section IV – Selected References for Assistance in Searching the NTIS Database:** Contains a list of references to the authority files used by NTIS and its cooperating agencies at the Department of Energy, NASA and the Defense Technical Information Center.

**Section V – Online Access:** Presents contact information for the vendors that provide access to the database, including the company name, address, telephone number and fax number. Each online service's search and display commands are presented. An NTIS Database bibliographic record is furnished in each vendor's format showing the vendor Field Names and labels for the NTIS Database. Vendor system features are listed. For additional examples of the search process, request individual documentation from each online vendor.

**Appendix A – NTIS Subject Categories:** Alphabetical Listing by Major Categories

**Appendix B – NTIS Subject Categories:** Alphabetical Listing of All Categories

**Appendix C – NTIS Subject Categories:** Alphabetical Listing with Scope Descriptions

**Appendix D – NTIS Subject Categories:** Numerical Listing of Major Categories

**Appendix E – NTIS Subject Categories:** Numerical Listing with Scope Descriptions

### Purpose of the Search Guide

This guide provides the information necessary for productive, efficient and cost-effective search and retrieval.

Use this manual to:

- Minimize "false hits," which are common to such large and varied databases;
- Clarify the NTIS Database information derived from multiple government sources;
- Gain an in-depth understanding of the database structure;
- Provide background references and historical perspective; and
- Serve as a reference manual for users, or a teaching tool at training seminars.

### Audience

This publication targets:

- New online searchers;
- Users who are familiar with online search techniques but not familiar with the NTIS Database;
- Librarians or instructors who train users of library services; and
- Researchers using online systems.



## Section I

### Introduction

The NTIS Database contains summaries of scientific, technical, engineering, and business information products acquired by NTIS from 1964 to the present. Printed or microform indexes provide access to the titles that predate the online database. The database is available to the public through a number of commercial vendors that are listed in Section V. The NTIS Database is updated on a weekly basis by NTIS. However, commercial vendor update schedules can vary.

The NTIS Database combines unclassified input from the Department of Defense, Department of Energy, and NASA, with that of numerous other government agencies, among which are the Environmental Protection Agency, National Institute of Standards and Technology, and Department of the Interior, to offer users a wide range of information resources. The full reports are available from NTIS for almost 90 percent of the titles announced on the database. There are more than 600,000 titles available in digital format.

### Leasing the NTIS Database

Organizations making frequent use of the NTIS Database for research purposes, or wanting to develop and distribute value-added products, may wish to consider leasing the NTIS Database directly from NTIS. Requirements and pricing information may be obtained by contacting the Office of Product and Program Management 703-605-6515.

### Subscription Access to the National Technical Reports Library

Organizations needing fixed-fee search and retrieval access to the more than 2,000,000 NTIS Database metadata records with links to more than 600,000 corresponding digitized full-text reports can subscribe to the National Technical Reports Library (NTRL). See page 15 for more information about the NTRL, or visit <http://www.ntis.gov/products/ntrl.aspx>.

### Document Delivery via NTIS

Reports are available from NTIS for almost 90 percent of the titles found in the NTIS Database. Customers can order full-text reports from NTIS by calling 1-800-553-6847 or (703)-605-6000. Customers can e-mail their document requests to: [orders@ntis.gov](mailto:orders@ntis.gov), or order from the NTIS Web site at <http://www.ntis.gov/>. NTIS Price Schedules are on the Web at <http://www.ntis.gov/pdf/price200805.pdf>.

### NTIS Online Searching Help Desk

The Help Desk will answer your questions on searching the database and its subject content from 8:30 a.m. to 5 p.m., Eastern time. Call (703) 605-6585.

### NTIS Database Distribution - Fiscal Year 2011

subject heading	percent
Administration & Management	13.00
Aeronautics & Aerodynamics	4.00
Agriculture & Food	6.00
Astronomy & Astrophysics	2.00
Atmospheric Sciences	4.00
Behavior & Society	16.00
Biomedical Technology & Human Factors Engineering	2.00
Building Industry Technology	2.00
Business & Economics	10.00
Chemistry	5.00
Civil Engineering	4.00
Combustion, Engines, & Propellants	2.00
Communication	2.00
Computers, Control, & Information Theory	6.00
Detection & Countermeasures	3.00
Electrotechnology	2.00
Energy	6.00
Environmental Pollution & Control	10.00
Government Inventions for Licensing	0.1
Health Care	8.00
Industrial & Mechanical Engineering	2.00
Library & Information Sciences	3.00
Manufacturing Technology	2.00
Materials Science	3.00
Mathematical Sciences	3.00
Medicine & Biology	19.00
Military Sciences	13.00
Missile Technology	0.1.10
Natural Resources & Earth Sciences	11.00
Navigation, Guidance, & Control	0.5
Nuclear Science & Technology	3.00
Ocean Technology & Engineering	8.00
Ordnance	3.00
Photography & Recording Devices	0.5
Physics	10.00
Problem Solving Information for State & Local Governments	10.00
Space Technology	5.00
Transportation	6.00
Urban & Regional Technology & Development	10.00

*Note: Citations may have been coded with more than one category. The citations have been counted for each category used, on average 3-5 categories.*

## Scope of the Collection

On average, NTIS has added 30,000 new titles per year to the NTIS Database over the past ten years. These reports become a permanent part of the NTIS collection. As the U.S. Government's central technical and scientific information service, NTIS announces summaries of the research and studies sponsored by more than 600 Federal agencies as well as from state and local governments.

## Subject Coverage

Because the U.S. Government funds more than half of the research and engineering activities in the United States, the NTIS Database contains information on most scientific and technical subjects. The chart on page 2 shows this coverage for FY 2011. The subject categories, which NTIS uses in coding its database entries, are explained in detail in the appendices.

## Information Sources

The titles in the NTIS collection are submitted by hundreds of government agencies, numerous state and local governments, federal contractors, academic institutions, foreign governments, international organizations and private sector organizations.

Since the American Technology Preeminence Act (Public Law 102-245) passed in 1991, NTIS' wealth of information has increased dramatically. The ATPA requires all federal agencies to submit their federally-funded scientific, technical and engineering information to NTIS within 15 days of the date the product is made publicly available. Consequently, NTIS can provide its customers with timely access to a more diverse and comprehensive range of information.

## International Sources

NTIS is the lead U.S. Government agency for cooperation in international technical information exchange. Overseas organizations that currently contribute to the NTIS collection include the Japan Aerospace Exploration Agency, Environment Canada, Swedish Defence Research Agency, and many more.

## Information Product Types

The NTIS information collection contains a wide variety of types of publications, as well as other media for distributing information. The following table provides a snapshot of some of the types of information products received by NTIS in 2011.

<b>Types of Information Products</b>	
<i>U.S. Government Produced</i>	<i>Number</i>
Technical reports	28,037
Conference proceedings	1,428
Journal articles	2,349
Theses	1,078
Bibliographies	12
Computer Products	50
Audiovisuals	9
Patent application or Patents	21
<i>Foreign Acquisitions</i>	
Technical reports	208
Conference proceedings	0
Theses	0
Bibliographies	0

## Top Ten Foreign Contributors Fiscal Year 2011

<i>country of origin</i>	<i>number of citations</i>
1. United Kingdom	51
2. Sweden	34
3. International	30
4. Norway	28
5. Italy	18
6. China	18
7. India	9
8. Turkey	6
9. Pakistan	5
10. Hungary	4

## Section II

In the 1960's, under the aegis of the Committee on Scientific and Technical Information (COSATI), Federal Council on Science and Technology, the managers of scientific and technical information (STI) programs in the federal government adopted standard guidelines for cataloging technical reports. Four of these agencies, NTIS, the Department of Energy's Office of Scientific and Technical Information, the National Aeronautics and Space Administration's Scientific and Technical Information Program, and the Defense Technical Information Center, exchange bibliographic data and cooperate on information services-related projects. These agencies, along with the Department of Health and Human Services, sponsor more than 90 percent of federally funded research and development.

The fields of the NTIS Database are presented below in the order that they appear on the electronic media sent to online database vendors, and other organizations that lease the database from NTIS for internal use. Each vendor has a unique load of the NTIS Database and the placement of the fields and vendor Field Names may vary.

**Field Name: NTIS Order No.****Examples:**

Citations indexed and abstracted by NTIS  
PB2000-123456/XAB

Citations provided by NASA  
N2000-12345/6/XAB

Citations provided by the Department of Defense  
AD-A123 456/7/XAB, AD-D123 456/XAB,  
AD-M123456/XAB

Citations provided by the Department of Energy  
DE2000123456/XAB

**Definition:** Each title has a unique NTIS order number (accession number/identification number/product number) assigned in this field. This number should be used when ordering the title from NTIS.

All NTIS order numbers have alphabetic prefixes. Some alphabetic prefixes indicate the originating agency of the report collections, as shown in the above examples. The alphabetic prefix is followed by a five- to eight-digit number and three alphabetic characters. When searching, it is a good practice to truncate after the first six digits to find an accession number; however, when placing an order, the entire alphanumeric number order must be used.

*Note: Not all of the government agencies that have individual accession number alphabetic prefixes are shown in the examples. The examples are limited to agencies with the largest volume of records in the database.*

Search and retrieval systems may require removal of select characters (-, /, etc.) to retrieve the NTIS order number. Consequently, users are advised to refer to vendor documentation for search and retrieval guidance and recommendations.

**Field Name: Subject Category Codes**

**Examples:** 70A, 48D

**Definition:** NTIS classifies citations into 39 subject categories. Each of these subject categories is divided into subcategories. This method provides sorting categories for both hard and soft sciences. All subject categories consist of three character codes: two numerics and one alpha character. The numeric codes represent entire categories, the alpha codes are used to designate subcategories within these broad categories.

Any one document may have up to five subject categories assigned to it, although some documents may have more. If a title covers three or more subcategories of a major subject category, it is assigned to the general section of the major category code. Each citation in the database contains the full number of subject category codes that reflect the subjects covered by 20 percent or more of the report.

The NTIS Subject Category Classification System has been used exclusively since July 1986. A list of the subject category codes is included in this guide as Appendix B. It is used to arrange the citations into subject areas. COSATI category codes used prior to 1986 were converted to the NTIS Subject Category Code(s), thus the NTIS Database no longer contains COSATI codes 1-22.

**Field Name: NTIS Prices**

*Note: This field is not searchable.*

**Example:** PC A02/MF A01

**Definition:** These are alphabetic codes for each medium in which the item is delivered:

Download (DL), Paper Copy (PC), Color dependent (AC), Microfiche (MF), CD-ROM (CD), Audiovisual (AV), magnetic tape (mag tape), and diskette. The numeric part of the code determines the price of an individual item. The current NTIS Price Schedules are accessible from the NTIS Customer Support Web Page at <http://www.ntis.gov/pdf/price200805.pdf>.

**Field Name: Corporate Source(s)**

**Example:** Army Information Systems Command, Chambersburg, Pennsylvania.

**Definition:** This is the name of the organization(s) and/or author affiliation(s) that performed the research and prepared the report(s). The corporate source is also known as the corporate author and performing organization.

Since 1980, NTIS has maintained an up-to-date machine-readable corporate source authority list with standardized names and a nine-digit organization code number. The nine-digit code appears in the database and is searchable.

Some online services asterisk the performing organization names to distinguish them from the sponsoring organization(s). The names of organizations have been entered in full and in abbreviated forms.

**Examples:** Massachusetts Inst. of Tech  
Mass Inst. of Tech

## Field Name: Title

**Example:** Guide to Evaluating Thermal Effects in Concrete Pavements

**Definition:** The name of the document that appears on the title page or document cover. A colon is used when separating a subtitle from the main title.

Foreign language reports present the foreign language title first, followed by the English translated title in parenthesis. When English translations are made of foreign language documents, the English title is presented prior to the foreign language title.

## Field Name: Journal and Database Issue

This field contains a title's original announcement journal volume and issue in the format "JV VII":

where J = a letter designating the journal  
where VV = a two-digit volume number; and  
where II = a two-digit issue number.

**Example:** u9412, GRAI9412, GRA&I9412.

This corresponds to reports that were announced in GRA&I Issue 9412. Following the GRA&I issue number are letter codes that designate other agencies' announcement journals. Some online vendors list the example shown and some translated the "u" into GRAI or GRA&I with the volume and issue. "n" was the designated prefix code for documents which were announced in the *Department of Energy Announcement Journals Nuclear Science Abstracts* from 1964–1976 and *Energy Research Abstracts* from January 1976 – August 1976. After August 1976, the "n" code in this field was discontinued. "s" is used in this field to identify NASA documents announced in the journal, *Scientific and Technical Aerospace Reports (STAR)*. Some vendors use the "s" and some present the name of the STAR journal in this field. The GRA&I ceased publication in December 1996.

**Definition:** This field is used to identify the NTIS Announcement Journal volume and issue in GRA&I, and any source agency announcement journal volume and issue in which the citation first appeared.

## Field Name: Title Note

**Example:** Datafile, Audiovisual, Thesis, Software, Final Report, Master's Thesis, Patent, Patent Application, Models-simulation, VHS video, CD-ROM.

**Definition:** Additional title information that clarifies the document or report type.

## Field Name: Personal Author(s)

**Example:** Hyder, M. L., Smith, J. C.

**Format:** Full last name comma [space] first initial period [space] middle initial [period].

**Definition:** This field lists the personal author(s) name(s).

Format: Names are recorded in the same order and as they appear in the document, with first and middle initials. All titles, degrees, Jr., Sr., II, III and IV are omitted. Prior to 1984, some names appear with the last name followed by the first name and middle name or middle initial.

**Note:** There is no authority list for personal author names. Searchers will need to develop search strategies to provide for variations, using truncation, adjacent, etc., to obtain all the reports by one author. Truncation in online searching means to cut a word short at any point in its order, for example, to retrieve all terms with a common root or both singular and plural forms.

## Field Name: Report Date

**Example:** Dec 2010  
02 June 2010  
c19 Mar 2001

**Definition:** This field contains the date the document was completed. However, on translations and journal articles this date may correspond to some other time, such as the date of the translation, the date of the journal issue, the date of a filing for a patent, or the date of publication in some other journal.

**Note:** Beginning in mid-1978, a lower case "c" appears for the citations of copyrighted material, as seen in the third example.

## Field Name: Pagination or Number of Items

**Example:** 103 p\*  
1 mag tape  
2 diskettes

**Definition:** This field contains the number of paper or microfiche pages in a document. Blank pages are not counted. The field also notes the number of magnetic tapes, diskettes, VHS tapes, cassettes, etc.

**Note:** An asterisk appearing after the page count indicates that the report generated a great deal of interest when it was announced. This is not a searchable field.

## Field Name: Country of Publication

**Example:** France

**Definition:** The country in which the document originated or was published.

**Note:** Each online vendor provides either the full country name or code in its specific search process. International agencies may supply the country in which they are located. In some cases, this field may be blank because the source agency did not provide the information.



**Field Name: Language of Document****Example:** English, French**Definition:** The language in which the full document was written.*Note: If the abstract is in English, but the document is written in another language, then only the language of the full document is identified, and not the language of the abstract.***Field Name: Report Number****Example:** Department of Energy (DOE)  
ORNL/TM-2009/149National Science Foundation (NSF)  
ISBN-0-309-11699-6**Definition:** The number the sponsoring agency assigns to the title. Most report numbers have alpha prefixes followed by numerics. This field may be blank or may contain one or two report numbers assigned by the performing organization(s).*Note: When the performing and sponsoring organization are the same, the sponsoring organization's report number will appear in this field, but not in the monitor agency number field. If the document doesn't have an agency report number, this field is blank.***Field Name: Contract or Grant Number(s)****Example:** USDA-88-COOP-2-3482  
NSFNCCO-073158  
DE-FC07-06ID14750  
EAR-0625247**Definition:** This field contains the contract or grant number assigned by a federal agency to the research project which resulted in the cited document.**Field Name: Project and Task Numbers***Note: These have not been used since 1984.***Example:** UCAI-WRC-W-428 ARGUS Calibration**Field Name: Monitoring Agency Number****Example:** AFGL-TR-85-0194  
EPA/560/7-85/000-1**Definition:** This field provides the report number(s) assigned by the sponsoring organization(s) unless the latter is also the performing organization(s). When the sponsoring and performing organization are the same, the monitoring agency numbers are placed in the report number field.**Field Name: Supplementary Notes****Example:** See also...  
Supersedes...  
Other related reports  
Pub. in Proceedings of the  
American Control Conference...  
Sponsored by Department of Energy,  
Washington, D.C.  
Sponsored in cooperation with...  
Any additional information about the document**Definition:** This field presents: the source of a translation; language of a report, if other than English; source of a periodical citation; supplemental performing or sponsoring organizations; additional contracts or grants; and conferences, etc.**Field Name: Availability Statement****Example:** Also available as PBYYYY-1234  
Also available as a set of reports**Definition:** A statement of availability that appears when there are special ordering instructions, especially when a report is not available from NTIS or when the report is available from NTIS and another organization. Magnetic tapes and diskette products always carry a special descriptive statement in this field concerning their format.**Field Name: Descriptors****Example:** \*Corrosion prevention  
Air pollution control  
Mechanical properties**Definition:** Descriptors are single or multiword subject terms assigned by NTIS or other contributing agencies. These descriptors use the controlled vocabulary thesauri or word lists which appear in the reference list Appendix A.

Descriptors preceded by an asterisk are those terms determined to be of greatest importance in describing the subject content of a report. Use these asterisked terms to limit an online search. Reports indexed by NTIS are assigned descriptors for the most specific concepts covered in the documents and for applications of the research.

Reports announced by NTIS but indexed by another agency contain that agency's descriptors from its own thesauri. The two major agencies currently providing their own descriptors are: the Department of Defense Technical Information Center (DTIC); and the National Aeronautics and Space Administration (NASA).

**Field Name: Identifier****Example:** Nanomaterials  
National Study of Childcare Supply and  
Demand (NSCCSD)  
Aerodynamic braking  
Nanoelectronics**Definition:** Identifiers are single or multiword subject terms used to express concepts for which there are currently no adequate descriptors. As new concepts and technologies arise, new subject terms not found in existing thesauri are placed in the Identifier field.

Identifiers preceded by an asterisk have the same significance as Descriptors preceded by an asterisk. Identifiers include names of chemical compounds, cities, biological species, computer programs, research projects, scientific instruments, and more.

**Field Name: Abstract**

**Example:** Electron spectroscopy has become one of our most important tools for the study of electronic structure of solids and surfaces. Under this contract, we studied the passivation and inhibition of corrosion, utilizing the spectroscopic techniques of x-ray photoelectron absorption fine structure (NEXAFS).

**Definition:** Abstracts in the NTIS Database may be either indicative or informative, based on the type of document. Informative abstracts identify the methods, results, applications, and conclusions. Indicative abstracts describe content or scope, i.e., a handbook of chemical formulas, chapter titles, or table of contents of a textbook.

Abstracts are usually limited to 200 words. The NTIS Database contains a mixture of author and NTIS-written abstracts. Many of the author abstracts are modified by NTIS.

## Section III

**Abbreviations**

Abstracts and other fields often contain abbreviations. However, all subject terms are spelled out in the descriptor or identifier fields.

**Accession Numbers (also known as NTIS Order Numbers)**

NTIS order numbers consist of this pattern: alpha character-4 digit year-six digits-three letter code.

Example: PBYYYY-123456/XAB may be truncated as PBYYYY-123456 plus truncation symbol number, or PBYYYY123456.

When searching, truncate the number after the sixth digit. When searching for an NTIS order number there are two options: (1) to display a list of the neighboring order numbers to select the correct number and closing 3-letter code or; (2) to truncate the order number after the sixth digit following the year number.

NTIS produces PB numbers with a first digit or first two-digit number series designating a type of information product:

**Example:**

Subscription products	SUB
Standing order products	PB2010-9
Computer Products	PB2010-5
Computer Product Subscriptions	PB2010-59

(Each example should be followed by a truncation symbol, which varies by online vendor.)

Some agencies that maintain their own number series are noted in the accession number field description. The NTIS accession/order number is not always the same as the host vendor's. Searchers should review the record format and field qualifiers of the vendor(s) of their choice. Similarly, vendor Field Names may vary.

Searching for report numbers in the NTIS Database requires skill because of the punctuation used between letters and numbers. The above examples are specific to certain product types.

**Hint:** To limit a search to computer products, in addition to using descriptor or identifier terms such as "data file" and "software," combine the set with PBYYYY-5 plus truncation symbol.

**Acronyms**

NTIS spells out each acronym used in a citation if the author has supplied it, unless it is so common that it would be unnecessary to do so, e.g., DNA for Deoxyribonucleic Acid. Within the abstract, the phrase explaining the acronym is placed first, followed by the acronym in parenthesis. In the identifier field, both the complete phrase and acronym are provided for searching.

**Biological Species**

Plants, animals, and microorganisms are indexed with their genus and species names and/or the family name. The common name is also indexed if the author has used it and/or if it is known. If a

biological subject term is in one of the recommended thesauri, it is posted in the descriptor field.

Examples:

Descriptors: Parasite diseases

Identifiers: Liriodendron tulipifera  
and also Tulip tree.

Descriptors: Mammals; Carnivora; Taxonomy; Laboratory animals

Identifiers: Hyaena; Hyaena Brisson; Striped Hyaena, Felidae; Panthera leo persica

**Subject Category Codes/Classification****What they are**

NTIS classifies citations into 39 subject categories. Each of these subject categories is divided into subcategories. This method provides sorting categories for both hard and soft sciences.

All subject categories consist of three character codes: two numerics and one alpha character. The numeric codes represent entire categories such as chemistry, environmental pollution and control, civil engineering, et al. The alpha codes are used to designate subcategories within these broad categories. The number of NTIS subcategories posted to an information product average from one to five, although there are some reports with more.

**What they do**

Although most online searching is conducted using subject index terms (keywords), subject categories are also very important. Subject categories can be combined with keywords to eliminate false retrievals ("hits").

**Example:** Combining "Lead" with the NTIS subject category 57Y (Toxicology), retrieves report citations about the toxicity of lead, rather than lead use as an additive in iron alloys.

**Example:** Citations for "Geothermal energy" reports can be retrieved by searching the NTIS category 97P because this category is specific to geothermal energy.

*Note: Subject categories may be designated as Category Codes or Subject Headings by the online vendor. Always review field designations in the vendor(s) documentation.*

**NTIS Subject Categories**

Listed in Appendix B are the subject categories NTIS uses to classify new documents. Each subject category is followed by a list of secondary subject categories. Searches can be conducted by using the actual text of a subject category (i.e., management information systems), or using the subject category code (i.e., 70C) that follows each subject. Because each abstract in the database is indexed on all words in the abstract, searching using the subject category code will reduce the number of stray hits and provide a list of more relevant documents.

## Category Codes with Asterisks (Highlighted Subject Category Codes)

An asterisk displayed after the subject category code indicates that the report is highlighted for being particularly significant in its content, approach or presentation. To limit a search, use an asterisk with the subject code in the search statement.

## Chemical Nomenclature

NTIS uses the chemical names, trade names, CAS registry numbers, and common names included in the document as descriptors or identifiers. For a comprehensive retrieval, search all known names and classes of a compound.

Chemical compounds are listed with their common name, chemical name, and class of compounds. NTIS lists compounds hierarchically with their chemical classes posted in the descriptor field as well as the individual chemical name. If numerous chemical compounds are the subjects of the research, the classes of compounds are generally listed, but not each individual chemical compound.

Standard chemical abbreviations for the elements may be used in the abstracts, but the name of the element is always posted in its entirety in the descriptor field. Chemical elements may also be posted in their element groups, such as alkali metals, alkaline earth metals, rare earth metals, etc.

### Examples:

Descriptors: Hydrochloric acid  
Chlorine  
Anilines  
Amines

### Examples

1. Descriptors: Chlorobenzenes (general class)  
Identifiers: Trichlorobenzenes  
1,2,4-Trichlorobenzene  
1,2,3-Trichlorobenzene
2. Descriptors: Metals  
Platinum  
Precious metals (general class)  
Rhodium
3. Descriptor: Chlorobenzenes (general class)  
Identifier: Pentachlorobenzene (specific compound not found in recognized thesauri)
4. Descriptors: Chlorine organic compounds (general class)  
Chlorobenzenes  
Chloroform  
Carbon tetrachloride
5. Inorganic compounds not found in thesauri:  
Lead acetate  
Descriptor: Lead inorganic compounds  
Identifier: Lead acetate

Since 1979, the Chemical Abstract Service's (CAS) Registry Number System cites unique numbers if they are mentioned in the item being indexed. Registry numbers are recorded in two formats: the standard format *with* dashes between numbers,

or the abbreviated format *without* dashes. Thus the number may appear as "CAS Registry No: 10016-20-3" or as "CAS Registry No: 10016203" in the identifier field. It may also be known as "CAS No. 10016-20-3." Each online supplier has a field qualifier for these numbers.

### Example:

Identifier: Chloramines, CAS 7782505.

Identifier: Formaldehyde, CAS 50-00-0.

For industrial chemicals, pesticides, and pharmaceuticals, NTIS uses the Chemical Abstracts Service nomenclature and the approved common name. NTIS uses the United States Adopted Names (USAN) (Reference No.) when classifying drugs.

### Example:

Descriptor: Metal Complexes

Identifier: FDDC (Bis(trifluoroethyl)dithiocarbamate)

### Example:

Descriptor: Chlorinated aromatic hydrocarbons

Identifier: PCBs(Polychlorinated biphenyls)

Polychlorinated biphenyls

## Chemical Trade Names

Trade names such as Nylon are posted in addition to the generic plastic or polymer name.

**Example:** Descriptors: Nylon, Polyamide resins.

## Computer Programs and Products

Computer products include data files and software available on magnetic tape, diskette, DVD, CD-ROM, videotapes, and optical disks.

Search for items that identify programs and products by adding the terms "software," "computer programs," "datafile," and/or "model-simulation" whenever applicable. When searching for computer programs in machine-readable form, combine the terms "software" or "computer program" and the terms "magnetic tape" or "diskette," (found in the Title Note field, see p. 5 of this manual) using the appropriate field qualifier.

## Corporate Sources

Two types of corporate sources are found in the NTIS Database: performing organization(s) and sponsoring organization(s).

## Performing Organization(s)

Most reports are cataloged with the name of the organization(s) that prepared the report. When searching for corporate sources for the years prior to 1980, users must be aware of the cataloging differences caused by multiple agency rules. These differences generally occurred in abbreviations and in punctuation. In 1980, NTIS created a corporate source authority database and a nine-digit code for each corporate source, eliminating these discrepancies. The nine-digit codes appear in each citation.



### Sponsoring Organization(s)

The sponsoring organization is always a government agency. The sponsoring organization is listed if it is also the performing organization. Beginning with NTIS Database GRA&I issue 74-21, reports cataloged by NTIS have included the sponsoring organization as well as the performing organization. Beginning with NTIS Database GRA&I issue 76-21, DOE reports have been cataloged with the sponsoring organization.

Examples of performing organization(s) and sponsoring organization(s) in the same report(s):

- Example:** PB2010-100486  
**P.O.** Federal Interagency Forum on Aging Related Statistics, Hyattsville, MD.  
**S.O.** Bureau of the Census, Washington, DC.
- Example:** PB2010-100839  
**P.O.** Wichita State Univ., KS.  
**S.O.** Federal Aviation Administration, Washington, DC.
- Example:** DE2010-963080  
**P.O.** Rutgers - The State Univ., New Brunswick, NJ.  
**S.O.** Department of Energy, Washington, DC

See also listing under "Sponsoring agency keyword acronyms" on page 19.

### Data

Reports containing large amounts of tabular data are tagged by the keywords "Tables (Data)" or "Statistical data."

### Delimited/Declassified Reports

Declassified materials and reports with limited distribution status are added to the NTIS Database with the date it was acquired by NTIS, rather than the date the report was prepared. Generally the phrase, "Distribution limitation now removed" will be included in the Supplemental Notes in any record for declassified/delimited materials.

### Department of Defense (DoD) Declassified/Delimited Items

Declassified reports from the Department of Defense contain a special searchable code in the identifier field: NTISDODXA, NTISDODXB, NTISDODXD, etc. Using this code as a search term restricts a search to declassified reports, or, alternatively, to ensure that no such reports are included in the final search results. Between 1975 and 1977, more than 30,000 declassified items were added to the database. After 1977, NTIS receives documents from DOD as they are declassified. It is advisable to look for the phrase, "Distribution limitation now removed" on DOD reports in addition to the code.

### Developing Countries

NTIS announces reports for and about developing countries. Since 1979, NTIS has used the descriptor "developing country application" for titles relevant to foreign governments. Reports about a developing country are usually indexed with one of the following descriptors: "developing countries" or "developing nations." See also subject category code 96G and 96H.

### Environmental Impact Statements (EIS)

Environmental Impact Statements are the environmental reviews required for major federal projects that might adversely affect the environment. All previously released EIS were announced through the NTIS Database beginning with the June 1, 1971 update and ending with the April 15, 1974 update. Since then, NTIS has received irregular shipments of EIS.

Most of these environmental impact statements can be searched by entering the term, "environmental impact statements-Final" or "environmental impact statements-Draft" in the descriptor or identifier field. Some early EIS were not assigned either of these terms; however, they can be retrieved by searching for the prefix "EIS" as part of the NTIS accession/order number, truncating after the first three characters of the number, and using the appropriate field qualifier.

Another method of selecting EIS is to use the NTIS subject category code Environmental Impact Statements, 68H.

*Note: This subcategory has been in use since March 15, 1973.*

### Foreign Language

In 1979, NTIS created a field to classify reports written in a language other than English. Prior to 1979, reports in foreign languages were mentioned in the notes field. English cannot be searched directly.

### Reports of Non-U.S. Origin

Country names are assigned in the descriptor or identifier fields. Using a country name in the descriptor or identifier field searches for reports about that country.

Country names in citations prior to 1980 indicate that the document either originated in that country or that the document is about that country. In 1980, a field for country of publication was added to the bibliographic citation when the source country was other than United States. Since country codes are not assigned to documents originating in the United States, non-U.S. items can be eliminated using NOT logic.

*Note: Each online supplier provides search instructions for documents originating in the United States.*

### Foreign Research and Technology

In 1979, NTIS began using the subject term "foreign technology" to identify documents about current foreign research, techniques, and technology. Many of these reports have been prepared outside of the U.S., and include documents published as a result of fellowships or research programs awarded to foreign nationals and sponsored by U.S. government agencies.

## International Business Information

The NTIS Database contains a substantial amount of non-U.S. business-related information especially in the areas of science, engineering and technology. Reports include foreign market surveys, foreign sectoral analysis, industry subsector analysis, and other economic studies. Key sources of this type of information are: the U.S. Trade and Development Program, the International Trade Administration, and the Department of Commerce's Office of General Counsel. Titles are posted with "export trade information" and/or "foreign marketing" identifiers.

*Note: The terms foreign marketing and foreign technology are different. For example, tourism doesn't have a technology component, but it does have a marketing component.*

See also listing under "translations" on page 12.

## Geographical Areas

Geographic location is included only when it is an important facet of an indexed item.

The following indexing guidelines apply:

1. Items referring to an area in a country covering two or more states or provinces are indexed to the region and not the individual states or provinces:

**Example:** Central Regions (United States)  
Great Plains Region (United States)  
New England (exception- region not included)

2. Reports referring to individual states, provinces, or parts of states within a country are indexed to the states, provinces, and its parent political unit:

**Example:** Northwest Region (Iowa)  
Ozark Region (Missouri)  
Northern Region (Virginia)

3. States and other political regions, including cities, are modified with the country name except for those of Great Britain, Canada and the United States. They may be posted in the descriptor or identifier field.

**Example:** Arkansas  
Bavaria Region (Germany)  
British Columbia

4. Coasts are modified with the country or land area and posted in the identifier field:

**Example:** Atlantic Coast (United States)  
Atlantic Coast (Canada)  
Gulf Coast (United States)  
Pacific Coast (Mexico)

5. Natural features, other than coasts, do not receive a political modifier. The natural feature modifier appears last and is posted in the descriptor field.

**Example:** Mississippi Delta  
Susquehanna River Basin  
Mexico Gulf (for Gulf of Mexico)

6. Lakes and mountains appear as they are listed on standard maps. They are posted in the descriptor field.

**Example:** Alps Mountains (Europe)  
Lake Erie  
Great Salt Lake

## Government-Owned Inventions for Licensing (See also Patents)

Effective with NTIS Database GRA&I Issue 72-23 (Dec. 1, 1972), NTIS began to announce all patents and patent applications issued to U.S. government agencies that are available for public licensing.

Hint: U.S. government-owned applications can be searched by combining the terms "patents" or "patent applications" with NTIS Subject Category 90. If NTIS subject category 90 is not combined with either of these terms, foreign patents will also be retrieved.

## Health Care/Medicine Subjects

Since 1980, NTIS has used the National Library of Medicine's thesaurus, Medical Subject Headings-Annotated Alphabetic Listing, as its indexing authority for reports in the health care and medicine fields. The subject categories specific to this subject are:

- Medicine & Biology (57);
- Health Care (44); and
- Biomedical Technology and Human Factors Engineering (95).

Three subcategories specific to this subject are:

- Urban and Regional Technology and Development-Health Services (91F);
- Problem Solving for State and Local Governments-Human resources (43C); and Police, Fire and Emergency Services (43D).

## Journal Reprints

NTIS receives and announces approximately 500 - 600 journal reprints each year. The majority of these articles are originated by the U.S. Department of Defense (others are from the Environmental Protection Agency, the USDA, the DOE, etc.).

Some journal articles are available from NTIS depending upon the funding agency. Beginning with NTIS Database GRA&I issue 75-03, February 1975, the descriptor "reprints" has been assigned to the majority of the reprints. The document type is also noted as a journal article.

## Maps

The descriptor "maps" is used whenever maps are an integral part of a report. Reports describing the way maps are made are indexed with the descriptor "mapping."

## Patents

All U.S. government patents and patent applications entered into the NTIS Database are assigned either “patents” or “patent applications” in the descriptor or title note field. Some online vendors display it as the document type field.

## Sponsoring Agency Keyword Acronyms

Effective with NTIS Database issue 7309, May 1973, NTIS placed an acronym representing the report’s sponsoring organization(s) in the identifier field. This information can also be found by entering the agency name as a search term in the corporate source/sponsoring agency field.

Beginning with NTIS Database issue 7419, October 1974, the agency acronyms are prefixed with the “NTIS” acronym.

### Examples:

NTISDE	Department of Energy
NTISDOD	Department of Defense
NTISNASA	NASA
NTISCOMNBS	National Institute of Standards & Technology (NIST).

*Note: This acronym combines the Department of Commerce and the former agency name of National Bureau of Standards (NBS).*

These codes are helpful when searching for sponsoring organizations rather than performing organizations, or to find all reports submitted to NTIS by one specific agency.

*Note: The meaning of an agency acronym often may be determined from the corporate source field.*

## Superfund

The U.S. Environmental Protection Agency (EPA) administers the Superfund program, which was established in 1980 with the passage of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1986, Congress passed the Superfund Amendment and Reauthorization Act (SARA) which updated and improved CERCLA.

Publicly available documents from the Office of Emergency and Remedial Response (OERR) are available from NTIS.

**Hint:** Use the descriptor “Superfund” to locate relevant documents, such as Superfund Record of Decision reports.

## Translations

Each year, NTIS announces approximately 1,000 translations received from and funded by government agencies. Prior to 1976, all translations, except those originating with DOE and NASA, were assigned the descriptor “translations.” Since 1976, DOE and NASA translations also have been indexed with “translations.”

See also listing under “foreign language.”

## Verbalization

All subscripts, superscripts, Greek letters, scientific and mathematical formulae are fully spelled out in the abstract of the record.

**Example:** alpha, beta, gamma, etc.  
Peroxide appears as H<sub>2</sub>O<sub>2</sub> or H sub 2 O sub 2.  
Water appears as H<sub>2</sub>O or H sub 2 O

# Selected References for Assistance in Searching the NTIS Database

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## Section IV

Items with an asterisk (\*) are available from NTIS; U.S. Department of Commerce, NTIS, Alexandria, VA 22312. When ordering, you will need the NTIS order number as indicated. Your ordering options include: Online - insert order number as requested at <http://www.ntis.gov/help/orderplacing.aspx>, By phone (NTIS Sales Desk) - 1-800-553-6847 or 703-605-6000, Fax - 703-605-6900, via e-mail - [orders@ntis.gov](mailto:orders@ntis.gov)

The NTIS Sales Desk is available for assistance 8 a.m. - 6 p.m.; EST, Monday-Friday. The Sales representative will verify a title, order number or price for you. For further ordering information see the NTIS Web page at <http://www.ntis.gov/help/orderplacing.aspx>

Many of these references are made available online on the source agency's web site. Where available, these web addresses are listed at the end the entry.

### **\*Countries, Dependencies, Areas of Special Sovereignty, and Their Principal Administrative Divisions.**

For diskette, NTIS Order No.: PB95-503504, \$30

### **\*Guidelines for Descriptive Cataloging of Reports: A Revision of COSATI Standard for Descriptive Cataloging of Government Scientific and Technical Reports.**

NTIS Order No.: PB86-112349

### **NTIS DIALOG Information Services, Inc. (File 6) Bluesheets.**

DIALOG Information Services, Inc. Includes field-by-field description of DIALOG system search capabilities.

<http://library.dialog.com/bluesheets/html/bl0006.html>

## **List of Applicable Thesauri**

### **\*Defense Technical Information Center Thesaurus.**

Defense Technical Information Center, Alexandria, Va.

NTIS Order No.: AD-A 378 274

<http://stinet.dtic.mil/str/index.html>

[http://www.dtic.mil/dtic/stresources/techreports/DTICSearchTools/thesaurus\\_desc.html](http://www.dtic.mil/dtic/stresources/techreports/DTICSearchTools/thesaurus_desc.html)

### **International Energy Subject Thesaurus.**

*Joint Thesaurus: ETDE/INIS Joint Reference Series No. 1 (Rev. 1)* June 2004

DOE report no.: IAEA-ETDE/INIS-1 (Rev.1). Contains over 21,000 terms and includes definitions, entry date, and broader and narrower terms.

<http://www.etde.org/edb/reference.html>

### **International Energy Subject Thesaurus Supplement.**

*ETDE/INIS Joint Thesaurus*, IAEA-ETDE/INIS-1(Suppl.42)

Updated monthly.

<http://www.etde.org/edb/reference.html>

### **\*Medical Subject Headings Publications**

Alphabetical listing of all subject descriptors used by the indexers and catalogers at the National Library of Medicine (NLM). Update annually, for information about ordering from NTIS, go to <http://www.ntis.gov/product/mesh.aspx>

<http://www.nlm.nih.gov/mesh/MBrowser.html>

### **\*NASA Thesaurus, Volume 1: Hierarchical Listing.**

January 1998.

Contains over 25,000 subject terms that are used in the NASA Scientific and technical information system

NTIS Order No.: N1998-0010926

<http://www.sti.nasa.gov/thesfrm1.htm>

### **\*NASA Thesaurus, Volume 2: Rotated Term Display.**

January 1998.

NTIS Order No.: N1998-0010863

<http://www.sti.nasa.gov/thesfrm1.htm>

### **\*NASA (National Aeronautics and Space Administration) Thesaurus Supplement: A Three-Part Cumulative Supplement to the 1998 Edition of the NASA Thesaurus. Supplement 7.**

The supplement to the 1998 edition of the *NASA Thesaurus* includes all new terms and associated heirarchies added since the cutoff for the 1998 edition (December 1997).

NTIS Order No.: N2001-0066734

<http://www.sti.nasa.gov/thesfrm1.htm>

### **TEST: Thesaurus of Engineering and Scientific Terms.**

1967. Available from American Association of Engineering Societies, 1111 19th St, NW, Suite 403, Washington, D.C., 20036. 1-888-400-2237 or (202)296-2237.

### **Transportation Research Thesaurus (TRT).**

July 1999. CD-ROM or paper copy available from CDB Enterprises, Inc.

Davidbatty@aol.com; Telephone: 301-593-8901.

<http://trt.trb.org/trt.asp>

### **\*Thesaurus of Water Resources Terms: A Collection of Water Resources and Related Terms for Use in Indexing Technical Information**

1989. Bureau of Reclamation, Denver CO.

NTIS Order No.: PB95-146213



## Section V

The NTIS Database is available from several online vendors. Each online service has its own commands, prompts, menu screens, searchable fields, display and print formats, search software and special features. This section presents a summary of the basic features offered by the online vendors. For more detailed instructions, contact the individual online provider.

## National Technical Reports Library (NTRL)

National Technical Information Service  
5301 Shawnee Road  
Alexandria, VA 22312  
Telephone: 800-553-6847  
Fax: 703-605-6880  
E-mail: [subscriptions@ntis.gov](mailto:subscriptions@ntis.gov)

Coverage: 1964 to present  
Update frequency: Each Government Business Day  
Bibliographic Records: over 2 Million

## System Features:

- Web-based Subscription Access
- Links to over 600,000 corresponding full-text reports
- Quick Search – intuitive interface supports access for novice researcher
- Advanced Search – more precise search and retrieval
- Easy access to Help and Search Tips
- E-mailing of results

## For more information:

About NTRL: <http://www.ntis.gov/pdf/ntrl-presentation.pdf>

Where to get NTRL outside the U.S.: <http://www.ntis.gov/help/cooperate.aspx>

## In Quick Search

*Search fields include:*

Accession No.

Keyword

Title

Abstract

Author

## In Advanced Search

*Search fields can be limited:*

With All of the words

With the exact phrase

With at least one of the words

Exclude words

*Refine your results by:*

Subject Category

Year

Year Range

Source agency

## NTRL Search Tips:

You can make your search more precise and get more useful results by following these tips:

- Select the field to search from the drop down menu. Selecting All will search all fields.
- Enter search phrase/terms in the text box and click the search button.
- Do not use operators such as AND, OR in the search text box; use the appropriate text box instead.
- To search for all words (logical operator AND) enter your search in the With All of the words input text box.
- To force inclusion of certain search terms (logical operator OR), search in the With at least one of the words input box.
- To search for the exact phrase enter your search next to the With the exact phrase input text box.
- To limit results by category click on the Subject Category dropdown and select category from the dropdown list.
- To limit the results by year, select From Year and To Year from the dropdown list.
- You can sort the results by Relevancy or by Year using the Sort By dropdown list.

Sample NTRL Record	
Accession Number:	PB2010-107926
Title:	Understanding Climate's Influence on Human Evolution.
Publication Year:	2010
Pages:	00127
Abstract:	<p>The hominin fossil record documents a history of critical evolutionary events that have ultimately shaped and defined what it means to be human, including the origins of bipedalism; the emergence of our genus Homo; the first use of stone tools; increases in brain size; and the emergence of Homo sapiens, tools, and culture. The geological record suggests that some of these evolutionary events were coincident with substantial changes in African and Eurasian climate, raising the intriguing possibility that key junctures in human evolution and behavioral development may have been affected or controlled by the environmental characteristics of the areas where hominins evolved. However, with both a sparse hominin fossil record and an incomplete understanding of past climates, the particular effect of the environment on hominin evolution remains speculative. This presents an opportunity for exciting and fundamental scientific research to improve our understanding of how climate may have helped to shape our species, and thereby to shed light on the evolutionary forces that made us distinctively human.</p>
Keyword:	Environmental effects, Homo sapiens, Culture, Geology, Fossil fuels, Earth sciences, Implementation, Research program, Climate change, Human impact, Hominin, Human revolution
Source Agency:	National Academy of Science National Research Council(NASNRC)
Category:	Natural Resources & Earth Sciences(48), Atmospheric Sciences(55), Environmental Pollution & Control(68)
Prime Corp Author Name:	National Research Council, Washington, DC. Division on Earth and Life Studies.
Document Type:	RPT
Document Type:	RPT
Contract Number:	EAR-0625247

## DataStar

Dialog, LLC

2250 Perimeter Park Drive, Suite 300

Morrisville, North Carolina 27560

Telephone: 919-804-6400

Fax: 919-804-6410

E-mail: [customer@dialog.com](mailto:customer@dialog.com)

Database Label: NTIS

Years Online: NTIS–October 1980–to date  
 NT80–1975 to September 1980  
 NT74–1970 to 1974  
 NTZZ–All of NTIS since 1970

Update frequency: Monthly

### System Features:

- MAP–extracts and saves terms to use in another database
- RANK–statistical analysis of search results
- Left-hand truncation on Imsmarq trademark databases
- Telecommunications link to DIALOG
- Prompted offline print and alert requests
- Smart Alerts–you choose the day the Alerts run
- KWIC print format–see search terms in context
- Subaccount expanded to 16 characters

### List of Selected DataStar Search Commands

<i>Label</i>	<i>Description</i>	<i>Example</i>
AN	Accession number & update	ADA511653 ADJ XAB.AN.
AU	Author(s)	JAKOB-\$.AU.
IN	Corporate source	MINERAL\$ ADJ MANAGEMENT.IN.
TI	Title	AIR ADJ QUALITY WITH OZONE.TI.
TA	Annotated title	ANNUAL REPORT.TA.
NT	Notes	- Display only -
YR	Publication date	2010.YR.
JN	Journal announcement code	U200923.JN.
SN	Sponsoring agency	- Display only –
RN	Report number	JSC ADJ CN ADJ 18584.RN.
CN	Contract number	200 ADJ 205 ADJ 13434.CN.
PN	Task (project) number	NASA ADJ NCC8 ADJ 200.PN.
PR	Price	- Display only –
AV	Availability	- Display only –
CC	Classification codes	68D.CC.
MJ	Major descriptors	OFFSHORE-DRILLING.MJ.
MN	Minor descriptors	WATER-POLLUTION.MN.
ID	Keywords	OIL ADJ SPILL\$.ID.
DE	Descriptors (superlabel)	OFFSHORE ADJ DRILLING.DE.
AB	Abstract	OIL WITH EXPLORATION.AB.

### Limit Options

YEAR	Publication year	1_ : OFFSHORE ADJ DRILLING 2_ : ..: 1 YEAR=2009
UMONTH	Update month	3_ : ..L 1 UMONTH>201002
JNYR	Journal announcement year	4_ : ..L 1 JNYR<2009
JNMO	Journal announcement month	5_ : ..L 1 JNMO=200701

Print Formats		
<b>SHORT</b>	AN AU TI YR TA	-: ..P SHORT/1-5
<b>MEDIUM</b>	AN AU TI YR TA AB	-: ..P MEDIUM/1-10
<b>LONG</b>	AN AU TI YR TA AB DE	-: ..P LONG/2,6,9
<b>By paragraph</b>	(e.g., Title)	-: ..P TI/1-5
<b>Full document</b>	All paragraphs	-: ..P ALL/1-10
<i>Note: There is no free format for this database.</i>		
<b>RANK</b> counts the occurrences of unique terms within a specific field from a search set you have created.		
<b>MAP</b> automatically extracts and saves data from selected fields of a set of records, thereby eliminating time-consuming scanning and re-keying. The stored search may then be executed in another database, or saved for later use.		

Sample Record – DataStar	
AN	ADA513500-XAB 201003.
AU	Kuo-S, Cheng-W, Snyder-A, Kossey-P, Battis-J.
IN	Performer(s): Air Force Research Lab., Hanscom AFB, MA. Space Vehicles Directorate. Performing author code(s): 114801001 434329.
TI	Contrasting O/X-mode Heater Effects on O-Mode Sounding echo and the Generation of Magnetic Pulsations.
TA	Contrasting O/X-mode Heater Effects on O-Mode Sounding echo and the Generation of Magnetic Pulsations.
NT	Journal article. Published in the Geophysical Research Letters v37 2010.
YR	6 Jan 2010, 6p
JN	u201012.
RN	AFRL-RV-HA-TR-2010-1001.
CN	Contract N00014-05-1-0109.
PN	Task HR, Proj. 1010.
PR	PC A02.
AV	Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703)605-6000 (other countries); fax at (703)605-6900; and email at orders@ntis.gov. NTIS is located at 5301 Shawnee Road, Alexandria, VA, 22312, USA.
CC	55A
MJ	Ionosphere, Heating, Micropulsations, Magnetic-fields.
MN	Sequences, Echoes, Magnetometers, Intensity, Excitation, Monitoring, Reprints, Facilities.
ID	X-mode, O-mode, HAARP-High-Frequency-Active-Auroral-Research-Program, Experimental-observations.



## DIALOG, LLC

<http://www.dialog.com>

2250 Perimeter Park Drive, Suite 300

Morrisville, North Carolina 27560

Telephone: +1 800 3-DIALOG (North America) or +1 919-804-6400

Fax: +1 919-804-6410

E-mail: [customer@dialog.com](mailto:customer@dialog.com)

### List of Selected DIALOG Search Commands

<i>Command</i>	<i>Explanation</i>	<i>Example</i>
Begin	To connect to NTIS file	B6
S term	Search term	SELECT (or S) MEDIA
E term	Expand term: displays online index in alpha order around search term	EXPAND (or E) MEDIA
T or D	To view online results using one of Dialog's eight formats	t5/3/1-4
PR	To print off-line search results	PR S5/3/1-4
PR-	To cancel off-line prints	pr-p002
AND, OR, NOT	Logical connectors	
(w)(1w)	Proximity connectors	
(n)(1n)	Proximity connectors	
(f)	Proximity connectors	field
(l)	Proximity connectors	descriptors
(s)	Proximity connectors	subfield
SAVE TEMP	To save search strategy for 7 days	SAVE TEMP
SAVE	To save search strategy permanently	save
EXS	To run a saved search	exs sa001
LOGOFF HOLD	To save a search for 30 minutes	
RECALL	To list search saves	recall save
RELEASE	To purge search saves	release save
HELP	To explain system commands	help file6;
	and file structure	help field6
	file price list	help rates6
	Limit by years	help limit6
DS	To display search history	DS3; DS 1-10
	To display selected sets	
SORT	To sort search results by title, etc.	sort s1/all/ti
NTIS price code tables	Paper/Microfiche	HELP NTISCODE;
	Paper copy exception	HELP NTISECOD;
	Diskettes	HELP NTISDCOD;
	Magnetic tape products	HELP NTISTCOD
Time & Charges	At logoff & end	COST
RANK<DE>	To analyze term frequency	
TARGET	Search using relevance ranking	

#### Print Options

User-defined formats: can be specified using the display codes indicated in the search options tables, e.g., TYPE S3/TI, JN, PY/1-5.

## Predefined Format Options

Number	Record Content
Format 1	DIALOG accession number
Format 2	Full record except abstract
Format 3	Bibliographic citation
Format 4	Full record with tagged fields
Format 5, 9	Full record
Format 6	Title
Format 7	Bibliographic citation and abstract
Format 8	Title and indexing
<i>Note: Menu mode is also available</i>	

## Sample Record–Dialog

AA	PB2001-104037/XAB	NTIS Accession No.
TI	Logic-Based, Performance Driven Electric Vehicle Software Design Tool (Final rept. Jul 98-Aug 00)	Title
AU	Blacketter, D. M. ; Alexander, D. G.	Personal Author
CS	Idaho Univ., Moscow. National Inst. for Advanced Transportation Technology.	Corporate Source
	Corp. Source Codes: 009858007	Corp. Source Codes
SP	Department of Transportation, Washington, D.C. Research and Special Programs Administration	Sponsoring Agency
RN	Report No.: NIATT-N01-10	Report No.
CN	DTRS98-G-0027	Contract Number
PY	Feb-01	Report date
PG	30p	pagination
NT	Sponsored by Department of Transportation, Washington, D.C., Research and Special Programs Administration. Product reproduced from digital image. Order this product from NTIS by phone at 1-800-553-NTIS (U.S. customers); (703) 605-6000 (other countries); fax at (703) 605-6900; and email at orders@ntis.gov. NTIS is located at 5285 Port Royal Road, Springfield, VA 22161, USA.	Note
LA	English	Language
JA	Journal Announcement: USGRDR0113	Journal Announcement
PC	NTIS Prices: PC A03/MF A01.	–display only–
CP	United States	Country of Publication
AB	The goal of this research was to develop computer-based logic algorithms and build them into SmarTHEV, a series hybrid electric vehicle software design program. (Abstract abbreviated for this example.)	Abstract
DE	Electric Vehicles; *Computer aided design; *Vehicle design; Vehicle Performance; Computer software; Algorithms; Hybrid vehicles;	Descriptors
ID	SmarTHEV design program; NTISDOTOUR	Identifiers
SH	85H (Transportation – Road Transportation); 41A (Manufacturing Technology – Computer Aided Design (CAD))	Section Headings (Subject Categories)

## EBSCO Publishing

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The following list will help you locate detailed information referenced in this database as a field.

List of Searchable Fields		
Search tag	Name/Description	Example
AA	Abstract Available [Phrase Indexed] Searches the abstract available field	AA Y
AU	Author [Word Indexed] Searches author by Initials and last name	AU M. Beyermann
AB	Abstract [Word Indexed] Searches the Abstract summary for keywords	AB Phase Particles
AN	Accession number [Phrase Indexed] Searches the exact accession Number/unique identifier.	AN PB97-210801/XAB
CA	Corporate Source [Word Indexed] Searches corporate source by source name	CA Oak Ridge National Lab
CC	Subject Category Code [Word Indexed] Searches for words in the subject category code. This can be searched both by code and by spelled-out subject	CC 46C or CC Optics & Lasers
CR	Contract Number [Phrase Indexed] Searches for the exact contract number	CR AC05-96OR22464
CY	Country of Publication [Phrase Indexed] Searches for the exact country of publication	CY France
DE	Subject headings [Phrase Indexed] Searches for the exact descriptor	DE Sovereignty
DT	Publication Date [Numerically Indexed] Searches the Publication date in YYYY format	DT 1997

## List of Searchable Fields

<i>Search tag</i>	<i>Name/Description</i>	<i>Example</i>
ID	Identifiers [Word Indexed] Searches for words within the identifiers field	ID International Affairs
LA	Language [Phrase Indexed] Searches the original language of the document	LA German
MC	Major Concepts [Phrase Indexed] Searches for the exact major concept	MC International Relations
NI	Number of Items [Word Indexed] Searches for words or numbers in the number of items field	NI 52
NO	Note [Word Indexed] Searches for keywords in the notes field	NO Report to Congress
PG	Pagination [Numerically Indexed] Searches the number of pages numerically	PG 10
RE	Report Number [Numerically Indexed] Searches the report number field	RE SUNY-TR-48
SO	Source [Word Indexed] Searches for words within a title listed in the source field of a review	SO Department of Energy
SP	Sponsoring Organization [Word Indexed] Searches for words in the sponsoring organization	SP Department of Energy
SU	Descriptors [Word Indexed] Searches for words in the Subject, Descriptors and Identifiers field	SU International Relations
TI	Title [Word Indexed] Searches for words in the title of the article	TI Preventive Action:Cases and Strategies
<i>For additional information, please refer to database specific help in EBSCOhost.</i>		



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<http://www.engineeringvillage2.org>

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- Total records: 2,250,000
- Updated Weekly

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- OpenURL linking to Endeavor LinkFinder Plus, Ex Libris SFX, Serials Solutions Article Linker, Innovative Interfaces Web Bridge and others for local holdings checking and full text option presentation.
- Context sensitive help
- Reference Services: Ask a Librarian & Ask an Engineer

### In Quick Search mode, fields that can be searched:

Abstract
All fields
Author
Author Affiliation
Classification Code
Contract Number
Country of Origin
Monitoring Agency
NTIS Accession Number
NTIS Controlled Terms
Report Number
Subject/Title/Abstract
Title

### In Expert Search, fields that can be searched:

Field	Field Code
Abstract	AB
Accession number	AN
All fields	All
Author	AU
Author affiliation	AF
Availability	AV
Classification code	CL
Contract number	CT
Controlled term	CV
Country of origin	CO
Document type	DT
Filing date	PA
Language	LA
Monitoring agency	AG
Notes	NT
Patent issue date	PI
Report number	RN
Subject/Title/Abstract	KY
Title	TI
Uncontrolled term	FL

NTIS can be viewed in 3 record formats: citation, abstract and detailed records. Each abstract and detailed record has a link named “Order From NTIS” which takes the user to the NTIS order system.

Hyperlinked Fields that can be searched from the record:

- Author
- NTIS Controlled Terms
- Uncontrolled Terms
- NTIS Classification Code
- Project Number
- Monitoring Agency
- Contract Number

#### Example of an NTIS Detailed Record

<b>Accession number:</b>	ADA410873
<b>Title:</b>	Energy Conversion in Laser Propulsion II
<b>Authors:</b>	Larson, C. W.; Mead, F. B.; Kalliomaa, W. M.
<b>Author affiliation:</b>	Air Force Research Lab., Edwards AFB, CA. Space and Missile Propulsion Div.
<b>Author affiliation codes:</b>	115210002 441421
<b>Report number:</b>	AFRL/PRS-ED-TP-2001-247
<b>Publication date:</b>	Dec-01
<b>Pages:</b>	22p
<b>Language:</b>	English
<b>Country of origin:</b>	United States
<b>Document type:</b>	Technical paper
<b>Notes:</b>	Paper presented at the AIAA Aerospace Sciences Meeting & Exhibit (40th) held in Reno, NV, on 14-17 Jan 2002.
<b>Abstract:</b>	This paper reports on an analysis of overall energy conversion in laser propulsion. Experimental studies of a laboratory-scale propulsion device that absorbs laser energy and converts that energy to propellant kinetic energy were carried out. The Myrabo Laser Lightcraft (MLL), propelled by laser-heated air, was studied.
<b>Availability:</b>	Product reproduced from digital image. Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703)605-6000 (other countries); fax at (703)605-6900; and email at orders@ntis.gov. NTIS is located at 5285 Port Royal Road, Springfield, VA, 22161, USA.
<b>NTIS price code:</b>	PC A03/MF A01
<b>Project number:</b>	1011
<b>Task number:</b>	Task 0046
<b>Journal announcement:</b>	u0314
<b>NTIS controlled terms:</b>	Laser applications   Energy conversion   Kinetic energy   Carbon dioxide lasers   Rocket propulsion   Solid propellants   Blowdown   Experimental data   Symposia   Spacecraft   Thermodynamics   Pulsed lasers   Thermal expansion   Heating   High energy lasers   Ionization   Chemical equilibrium   Reflectors   Equations of state   Delrin
<b>Uncontrolled terms:</b>	Laser heated propellant   Laser propulsion   Laser energy   Conversion efficiency   Laser heated air   Mll(Myrabo laser lightcraft)   Lightcraft   Equilibrium expansion   Frozen expansion   Air expansion   Equilibrium blowdown   Frozen blowdown
<b>NTIS classification codes:</b>	46C Optics and Lasers   81B Combustion, Engines and Propellants Electric and Ion Propulsion   81G Rocket Engines and Motors   84A Astronautics
<b>Database:</b>	NTIS

## Ovid Technologies

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In New York City: 646- 674-6300

Fax: 646-674-6301

E-mail: [sales@ovid.com](mailto:sales@ovid.com)

Coverage: 1964 to present

Document Delivery: Document availability from NTIS is indicated in each citation.

### List of Selected Ovid Search Fields

<i>Record Structure</i>			
<i>Label</i>	<i>Field</i>	<i>Function</i>	<i>Examples</i>
AN	Accession No.	Search	tib-b89-82561-xab.an
UP	Update Code	Search	9406.up
		limit	..1/ 1 up = “9406”
AU	Author	Search	strueder, L.au
			strueder, \$.au
IN	Institution and Institution Code	Search	computer applications.in
			ij535353.in
TI	Title	Search	eigenvalue problem.ti
TA	Title Annotation		–display only–
NT	Notes		–display only–
YR	Publication Year	Search	nov 1993.yr., 1993.yr
		limit	..1/ 2 yr = 1993
JN	Journal Announcement	Search	u9006.jn
SA	Sponsoring Agency	Search	nasa-cr-194662.sa
			nasa.sa
RN	Report Number	Search	mpi-pae-exp-el-208.rn
CN	Contract and/or Grant Numbers	Search	nasi-18605.cn
PN	Project and/or Task Numbers		–display only–
PR	Price		–display only–
AV	Availability		–display only–
CC	Subject Category Codes	Search	89d.cc. and 72b.cc
MJ	Major Descriptors	Search	problem solving.mj
MN	Minor Descriptors	Search	energy resolution.mn
DE	Descriptors (MJ,MN)	Search	algorithms.de
			reacting flow.de
ID	Identifiers	Search	ntisnasa.id
AB	Abstract	Search	supersonic
			combustion.ab

Sample Record – Ovid Technologies	
Accession Number	PB2001-107910-XAB
Author	Bunte K; Abt SR.
Institution	Rocky Mountain Research Station, Fort Collins, CO.; 114618000
Title	Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-Bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring.
Year of Publication	May
Abstract	This document provides guidance for sampling surface and subsurface sediment from wadable gravel- and cobble-bed streams. After a short introduction to streams types and classifications in gravel-bed rivers, the document explains the field and laboratory measurement of particle sizes and the statistical analysis of particle-size distributions. Analysis of particle parameters, including shape, density, and bulk density are also discussed. The document describes the spatial variability of bed-material particle sizes as well as the horizontal and vertical structure of particle deposits. The discussion of sampling procedures and equipment helps the user to make appropriate selections that support the sampling objective. Sample-size estimates may be obtained from empirical data or computed from statistical relationships between sample size and accuracy. The document explains a variety of methods, their usage and prerequisites. A detailed discussion of sampling schemes guides the ! user to select appropriate spatial sampling patterns necessary to produce representative samples.
Journal Announcement	u0122
Report Number	RMRS-GTR-74
Price	NTIS Prices: PC A21/MF A04
Availability	Product reproduced from digital image. Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703)605-6000 (other countries); fax at (703)605-6900; and email at orders@ntis.gov. NTIS is located at 5301 Shawnee Road, Alexandria, VA, 22312, USA.
Subject Category Codes	48G. 48E
Major Subject Descriptors	Hydraulics
	Streambeds
	Sediment transport
Minor Subject Descriptors	Sampling procedures
	Sampling equipment
	Sample size
Identifiers	*Particle-size analysis. Bed materials. Spatial sampling structures. Spatial variability
Notes	Final rept. 454 PAGES
Update Code	122

## ProQuest

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Update Frequency: Weekly

Size: Over 2,400,000 records as of March 2010

### Field Codes

AB = Abstract	NU = Other Numbers
AG = Agency	PA = Patent Application Data
AN = Accession Number	PB = Publisher
AU = Author	PD = Publication Date
AV = Availability	PI = Patent Issue Date
CL = Classification	PY = Publication Year
CO = Country of Origin	RP = Report Number
DE = Descriptors	SF = Subfile
ID = Identifiers	SO = Source
LA = Language	TI = Title
NT = Notes	UD = Update
<b>AN Accession Number:</b> Use this number to order the fulltext from NTIS.	

### Sample Record - ProQuest

TI:	Title	Production, Prices, Employment, and Trade in Northwest Forest Industries, Fourth Quarter 1996
AU:	Author	Warren, DD
AV:	Availability	Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703) 605-6000 (other countries); fax at (703) 321-8547, and email: <a href="mailto:orders@ntis.gov">orders@ntis.gov</a> . NTIS is located at 5285 Port Royal Road, Springfield, VA 22161, USA. NTIS Prices: PC A08/MF A02
SO:	Source Performer:	Forest Service, Portland, OR. Pacific Northwest Research Station. July 1997. 143p. Report: FSRB-PNW-226
RP:	Report Number	FSRBPNW226; PB97199830
AB:	Abstract	Provides current information on lumber and plywood production and prices; employment in the forest industries; international trade in logs, lumber, and plywood; volume and average prices of stumpage sold by public agencies; and other related items.
LA:	Language	English
PY:	Publication Year	1997
PD:	Publication Date	19970700
CO:	Country of Origin	United States
PT:	Publication Type	Forest Service resource bulletin
DE:	Descriptors	Wood products; Forest industry; Sectoral analysis; Lumber; Plywood; Production; Prices; International Trade; Industries; Employment; Volume; Exports; Imports; Tables (Data); Agricultural economics
CL:	Classification	48D Natural Resources & Earth Sciences: Forestry; 96A Business & Economics: Domestic Commerce, Marketing, & Economics; 96C Business & Economics: International Commerce, Marketing & Economics
UD:	Update	199722
AN:	Accession Number	PB97199830



## SilverPlatter Information, Inc.

<http://www.silverplatter.com>

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Norwood, MA 02062-5043

Telephone: 800- 343-0064 or 781-769-2599

Fax: 781-769-8763

E-mail: [us\\_customerrelations@silverplatter.com](mailto:us_customerrelations@silverplatter.com)

Below are the NTIS fields with their abbreviation. Fields listed in bold are limit fields.

List of Selected SilverPlatter Search Fields	
<i>Label</i>	<i>Field Name</i>
AB	Abstract
AG	Agency Source Code
AN	Accession Number
AU	Personal Author
AV	Availability Note*
CA	Corporate Author Code
CC	Subject Category Codes
CI	Country of Intellectual Origin
CN	Contract/Grant Number(s)
CS	Corporate Source
DE	Descriptors
DEM	Major Descriptors
DER	Minor Descriptors
ID	Identifiers
IDM	Major Identifiers
IDR	Minor Identifiers
LA	Language
NT	Descriptive Note*
PR	NTIS Price Codes*
PY	Publication Year
RD	Report Date/Pagination*
RN	Report Number
SC	Subject Categories
TI	Title
UD	Update Date
<ul style="list-style-type: none"> <li>The AV, NT, PR, and RD fields are not searchable. The citation, a brief record, consists of the TI, AN, CS, RD, NT, AV, PR, RN, and CN fields. For more on NTIS fields, select Guide from the Help menu.</li> </ul>	

Sample Record - SilverPlatter		
TI	Preventing the Diseases of Aging: Special Focus: Healthy Aging. Chronic Disease Notes and Reports, Volume 12, Number 3, Fall 1999	Title
AN	PB2001102122XSP	Accession Number
AU	Ramsey-T.	Personal Authors
CS	Performer: National Center for Chronic Disease Prevention	Corporate Source
RD	1999. 20p.	Report Date/Pagination
PY	Jun-05	Publication Year
NT	Color illustrations reproduced in black and white	Descriptive Note
AV	Product reproduced from digital image. Order this product from NTIS by: phone at 1-800-533-NTIS (U.S. customers); (703) 605-6000 (other countries); fax at (703) 605-6900; and email at orders@ntis.fedworld.gov. NTIS is located at 5301 Shawnee Road, Alexandria, VA, 22312, USA	Availability Note
CI	UNITED-STATES	Country of Intellectual Origin
LA	ENGLISH	Language
PR	PC A03/MF A01	NTIS Price Codes
DE	Elderly-persons; Treatment-; Population-growth; Alzheimer's-	Descriptors
DE	*Aging-; *Chronic-diseases; *Prevention-;	Descriptors
ID	*CDC-Center-for-Disease-Control; *Center-for-Disease-Control	Identifiers
SC	Medicine-and-biology-Clinical-Medicine (57E); Medicine-and-biology-Public-health-and-industrial-medicine (57U); Health-planning-and-health-services-research-Community-and -population-characteristics (44C)	Subject Categories
CC	57E, 57U, 44C, 44, 57	Subject Category Codes
AB	The new millenium brings the nation many challenges, but none of Americans older than 65 years. Not only has the birthrate decreased since 1964, when the baby boom ended; at the same time, life expectancy has increased dramatically, from 47 years in 1900 to 76 years in 1990. Adults over than 85 years are the fastest-growing part of the population; by 2030, they are expected to number 8.5 million. 'If disease patterns stay the same, the health care system will have to spend an additional \$400 to \$500 billion to cover the costs of an older population', said James S. Marks, MD, MPH, Director, NCCDPHP. However lifesyle changes and increased emphasis on prevention could reverse the trends of increasing chronic disease, disability, and death.	Abstract
AG	HEWCDC	Agency Source Code
CA	104227000	Corporate Author Code
UD	200106	Update Date

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Fax: 614-447-3751  
E-mail: [help@cas.org](mailto:help@cas.org)  
Internet: <http://www.cas.org>

## In Europe

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STN Europe  
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76012 Karlsruhe  
Germany  
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Fax: +49-7247-808-259  
E-mail: [helpdesk@fiz-karlsruhe.de](mailto:helpdesk@fiz-karlsruhe.de)  
Internet: [www.stn-international.com](http://www.stn-international.com)

## In Japan

JAICI (Japan Association for  
International Chemical Information)  
STN Japan  
Nakai Building  
6-25-4 Honkomagome, Bunkyo-ku  
Tokyo 113-0021, Japan  
Phone: +81-3-5978-3601 (Technical Service)  
+81-3-5978-3621 (Customer Service)  
Fax: +81-3-5978-3600  
E-mail: [support@jaici.or.jp](mailto:support@jaici.or.jp)  
[customer@jaici.or.jp](mailto:customer@jaici.or.jp)  
Internet: [www.jaici.or.jp](http://www.jaici.or.jp)

### System Features:

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- More than 2,121,220 records (9/00)
- Updated weekly
- Automatic current-awareness searches (SDIs) are run weekly

## STN Search and Display Field Codes

<i>Search Field Name</i>	<i>Search Code</i>	<i>Search Examples</i>	<i>Display Codes</i>
Basic Index* (contains single words from the title (TI), abstract (AB), controlled term (CT), uncontrolled term (UT) and CAS Registry Number (RN) fields)	None or /BI	S MOTORISTS S DRIVING HABIT# S DRIV?(2W)EXPER? S COAL(S)MINE# S PAT CL 110? S ANALYSIS/BI,CC S 50-23-7	TI, AB, CT, UT, RN
Accession Number	/AN	S "2001(17):03220"/AN	AN
Application Date (1)	/AD	S AD=JAN 1999	AI
Application Number	/AP	S US2001-983047/AP	AI
Application Year (1)	/AY	S AY=1999	AI
Author (patent inventor)	/AU (or /IN)	S MCCARTHY, P E/AU S AMES G/AU	AU
Availability	/AV	S CD ROM/AV	AV
Classification Codes, COSATI, NTIS etc. (code, main code (NTIS) and text) (2)	/CC	S 85/CC S 85A/CC S *57E/CC S TRANSPORTATION?/CC	CC
Controlled Term (main headings)	/CT	S ALCOHOL LAWS/CT S *HEAT RECOVERY/CT	CT
Controlled Word	/CW	S EARTH/CW	CT
Corporate Source (performing, sponsoring or cooperating performing organization, patent assignee)	/CS	S (DEPART?(2W)INTERIOR)/CS S COMBUSTION ENGINEERING?/CS	CS
Country (of Intellectual Origin) (code and text)	/CY	S GERMANY?/CY S GB/CY	CY
Document Type (code and text)	/DT (or /TC)	S PATENT/DT S P/DT	DT
Inventor	/IN	S MANDAVA N/IN	IN
Language (code and text)	/LA	S FRENCH/LA	LA

**STN Search and Display Field Codes**

<i>Search Field Name</i>	<i>Search Code</i>	<i>Search Examples</i>	<i>Display Codes</i>
Note	/NTE	S SEAWIFS/NTE	NTE
Number of Contract (grant, project or task)	/NC	S AID-DSAN-C-0062/NC	NC
Number of Report, NTIS Order Number (number and prefix)	/NR	S PB85-138436/XAD/NR S PB85/NR	NR, AN
Other Source (journal and database issue)	/OS	S GRA&I8507/OS S GREENHOUSE# NOT INIS/OS	OS
Patent Assignee	/PA	S MARTIN MARIETTA/PA	PA
Patent Number	/PN	S US2804506/PN	PI
Publication Date (1)	/PD	S PD=FEB 2000	PD
Publication Year (1)	/PY	S 1983-1984/PY	PD
Source (contains number of contract, number of report)	/SO	S TRRLSR826/SO	SO
Title	/TI	S REAL-TIME/TI AND SOFTWARE/TI	TI
Update Date (1)	/UP (or /ED)	S UP=JUL 2002	UP
Word Count, Title (1)	/WC.T	S WC.T>=10	WC.T
(1) Numeric search field that may be searched with numeric operators or ranges.			
(2) Search with implied (S) proximity is available.			

**STN DISPLAY and PRINT Formats**

<i>Format</i>	<i>Content</i>	<i>Examples</i>
AB	Abstract	D AB, TI
AI (AP)	Application Information	D AI
AN	Accession Number	D 1-5 AN
AU (IN)	Author (patent inventor)	D AU TI
AV	Availability	D AV
AY (1)	Application Year	D AY
CC	Classification Code	D CC
CS	Corporate Source	D CS
CT	Controlled Term	D CT
CY	Country (of Intellectual Origin)	D CY
DT (TC)	Document Type	D DT
IN	Patent Inventor	D IN
NC	Number of Contract (grant, project or task)	D NC
NR (SO)	Number of Report (patent number, application number)	D NR
NTE	Note	D NTE
OS	Other Source	D OS
PA	Patent Assignee	D PA
PD (1)	Publication Date	D PD
PI (PN)	Patent Information	D PI
PY (1)	Publication Year	D PY
RN	CAS Registry Number	D RN
TI	Title	D TI 1-10

**STN DISPLAY and PRINT Formats**

<i>Format</i>	<i>Content</i>	<i>Examples</i>
UP (1)	Update Date	D UP
UT	Uncontrolled Term	D CT UT 5-15
WC.T (1)	Word Count, Title	D WC.T
ALL	BIB, AB, CC, CT, UT, RN	D 1-3 ALL
DALL	ALL, delimited for post-processing	D DALL
IALL	ALL, indented with text labels	D IALL
BIB	AN, TI, AU, IN, CS, PA, NC, NR, PI, AI, CY, LA, NTE, AV, OS (BIB is default)	D 8 BIB
IBIB	BIB, indented with text labels	D IBIB
IND	AN, CC, CT, UT, RN	D IND
SCAN (2)	TI, CT	D SCAN
TRIAL (TRI, SAM, SAMPLE, FREE)	TI, CC, CT, UT, RN	D TRI
HIT	Hit term(s) and field(s)	D HIT
KWIC	Up to 50 words before and after hit term(s) (KeyWord-In-Context)	D KWIC
OCC	Number of occurrences of hit term(s) and field(s) in which they occur	D OCC

**STN SELECT, ANALYZE, and SORT Fields**

The SELECT command is used to create E-numbers containing terms taken from the specified field in an answer set.  
The ANALYZE command is used to create an L-number containing terms taken from the specified field in an answer set.  
The SORT command is used to rearrange the search results in either alphabetic or numeric order of the specified field(s).

<i>Field Name</i>	<i>Field Code</i>	<i>ANALYZE / SELECT</i>	<i>SORT</i>
Abstract	AB	Y	N
Accession Number	AN	Y	N
Application Date	AD	Y	Y
Application Number	AP	Y	Y
Application Year	AY	Y	Y
Author (Patent Inventor)	AU	Y	Y
Availability	AV	Y	Y
CAS Registry Number	RN	Y	Y
Classification Code	CC	Y	Y
Controlled Term	CT	Y	N
Corporate Source	CS	Y	Y
Country (of Intellectual Origin)	CY	Y	Y
Document Type	DT	Y	Y
Language	LA	Y	Y
Note	NTE	Y	Y
Number of Contract	NC	Y	Y
Number of Report (NTIS Order Number)	NR	Y	Y
Other Source	OS	Y	Y
Patent Assignee	PA	Y	Y
Patent Information	PI	Y	Y
Patent Number	PN	Y	Y
Publication Date	PD	Y	Y
Publication Year	PY	Y	Y



## STN SELECT, ANALYZE, and SORT Fields

Field Name	Field Code	ANALYZE / SELECT	SORT
Source	SO	Y	N
Title	TI	Y (default)	Y
Uncontrolled Term	UT	Y	N
Update Date	UP (ED)	Y	Y
Word Count, Title	WC.T	Y	Y

## Sample Records – STN International

## DISPLAY ALL

AN 2010(12):01113 NTIS Order Number: PB2010-107165/XAB

TI Impacts of a 15-Percent Renewable Portfolio Standard.

CS Energy Information Administration, Washington, DC. Office of Integrated Analysis and Forecasting. (052896003)

NR PB2010-107165/XAB; SR/OIAF/2007-03

29p; Jun 2007

DT Report

CY United States

LA English

AV Order this product from NTIS by: phone at 1-800-553-NTIS (U.S.customers); (703)605-6000 (other countries); fax at (703)605-6900; and email at orders@ntis.gov. NTIS is located at 5301 Shawnee Road, Alexandria, VA, 22312, USA.

NTIS Prices: PC A03

OS GRA&I1012

AB This report responds to a request from Senator Jeff Bingaman asking EIA to analyze a renewable portfolio standard (RPS) requiring that 15 percent of U.S. electricity sales be derived from qualifying renewable energy resources. The proposal exempts smaller electricity providers - those with fewer than 4 billion kilowatt hours in annual sales - from meeting the requirement, and would not allow current generation from existing hydroelectric and municipal solid waste facilities to meet the requirement. However, retail sellers who generate from existing hydroelectric and municipal solid waste facilities are allowed to exclude this generation from their sales base when calculating their required renewable share. *(Actual abstract abbreviated for this example.)*

CC 97G Policies, regulations, and studies

CT \*Energy market impacts; \*Energy resources; Electric power generation; Impacts; Fuel use; Prices; Emissions; Expenditures; Tables (Data); Figures; Comparisons

\*RENEWABLE PORTFOLIO STANDARD (RPS); \*RENEWABLE ENERGY RESOURCES; ELECTRICITY SALES; RENEWABLE PORTFOLIO STANDARD PROPOSAL

## DISPLAY BIB

ACCESSION NUMBER: 2010(13):01033

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TITLE: Acceleration Strain Transducer with Increased Sensitivity. Patent Application.

INVENTOR: Maguire, J. M.

PATENT ASSIGNEE: Naval Undersea Warfare Center Div., Newport, RI. Office of Counsel. (103709005 602677)

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CONTROLLED TERM: Patent

COUNTRY: United States

LANGUAGE: English

AVAILABILITY: This Government-owned invention available for U.S. licensing and, possibly, for foreign licensing. Copy of application available NTIS. Order this product from NTIS by: phone at 1-800-553-NTIS (U.S. customers); (703)605-6000 (other countries); fax at (703)605-6900; and email at orders@ntis.gov. NTIS is located at 5301 Shawnee Road, Alexandria, VA, 22312, USA.

NTIS Prices: PC N03

OTHER SOURCE: GRA&I1013

# NTIS Subject Categories

## Alphabetical Listing by Major Categories

### Appendix A

#### **70-ADMINISTRATION & MANAGEMENT**

- 700-General
- 70A-Inventory Control
- 70B-Management Practice
- 70C-Management Information Systems
- 70D-Personnel Management, Labor Relations  
& Manpower Studies
- 70E-Research Program Administration  
& Technology Transfer
- 70F-Public Administration & Government
- 70G-Productivity

#### **51-AERONAUTICS & AERODYNAMICS**

- 510-General
- 51A-Aerodynamics
- 51B-Aeronautics
- 51C-Aircraft
- 51D-Parachutes & Decelerators
- 51E-Avionics
- 51F-Test Facilities & Equipment

#### **98-AGRICULTURE & FOOD**

- 980-General
- 98A-Agricultural Chemistry
- 98B-Agricultural Economics
- 98C-Agricultural Equipment, Facilities,  
& Operations
- 98D-Agronomy, Horticulture, & Plant Pathology
- 98E-Animal Husbandry & Veterinary Medicine
- 98F-Fisheries & Aquaculture
- 98G-Agriculture Resource Surveys
- 98H-Food Technology

#### **54-ASTRONOMY & ASTROPHYSICS**

- 540-General
- 54A-Astrogeology
- 54B-Astronomy & Celestial Mechanics
- 54C-Astrophysics
- 54D-Cosmic Ray Research

#### **55-ATMOSPHERIC SCIENCES**

- 550-General
- 55A-Aeronomy
- 55B-Dynamic Meteorology
- 55C-Meteorological Data Collection, Analysis,  
& Weather Forecasting
- 55D-Meteorological Instruments  
& Instrument Platforms
- 55E-Physical Meteorology
- 55F-Weather Modification

#### **92-BEHAVIOR & SOCIETY**

- 920-General
- 92A-Job Training & Career Development
- 92B-Psychology
- 92C-Social Concerns
- 92D-Education, Law, & Humanities
- 92E-International Relations

#### **95-BIOMEDICAL TECHNOLOGY & HUMAN FACTORS ENGINEERING**

- 950-General
- 95A-Prosthetics & Mechanical Organs
- 95B-Tissue Preservation & Storage
- 95C-Biomedical Instrumentation  
& Bioengineering
- 95D-Human Factors Engineering
- 95E-Life Support Systems
- 95F-Bionics & Artificial Intelligence
- 95G-Protective Equipment

#### **89-BUILDING INDUSTRY TECHNOLOGY**

- 890-General
- 89B-Architectural Design  
& Environmental Engineering
- 89C-Construction Management & Techniques
- 89D-Structural Analyses
- 89E-Building Standards & Codes
- 89G-Construction Materials, Components,  
& Equipment
- 89H-Building Equipment, Furnishings,  
& Maintenance

#### **96-BUSINESS & ECONOMICS**

- 960-General
- 96A-Domestic Commerce, Marketing,  
& Economics
- 96C-International Commerce, Marketing,  
& Economics
- 96D-Consumer Affairs
- 96E-Minority Enterprises
- 96F-Banking & Finance
- 96G-Foreign Industry Economic Development
- 96H-Foreign Business & Economics

**99-CHEMISTRY**

- 990-General
- 99A-Analytical Chemistry
- 99B-Industrial Chemistry  
& Chemical Process Engineering
- 99C-Polymer Chemistry
- 99D-Basic & Synthetic Chemistry
- 99E-Photochemistry & Radiation Chemistry
- 99F-Physical & Theoretical Chemistry

**50-CIVIL ENGINEERING**

- 500-General
- 50A-Highway Engineering
- 50B-Civil Engineering
- 50C-Construction Equipment, Materials,  
& Supplies
- 50D-Soil & Rock Mechanics

**81-COMBUSTION, ENGINES, & PROPELLANTS**

- 810-General
- 81A-Combustion & Ignition
- 81B-Electric & Ion Propulsion
- 81C-Fuel & Propellant Tanks
- 81D-Jet & Gas Turbine Engines
- 81G-Rocket Engines & Motors
- 81H-Rocket Propellants
- 81I-Nuclear Propulsion
- 81J-Reciprocation  
& Rotating Combustion Engines

**45-COMMUNICATION**

- 450-General
- 45A-Policies, Regulations, & Studies
- 45B-Radio & Television Equipment
- 45C-Common Carrier & Satellite
- 45D-Sociopolitical
- 45E-Graphics
- 45F-Verbal
- 45G-Communication & Information Theory

**62-COMPUTERS, CONTROL  
& INFORMATION THEORY**

- 620-General
- 62A-Computer Hardware
- 62B-Computer Software
- 62C-Control Systems & Control Theory
- 62D-Information Processing Standards
- 62E-Information Theory
- 62F-Pattern Recognition & Image Processing
- 62R-Applications Software
- 62S-Data Files

**63-DETECTION & COUNTERMEASURES**

- 630-General
- 63A-Acoustic Detection
- 63B-Electromagnetic  
& Acoustic Countermeasures
- 63C-Infrared & Ultraviolet Detection
- 63D-Magnetic Detection
- 63E-Nuclear Explosion Detection
- 63F-Optical Detection
- 63G-Personnel Detection
- 63H-Radiofrequency Detection
- 63I-Seismic Detection

**49-ELECTROTECHNOLOGY**

- 490-General
- 49A-Antennas
- 49B-Circuits
- 49C-Electromechanical Devices
- 49D-Electron Tubes
- 49E-Optoelectronic Devices & Systems
- 49F-Power & Signal Transmission Devices
- 49G-Resistive, Capacitive,  
& Inductive Components
- 49H-Semiconductor Devices

**97-ENERGY**

- 970-General
- 97A-Reserves
- 97B-Energy Use, Supply, & Demand
- 97E-Electric Power Transmission
- 97F-Fuel Conversion Processes
- 97G-Policies, Regulations & Studies
- 97I-Electric Power Production
- 97J-Heating & Cooling Systems
- 97K-Fuels
- 97L-Engine Studies (Energy Related)
- 97M-Batteries & Components
- 97N-Solar Energy
- 97O-Miscellaneous Energy Conversion  
& Storage
- 97P-Geothermal Energy
- 97Q-Selected Studies In Nuclear Technology
- 97R-Environmental Studies

**68-ENVIRONMENTAL POLLUTION & CONTROL**

- 680-General
- 68A-Air Pollution & Control
- 68B-Noise Pollution & Control
- 68C-Solid Wastes Pollution & Control
- 68D-Water Pollution & Control
- 68E-Pesticides Pollution & Control
- 68F-Radiation Pollution & Control
- 68G-Environmental Health & Safety
- 68H-Environmental Impact Statements

## **90-GOVERNMENT INVENTIONS FOR LICENSING**

- 900-General
- 90A-Mechanical Devices & Equipment
- 90B-Chemistry
- 90C-Nuclear Technology
- 90D-Biology & Medicine
- 90E-Metallurgy
- 90F-Electrotechnology
- 90G-Instruments
- 90H-Optics & Lasers
- 90I-Ordnance
- 90J-Food Technology

## **44-HEALTH CARE**

- 440-General
- 44A-Planning Methodology
- 44B-Agency Administrative  
& Financial Management
- 44C-Community & Population Characteristics
- 44D-Health Care Assessment  
& Quality Assurance
- 44E-Health Care Measurement Methodology
- 44F-Health Care Forecasting Methodology
- 44G-Environmental & Occupational Factors
- 44H-Health Care Technology
- 44J-Health Delivery Plans, Projects & Studies
- 44K-Health Services
- 44L-Health Care Needs & Demands
- 44M-Health Resources
- 44N-Health Care Utilization
- 44P-Health Education & Manpower Training
- 44Q-Health-Related Costs
- 44R-Economics & Sociology
- 44S-Legislation & Regulations
- 44T-Data & Information Systems
- 44U-Health Care Delivery Organization  
& Administration

## **94-INDUSTRIAL & MECHANICAL ENGINEERING**

- 940-General
- 94A-Production Planning & Process Controls
- 94B-Quality Control & Reliability
- 94C-Plant Design & Maintenance
- 94D-Job Environment
- 94E-Environmental Engineering
- 94F-Tooling, Machinery, & Tools
- 94G-Manufacturing Processes  
& Materials Handling
- 94H-Industrial Safety Engineering
- 94I-Hydraulic & Pneumatic Equipment
- 94J-Nondestructive Testing
- 94K-Laboratory & Test Facility Design  
& Operation

## **88-LIBRARY & INFORMATION SCIENCES**

- 880-General
- 88A-Operations & Planning
- 88B-Information Systems
- 88C-Marketing & User Services
- 88D-Personnel
- 88E-Reference Materials

## **41-MANUFACTURING TECHNOLOGY**

- 410-General
- 41A-Computer Aided Design (CAD)
- 41B-Computer Aided Manufacturing (CAM)
- 41C-Robotics/Robots
- 41D-Productivity
- 41E-Manufacturing, Planning, Processing  
& Control
- 41F-Joining
- 41G-Quality Control & Reliability
- 41H-Plant Design & Maintenance
- 41I-Job Environment
- 41J-Tooling, Machinery, & Tools
- 41K-Engineering Materials
- 41L-Tribology
- 41M-Optics & Lasers
- 41N-Computer Software
- 41O-Domestic Commerce, Marketing,  
& Economics
- 41P-Research Program Administration  
& Technology Transfer

## **71-MATERIALS SCIENCES**

- 710-General
- 71A-Ablative Materials & Ablation
- 71B-Adhesives & Sealants
- 71C-Carbon & Graphite
- 71D-Ceramics, Refractories, & Glass
- 71E-Coatings, Colorants, & Finishes
- 71F-Composite Materials
- 71G-Corrosion & Corrosion Inhibition
- 71H-Elastomers
- 71I-Fibers & Textiles
- 71J-Iron & Iron Alloys
- 71K-Lubricants & Hydraulic Fluids
- 71L-Materials Degradation & Fouling
- 71M-Miscellaneous Materials
- 71N-Nonferrous Metals & Alloys
- 71O-Plastics
- 71P-Refractory Metals & Alloys
- 71Q-Solvents, Cleaners, & Abrasives
- 71R-Wood & Paper Products

**72-MATHEMATICAL SCIENCES**

- 720-General
- 72B-Algebra, Analysis, Geometry,  
& Mathematical Logic
- 72E-Operations Research
- 72F-Statistical Analysis

**57-MEDICINE & BIOLOGY**

- 570-General
- 57A-Anatomy
- 57B-Biochemistry
- 57C-Botany
- 57D-Clinical Chemistry
- 57E-Clinical Medicine
- 57F-Cytology, Genetics, & Molecular Biology
- 57G-Dentistry
- 57H-Ecology
- 57I-Electrophysiology
- 57J-Immunology
- 57K-Microbiology
- 57L-Nutrition
- 57M-Occupational Therapy, Physical Therapy,  
& Rehabilitation
- 57N-Parasitology
- 57O-Pathology
- 57P-Pest Control
- 57Q-Pharmacology  
& Pharmacological Chemistry
- 57S-Physiology
- 57T-Psychiatry
- 57U-Public Health & Industrial Medicine
- 57V-Radiobiology
- 57W-Stress Physiology
- 57X-Surgery
- 57Y-Toxicology
- 57Z-Zoology

**74-MILITARY SCIENCES**

- 740-General
- 74A-Antiaircraft Defense Systems
- 74B-Antimissile Defense Systems
- 74C-Antisubmarine Warfare
- 74D-Chemical, Biological,  
& Radiological Warfare
- 74E-Logistics, Military Facilities, & Supplies
- 74F-Military Intelligence
- 74G-Military Operations, Strategy, & Tactics
- 74H-Nuclear Warfare
- 74I-Passive Defense Systems

**75-MISSILE TECHNOLOGY**

- 750-General
- 75A-Air & Space-Launched Missiles
- 75B-Missile Guidance & Control Systems
- 75C-Missile Launching & Support Systems
- 75D-Missile Tracking Systems

- 75E-Missile Trajectories & Reentry Dynamics
- 75F-Missile Warheads & Fuses
- 75G-Surface-Launched Missiles
- 75H-Underwater-Launched Missiles

**48-NATURAL RESOURCES & EARTH SCIENCES**

- 480-General
- 48A-Mineral Industries
- 48B-Natural Resource Management
- 48C-Natural Resource Surveys
- 48D-Forestry
- 48E-Soil Sciences
- 48F-Geology & Geophysics
- 48G-Hydrology & Limnology
- 48H-Snow, Ice, & Permafrost
- 48I-Cartography

**76-NAVIGATION, GUIDANCE, & CONTROL**

- 760-General
- 76A-Control Devices & Equipment
- 76B-Guidance Systems
- 76C-Navigation & Guidance System Components
- 76D-Navigation Systems

**77-NUCLEAR SCIENCE & TECHNOLOGY**

- 770-General
- 77A-Fusion Devices (Thermonuclear)
- 77B-Isotopes
- 77C-Nuclear Auxiliary Power Systems
- 77D-Nuclear Explosions & Devices
- 77E-Nuclear Instrumentation
- 77F-Radiation Shielding, Protection, & Safety
- 77G-Radioactive Wastes & Radioactivity
- 77H-Reactor Engineering  
& Nuclear Power Plants
- 77I-Reactor Fuels & Fuel Processing
- 77J-Reactor Materials
- 77K-Reactor Physics

**47-OCEAN SCIENCES & TECHNOLOGY**

- 470-General
- 47A-Marine Engineering
- 47B-Dynamic Oceanography
- 47C-Physical & Chemical Oceanography
- 47D-Biological Oceanography
- 47E-Marine Geophysics & Geology
- 47F-Oceanographic Vessels, Instruments,  
& Platforms
- 47G-Hydrography
- 47H-Underwater Construction & Habitats



**79-ORDNANCE**

- 790-General
- 79A-Ammunition, Explosives, & Pyrotechnics
- 79B-Armor
- 79C-Bombs
- 79D-Combat Vehicles
- 79E-Detonations, Explosion Effects, & Ballistics
- 79F-Fire Control & Bombing Systems
- 79G-Guns
- 79H-Rockets
- 79I-Underwater Ordnance

**82-PHOTOGRAPHY & RECORDING DEVICES**

- 820-General
- 82A-Holography
- 82B-Photographic Techniques & Equipment
- 82C-Recording Devices

**46-PHYSICS**

- 460-General
- 46A-Acoustics
- 46B-Fluid Mechanics
- 46C-Optics & Lasers
- 46D-Solid State Physics
- 46E-Structural Mechanics
- 46G-Plasma Physics
- 46H-Radiofrequency Waves

**43-PROBLEM-SOLVING INFORMATION  
FOR STATE & LOCAL GOVERNMENTS**

- 430-General
- 43A-Finance
- 43B-Economic & Community Development
- 43C-Human Resources
- 43D-Police, Fire, & Emergency Services
- 43E-Energy
- 43F-Environment
- 43G-Transportation

**84-SPACE TECHNOLOGY**

- 840-General
- 84A-Astronautics
- 84B-Extraterrestrial Exploration
- 84C-Manned Spacecraft
- 84D-Spacecraft Trajectories & Flight Mechanics
- 84E-Space Launch Vehicles  
& Support Equipment
- 84F-Space Safety
- 84G-Unmanned Spacecraft

**85-TRANSPORTATION**

- 850-General
- 85A-Air Transportation
- 85C-Metropolitan Rail Transportation
- 85D-Transportation Safety
- 85E-Pipeline Transportation
- 85F-Global Navigation Systems
- 85G-Marine & Waterway Transportation
- 85H-Road Transportation
- 85I-Railroad Transportation

**91-URBAN & REGIONAL TECHNOLOGY  
& DEVELOPMENT**

- 910-General
- 91A-Environmental Management & Planning
- 91B-Transportation & Traffic Planning
- 91C-Fire Services, Law Enforcement,  
& Criminal Justice
- 91D-Communications
- 91E-Housing
- 91F-Health Services
- 91G-Urban Administration & Planning
- 91H-Regional Administration & Planning
- 91I-Emergency Services & Planning
- 91J-Economic Studies
- 91K-Social Services
- 91L-Recreation

# NTIS Subject Categories

## Alphabetical Listing by All Categories

### Appendix B

Ablative Materials and Ablation .....	(71A)	Atmospheric Sciences .....	(55)
Acoustic Detection .....	(63A)	Atmospheric Sciences	
Acoustics .....	(46A)	Dynamic Meteorology .....	(55B)
Adhesives and Sealants .....	(71B)	Avionics .....	(51E)
Administration and Management .....	(70)	Banking and Finance .....	(96F)
Aerodynamics .....	(51A)	Basic and Synthetic Chemistry .....	(99D)
Aeronautics .....	(51B)	Batteries and Components .....	(97M)
Aeronautics -Test Facilities		Behavior and Society .....	(92)
and Equipment .....	(51F)	Biochemistry .....	(57B)
Aeronautics and Aerodynamics .....	(51)	Biological Oceanography .....	(47D)
Aeronomy .....	(55A)	Biomedical Instrumentation	
Agricultural Chemistry .....	(98A)	and Bioengineering .....	(95C)
Agricultural Economics .....	(98B)	Biomedical Technology	
Agricultural Equipment, Facilities,		and Human Factors Engineering .....	(95)
and Operations .....	(98C)	Bionics and Artificial Intelligence .....	(95F)
Agricultural Resource Surveys .....	(98G)	Bombs .....	(79C)
Agriculture and Food .....	(98)	Botany .....	(57C)
Agronomy, Horticulture,		Building Construction Management	
and Plant Pathology .....	(98D)	and Techniques .....	(89C)
Air and Space-Launched Missiles .....	(75A)	Building Construction Materials,	
Air Pollution and Control .....	(68A)	Components, and Equipment .....	(89G)
Air Transportation .....	(85A)	Building Equipment, Furnishings,	
Aircraft .....	(51C)	and Maintenance .....	(89H)
Algebra, Analysis, Geometry,		Building Industry Technology .....	(89)
and Mathematical Logic .....	(72B)	Building Standards and Codes .....	(89E)
Ammunition, Explosives,		Building Structural Analyses .....	(89D)
and Pyrotechnics .....	(79A)	Business - Foreign Industry Development	
Analytical Chemistry .....	(99A)	and Economics .....	(96G)
Anatomy .....	(57A)	Business - International Commerce,	
Animal Husbandry and Veterinary		Marketing, and Economics .....	(96C)
Medicine .....	(98E)	Business and Economics .....	(96)
Antennas .....	(49A)	Business Domestic Commerce, Marketing,	
Antiaircraft Defense Systems .....	(74A)	and Economics .....	(96A)
Antimissile Defense Systems .....	(74B)	Carbon and Graphite .....	(71C)
Antisubmarine Warfare .....	(74C)	Cartography .....	(48I)
Architectural Design		Ceramics, Refractories, and Glass .....	(71D)
and Environmental Engineering .....	(89B)	Chemical, Biological,	
Armor .....	(79B)	and Radiological Warfare .....	(74D)
Astrogeology .....	(54A)	Chemistry .....	(99)
Astronautics .....	(84A)	Chemistry - Physical and Theoretical .....	(99F)
Astronomy and Astrophysics .....	(54)	Chemistry - Photo and Radiation .....	(99E)
Astronomy and Astrophysics		Circuits .....	(49B)
Cosmic Ray Research .....	(54D)	Civil Engineering .....	(50B)
Astronomy and Celestial Mechanics .....	(54B)	Civil Engineering (Heading) .....	(50)
Astrophysics .....	(54C)		

Civil Engineering Construction Equipment, Materials, and Supplies ..... (50C)	Electronic Resistive, Capacitive, and Inductive Components ..... (49G)
Clinical Chemistry ..... (57D)	Electrotechnology ..... (49)
Clinical Medicine ..... (57E)	Energy ..... (97)
Coatings, Colorants, and Finishes ..... (71E)	Energy Environmental Studies ..... (97R)
Combat Vehicles ..... (79D)	Energy Policies, Regulations, and Studies ..... (97G)
Combustion and Ignition ..... (81A)	Energy Reserves ..... (97A)
Combustion, Engines and Propellants Electric and Ion Propulsion ..... (81B)	Energy Use, Supply, and Demand ..... (97B)
Combustion, Engines, and Propellants ..... (81)	Engine Studies (Energy Related) ..... (97L)
Common Carrier and Satellite ..... (45C)	Engineering Materials ..... (41K)
Communication ..... (45)	Environmental Engineering ..... (94E)
Communication Graphics ..... (45E)	Environmental Health and Safety ..... (68G)
Communication and Information Theory ..... (45G)	Environmental Impact Statements ..... (68H)
Communication Policies, Regulations, and Studies ..... (45A)	Environmental Pollution and Control ..... (68)
Communications - Sociopolitical ..... (45D)	Fibers and Textiles ..... (71I)
Communications - Verbal ..... (45F)	Fisheries and Aquaculture ..... (98F)
Composite Materials ..... (71F)	Fluid Mechanics ..... (46B)
Computer Aided design (CAD) ..... (41A)	Food Technology ..... (98H)
Computer Aided Manufacturing (CAM) ..... (41B)	Forestry ..... (48D)
Computer Control Systems and Control Theory ..... (62C)	Fuel and Propellant Tanks ..... (81C)
Computer Hardware ..... (62A)	Fuel Conversion Processes ..... (97F)
Computer Information Processing Standards ..... (62D)	Fuels ..... (97K)
Computer Information Theory ..... (62E)	Fusion Devices (Thermonuclear) ..... (77A)
Computer Software ..... (62B)	Geology and Geophysics ..... (48F)
Computers, Control, and Information Theory ..... (62)	Geothermal Energy ..... (97P)
Consumer Affairs ..... (96D)	Global Navigation Systems ..... (85F)
Corrosion and Corrosion Inhibition ..... (71G)	Government Inventions - Biology and Medicine ..... (90D)
Cytology, Genetics, and Molecular Biology ..... (57F)	Government Inventions - Chemistry ..... (90B)
Dentistry ..... (57G)	Government Inventions - Electrotechnology ..... (90F)
Detection and Countermeasures ..... (63)	Government Inventions - Food Technology ..... (90J)
Detonations, Explosion Effects, and Ballistics ..... (79E)	Government Inventions - Instruments ..... (90G)
Dynamic Oceanography ..... (47B)	Government Inventions - Mechanical Devices and Equipment ..... (90A)
Ecology ..... (57H)	Government Inventions - Metallurgy ..... (90E)
Education, Law, and Humanities ..... (92D)	Government Inventions - Nuclear Technology ..... (90C)
Elastomers ..... (71H)	Government Inventions - Optics and Lasers ..... (90H)
Electric Power Production ..... (97I)	Government Inventions - Ordnance ..... (90I)
Electric Power Transmission ..... (97E)	Government Inventions for Licensing ..... (90)
Electromagnetic and Acoustic Countermeasures ..... (63B)	Guns ..... (79G)
Electromechanical Devices ..... (49C)	Health Care ..... (44)
Electron Tubes ..... (49D)	Health Care Agency Administrative and Financial Management ..... (44B)
	Health Care Assessment and Quality Assurance ..... (44D)

Health Care Community and Population Characteristics ..... (44C)	Joining .....(41F)
Health Care Data and Information Systems .....(44T)	Library and Information Science Marketing and User Services ..... (88C)
Health Care Delivery Organization and Management ..... (44U)	Library and Information Science Personnel ..... (88D)
Health Care Economics and Sociology ..... (44R)	Library and Information Sciences ..... (88)
Health Care Environmental and Occupational Factors ..... (44G)	Library and Information Sciences Operations and Planning ..... (88A)
Health Care forecasting Methodology .....(44F)	Library Information Systems .....(88B)
Health Care Legislation and Regulations ..... (44S)	Life Support Systems .....(95E)
Health Care measurement Methodology .....(44E)	Logistics, Military Facilities, and Supplies .....(74E)
Health Care Needs and Demands .....(44L)	Lubricants and Hydraulic Fluids ..... (71K)
Health Care Technology ..... (44H)	Magnetic Detection ..... (63D)
Health Care Utilization ..... (44N)	Management Information Systems ..... (70C)
Health Delivery Plans, Projects, and Studies ..... (44J)	Management Practice .....(70B)
Health Education and Manpower Training .....(44P)	Manned Spacecraft ..... (84C)
Health Planning Methodology ..... (44A)	Manufacturing Job Environment .....(41I)
Health Resources .....(44M)	Manufacturing Computer Software ..... (41N)
Health Services ..... (44K)	Manufacturing Domestic Commerce, Marketing, and Economics ..... (41O)
Health-Related Costs ..... (44Q)	Manufacturing Optics and Lasers .....(41M)
Heating and Cooling Systems ..... (97J)	Manufacturing Plant Design and Maintenance ..... (41H)
Highway Engineering ..... (50A)	Manufacturing Processes and Materials Handling ..... (94G)
Holography ..... (82A)	Manufacturing Productivity ..... (41D)
Human Factors Engineering ..... (95D)	Manufacturing Quality Control and Reliability ..... (41G)
Hydraulic and Pneumatic Equipment .....(94I)	Manufacturing Research Program Administration and Technology Transfer .....(41P)
Hydrography ..... (47G)	Manufacturing Technology ..... (41)
Hydrology and Limnology ..... (48G)	Manufacturing Tooling, Machinery, and Tools ..... (41J)
Immunology ..... (57J)	Manufacturing, Planning, Processing, and Control .....(41E)
Industrial and Mechanical Engineering ..... (94)	Marine and Waterway Transportation ..... (85G)
Industrial and Mechanical Engineering Plant Design and Maintenance ..... (94C)	Marine Engineering ..... (47A)
Industrial and Mechanical Engineering Production Planning and Process Controls ..... (94A)	Marine Geophysics and Geology .....(47E)
Industrial and Mechanical Engineering Quality Control and Reliability .....(94B)	Materials Degradation and Fouling .....(71L)
Industrial Chemistry and Chemical Process Engineering .....(99B)	Materials Sciences ..... (71)
Industrial Job Environment ..... (94D)	Mathematical Sciences ..... (72)
Industrial Laboratory and Test Facility Design and Operation ..... (94K)	Medicine and Biology ..... (57)
Industrial Safety Engineering ..... (94H)	Medicine and Biology Electrophysiology .....(57I)
Infrared and Ultraviolet Detection ..... (63C)	Meteorological Data Collection, Analysis, and Weather Forecasting ..... (55C)
International Relations .....(92E)	Meteorological Instruments and Instrument Platforms ..... (55D)
Inventory Control ..... (70A)	Metropolitan Rail Transportation ..... (85C)
Iron and Iron Alloys ..... (71J)	ESM / PETITIONER EX 1013_43
Isotopes .....(77B)	
Jet and Gas Turbine Engines ..... (81D)	

Microbiology .....	(57K)	Operations Research .....	(72E)
Military Intelligence .....	(74F)	Optical Detection .....	(63F)
Military Operations, Strategy, and Tactics .....	(74G)	Optics and Lasers .....	(46C)
Military Sciences .....	(74)	Optoelectronic Devices and Systems .....	(49E)
Mineral Industries .....	(48A)	Ordnance .....	(79)
Minority Enterprises .....	(96E)	Ordnance - Fire Control and Bombing Systems .....	(79F)
Miscellaneous Energy Conversion and Storage .....	(97O)	Parachutes and Decelerators .....	(51D)
Miscellaneous Materials .....	(71M)	Parasitology .....	(57N)
Missile Guidance and Control Systems .....	(75B)	Passive Defense Systems .....	(74I)
Missile Launching and Support Systems .....	(75C)	Pathology .....	(57O)
Missile Technology .....	(75)	Pattern Recognition and Image Processing .....	(62F)
Missile Tracking Systems .....	(75D)	Personnel Detection .....	(63G)
Missile Trajectories and Reentry Dynamics .....	(75E)	Pest Control .....	(57P)
Missile Warheads and Fuses .....	(75F)	Pesticides Pollution and Control .....	(68E)
Natural Resource Management .....	(48B)	Pharmacology and Pharmacological Chemistry .....	(57Q)
Natural Resource Surveys .....	(48C)	Photographic Techniques and Equipment .....	(82B)
Natural Resources and Earth Sciences .....	(48)	Photography and Recording Devices .....	(82)
Navigation and Guidance System Components .....	(76C)	Physical and Chemical Oceanography .....	(47C)
Navigation Control Devices and Equipment .....	(76A)	Physical Meteorology .....	(55E)
Navigation Guidance Systems .....	(76B)	Physics .....	(46)
Navigation Systems .....	(76D)	Physiology .....	(57S)
Navigation, Guidance, and Control .....	(76)	Pipeline Transportation .....	(85E)
Noise Pollution and Control .....	(68B)	Plasma Physics .....	(46G)
Nondestructive Testing .....	(94J)	Plastics .....	(71O)
Nonferrous Metals and Alloys .....	(71N)	Polymer Chemistry .....	(99C)
Nuclear Auxiliary Power Systems .....	(77C)	Power and Signal Transmission Devices .....	(49F)
Nuclear Explosion Detection .....	(63E)	Problem Solving for State and Local Governments - Finance .....	(43A)
Nuclear Explosions and Devices .....	(77D)	Problem Solving for State and Local Governments-Economic and Community Development .....	(43B)
Nuclear Instrumentation .....	(77E)	Problem Solving for State and Local Governments Environment .....	(43F)
Nuclear Propulsion .....	(81I)	Problem Solving Information for State and Local Governments .....	(43)
Nuclear Reactor Engineering and Nuclear Power Plants .....	(77H)	Productivity .....	(70G)
Nuclear Reactor Fuels and Fuel Processing .....	(77I)	Prosthetics and Mechanical Organs .....	(95A)
Nuclear Reactor Materials .....	(77J)	Protective Equipment .....	(95G)
Nuclear Reactor Physics .....	(77K)	Psychiatry .....	(57T)
Nuclear Science and Technology .....	(77)	Psychology .....	(92B)
Nuclear Technology Selected Studies .....	(97Q)	Public Administration and Government .....	(70F)
Nuclear Warfare .....	(74H)	Public Health and Industrial Medicine .....	(57U)
Nutrition .....	(57L)	Radiation Pollution and Control .....	(68F)
Occupational Therapy, Physical Therapy, and Rehabilitation .....	(57M)	Radiation Shielding, Protection, and Safety .....	(77F)
Ocean Technology and Engineering .....	(47)		
Oceanographic Vessels, Instruments, and Platforms .....	(47F)		



Radio and Television Equipment .....	(45B)	Tissue Preservation and Storage .....	(95B)
Radio Frequency Detection .....	(63H)	Tooling, Machinery, and Tools .....	(94F)
Radio Frequency Waves .....	(46H)	Toxicology .....	(57Y)
Radioactive Wastes and Radioactivity .....	(77G)	Transportation .....	(85)
Radiobiology .....	(57V)	Transportation Safety .....	(85D)
Railroad Transportation .....	(85I)	Tribology .....	(41L)
Reciprocating and Rotating Combustion Engines .....	(81J)	Underwater Construction and Habitats .....	(47H)
Recording Devices .....	(82C)	Underwater Ordnance .....	(79I)
Reference Materials .....	(88E)	Underwater-Launched Missiles .....	(75H)
Refractory Metals and Alloys .....	(71P)	Unmanned Spacecraft .....	(84G)
Research Program Administration and Technology Transfer .....	(70E)	Urban Administration and Planning .....	(91G)
Road Transportation .....	(85H)	Urban and Regional Technology and Development .....	(91)
Robotics/Robots .....	(41C)	Urban and Regional Technology Communications .....	(91D)
Rocket Engines and Motors .....	(81G)	Urban Economic Studies .....	(91J)
Rocket Propellants .....	(81H)	Urban Emergency Services and Planning .....	(91I)
Rockets .....	(79H)	Urban Environmental Management and Planning .....	(91A)
Seismic Detection .....	(63I)	Urban Fire Services, Law Enforcement, and Criminal Justice .....	(91C)
Semiconductor Devices .....	(49H)	Urban Health Services .....	(91F)
Snow, Ice, and Permafrost .....	(48H)	Urban Housing .....	(91E)
Social Concerns .....	(92C)	Urban Recreation .....	(91L)
Soil and Rock Mechanics .....	(50D)	Urban Regional Administration and Planning .....	(91H)
Soil Sciences .....	(48E)	Urban Social Services .....	(91K)
Solar Energy .....	(97N)	Urban Transportation and Traffic Planning .....	(91B)
Solid State Physics .....	(46D)	Water Pollution and Control .....	(68D)
Solid Wastes Pollution and Control .....	(68C)	Weather Modification .....	(55F)
Solvents, Cleaners, and Abrasives .....	(71Q)	Wood and Paper Products .....	(71R)
Space Extraterrestrial Exploration .....	(84B)	Zoology .....	(57Z)
Space Launch Vehicles and Support Equipment .....	(84E)		
Space Safety .....	(84F)		
Space Technology .....	(84)		
Spacecraft Trajectories and Flight Mechanics .....	(84D)		
State and Local Governments - Transportation .....	(43G)		
State and Local Government Energy .....	(43E)		
State and Local Governments - Human Resources .....	(43C)		
State and Local Governments Police, Fire, and Emergency Services .....	(43D)		
Statistical Analysis .....	(72F)		
Stress Physiology .....	(57W)		
Structural Mechanics .....	(46E)		
Surface-Launched Missiles .....	(75G)		
Surgery .....	(57X)		

# NTIS Subject Categories

## Alphabetical Listing with Scope Descriptions

### Appendix C

#### 70-ADMINISTRATION & MANAGEMENT

##### 700-General

Organizational structure and organization theory.

##### 70A-Inventory Control

Inventory analysis; Inventory models; Obsolescence; Repair-replacement tradeoffs; Spare parts; Stock level control; Usage prediction; Warehouse automation; Stockpiling.

##### 70B-Management Practice

Theory and concepts of management including record keeping, planning, scheduling, organization, coordination, decision making, policy making; Productivity management; Cost effectiveness; Systems management; Contact management; Management methods (PERT, PPB, etc.); Management games. Applied studies are classified in the application.

For research management, use 70E.

##### 70C-Management Information Systems

Information systems which include data collection, data processing, and information delivery for use in decision making an evaluation by managers; Manual and automated systems.

See also 88B.

##### 70D-Personnel Management, Labor Relations & Manpower Studies

Selection, recruitment, management, utilization, and evaluation of personnel; Job descriptions; Job analysis; Salary administration; Labor supply; Labor unions; Arbitration and bargaining; Industrial relations; Fringe benefits, and incentives; Manpower allocation requirements and utilization.

For library and information science personnel, use 88D.

For health personnel, use 44P.

#### 70E-Research Program Administration & Technology Transfer

Research management, development, and forecasting; Research contract management; Research needs; Technology transfer and forecasting. Excludes research methods per se. Studies of specific programs are excluded unless they discuss a program at the national level, technology innovation, or trends and impacts of new technology.

#### 70F-Public Administration & Government

National, state, and local government structure, operation, and administration. Operations of government agencies and their interactions; Intergovernmental relations.

See also 43, 91G, and 91H.

#### 70G-Productivity

Productivity of businesses, government, employees, management, and services; Improving quality of work life; Measurement of productivity efficiency and effectiveness; Employee attitudes and motivation, manpower utilization and performance improvement, job satisfaction, job security; Labor-management cooperation, joint committees participative management, job redesign; Alternative work schedules; Incentive plans. Productivity barriers including regulations, obsolete practices, paperwork, and financing methods.

See also 70B, 70D, 70F, 96A, and 96G.

For specific applications of productivity to manufacturing, use 41D and 94.

#### 51-AERONAUTICS & AERODYNAMICS

##### 510-General

Includes landing mats.

##### 51A-Aerodynamics

Aerodynamic characteristics and problems of bodies as they are affected by the dynamics of phenomena relating to boundary layer, lift, drag, laminar and turbulent flow, compressible flow, lift, aerodynamic heating, vortex flow, wake, etc. in aerodynamic regimes. Includes aircraft, ground vehicles, and structures.

See also 46B.

For missile reentry dynamics, use 75E.

For spacecraft reentry dynamics, use 84D.

##### 51B-Aeronautics

Aircraft operations such as takeoff and landing, all-weather and night flight, taxiing, approach, letdown, in-flight refueling, etc. Includes aviation accidents.

##### 51C-Aircraft

Design, production, and maintenance of aircraft, aircraft components and equipment. Structural studies of airframes, bodies, wings, fuselages; Military and commercial aircraft; Balloons (excludes meteorological balloons); Air cushion vehicles (excludes tracked vehicles).

See also 85A and 81D.

For meteorological balloons, use 55D.

For tracked air cushion vehicles, use 85C.

For electronic equipment, use 51E.

\* Every primary subject category has a "General" subcategory which contains items whose subject matter falls either into several subcategories or none of the subcategories within a primary category.

In the generic example that follows, the Primary Subject Category is Administration & Management; the Subject Category Code is 70; the Subcategory and Code is 70A; and the descriptions follow. The descriptions are the concepts contained in a report; be careful to avoid "word matching."

#### 70-ADMINISTRATION & MANAGEMENT

##### 70A-Inventory control

Inventory analysis; Inventory models; Obsolescence; Repair-replacement tradeoffs; Spare parts; Stock level control; Usage prediction; Warehouse automation; Stock-piling.

**51D-Parachutes & Decelerators**

Deployable devices and structures to induce drag and deceleration of aircraft, spacecraft, and test vehicles such as rocket sleds.

**51E-Avionics**

Airborne electronic equipment. Includes electronic equipment used for communications; Navigation; Control systems; Onboard air traffic control; Detection.

See also 45, 49, 63, and 76.

**51F-Test Facilities & Equipment**

Wind tunnels; Simulators; Flight simulators.

For flight simulators used for training, use 92A.

**98-AGRICULTURE & FOOD****980-General****98A-Agricultural Chemistry**

The application of chemistry and chemical analysis to agriculture; Fertilizer production; Soil chemistry; Chemistry of feeding stuffs; Crop chemistry; Biochemical studies.

For food chemistry, use 98H.

**98B-Agricultural Economics**

Economics conditions, markets, subsidies, and policies affecting agriculture; Farm management and finance; Land and labor economics; Prices and price control.

See also 96C.

**98C-Agricultural Equipment, Facilities, & Operations**

Agricultural engineering; Agricultural machinery and tools; Seed preservation; Planting, fertilizing, mulching, weeding, and harvesting; Pest and disease control techniques and equipment; Crop protection; Crop drying and storage; Farm water supplies; Irrigation systems; Farm safety; Farm construction and operation.

For pest control, see also 57P.

For food processing, use 98H.

**98D-Agronomy, Horticulture, & Plant Pathology**

Field crop production; Cultivation of orchards, gardens and nurseries; Plant biology; Plant breeding, propagation, and hybridizing; Hydroponics.

See also 57C.

**98E-Animal Husbandry & Veterinary Medicine**

Production and care of domestic and wild animals; Breeding, feeding, management, rearing, testing, and training; Pets; Animal pathology; Toxic effects on domestic animals; Animal quarantine; Disease resistance, control and treatment; Breeding, care, and utilization of laboratory animals.

See also 57Z.

**98F-Fisheries & Aquaculture**

Fishing, fishing equipment, and shipboard processing of fisheries products; Cultivation of fishes, shellfish, and algae in fresh or salt water for commercial or recreational use; Use of fish ladders and weirs; Sport fishing.

See also 47D, 48B, and 57Z.

For fish processing, use 98H.

**98G-Agriculture Resource Surveys**

Surveys to scan crop yields, soil moisture content, crop diseases, and forest diseases. Includes fishery surveys; Satellite and aerial surveys.

**98H-Food Technology**

Pasteurizing, curing, canning, dehydrating, freezing, irradiation, freeze drying, etc., of foods and other agricultural products; Sanitation and fumigation of products; Food additives and preservatives; Analysis and inspection of products; Storage, packaging, and display of products; Kitchen and cooking equipment.

For biochemical studies of foods, see also 57B.

**54-ASTRONOMY & ASTROPHYSICS****540-General****54A-Astrogeology**

Studies of the structure and composition of planets and other bodies in the solar system.

For geology and geophysics, see also 48F.

**54B-Astronomy & Celestial Mechanics**

Positions and motions of the celestial bodies; Ephemerides, Eclipses.

**54C-Astrophysics**

Physical and chemical aspects of celestial bodies, their origin and evolution. Includes astronomical spectroscopy, radio astronomy, solar structure, and planetary atmospheres.

**54D-Cosmic Ray Research**

Detection and analysis of cosmic rays.

**55-ATMOSPHERIC SCIENCES****550-General****55A-Aeronomy**

Physics and chemistry of the upper atmosphere; Composition; Chemical reactions; Aurora; Airglow; Solar-terrestrial relationships.

For cosmic ray research, use 54D.

**55B-Dynamic Meteorology**

Studies of atmospheric motions; Atmospheric diffusion models; Atmospheric circulation.

For air pollution movement studies, use 68A.

**55C-Meteorological Data Collection, Analysis, & Weather Forecasting**

Climatology; Satellite meteorology; Weather prediction; Ice forecasting.

**55D-Meteorological Instruments & Instrument Platforms**

Instruments used to record meteorological parameters; Meteorological balloons; Weather stations; Sounding rockets; Remote sensors.

**55E-Physical Meteorology**

Acoustical, electrical, optical, and thermodynamic properties of the atmosphere; Cloud physics; Precipitation theory; Global warming.

See also 68A.

**55F-Weather Modification**

Change of weather conditions through artificial means; Fog dispersal; Artificial precipitation.

**92-BEHAVIOR & SOCIETY****920-General**

Includes general overall census studies; Political science.

**92A-Job Training & Career Development**

Vocational training; On-the-job training; Retraining; Vocational rehabilitation; Use and design of training simulators (including flight simulators) and equipment; Instructional aids; Professional development; Career development.

For curriculum development, use 92D.

**92B-Psychology**

Human behavior; Personality; Intelligence; Learning ability; Judgment; Motivation; Perception; Job satisfaction; Leadership characteristics; Psychometrics; Adaptability; Social, industrial, group, organizational, interpersonal, and experimental psychology; Clinical psychology; Physiological psychology.

For the measurement of hearing, vision, heart rate, respiration and other physiological responses as related to behavior, use 57T or 57W.

**92C-Social Concerns**

Sociology and sociometrics; Race relations; Age group and minority group studies; Social rehabilitation of drug abusers, alcoholics, physically, emotionally, and mentally handicapped, offenders, etc.; Cultural and economic deprivation; Social discrimination; Immigration; Demography; Social services, including child care, welfare, counseling, financial assistance, and employment and unemployment services; Attitude studies.

See also 43C, 44, and 91K.

**92D-Education, Law, & Humanities**

Formal education; School systems; Educational administration; Curricula; Instructional devices and materials, including audiovisual; Teaching methods; Computer-assisted instruction; Laws; Linguistics; Machine translation; Fine arts; Archaeology; History; Anthropology; Humanities; Religion.

**92E-International Relations**

Political and social indicators; Crises and crisis management; Conflict analysis; Foreign aid; Foreign policy and foreign affairs; International political science; Disarmament and arms control; Espionage; Includes international relationships concerning territorial seas, fishing, extradition, and natural resources.

See also 74H.

For international commerce, use 96C.

**95-BIOMEDICAL TECHNOLOGY & HUMAN FACTORS ENGINEERING****950-General****95A-Prosthetics & Mechanical Organs**

Includes materials and equipment going into human bodies, enabling them to function properly, either temporarily or permanently. Artificial limbs and limb braces; Facial prosthetics, including artificial eyes; Dental prosthetics; Mechanical organs and mechanical hearts; Circulatory assist devices; Artificial kidneys, etc.; Biocompatible materials including tissue adhesives, tissue compatible materials, and antithrombogenic materials.

For prosthodontics, use 57G.

**95B-Tissue Preservation & Storage**

Preservation of organs, tissue, and blood for transplantation or transfusion to living organs; Blood and tissue banks; Properties and evaluation of preserved and stored materials.

See also 57J, 57S, and 57X.

**95C-Biomedical Instrumentation & Bioengineering**

Includes materials and equipment used to monitor human body functions. Design, use, and performance of biomedical equipment; Biotelemetry including biotelemetry transducer and transmitter equipment; Hospital equipment and supplies; Dental materials and equipment; Equipment for physiological monitoring; Diagnostic equipment; Biomedical laboratory equipment.

See also 95A.

**95D-Human Factors Engineering**

Design of tools, instruments, equipment, and machinery with emphasis on optimum utilization by humans; Habitability of work and living space; Ergonomics; Interaction of man and equipment in terms of subsystem and system performance requirements and evaluation. Encompasses manual controls, tactical kinesthesia, and other human sensory modalities involved in operation of equipment and understanding of personnel subsystems; Man-machine systems. Includes anthropometric studies, protective equipment, protective clothing, and life support systems.

**95E-Life Support Systems**

Equipment and techniques for sustaining life in foreign environments, such as space, underground, and underwater; Closed ecological systems (includes pressure suits, diving gear, and breathing apparatus).

See also 95D.

**95F-Bionics & Artificial Intelligence**

Study of biological processes in order to develop engineering systems; Simulation of biological processes; Comparative studies of control systems formed by the brain and nervous system; Pattern recognition systems based on biological modes; Biological applications of information theory; Cybernetics.

**95G-Protective Equipment**

Equipment providing protection against such environmental elements as heat, cold, noise, machinery, and radiation.

For equipment and techniques for sustaining life in environments where normal respiration is not possible, use 95E.

**89-BUILDING INDUSTRY TECHNOLOGY**

Includes fires in buildings.

**890-General**

Includes fires in buildings.

**89B-Architectural Design & Environmental Engineering**

Architecture; Human engineering; Site surveys; Interior design; Lighting; Heating, ventilating, and air conditioning; Heat loss studies. Includes environmental engineering equipment.

See also 97J and 94E.

**89C-Construction Management & Techniques**

Excavation; Fabrication (presite and onsite); Construction techniques; Reconstruction; Management including planning, manpower, and labor studies.



**89D-Structural Analyses**

Dynamics and statics of structures and structural members including kinetics, kinematics, vibration and stress analyses; Induced environmental stresses including earthquakes, wind, and flood; Foundation stresses; Soil-structure interactions.

**89E-Building Standards & Codes**

Standards and codes for buildings, equipment, components, and materials.

**89G-Construction Materials, Components, & Equipment**

Plumbing; Wiring; Insulation; Doors and windows; Walls; Joints; Beams; Construction equipment such as bulldozers and cranes. Includes flammability and fire studies. Cement and concrete.

See also 50C.

For cement properties, see also 71D.

**89H-Building Equipment, Furnishings, & Maintenance**

Equipment including security alarms (i.e. Burglar alarms), elevators, and fire safety devices; Furnishings, including major household appliances, rugs, and furniture; Maintenance, including repair, pest control, and cleaning.

For environmental engineering equipment, use 89B.

**96-BUSINESS & ECONOMICS****960-General**

Includes economic theory; Business and economic census studies; Insurance not covered by another subcategory; Small businesses.

**96A-Domestic Commerce, Marketing, & Economics**

National and state-level studies; Industrial costs and economics; Economic impact of industries; Economic impacts on industries; Industrial statistics; Agricultural economics; Productivity; Labor supply and demand; Labor costs and economics; Inflation; Economic aspects of unemployment; Employment and unemployment statistics; Wage surveys; United States commerce; Wholesale and retail trade; Domestic market surveys; Business, personal, and property taxes; Income tax data; Franchising.

See also 43B, 70D, 91J, and 98B.

For studies of individual plants or operations, see the field of application.

For economic impacts of individual plants or operations, see the field of application.

For regional development, use 43B and 91J.

**96C-International Commerce, Marketing, & Economics**

Foreign market surveys and research; International trade; Imports and exports; Customs and tariffs; Multinational businesses; Trends and forecasting.

For international finance, use 96F.

**96D-Consumer Affairs**

Consumer problems and protection; Truth in advertising; Commercial psychology; Product maintenance and reliability problems; Home appliances safety; Product comparison studies; Flammability studies; Motor vehicle recalls.

**96E-Minority Enterprises**

Minority owned and operated businesses; Business training of minority groups; Franchising; Equal opportunities in business.

**96F-Banking & Finance**

Investments; Credit; Banks and trust companies; Mortgage finance; Savings and loan associations; Security and commodity brokerage; Balance of payments; Gold and silver movement; Cash flow; Regulations; International finance.

For government financial operations, use 43A, 70F, 91G, and/or 91H.

**96G-Foreign Industry Economic Development**

Private and governmental industrial and economic development in foreign countries including industrialized and developing countries; International technology transfer.

For foreign market surveys and international trade, use 96C.

**96H-Foreign Business & Economics**

Foreign and developing countries; Businesses, economic conditions and socioeconomic.

For foreign market surveys and international trade, use 96C.

For social concerns related to economics, see also 92C.

**99-CHEMISTRY****990-General****99A-Analytical Chemistry**

Techniques and instrumentation for the separation and analysis of individual compounds or specific groups or compounds, both inorganic and organic. Includes qualitative, quantitative, volumetric, gravimetric, optical, spectroscopic; electrochemical, ion exchange, chromatographic analysis; Test methods; Forensic chemistry; Data interpretation; Routine analysis or experimental results.

**99B-Industrial Chemistry & Chemical Process Engineering**

Techniques, processes, unit operations, and plant equipment that apply to chemical manufacturing, processing, transportation, and storage; Petroleum refining; Desalination technology; Pollution control equipment; Process control technology; Process engineering; Chemical reactors.

For coal gasification and liquefaction processes, see also 97F and 97K.

For specific environmental pollution control, see also 68.

For water purification, see also 50B and 68D.

**99C-Polymer Chemistry**

Synthesis, properties, reactions and theories of polymers and copolymers. Includes all types of polymerization, curing, crosslinking, reaction kinetics, etc.

For mechanical properties of polymers, use 71O and 71H.

**99D-Basic & Synthetic Chemistry**

Synthesis, properties, and reactions of inorganic and organic compounds; Studies of individual or specific groups of chemical elements; Molecular structure; Stereochemistry.

For chemical reaction mechanisms between atoms, ions, or molecules, see also 99F.

For spectrum analysis of compounds, use 99A and 99F.

**99E-Photochemistry & Radiation Chemistry**

Studies involving the interrelationships of electromagnetic or particle radiation and chemical reactions; Studies of radioactive elements and their reactions; Radiochemistry; Photochemical reactions.

See also 55A and 68A.

**99F-Physical & Theoretical Chemistry**

Physical chemistry; Thermodynamics; Thermochemistry; Colloids and gels; Surface chemistry; Catalysis and catalysts; Electrochemistry; Solutions; Chemical equilibria; Membranes; Reaction kinetics; Quantum mechanics; The mathematical determination of atomic or molecular orbitals, energy levels, or properties; The application of mathematics to chemical systems and electronic spectra, excluding routine analysis or experimental results; Molecular spectra interpretation; Chemical reaction mechanisms in the gas, liquid, or solid phase between atoms, ions, or molecules; Atomic and molecular energy studies; Phase studies of nonmetallic systems; Isotherms; Crystallography.

For advanced materials, use 71Gen or the field of application.

For solid state physics, use 46D.

For thermodynamics, see also 460 General.

**50-CIVIL ENGINEERING****500-General****50A-Highway Engineering**

Construction of roads and highways; Highway and rights-of-way maintenance including weed control; Bridges and bridge systems; Highway paints and markings; Highway and road signs; Beautification; Slope stability and soil subbases.

**50B-Civil Engineering**

Dredging; Dams; Water purification; Reservoir engineering; Flood control; Sewers; Waterway engineering; Runway construction; Shore protection; Breakwaters; Harbor engineering; Tunneling.

See also 47.

For sewage treatment, use 68D.

For building construction, use 89.

For oil and gas reservoir engineering, use 97 or 48A.

**50C-Construction Equipment, Materials, & Supplies**

Excavation and earth moving equipment; Hoisting and conveying equipment; Concrete and cement.

See also 89G.

For properties of concrete and cement, see also 71D.

**50D-Soil & Rock Mechanics**

Physical properties of soil and rock for utilization in engineering; Landslides; Soil stabilization.

For soil sciences, use 48E.

For soil conservation, use 48B.

For geology and geophysics, use 48F.

**81-COMBUSTION, ENGINES, & PROPELLANTS****810-General****81A-Combustion & Ignition**

Autoignition, ignition, and combustion. Includes flame studies; Combustion products studies; Ignition systems; Combustion chemistry; Flammability studies.

See also 89 and 94H.

**81B-Electric & Ion Propulsion**

All types of engines deriving power from free ions and electrons. Includes ion, plasma, and arc jet systems; Propulsion by means of solar wind; Laser propulsion.

For electrically propelled surface vehicles, use 85.

**81C-Fuel & Propellant Tanks**

Design, performance, and testing of fuel and propellant tanks including those for automobiles, petroleum products, and rocket propellants.

**81D-Jet & Gas Turbine Engines**

Design, performance, and testing of all types of jet and gas turbine engines, their components, engine nozzles. Includes Ramjet, Scramjet, and Turbofan engines, and hydroduct and turbomachinery as well as nonpropulsive turbines.

See also 97L and 51C.

**81G-Rocket Engines & Motors**

Design, performance, and testing of rocket engines and motors and their components.

**81H-Rocket Propellants**

Production, handling, stability, and performance of liquid, solid, thixotropic, and exotic propellants. Includes fuels, oxidizers, additives, and binders.

For combustion and ignition, use 81A.

**81I-Nuclear Propulsion**

Design, performance, and testing of nuclear engines for surface, air, and space propulsion.

See also 85.

**81J-Reciprocation & Rotating Combustion Engines**

Design, performance, and testing of reciprocating and rotating engines of various configurations for all types of propulsion.

Includes internal and external combustion engines; Engine exhaust systems; Engine air systems components; Engine structures; Stirling and diesel engines.

See also 97L and 85H.

**45-COMMUNICATION****450-General****45A-Policies, Regulations, & Studies**

Licensing; Legislation; National policies and Federal regulatory controls; Frequency management; Broadcasting standards; Time signals, etc.

**45B-Radio & Television Equipment**

Design and maintenance of radio and television transmitting and receiving equipment only.

See also 51E.

**45C-Common Carrier & Satellite**

All communication equipment except radio and television. Optical, radio, microwave, wire, and acoustic communication; Telephone, telemeter, telegraph, television, and radio communication systems; Computer network communications; Digital communication; Intercommunication systems; Optical scanning.

For information systems, see also 88B.

For design and construction of communication satellites, see also 84G.

**45D-Sociopolitical**

Propaganda; Social communication; Sign language, Effects of communication on society and behavior; Postal service; Mass media communication.

**45E-Graphics**

Publishing; Printing; Graphic arts; Reprography; Xerography; Facsimile; Desktop publishing.



#### 45F-Verbal

Research and development in vocal communication; Speech intelligibility; Speech recognition.

#### 45G-Communication & Information Theory

Theoretical studies relating to the measurement and transmission of information in a communication channel. Includes coding theory, information capacity, detection of signals in noise.

See also 62E.

### 62-COMPUTERS, CONTROL & INFORMATION THEORY

#### 620-General

Includes computer security; Artificial intelligence; Signal processing (unapplied).

#### 62A-Computer Hardware

Design and development of computers and peripheral equipment, including analog computers, digital computers, hybrid computers, special purpose computers, minicomputers, microcomputers; Computer accessories, supplies and installation; Logic circuits; Computer architecture; Computer network hardware.

For computer hardware applied to a specific application, see the field of application.

For Very Large Scale Integration (VLSI), use 49H.

#### 62B-Computer Software

Computer programming; Programming languages; Compilers; Database management systems; Software tools; Software reliability; Computer graphics.

For computer software and database development applied to a specific application, see the field of application.

For CAD/CAM, use 41A and 41B.

#### 62C-Control Systems & Control Theory

Theoretical studies of open-loop and closed-loop control systems; Automatic control systems; Principles including adaptive, continuous, digital, distributed parameter, linear, multivariable, nonlinear, optional, predictive, and proportional; Process controllers.

See also 720 General.

For control systems applied to a specific application, see the field of application.

#### 62D-Information Processing Standards

Standards for the use of automatic data processing equipment and systems. Includes standards for hardware, software, applications, and data; Federal Information Processing Standards (FIPS).

#### 62E-Information Theory

Theoretical studies relating to the measurement and transmission of information in a communication channel, including coding theory, information capacity, and detection of signals in noise.

See also 45G.

#### 62F-Pattern Recognition & Image Processing

Includes feature extraction; Image enhancement; Image restoration; Scene analysis; Character recognition; Barcoding; Computer vision.

#### 62R-Applications Software

#### 62S-Data Files

### 63-DETECTION & COUNTERMEASURES

#### 630-General

Automated access control systems.

For industrial security, see also 940 General

#### 63A-Acoustic Detection

Techniques and equipment used for the detection and tracking of objects by means of sound waves, including ultrasonic and infrasonic radiation; Sonar.

For acoustic testing, use 94.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 54, 47, 57, 41, and 94, respectively.

#### 63B-Electromagnetic & Acoustic Countermeasures

Interception, jamming, antijamming, and deception of acoustic and electromagnetic signals; Techniques to nullify the use of detection, surveillance, guidance, and communication systems; Radar jamming; Chaff; Counter-countermeasures.

See also 74.

#### 63C-Infrared & Ultraviolet Detection

Techniques and equipment for the detection and tracking of objects by infrared and ultraviolet radiation; Infrared night vision devices; Infrared homing.

See also 76B.

For earth resource surveys, use 48C and 98G.

For mapping, use 48I.

For photography, use 82B.

For nondestructive testing, use 94J.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 57, 41, and 94, respectively.

#### 63D-Magnetic Detection

Techniques and equipment for the detection of objects by means of magnetic fields.

For geomagnetism, use 48.

#### 63E-Nuclear Explosion Detection

Techniques and equipment for the detection of nuclear explosions at high altitude, underground, and in space. Includes the use of shock waves, earth movement, and measurement of nuclear radiation levels.

See also other applicable subcategories in 63, especially 63I.

#### 63F-Optical Detection

Techniques and equipment for the detection by means of light.

Includes the use of binoculars, periscopes, telescopes, and night vision devices for object detection, and smoke particle detectors.

See also 46C.

For detection using only infrared or ultraviolet radiation, use 63C.

For earth resources surveys, use 48C and 98G.

For photography, use 82B.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 54, 47, 41, and 94, respectively.

#### 63G-Personnel Detection

Techniques and equipment for the detection of personnel. Includes the use of acoustic, seismic, olfactory, chemical, and optical detectors; Antiintrusion devices; Motion detectors; Security devices.

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**63H-Radiofrequency Detection**

Techniques and equipment for the detection and tracking by means of radiofrequency waves; Radar; Microwave detection.

See also 76.

For mapping, use 48I.

For detection techniques applied to meteorology, astronomy, oceanography, medicine, and manufacturing, use 55, 54, 57, 41, and 94 respectively.

**63I-Seismic Detection**

Techniques and equipment for the detection of objects by means of seismic waves.

For earthquake detection, use 48F.

For seismic prospecting, use 48A.

**49-ELECTROTECHNOLOGY****490-General**

Includes standards, measurements, and instrumentation not applied to any other subcategories.

**49A-Antennas**

Antennas; Antenna theory; Antenna radiation patterns; Radomes.

**49B-Circuits**

Circuit theory; Network analysis; Filters; Oscillators; Logic circuits; Printed circuits; Electronic modules; Commutators; Power supply circuits; Waveform generators; Analog to digital converters; Phase locked systems.

For integrated circuits, use 49H.

**49C-Electromechanical Devices**

Electric motors; Relays; Mechanical switches; Connectors; Circuit breakers; Electric fuses.

**49D-Electron Tubes**

All electron tubes except those in 49E.

**49E-Optoelectronic Devices & Systems**

Display systems; Phototubes; Image tubes; Cathode ray tubes; Electroluminescent panels; Light emitting diodes; Photodiodes; Phototransistors; Magneto-optics; Electro-optics; Optical detectors, including infrared and ultraviolet detectors.

See also 63C and 63F.

For solar cells, see also 97N.

For lasers, use 46C.

**49F-Power & Signal Transmission Devices**

Transmission lines; Electric wire and cable; Waveguides; Fiber optics transmission lines.

**49G-Resistive, Capacitive, & Inductive Components**

Resistors; Capacitors; Inductors; Transformers; Electromagnets; Potentiometers; Thermistors; Delay lines; Transducers; Crystal resonators. Includes miscellaneous and basic components.

**49H-Semiconductor Devices**

Transistors; Semiconductor diodes; Integrated circuits.

For photodiodes, phototransistors, light emitting diodes, and optical detectors, use 49E.

**97-ENERGY****970-General**

Includes energy source development.

**97A-Reserves**

Natural reserves; Fuel stockpiles; Mineral and fossil fuel deposits including coal, uranium, petroleum, natural gas, geothermal, peat, and oil shale; Water power potential; Site studies of wind power potential and solar radiation availability.

For individual mine studies, use 48A.

**97B-Energy Use, Supply, & Demand**

Electric power and fuel consumption and requirements; Supply and demand; Heat use, supply, and demand.

**97E-Electric Power Transmission**

Electric power distribution; Electric transmission lines and substations; Electric power pools; Wireless energy transmission.

**97F-Fuel Conversion Processes**

Methods to convert a fuel to a different chemical form including coal gasification and liquefaction; Upgrading fuels by chemical synthesis.

For petroleum refining, oil shale retorting and refining, use 97K and 99B.

For environmental studies, use 97R.

**97G-Policies, Regulations & Studies**

Energy conservation; Licensing; Legislation; Government policies and regulatory controls; Energy goals; Research needs; Energy management, economics, and financing; Depletion allowances and leasing policies; Rates and energy models; Energy shortages; International issues.

**97I-Electric Power Production**

Design and operation of electric power plants; Commercial, industrial, and residential electric power production; Site surveys; Large-scale nuclear, hydro, solar, geothermal, and fossil fuel electric power plants; Power plant boilers.

Note: usually restricted to large-scale electric power production.

For small-scale electric power production, use 97N, 97O, or 97P.

For pollution control and environmental impact, use 68 and 97R.

For some nuclear power plant studies, use 77 and 97Q. 97Q should be those that are most pertinent to the use of nuclear technology for energy production.

**97J-Heating & Cooling Systems**

Design and operation of space heating and cooling systems and equipment; Furnace and boiler studies when related to energy conservation and energy use; Cooling towers; MIUS technology; Total energy systems.

See also 97N.

**97K-Fuels**

Production, performance, properties, storage, prices, and transportation of all types of solid, liquid, and gaseous fuels; Chemical composition of fuels; Fuel compatibility; Hydrogen production; Refuse derived fuels; Fuel desulfurization; Oil shale retorting; Petroleum refining; Fuel additives; Growing plants for fuels; Bioconversion and biomass plantations.

See also 48D and 97N.

For fuel tanks, use 81C.

For nuclear fuels, use 77I.

For fuel conversion, use 97F.

For rocket fuels, use 81H.

For supply and demand, use 97B.

For oil and gas drilling and recovery, coal mining and other energy related mining studies, use 48A.

**97L-Engine Studies (Energy Related)**

Operation and design of engines when related to energy conservation and energy use. Covers turbine, rotary, and reciprocating engines.

See also 81.

**97M-Batteries & Components**

Electrochemical batteries of all types including alkaline cells, dry cells, metal-air batteries, primary cells, reserve batteries, storage batteries, thermal batteries, wet cells; Battery containers, depolarizers, electrodes, electrolytes, separators, and other components and materials; Battery chargers and testers; Battery electrochemistry.

For thermoelectric and thermionic batteries, use 97O.

**97N-Solar Energy**

Solar collectors, concentrators, and absorbers; Solar cells; Solar cookers, dryers, furnaces, generators; Solar heat engines; Solar heating and cooling systems; Solar power plants; Solar stills; Solar water heaters; Solar heat storage systems; Solar water pumps; Solar sea power plants; Orbital solar power plants; Optical coatings and filters for solar devices; Solar energy policies, use, supply, trends, and economics.

**97O-Miscellaneous Energy Conversion & Storage**

Fuel cells; Magnetohydrodynamics; Experimental electric generators; Turbogenerators; Heat storage; Compressed air energy storage; Mechanical conversion; Thermoelectric and thermionic conversion; Photovoltaic conversion (excludes solar cells); Wind power; Tidal power; Nuclear fusion power plants.

For commercial, industrial, and residential use of energy conversion and storage devices, use 97I or 97J.

**97P-Geothermal Energy**

Geothermal exploration and prospecting methods and equipment; Geothermal resources; Geothermal energy conversion; Geology applied to geothermal systems; Drilling; Reservoirs; Extraction; Site selection; Geothermal power plants; Corrosion studies; Materials used in geothermal systems.

**97Q-Selected Studies In Nuclear Technology**

Reports assigned to this subcategory are selected for their broad interest to users in the nuclear energy field.

For other nuclear energy subcategories, use 77.

**97R-Environmental Studies**

Air, noise, water, and solid waste pollution and pollution control from energy resource development, fuel production, energy production, and energy use; Environmental impacts of energy production and use.

See also 68.

**68-ENVIRONMENTAL POLLUTION & CONTROL****680-General**

Any study covering multiple types of pollution. Includes broad pollution studies, such as life-cycle analysis of wastes.

**68A-Air Pollution & Control**

Air pollution from flue gases, exhaust gases, odors, dust, smog, microorganisms, etc.; Control techniques and equipment; Sampling and analytical techniques, and equipment; Waste gas recovery; Biological and ecological effects; Air pollution chemistry; Acid precipitation; Atmospheric motion; Laws, legislation, and regulations; Public administration; Economics; Land use.

See also 43F, 91A, 57, 85, 81, 99A, 99B, and 97R.

For effects on human health, use 68G.

For pesticides and radioactive contaminants, use 68E and 68F respectively.

**68B-Noise Pollution & Control**

Pollution in the environment by noise from any source including engine noise, traffic and transportation noise, machinery noise, industrial noise, urban noise, sonic boom; Theory and devices for control; Biological and ecological effects; Noise detection; Building technology; Laws, legislation, and regulations; Public administration; Land use.

See also 41I, 43F, 91A, 46A, 57, 85, 89, 94D, and 97R.

For effects on human health, use 68G.

**68C-Solid Wastes Pollution & Control**

Pollution by solid wastes including garbage, scrap, junked automobiles, spoil, sludge, containers; Disposal methods such as composts or land application, injection wells, incineration, sanitary landfills; Mining wastes; Processing for separation and materials recovery; Solid waste utilization; Recycling; Biological and ecological effects; Superfund (Records of Decision, etc.); SITE technology; Laws, legislation, and regulations; Public administration; Economics; Land use. Includes disposal of concentrated or pure liquids such as brines, oils, chemicals, and hazardous materials.

See also 43F, 91A, 57, 99B, and 97R.

For effects on human health, use 68G.

For the disposal of pesticides and radioactive contaminants, use 68E and 68F.

For the controlled disposal of radioactive wastes from nuclear reactors, use 77G.

**68D-Water Pollution & Control**

Pollution by municipal wastes, agricultural wastes, industrial wastes, mine wastes, radioactive contaminants; Chemistry and analysis of pollutants; Thermal pollution; Oil pollution; Control techniques and equipment; Sewage treatment; Industrial waste water pretreatment; Hydrology and limnology; Biological and ecological effects; Waste water reuse; Laws, legislation, and regulations; Public administration; Economics; Land use.

See also 43F, 91A, 47, 48G, 57, 97R, 98, 99A, and 99B.

For effects on human health, use 68G.

For pollution by pesticides and radioactive contaminants, use 68E and 68F respectively.

For the design and construction of sewers, and drinking water treatment, use 50B.

**68E-Pesticides Pollution & Control**

Pollution by insecticides, herbicides, fungicides, rodenticides; Residues; Decomposition studies; Analysis and detection; Soil chemistry and biology; Adverse biological effects; Ecology; Laws, legislation, and regulations; Public administration; Economics.

See also 57, 68A, 68C, 68D, 43F, 91A, 98, and 99A.

For effects on human health, use 68G.

**68F-Radiation Pollution & Control**

Involves pollution of the environment by particle and electromagnetic radiation from natural and synthetic sources, including neutrons, X-rays, ultraviolet radiation, microwaves, alpha particles; Radon; Sampling and analytical techniques; Fallout; Biological and ecological effects; Laws, legislation, and regulations; Public administration; Economics.

See also 57, 68A, 68C, 68D, 91A, 97R.

For effects on human health, use 68G.

For the controlled disposal of radioactive wastes from nuclear reactors, use 77G.

**68G-Environmental Health & Safety**

Effects of pollution on public health and safety; Toxicology; Industrial health; Physiology; Psychology; Clinical medicine; Radiobiology; Animals used as research experimental models.

See also 41I, 57, 44G, 68A, 68B, 68C, 68D, 91A, 43F, 94D, and 97R.

**68H-Environmental Impact Statements**

Only actual draft and final statements are posted in this subcategory. Environmental impact statements describing national effects are posted here and to other appropriate subcategories.

For studies about environmental impact statements, use 680 General.

**90-GOVERNMENT INVENTIONS FOR LICENSING**

For patents and patent applications only (will be labeled as such in the report title); Not for bibliographies.

**900-General**

Computer software.

**90A-Mechanical Devices & Equipment**

Devices and equipment for fuel ignition; Heating, illumination, and refrigeration; Cleaning; Printing; Product handling and transportation; Sprinklers; Fire extinguishers; Safety; Motor and other land vehicles; Earthworking and excavating; Tools; Jacks; Hydraulic and pneumatic systems; Power transmissions; Couplings, fasteners, and joints; Piping; Drilling and mining; Separators; Locks; Sewing machines; Winding and reeling; etc.

For metal shaping and forming, use 90E.

For medical equipment, use 90D.

**90B-Chemistry**

Organic and inorganic compounds; Batteries; Electrochemistry; Hydrocarbons; Lubricating compositions; Propellants and rocket fuels; Acids; Polymers; Plastics; Inks; Bleaching; Dyeing; Fertilizers; Food fermentation; Sugar and starch; Paper making; Textiles; Paints; Coatings (except metal coatings); Chemical reactors; etc.

**90C-Nuclear Technology**

Reactors; Radioactive materials; Nuclear instrumentation; Nuclear radiation safety; Nuclear power plants and reactor engineering; Nuclear fusion; Particle accelerators; Plasma devices; etc.

**90D-Biology & Medicine**

Drugs; Cosmetics; Prosthetics; Medical equipment; Pesticide biology; Biological laboratory equipment; Life support equipment.

**90E-Metallurgy**

Metal stock; Metal coatings; Molding, shaping, and treating processes; Laminating; Glasses; Material shaping; Sheet metal and wire working; Bonding and joining; Cutlery; etc.

For use of mechanical equipment, use 90A.

**90F-Electrotechnology**

Antennas, circuits, and electromechanical devices; Electron tubes; Optoelectronic devices; Power and signal transmission devices; Resistive, capacitive and inductive components; Semiconductor devices; Information transmission, storage, and retrieval; Communications; etc.

**90G-Instruments**

Photographic equipment; Measuring and testing instruments and equipments; Acoustic devices; Etc.

For nuclear instruments, use 90C.

**90H-Optics & Lasers**

Optical materials, components, equipment, and systems; Infrared, visible, ultraviolet, and X-ray lasers; Masers.

**90I-Ordnance**

Production and performance of projectiles, fuzes, explosive materials, pyrotechnics, and weapon systems (not limited to military applications); Ordnance storage systems; Fire control systems; Weapons delivery systems; Missiles, rockets, and propellants directly related thereto; Weapons carriers (tanks, aircraft ships, etc); Guns; Laser weapons; Bombs.

**90J-Food Technology**

Pasteurizing, curing, canning, dehydrating, freezing, irradiation, freeze drying, etc., of foods and other agricultural products; Sanitation and fumigation of products; Food additives and preservatives; Analysis and inspection of products; Storage, packaging, and display of products; Cooking devices.

For food fermentation, use 90B.

**44-HEALTH CARE****440-General****44A-Planning Methodology**

Health planning theory including methods, tactics, techniques and policies; Evaluation of planning theories and processes.

**44B-Agency Administrative & Financial Management**

Management practices and policies regarding technical assistance, evaluation of health care agency activities, public relations; Financial management and accounting methods.

**44C-Community & Population Characteristics**

Data and numerical information including health status, quality of care, malpractice, health care needs/demands; Health care utilization, health care cost, vital statistics; Demographic information, economic, environmental, nutritional, and societal factors affecting health, and health resource distribution.



#### **44D-Health Care Assessment & Quality Assurance**

Financial feasibility review, economic impact review, and project review; Certificate of need theory; Health manpower education institutional accreditation; Judicatory procedures, review, and assessment; Quality assurance theory; Certificatory methodology; Health manpower proficiency testing, and public health education evaluation; Classification of health care facilities and health care personnel.

#### **44E-Health Care Measurement Methodology**

Measurement of health status, quality of care, health facility supply, health manpower supply, proficiency and productivity, and health care costs; Health care needs/demands and utilization measurement.

See also 44L, 44N, and 44Q.

#### **44F-Health Care Forecasting Methodology**

Projecting health care needs/demands and health care utilization; Health care facility supply; Health manpower supply; Health care costs; Home health care; Cross-impact projections.

#### **44G-Environmental & Occupational Factors**

Environmental factors affecting health including housing, sanitation, water pollution, solid waste pollution, noise pollution, disease vectors, safety hazards, and occupational and industrial hazards; Overpopulation; Health facility environmental considerations and environmental impact; Energy sources in the health field.

See also 57U and 68G.

#### **44H-Health Care Technology**

Descriptions and applications of new health care technology and equipment; Ailment prevention techniques, and technology regarding diagnosis, therapy, rehabilitation, and food and nutrition; Health care equipment and facility design and performance considerations.

See also 57 and 95.

#### **44J-Health Delivery Plans, Projects & Studies**

Plans, projects, and studies related to the institutional delivery of health services including state/local health plans, state/local medical facility plans, plans for specific health services, and health delivery feasibility studies.

#### **44K-Health Services**

Personal and public health services, patient care, and maintenance of an individual's health status including hospital services acute in-patient services, long-term inpatient services, nursing home services, emergency services, public health services, mental services, nursing services, dental services, and medically-related social services including institution discharge services.

#### **44L-Health Care Needs & Demands**

Measurement of health care needs/demands, hospital care, acute in-patient care, long-term in patient care, nursing home care, medical care, mental care, nursing care, dental care, and health insurance; Home health care; Measurements of health manpower requirements/demands.

See also 44E.

#### **44M-Health Resources**

Surveys, reports, and studies related to specific health care resources including manpower, facilities, sources of financing, and government and private health-related organizations, agencies and individuals.

#### **44N-Health Care Utilization**

Measurements regarding utilization of health resources including manpower, ambulatory care, emergency care, public health care, medical care, mental care, nursing care, dental care, health insurance, health care facilities, and home health care.

See also 44E and 44L.

#### **44P-Health Education & Manpower Training**

Health manpower education including curricula and costs; Health manpower education facility needs/demands; Institutional financing; Financing for health related educational institutions; Student recruiting and retention methods; Continuing education; Career guidance and career advancement; Consumer health education and public health education methods.

#### **44Q-Health-Related Costs**

Health care costs, indexes, projections, in-patient care costs, acute in-patient care costs, long-term care costs, nursing home care costs, ambulatory care costs, emergency care costs, public health care costs, medical care costs; Insurance costs; Manpower income; Equipment costs; Facility utilization and construction costs; Ailment costs including preventive medicine costs and injury costs; Transportation costs including emergency transportation costs.

#### **44R-Economics & Sociology**

Discussions of economic and sociological factors and theories relevant to health care.

#### **44S-Legislation & Regulations**

Laws, bills, regulations, and model legislation. Includes certificate of need, health insurance certification, health manpower licensing, health facility licensing, health manpower employment, and support regarding health manpower education.

#### **44T-Data & Information Systems**

Techniques regarding information systems including document sources, acquisition, surrogation, and storage; Information retrieval; Data systems, Data gathering; Data processing; Data processing hardware; Information system feasibility studies, and confidentiality of information.

#### **44U-Health Care Delivery Organization & Administration**

Hospital and medical practice administration and management; Organizational structure of health services; Management policies and practices regarding personnel, community participation and relations, and coordination with other agencies; Financial management and accounting methods; Financing of health delivery and facilities; Reporting methods and requirements.

**94-INDUSTRIAL & MECHANICAL ENGINEERING****940-General**

Includes bearings; Mechanical elements; Pipes; Tubes; Levers; Cams; Springs; Mechanical joints; Containers and packing materials; Refrigeration systems and equipment; Industrial furnaces and boilers; Heat exchangers; Heat pumps; Heat pipes; Industrial security; Metrology.

For rocket engine components, use 81G.

For fuel tanks, use 81C.

For cooling towers, use 97J.

For nuclear security, use 77Gen.

**94A-Production Planning & Process Controls**

Materials control; Numerical control and automation; Time and motion studies ; Scheduling; Production controls and programming; Modeling techniques and program controls; Inventory management.

See also 44A, 41A and 41B.

**94B-Quality Control & Reliability**

Tolerances allocations; Maintainability requirements; Probability of satisfactory performance of components and equipment; Inspection methods; Destructive industrial testing; Reliability theory; Quality assurance.

See also 41E and 41G.

**94C-Plant Design & Maintenance**

Site selection; Plant design; Layout; Maintenance management; Scheduled, routine, and corrective maintenance.

See also 41H.

**94D-Job Environment**

Industrial hygiene and occupational diseases and injuries in settings such as factories, and office and commercial buildings; Industrial psychology; Industrial sociology; Workplace layout and design; Worker interactions.

See also 44G, 57U, 41I, and 92B.

For industrial safety engineering and accident prevention, use 94H.

**94E-Environmental Engineering**

Lighting; Heating; Ventilating; Air conditioning. Includes environmental engineering equipment related to industrial use. Excludes pollution control.

See also 41I, 89B and 97J.

**94F-Tooling, Machinery, & Tools**

Machine subassemblies; Robots; Robotics; Tools; Machinery, including hoists, conveyors and pumps.

See also 41C and 41J.

**94G-Manufacturing Processes & Materials Handling**

Fabrication, assembling, cleaning, and finishing; Industrial and manufacturing processes (limited to in-depth studies that directly discuss specific processes); Bonding and joining, including gluing, welding, soldering, and brazing; Materials forming and machining; Heat treatment; Coating processes; Materials handling, including palletizing, conveying, warehousing, storing, containerization, and packaging.

See also 71, 41B, 41E, and 41F.

For processing and packaging of food, use 98H.

For production of materials, use 71.

For chemical engineering and processing, use 99B.

For the beneficiation and processing of minerals, use 48A.

**94H-Industrial Safety Engineering**

Accident prevention; Safety measures; Fire prevention; Warning systems; Safety equipment, structures, and clothing.

For industrial safety engineering applied to a specific application, use the field of application.

**94I-Hydraulic & Pneumatic Equipment**

Design, production, performance, and testing of hydraulic and pneumatic systems, accumulators, actuators, compressors, and distribution equipment; Fluidic and flueric devices.

See also 41J.

For hydraulic fluids, see 71K.

**94J-Nondestructive Testing**

Nondestructive testing having industrial application; Ultrasonic, radiographic, hydrostatic, magnetic, and optical nondestructive techniques and equipment; Nondestructive testing of flaws, thickness, opacity, strength.

For destructive industrial testing, use 94B.

**94K-Laboratory & Test Facility Design & Operation**

Measuring, testing, and simulation devices. Includes laboratories, test facilities, and test equipment measuring testing and simulation. If the test facility, equipment, etc. is applied to a specific application, use the field of application.

**88-LIBRARY & INFORMATION SCIENCES****880-General**

Includes general studies about microforms; Film readers; Copyrights; Privacy Act; Report writing.

**88A-Operations & Planning**

Acquisitions, classification, cataloging, abstracting, and indexing; Circulation and reference systems; Information services; Interlibrary loans; Distribution; Manual and computerized information retrieval; Individual libraries and information center.

For library or information networks, use 88B.

**88B-Information Systems**

Library and information networks; Operations and planning of these systems; File maintenance and management; Database management; Information superhighway, National Information Infrastructure; Applied information systems (Management, medical, transportation, etc.)

See also 44T, 62, and 70C.

For database management, use 62B.

For communications and computer networks, use 45C.

For geographic information systems, see 48I.

**88C-Marketing & User Services**

User needs, surveys; Promotions; Fees.

**88D-Personnel**

Training and education; Selection; Management; Performance; Schools and accreditation.

See also 70D.

**88E-Reference Materials**

Bibliographies; Directories; Glossaries; Catalogs; Thesauri; Indexes; Abstract and title periodicals.



## 41-MANUFACTURING TECHNOLOGY

### 410-General\*

Includes mechanical elements; Pipes; Tubes; Levers; Cams; Springs; Clutches; Gears; Valves; Filters; Containers and packing materials; Refrigeration systems and equipment; Industrial furnaces and boilers; Heat exchangers; Heat pumps; Heat pipes; Energy management, economics, and financing; International issues.

See also 94O and 97G.

For engine components, use 81.

For fuel tanks, use 81C.

For cooling towers, use 97J.

### 41A-Computer Aided Design (CAD)

Application of computer hardware and software (programs) to enhance the design, computations, simulation, analysis and modeling, presentations, graphics, drafting, data base creation and human-machine interface, associated with the creation of engineering design specifications.

See also 94A.

### 41B-Computer Aided Manufacturing (CAM)

Application of computer hardware and software (programs) to enhance materials planning, processing and handling, tooling; Assembly; Quality and reliability control; Inspection; Tests; Scheduling and control; Facilities and equipment maintenance; Group technology applications; Inventory control (raw material, in process and finished); Numerical controls and automation; The creation of Direct Numerical Control (DNC) and Computer Numerical Control (CNC) manufacturing cells and systems.

See also 94A and 94G.

### 41C-Robotics/Robots

Application of computer hardware and software, controls, sensors, electromechanical and hydro-mechanical devices, to the creation of robots and the application of robots to all facets of manufacturing. Study of biological processes in order to develop engineering systems; Pattern recognition systems based on biological models. Includes feature extraction; Image enhancement; Image restoration; Scene analysis; Character recognition.

See also 95F and 62F.

### 41D-Productivity

Productivity of employees, management, and services; Improving quality of worklife; Measurement of productivity efficiency and effectiveness; Employee attitudes and motivation; Manpower utilization and performance improvement, job satisfaction, job security; Labor-management, job redesign; Alternative work schedules; Incentive plans; Productivity barriers including regulation, obsolete practices; Paperwork, and financing methods.

See also 70G and 70D.

### 41E-Manufacturing, Planning, Processing & Control

Fabrication, assembling, cleaning, and finishing; Industrial and manufacturing processes (limited to in-depth studies that directly discuss specific processes); Materials forming and machining; Heat treatment; Fabrication and manufacturing; Layout; Coating processes; Materials handling and control, including palletizing, conveying, warehousing, storing, containerization, and packaging; Time and motion studies; Scheduling; Production controls and programming; Modeling techniques and program controls; Inventory management.

See also 94A.

For the beneficiation and processing of minerals, use 48A.

For chemical engineering and processing, use 99B.

For computer-aided manufacturing, use 41B and 94G.

For lasers used in manufacturing, use 41M.

For processing and packaging of food, use 98H.

For production of materials, use 71.

### 41F-Joining

Bonding and joining including gluing, welding, soldering, brazing, and fastening; Joints and fasteners; Physical, mechanical, and structural properties of adhesives, sealants, glue, binders, seals, and gaskets.

See also 94G, 94O General, and 71B.

### 41G-Quality Control & Reliability

Tolerance allocation; Maintainability requirements; Probability of satisfactory performance of components and equipment; Inspection methods; Reliability theory; Quality assurance; Nondestructive testing having industrial application; Ultrasonic, radiographic, hydrostatic, magnetic, and optical non-destructive techniques and equipment; Nondestructive testing of flaws, thickness, opacity, strength; Destructive industrial testing; Metrology.

See also 94B, 94J, and 94O General.

### 41H-Plant Design & Maintenance

Site selection; Plant design; Maintenance Management; Scheduled, routine, and corrective maintenance; Security.

See also 94C.

### 41I-Job Environment

Industrial hygiene and occupational safety and health. See also 57U, 68G, and 44G. Workplace layout and design; Human factors engineering; Includes Industrial psychology and Industrial sociology; Worker interactions.

See also 94D and 95D.

Includes environmental engineering equipment related to industrial use. See also 97J, 89B, and 94E.

For mine safety, use 48A.

For ordnance safety, use 79A.

For nuclear radiation safety, use 77.

For transportation safety, use 85D.

### 41J-Tooling, Machinery, & Tools

Machine subassemblies; Tools; Machinery including hoists, conveyors, and pumps; Design, production performance, and testing of hydraulic and pneumatic systems, accumulators, actuators, compressors and distribution equipment; Fluidic and fluoric devices; Ergonomics interaction of man and equipment in terms of subsystem and system performance requirements and evaluation; Man-machine systems and human factors engineering.

See also 94F, 94I, 94D, and 95D.

For hydraulic fluids, use 71K.

### 41K-Engineering Materials

Performance; Properties, fabrication and manufacturing methods of ceramics, coatings and composite materials including ceramic coatings, ceramic fibers, corrosion resistant coatings, reinforced plastics, graphite or carbon composites, laminates; Metal matrix composites, and fiber and particulate composites.

See also 71B, 71D, and 71F.

**41L-Tribology**

Friction, lubrication and wear, including bearings; Unwanted chemical reaction effects on metals, corrosion of metals and corrosion resistant coatings; Lubricants.

See also 71L, 71G, and 71K.

**41M-Optics & Lasers**

Design and performance of optical equipment for use in manufacturing applications. Includes laser applications such as laser annealing, cutting, drilling, and welding.

See also 46C.

**41N-Computer Software**

Computer programming; Programming languages; Compilers; Data base management systems; CAD/CAM robotics.

See also 62B.

**41O-Domestic Commerce, Marketing, & Economics**

Economic impacts on industries; Productivity; Wage surveys; Domestic market surveys.

See also 96A.

**41P-Research Program Administration & Technology Transfer**

Research needs; Technology transfer and forecasting.

See also 70E.

**71-MATERIALS SCIENCES****710-General**

Advanced materials.

See also 41K.

**71A-Ablative Materials & Ablation**

Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Ablation processes and chemistry; Reentry vehicle heat shields.

For production planning, use 41 and 94.

**71B-Adhesives & Sealants**

Adhesives; Glues; Binders; Sealants; Seals; Gaskets; Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing; Equipment directly related to processing.

See also 71L and 94G.

For concrete cements, use 50C and 89G.

For propellant binders, use 79A and 81H.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71C-Carbon & Graphite**

Carbon and graphite fibers and textiles; Charcoal; Carbon black; Carbon and graphite coatings; Industrial diamonds; Physical, mechanical, and structural properties; Performance, fabrication and manufacturing methods; Equipment directly related to processing.

See also 71A, 71E, 71F, 71I, 71L, and 94G.

For carbon and graphite composites, use 71F.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71D-Ceramics, Refractories, & Glass**

Glasses; Brick; Porcelain; Ceramic coatings; Ceramic fibers; Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing; Equipment directly related to processing; Studies of individual structural members; Cement properties.

See also 71E, 71I, 71L, and 94G.

For concrete and cement used as building materials, use 50C and 89G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71E-Coatings, Colorants, & Finishes**

Paints and primers; Varnishes; Corrosion resistant coatings; Coating pigments; Carbon, ceramic, plastic, rubber and metal coatings; Physical, mechanical and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Electroplating; Electrodeposition; Flame and plasma spraying; Vapor deposition.

See also 71G, 71L, and 94G.

For surface treatment not involved with coatings, use 94G.

For dielectric and semiconducting films, use 46 and 49.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71F-Composite Materials**

Materials composed of two or more physically distinct constituents; Reinforced plastics, graphite or carbon composites; Laminates; Metal matrix composites; Fiber and particulate composites; Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71L and 94G.

For wood composites, use 71R.

For concrete and reinforced concrete, use 50C and 89G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71G-Corrosion & Corrosion Inhibition**

Unwanted chemical reaction effects on metals; Corrosion of metals; Rusting; Corrosion inhibitors; Corrosion resistant coatings; Corrosion electrochemistry.

See also 71E and 71L.

For concrete corrosion, use 50C and 89G.

**71H-Elastomers**

Rubbers; Additives; Curing agents; Elastomer polymerization; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71I, 71L, 94G, and 99C.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71I-Fibers & Textiles**

Glass, carbon, ceramic, metal, and polymeric fibers; Threads, yarns, textile, and fiber finishing, including dyeing and sizing; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members; Flame resistance.

See also 71L and 94G.

For fiber composites, use 71F.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71J-Iron & Iron Alloys**

Includes steels or alloys containing more than 50% iron. Coatings; Fibers; Extractive metallurgy; Refining; Embrittlement; Physical, mechanical, and structural properties; Microstructure; Phase studies; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71I, and 71L.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71K-Lubricants & Hydraulic Fluids**

Solid and liquid lubricants; Additives; Greases; Drilling fluids; Brake fluids; Physical, chemical, mechanical and structural properties; Performance; Manufacturing; Equipment directly related to processing; Chemical synthesis.

See also 71L and 41L.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71L-Materials Degradation & Fouling**

Aging; Erosion and cavitation erosion; Wear; Weathering; Decay; Effects of radiation on materials; Biodeterioration, including fungus deterioration.

See also 71C, 71D, 71F, 71H, 71I, 71J, 71K, 71N, and 71R.

For nuclear reactor materials degradation, see also 77I or 77J. If concerned with nuclear propulsion, use 81L.

**71M-Miscellaneous Materials**

Materials not included in another group, including leather, fur, refrigerants, and waxes; Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 94G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71N-Nonferrous Metals & Alloys**

Includes studies not specifying the type of metal. Coatings; Fibers; Extractive metallurgy; Refining; Embrittlement; Physical, mechanical, and structural properties; Microstructure; Phase studies; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; studies of individual structural members.

See also 71E, 71I, and 71L.

For metal fabrication, use 94G.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71O-Plastics**

Additives; Curing agents; Plastic coatings; Plastic polymerization; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71L, 94G, and 99C.

For plastic composites, use 71F.

For polymeric fibers, use 71I.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71P-Refractory Metals & Alloys**

Includes only the following metals and alloys having more than 50% of these metals: iridium, molybdenum, niobium (columbium), osmium, rhenium, tantalum, and tungsten. Coatings; Fibers; Extractive metallurgy; Refining; Embrittlement; Physical, mechanical, and structural properties; Microstructure; Phase studies; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71I, and 71L.

For metal fabrication, use 94G.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71Q-Solvents, Cleaners, & Abrasives**

Cleaning compositions; Solvents; Detergents; Soaps and abrasives; Cleaning action of these materials; Physical and chemical properties; Performance; Manufacturing; Equipment directly related to processing.

For cleaning techniques, use 94G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71R-Wood & Paper Products**

Sawing and milling; Lumbering; Plywood, particle and fiber board; Wood product fabrication; Pulp, papermaking, and conversion processes; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 94G.

For forestry and tree production, use 48D.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**72-MATHEMATICAL SCIENCES****720-General****72B-Algebra, Analysis, Geometry, & Mathematical Logic**

Algebra and number theory, including field theory (algebra), group theory, ring theory; Analysis, including calculus of variations, complex variables, differential equations, Fourier analysis, functional analysis, functions (mathematics), measure, and integration; Geometry, tensor analysis, and topology; Mathematical logic, including foundations of mathematics, lattices (mathematics), metamathematics, and set theory.

For applications of mathematics, see the appropriate category of application.

**72E-Operations Research**

Game theory; Queuing theory; Management games; Mathematical models; Mathematical programming, Network flows; Search theory.

See also Managerial practice, 70B.

For operations research applied to a specific application, see the field of application.

**72F-Statistical Analysis**

Analysis of variance; Correlations techniques; Discriminate analysis; Distribution theory; Experimental design; Factor analysis; Nonparametric statistics; Probability theory; Regression analysis; Statistical decision theory; Statistical inference; Statistical tests; Stochastic processes.

For statistical analysis applied to a specific application, see the field of application.

**57-MEDICINE & BIOLOGY****570-General****57A-Anatomy**

Descriptive and comparative anatomy of humans; Anthropometry; Dissection; Neuroanatomy; Morphology.

For plant anatomy, use 57C.

For animal anatomy, use 57Z.

**57B-Biochemistry**

Studies of the chemical processes which take place in biological systems. Identification and measurement of biochemical substances and methods of analysis, including assaying.

See also 57F, 57L, 57Q, and 99A.

For measurement of biochemical substances for clinical diagnoses, use 57D.

**57C-Botany**

Study of macroscopic and microscopic plants; Plant anatomy, physiology, pathology, and taxonomy; Phytotoxicity; Includes algae and diatoms.

See also 57H, 57K, 57Y, and 98D.

**57D-Clinical Chemistry**

Techniques and instrumentation for chemical analysis of body fluids, including blood, and tissues for clinical diagnoses.

See also 99A.

**57E-Clinical Medicine**

Prevention, diagnosis, and therapy of diseases; Nuclear medicine; Experimental medicine; Clinical protocols.

See also 57J, 57O, and 57X.

For veterinary medicine, use 98E.

For health care services, use 44.

For epidemiology and disease control, use 57U.

**57F-Cytology, Genetics, & Molecular Biology**

Origin, structure, and functions of living cells and cell components; Hereditary diseases; Use of chemistry and physics to study biological phenomena on the molecular level; Structure and function of biological macromolecules, e.g. proteins and nucleic acids.

See also 57B.

**57G-Dentistry**

Prevention, diagnosis, and treatment of diseases of the teeth, oral cavity, and associated parts; Oral hygiene.

For dental materials and equipment, use 95C.

For dental prosthetics, use 95A.

For dental services, use 44.

**57H-Ecology**

Interrelationships of organisms and their environment; Animal, plant, and human ecology; Marine, fresh water, and terrestrial ecology; Ecosystems; Adaptation; Acclimatization; Natural selection; Species diversity; Food chains; Energy balance; Ecological succession; Effects of polluted environments on organisms; Biological productivity.

See also 47D, 48B, 48G, 57C, 57Y, 57Z, 68, 98D, and 98B.

For effects of extreme environments or stimuli on humans, use 57W.

For the interrelationships of humans and their social environments, use 92.

For the effects of industrial environments on humans, use 57U.

**57I-Electrophysiology**

Electrical activity associated with living organisms and life processes; Electrophysiologic recording including electrocardiography, electroencephalography, and electromyography; Neural transmission; Intracellular potential; Bioelectricity; Bioluminescence; Responses of organisms to electrical stimulation.

**57J-Immunology**

Mechanisms of immune responses; Antigens and antibodies; Vaccines; Immune serums; Immunization; Immunopathology; Immunohematology; Immunochemistry; Serology; Immunity; Allergy; Histocompatibility; Autoimmune diseases. HIV/AIDS.

See also 57E and 57K.

**57K-Microbiology**

Studies of microscopic plants and animals; Vaccine and interferon production; Microbial metabolism and biochemistry.

For diagnosis and therapy of infectious diseases, use 57E.

For disease control and epidemiology, use 57U.

For biotechnology applications, see also field of application.

**57L-Nutrition**

Processes by which humans assimilate and utilize food substances; Experimental nutrition; Nutritive value of foods; Malnutrition; Diet; Food habits; Nutrition surveys; Nutritional requirements; Clinical nutrition.

For food processing, use 98H.

For animal nutrition related to animal husbandry, veterinary medicine or zoology, use 98E or 57Z.



**57M-Occupational Therapy, Physical Therapy, & Rehabilitation**

Restoration of normal form and function after injury or physical illness; Occupational therapy; Physical therapy; Vocational rehabilitation.

See also 44K, 92A, 95A.

For mental rehabilitation, use 57T.

For social rehabilitation, use 92C and 91K.

For rehabilitation centers, use 44K.

**57N-Parasitology**

Parasites and parasitism; Host-parasite interactions; Vectors of parasites; Parasitic diseases; Life cycles of parasites.

See also 57H, 57K, and 57P.

**57O-Pathology**

Studies of the structural and functional changes in tissues and organs which cause or are caused by diseases, trauma or injuries; Gross pathology; Histopathology; Cytopathology; Pathophysiology; Comparative and experimental pathology; Histological techniques; Autopsy.

For plant diseases, use 98D.

For animal diseases, use 98E.

For diagnosis and treatment of diseases, use 57E.

For immunopathology, use 57J.

**57P-Pest Control**

Agents and methods for the control of plant and animal pests; Pesticides, algicides, herbicides, insecticides, molluscicides, fungicides, rodenticides, etc.; Repellants and attractants; Fumigation and extermination; Traps; Biological pest control.

See also 68E and 98C.

For ecological aspects of pest control, use 57H.

**57Q-Pharmacology & Pharmacological Chemistry**

Synthesis, composition, properties, and effects of drugs; Pharmacy, Pharmacodynamics.

See also 57Y.

For social effects of drugs, use 91C and 92C.

For radiopharmaceuticals, use 57V.

For business studies of the drug industry, use 96A.

**57S-Physiology**

Functions of the human organism and its parts and comparative physiology; Metabolism; Endocrinology; Neurophysiology; Respiration; Biological rhythms; Growth; Aging; Regeneration.

See also 57B, 57F, 57J, and 57L.

For plant physiology, use 57C.

For animal physiology, use 57Z and 98E.

For psychophysiology, use 57T and 92B.

For electrophysiology, use 57I.

For pathophysiology, use 57O.

For stress physiology, use 57W.

**57T-Psychiatry**

Prevention, diagnosis, and treatment of mental, emotional, and behavioral disorders; Psychopathology; Psychoanalysis; Neuropsychiatry; Orthopsychiatry; Psychotherapy; Psychophysiology; Psychophysics.

For psychological mechanisms and processes, use 92B.

**57U-Public Health & Industrial Medicine**

Protection and improvement of community health; Effects of environments on public health; School and public health programs, services, and education; Health screening; Health statistics; Epidemiology; Toxic and infectious disease control; Preventive medicine; Hygiene and sanitation; Drinking water quality; Industrial hygiene and medicine; Safety engineering; Occupational safety and health; Industrial safety and detection equipment; Site-specific investigations.

See also 94D, 94H, 41I and 68G.

For occupational and For occupational and environmental factors related to health planning, use 44G.

**57V-Radiobiology**

Biological effects of radiation; Dosimetry; Health physics; Radiation sickness and injury; Radiation hazards; Radiation protection; Radiopharmaceuticals. Includes electromagnetic, ultrasonic, and particle radiation.

See also 68F and 99E.

For radioecology, use 57H.

For nuclear medicine, radiology, and radiotherapy, use 57E.

**57W-Stress Physiology**

Effects of extreme environments or stimuli on human biological processes; Physiological effects of motion, gravity, sound, temperature, electromagnetic, fields, pressure, sensory deprivation, and fatigue; Acclimatization. Includes aerospace and underwater medicine.

See also 51B, 57H, and 84.

For plants, use 57C.

For animals, use 57Z.

For stress psychology, use 92B or 57T.

**57X-Surgery**

Treatment of diseases, injuries, and deformities by manual or operative methods; Organ and tissue transplantation; Pre- and post-management of surgical patients; Experimental surgery.

See also 95A and 95B.

For dental surgery, use 57G.

For histocompatibility, use 57J.

**57Y-Toxicology**

Study of the adverse effects of substances on biological systems and the diagnosis and treatment of toxic diseases; Toxicity studies; Risk assessment of chemicals; Antidotes.

See also 57C, 57Q, 57S and 57Z.

**57Z-Zoology**

Animal anatomy and physiology; Natural history; Animal behavior; Taxonomy.

See also 47D, 48B, 57Y, and 98F.

For animal models used in biomedical research, use the research discipline.

For laboratory and domesticated animal care, or animal diseases, use 98E.

## 74-MILITARY SCIENCES

### 740-General

#### 74A-Antiaircraft Defense Systems

Tactical and terminal countermeasures against attacking aircraft that includes tracking and computing equipment, antiaircraft guns, rockets, and missiles.

For specific missiles and rockets, use 75.

#### 74B-Antimissile Defense Systems

Point and terminal defense and countermeasures against air-, surface-, or underwater-launched missiles, bombardment satellites. Includes land based and shipborne tracking and computing systems; Strategic Defense Initiatives (SDI), Star Wars; ballistic missile defense.

#### 74C-Antisubmarine Warfare

Operations conducted against submarines, their supporting forces and operating bases. Include air, surface, and underwater operations.

See also 63.

#### 74D-Chemical, Biological, & Radiological Warfare

Design, development, and utilization of chemical, biological, and radiological weapons; Production, generation, and stability of lethal and nonlethal agents; Biological agents including anticrop and defoliating agents.

For nuclear weapons, use 74H.

#### 74E-Logistics, Military Facilities, & Supplies

Procurement, storage, distribution, issue, repair, replacement of military equipment; Deployment of troops and cargo; Industrial mobilization; stock level controls and inventory techniques; Defense conversion; Downsizing; Base closures; Force reduction; Dual Use Technology; Continuous Acquisition and Life-cycle Support (CALS), formerly Computer Aided Acquisition and Logistics Support.

For related civilian studies, use 70 and 94.

#### 74F-Military Intelligence

Techniques for collecting, evaluating, and disseminating information concerning foreign nations. Includes damage assessment; Surveillance and reconnaissance systems.

#### 74G-Military Operations, Strategy, & Tactics

Joint and combined operations, campaigns, battles, invasions, theater operations; Planning analysis, appraisal, and threat evaluation; Methods of attack and support; Armed Forces maneuvers; Limited and unconventional warfare; Sabotage, insurgency, and counterinsurgency; Guerrilla warfare; Psychological and cold warfare.

#### 74H-Nuclear Warfare

Design, development, and applications of nuclear weapons and devices; Studies of the physical effects of nuclear weapons; Arms control.

For nuclear guided missile warheads, use 75F.

#### 74I-Passive Defense Systems

Systems, structures, and devices to provide area monitoring security and denial. Includes camouflage, barbed wire, minefields, warning systems, barriers, and other anti-intrusion devices.

For civil defense, see also 91I.

For personnel detection, see also 63G.

## 75-MISSILE TECHNOLOGY

### 750-General

#### 75A-Air & Space-Launched Missiles

Design, construction and performance of missiles launched from aircraft or spacecraft.

#### 75B-Missile Guidance & Control Systems

Techniques for guidance and control of missiles from launching to impact. Includes optical guidance, television guidance, wire guidance, preset and terminal guidance, inertial guidance, command guidance, and homing guidance.

#### 75C-Missile Launching & Support Systems

Missile handling and launching. Includes transportation, storage, and preparation for launching; Air, space, surface, and underwater launching and support equipment and techniques; Checkout equipment and procedures; Guided missile ranges.

#### 75D-Missile Tracking Systems

Techniques and systems for tracking missiles as defensive measures. Can be from surface installations or air and spaceborne platforms.

For antimissile defense systems, use 74B.

#### 75E-Missile Trajectories & Reentry Dynamics

Determination, analysis, and processing of missile trajectory data; Flight path analysis; Impact prediction; Atmospheric reentry. Includes aerodynamic studies.

For spacecraft reentry, use 84D.

#### 75F-Missile Warheads & Fuses

Design and performance of all types of missile warheads and fuzes-chemical, biological, nuclear and explosive.

For rockets, use 79H.

#### 75G-Surface-Launched Missiles

Design, construction, and performance of missiles launched from the ground, surface platforms, vehicles, silos, and surface ships.

#### 75H-Underwater-Launched Missiles

Design, construction, and performance of missiles launched from underwater.

## 48-NATURAL RESOURCES & EARTH SCIENCES

### 480-General

#### 48A-Mineral Industries

Industries and their processes that exploit metallic and nonmetallic, fuel and nonfuel resources. Includes coal mining, mining wastes, and acid mine drainage; Coal preparation; Petroleum exploration, drilling, and production; Metals exploration and mining; Exploration geophysics and seismology; Reserves; Mine safety; Mineral economics; Underwater and continental shelf mining; Natural resources studies (excluding Earth Resource Satellite Surveys).

If energy source production related, use 97.

For petroleum refining, use 97K and 99B.

#### 48B-Natural Resource Management

Conservation and management of natural resources, including land and soil, water, forest, grassland, and other vegetation; Fish and wildlife management; Mineral management; Policies and legislation including game laws and licensing; Water resource management; Water supply; Deforestation; Forest fire prevention.

See also 98F, 48A, 48C, and 48D.



## 48C-Natural Resource Surveys

Use of scientific satellites, aerial photography, and other remote sensing techniques to scan the earth's surface in data gathering experiments on soils, mineral resources, hydrology, animals, forests, and other resources; Surveying techniques such as image processing, photointerpretation, and pattern recognition.

For agricultural resource surveys, use 98G.

For equipment studies, use 63.

## 48D-Forestry

Forest description and measurement; Forest influences; Forest protection and management; Harvesting, logging, sawmills, and transportation; Silviculture; Forest nurseries; Afforestation reforestation, and deforestation; Forest fires and prevention.

For wood utilization, use 71R.

## 48E-Soil Sciences

Soil biology, chemistry, moisture, mineralogy, classification, surveys; Soil erosion and its prevention; Land reclamation, terracing, contouring, polders, tillage, and fertility; Soil banks.

For irrigation, use 98C.

For mechanical and engineering properties, use 50D.

## 48F-Geology & Geophysics

Structure, properties, and classification of rocks; Paleontology; Stratigraphy; Geodesy; Structural geology; Engineering geology; Vulcanology; Petrology; Petrography; Tectonics.

For astrogeology, use 54A.

For geological studies relating to energy or mineral reserves, use 97A and 48A respectively.

For marine geology and geophysics, use 47E.

## 48G-Hydrology & Limnology

Properties, distribution, and circulation of fresh water, including its surface and underground occurrence; Physical and chemical conditions in fresh water bodies; Eutrophication; Chemical-biological interrelationships; Water runoff; Water losses; Ground water; Streams; Aquifers.

For studies of estuaries or sea water, use 47.

## 48H-Snow, Ice, & Permafrost

Physical characteristics including trafficability, stability, and mechanical properties; Glaciology.

For sea ice, use 47C, and for sea ice movement, use 47B.

## 48I-Cartography

Map making; Photogrammetry; Terrain models; Topography. Geographic information systems; Cartography; Actual physical processes, procedures, and methods of map making.

# 76-NAVIGATION, GUIDANCE, & CONTROL

## 760-General

### 76A-Control Devices & Equipment

Navigation and guidance control equipment.

See also 76C.

### 76B-Guidance Systems

Design, development, and performance of complete guidance systems. Includes integration of specific components and subsystems necessary to assure course positioning.

### 76C-Navigation & Guidance System Components

Navigation computers; Gyros, radiators, sensors, indicators, etc., used in navigation of aircraft, ships, spacecraft, and ground vehicles.

## 76D-Navigation Systems

Design, development, and performance of complete navigation systems; Integration of specific components and subsystems necessary in direction finding (position, distance, and course of travel); Global navigation systems.

See also 85F.

# 77-NUCLEAR SCIENCE & TECHNOLOGY

## 770-General

Includes nuclear materials management, safeguards, accounting methods.

See also 77I.

## 77A-Fusion Devices (Thermonuclear)

Theory, design, construction, and operation of devices for producing controlled thermonuclear fusion reactions; Nuclear fusion reactor materials and fuels.

For plasma studies in thermonuclear devices, see also 46G.

## 77B-Isotopes

Identification, separation, and concentration of radioactive isotopes. Includes isotopic irradiation devices.

For radioactive isotopes polluting the environment, use 68F.

For the use of isotopes in labeling chemical reactions, use 99F.

For the use of isotopes in medical/biological applications, use 57.

## 77C-Nuclear Auxiliary Power Systems

SNAP technology, both isotopic and reactor; Isotopic power supplies; Small scale electricity generation by nuclear means.

For nuclear propulsion, see the field of application.

## 77D-Nuclear Explosions & Devices

Explosion effects, including shock waves, ground motion, electromagnetic pulses, primary radiation, injection of charged particles into radiation belts; Testing of nuclear devices (including nuclear simulation using chemical explosives); Peaceful applications (e.g., Plowshare).

For effects on communications and electronics systems, see the field of application.

For military applications, use 74H.

## 77E-Nuclear Instrumentation

Nuclear radiation detection and measurement devices and systems; Beta particle detectors.

For X-ray detectors, use 460 General.

For health physics instrumentation, use 57V.

## 77F-Radiation Shielding, Protection, & Safety

Shielding design, nuclear radiation transport properties of materials, decontamination; Container design and transportation requirements for radioactive materials; Fallout shelters.

See also 91I.

## 77G-Radioactive Wastes & Radioactivity

Separation, processing, handling, storage, disposal, and reuse of radioactive wastes; Radioactive fallout; Fission products; Man-made or natural radioactivity; Decommissioning.

For radiation pollution, use 68F.

## 77H-Reactor Engineering & Nuclear Power Plants

Engineering related directly to the design, safety, and operation of a reactor; Research and test reactors. Integrated assemblage, including reactor and turbogenerator equipment, plus control and regulatory devices of a nuclear power plant, either mobile or stationary; Includes site selection and feasibility studies;

See also 77C.

For critical assemblies and reactor simulation, use 77K.

### **77I-Reactor Fuels & Fuel Processing**

Production, testing, design, or reclamation of nuclear fuel materials, reactor fuel elements (includes cladding) and fuel assemblies.

Includes nuclear fuelcycle studies for nuclear materials management; Nuclear fuel reprocessing.

For processing of nonrecoverable fuel materials and fuel contaminants, use 77G.

### **77J-Reactor Materials**

Production, testing, design, or reclamation of coolants, control materials, moderators, structural materials such as pipe materials; Shielding materials, and steels. Includes fabricated elements or assemblies and specific configurations.

For the effects of radiation on materials, see also 71L or 71J.

For fuel materials, cladding, or fuel assemblies, use 77I. Excludes power generating equipment and nuclear fusion reactor materials.

### **77K-Reactor Physics**

Reactor kinetics, reactor theory, neutron transport theory, and criticality. Includes critical assemblies and reactor simulators.

## **47-OCEAN SCIENCES & TECHNOLOGY**

### **470-General**

Includes breakwaters; Onshore and offshore facilities; Ocean dredging operations; Beach erosion; Harbor engineering; Ocean mining; Anchors; Buoys; Seakeeping; Diving operations and equipment; Decompression equipment.

See also 50B, 47H, and 95E.

### **47A-Marine Engineering**

Design, construction, and maintenance of ships, boats, and related equipment; Salvage operations; Naval architecture; Shipyards and shipbuilding; Submarines; Shipborne containerization.

See also 85G.

### **47B-Dynamic Oceanography**

Ocean waves; Sea level changes; Ocean currents; Ocean tides; Littoral transport; Sea ice movement.

### **47C-Physical & Chemical Oceanography**

Physical and chemical properties of sea water, the ocean bottom, and estuaries; Sea ice.

For glaciers and fresh water ice, use 48H.

### **47D-Biological Oceanography**

Plant and animal life in the marine environment; Biological fouling; Marine ecology; Biological aspects of mariculture; Use of marine organisms as bioassay systems; Marine aspects of estuaries; Marine biology of anadromous fishes.

See also 57C, 57H, 57K, 57F, 57Z, and 98F.

### **47E-Marine Geophysics & Geology**

Geophysical and geological studies and surveys as applied to a marine environment; Plate tectonics; Sea floor spreading; Continental drift.

See also 48F.

### **47F-Oceanographic Vessels, Instruments, & Platforms**

Instrumentation and equipment to collect and process oceanographic data; Remote sensors.

### **47G-Hydrography**

Hydrographic surveying; Ocean bottom topography; Bathymetry.

### **47H-Underwater Construction & Habitats**

Closed environments; Underwater work and construction; Underwater construction equipment.

See also 470 General or 95E.

## **79-ORDNANCE**

### **790-General**

#### **79A-Ammunition, Explosives, & Pyrotechnics**

Projectiles, fuzes, demolition explosives, detonators, grenades, land mines, high explosives, primers, powder and liquid propellants, flame throwers, and equipment for handling these items; Production, performance, storage stability of incendiaries, pyrotechnics, screening agents (smokes), etc.

For nuclear weapons, use 74H.

For rocket propellants, use 81.

#### **79B-Armor**

Design, testing, and performance of armor and armor plate including bullet proof, flak proof, explosion proof, and fragment proof devices and related equipment.

For other types of protective devices, see the application.

#### **79C-Bombs**

High-explosive, fragmentation, antipersonnel, armor piercing, incendiary, napalm, general purpose, and similar types of bombs; Bomb handling equipment; Storage.

For bomb directors and bomb release mechanisms, use 79F.

For nuclear bombs, use 74H.

#### **79D-Combat Vehicles**

Military vehicles including armored wheeled and track-laying vehicles, tanks and reconnaissance vehicles, trucks, gun carriers; Components and accessories.

#### **79E-Detonations, Explosion Effects, & Ballistics**

Explosion effects (except nuclear) such as blast, shock waves, detonation waves, cratering, earth motion or movement, heat, etc.; Interior, exterior, and terminal ballistics; The study of motion, behavior, and aerodynamics of projectiles thrown or launched by ordnance projectors; Includes target vulnerability and damage assessment studies, weapons effects.

For nuclear explosion effects, use 77D.

#### **79F-Fire Control & Bombing Systems**

Fire control computers, sights, directors, range finders, gunlaying, bombing radar systems, boresighting, bomb releases, and other devices used specifically for directing the firing of weapons or the dropping of bombs.

#### **79G-Guns**

Small arms, automatic weapons, antipersonnel weapons, recoilless weapons, mortars, artillery and naval guns, their accessories and components; Gun carriages, gun mounts, remote control equipment, etc.

For ballistic studies, use 79E.

For gun control, social violence, use 92C or 43.

#### **79H-Rockets**

Unguided, self-propelled projectiles whose trajectory or course cannot be altered after launch; Ground launched, air launched, or ship launched rockets, launchers, and launch support equipment.

For sounding rockets, use 55D.

### 79I-Underwater Ordnance

Torpedoes, submarine mines, depth charges, hydrobombs, anti-submarine ammunition, etc.; Launching devices and support equipment.

## 82-PHOTOGRAPHY & RECORDING DEVICES

### 820-General

#### 82A-Holography

Techniques, materials, and uses of holography and holograms; Acoustic holography.

See also 46C.

#### 82B-Photographic Techniques & Equipment

Photographic techniques, including aerial photography, color photography, astronomical photography, cinematography, photomicrography, Schlieren photography; Cameras, lenses, shutters, projectors, photographic processes, and materials; Microphotography, Photographic copying; Direct recording and reproduction of visual images; Copying, reproduction and replication techniques; Thermography; Lithography, and related arts; Graphic arts, illustrating, visual design.

For photogrammetry, use 48I.

#### 82C-Recording Devices

Techniques and devices for recording other than visual images. Includes disk, magnetic, thermoplastic, electrostatic recording systems, CD-ROM, and playback equipment such as record players, tape recorders, etc.

## 46-PHYSICS

### 460-General

Includes electron and X-ray optics; Thermodynamics; Nuclear physics; elementary particles; Atomic and molecular physics.

#### 46A-Acoustics

Generation and transmission of sound through various media or enclosures. Includes ultrasonic and infrasonic radiation.

See also 63A.

#### 46B-Fluid Mechanics

Theoretical and experimental studies of the dynamics and statics of fluids and of relative motion between fluids and solid bodies; Aerodynamics and hydrodynamics; Water tunnel studies and equipment.

For wind tunnel equipment and facilities, use 51F.

For operational applications, use 51A, 75E, and 84D.

For plasma physics, use 46G.

#### 46C-Optics & Lasers

Generation and propagation of electromagnetic waves in the infrared, visible, and ultraviolet region of the spectrum; Theory; Design and performance of optical equipment; Lasers and masers.

#### 46D-Solid State Physics

Physical properties of solids as related to their structure. Fundamental research and theoretical studies on semiconductors, superconductors, structure of solids. Includes crystallography and superconductivity.

For semiconductor devices, use 49H.

For structural mechanics, use 46E.

For studies on ceramics, coatings, composite materials, metals, and alloys, use 71.

### 46E-Structural Mechanics

Dynamics and statics of solid bodies; Kinematics; Shock and vibration.

### 46G-Plasma Physics

Properties and actions of plasmas, including magnetohydrodynamics, pinch effect, plasma oscillations, plasma jets; Plasma diagnostics; Plasma dynamics. Plasmas in thermonuclear devices.

See also 77A.

For MHD generators, use 97O.

For astrophysics, use 54C.

For aeronomy, use 55A.

### 46H-Radiofrequency Waves

Generation and propagation of radiofrequency waves.

For communication systems, techniques, equipment, etc., use 45.

For radiofrequency detection, use 63H.

## 43-PROBLEM-SOLVING INFORMATION FOR STATE & LOCAL GOVERNMENTS

### 430-General

Includes internal government administration; State programs; Criminal justice, corrections planning, and administration.

### 43A-Finance

Taxation; Revenue; Budgeting; Revenue sharing; Financing; Allocation.

See also 91G and 91H.

For commercial banking and finance operations, use 96F.

### 43B-Economic & Community Development

Land use planning; Urban renewal; Economic effects; Economic planning and development; Recreation planning and development; Economic readjustment.

See also 91J and 96A.

### 43C-Human Resources

Education; Social services; Health care services; Manpower.

See also 91K and 92C.

### 43D-Police, Fire, & Emergency Services

Police and fire services and administration; Disaster services; Civil defense; Emergency weather services, Pollution alerts; Civil disturbances; Ambulance services; Disaster relief.

See also 91C and 91I.

### 43E-Energy

Management and planning on energy resources, use and production; Government administration and forecasting.

See also 97.

### 43F-Environment

Air, water, noise, waste management and planning; Monitoring services.

See also 68.

### 43G-Transportation

Planning for modes of public, private, and cargo transportation; Highway planning, Parking; Traffic engineering.

See also 85 and 91B.

**84-SPACE TECHNOLOGY****840-General**

Extraterrestrial biology, chemistry, and medicine.

**84A-Astronautics**

Space missions; Projects and logistics; Orbital rendezvous; Space exploration; Spacecraft operating problems; Extravehicular activity.

**84B-Extraterrestrial Exploration**

Space probe exploration; Space landings; Space construction and maintenance; Extravehicular activity on other planets.

**84C-Manned Spacecraft**

Design and construction of manned spacecraft, space stations, aerospace planes and their components.

**84D-Spacecraft Trajectories & Flight Mechanics**

Determination, analysis, processing of spacecraft trajectory data; Space mechanics; Orbital calculations; Flight path analysis; Atmosphere entry; Reentry dynamics.

**84E-Space Launch Vehicles & Support Equipment**

Handling and launching, including transportation, storage, preparation for launching, countdown, launching equipment, checkout equipment, ground support equipment, and information systems; Spacecraft tracking systems; Tracking networks; Recovery support.

**84F-Space Safety**

Safety measures and devices directed toward reducing the hazards of spaceflight.

**84G-Unmanned Spacecraft**

Design and construction of unmanned spacecraft, including space probes, scientific satellites, military satellites, communication satellites, reconnaissance satellites, and navigational satellites.

For satellites applied to a specific application, see the field of application.

**85-TRANSPORTATION****850-General****85A-Air Transportation**

Operation of systems for transport by air; Civil aviation; Airports and airport access; Airline operations; Air routing; Air traffic control systems; Multimodal systems; Aviation safety and aviation accidents; Aircraft fires; Aircraft fuel fires.

See also 43G, 74E, 76, 85D, and 91B.

For design of aircraft and components, use 51 and 81.

For runway construction and design, use 50B.

**85C-Metropolitan Rail Transportation**

Urban rail transit; Underground and above-ground rapid transit railways, including subways; Automated guideway transit systems; Tracked air cushion vehicles.

See also 85I and 91B.

**85D-Transportation Safety**

Safety and accidents involving air, land, and water transportation; Accident studies and prevention; Alcohol related studies; Breakaway barriers and structures; Standards and testing of components and equipment; Crashworthiness; Traffic safety; Collision research; Safety equipment and devices.

See also 91B.

For pipeline accidents, use 85E.

**85E-Pipeline Transportation**

Transportation of liquids, gases, and slurries through long-distance pipelines; Accidents and safety.

**85F-Global Navigation Systems**

Worldwide navigational aids to transportation; Global positioning system (GPS).

See also 76D.

**85G-Marine & Waterway Transportation**

Shipping; Safety and accidents; Safety equipment; Cargo handling and equipment; Cargo movement; Passenger movement; Traffic control; Boating; Trade routes; Shipborne containerization.

See also 43G, 74E, 76, and 85D.

For marine engineering, use 47A.

For waterway engineering, use 50B.

**85H-Road Transportation**

Passenger and cargo movement; Design and standards for vehicles and components; Motor vehicle engine studies; Safety engineering; Safety devices; Traffic and road safety; Collision research; Accident studies; Highway traffic; Traffic engineering; Passenger and cargo vehicles; Trailers; Motorcycles; Bicycles and bikeways; Hiking trails.

See also 43G, 50A, 74E, 81J, 85D, and 91B.

**85I-Railroad Transportation**

Safety and accidents; Safety equipment; Cargo handling and equipment; Cargo movement; Passenger movement; Traffic control; Terminals; Amtrak; Track studies; Rolling stock; Scheduling; Railroad engineering and equipment.

See also 43G, 85D, and 91B.

**91-URBAN & REGIONAL TECHNOLOGY & DEVELOPMENT****910-General**

Includes energy studies.

**91A-Environmental Management & Planning**

Air, water, noise, and waste management and control; Monitoring services; Solid wastes and recycling; Solid waste landfills; Water quality management; Environmental surveys; Design and operation of sewer systems (combined, etc.); Water supplies and services; Excludes natural resource management.

See also 68 and 43F.

**91B-Transportation & Traffic Planning**

Planning for modes of public and private, passenger and cargo transportation; Travel patterns and demand; Parking; Traffic engineering, traffic flow and control; Traffic surveys; Highway and street services; Rapid transit systems; Passenger transportation and planning; Pedestrian movement.

See also 43G and 85.

**91C-Fire Services, Law Enforcement, & Criminal Justice**

Fire, police, and court services and their administration; Law enforcement and criminal justice; Crime and fire prevention; Personnel recruitment, training, and utilization; Parole; Work release; Correctional institutions.

See also 43D.

For criminal justice and corrections, see also 430 General.



**91D-Communications**

Use and planning of communications; Mass media, emergency communications, public information.

See also 45.

**91E-Housing**

Surveys and assessments of existing housing; Planning and development; Building codes; Housing needs; Housing renovation; Public housing.

For design, architectural, or construction related studies, see also 89.

**91F-Health Services**

Urban health services; Emergency medical services; Mental health services; Nursing homes; Ambulatory health services; Hospital services; Public health access.

See also 43C, 43D, 44 and 91I.

**91G-Urban Administration & Planning**

General administration and planning; Feasibility studies; Appraisal of real property; Taxation; Land use and zoning; Urban revitalization; Financing.

See also 43 and 70F.

**91H-Regional Administration & Planning**

General administration and planning for county and regional areas that may also contain urban or urbanized areas; Intergovernmental relations and interactions (State, County, Local); Land use and zoning.

See also 43 and 70F.

For state government administration and planning, use 43.

**91I-Emergency Services & Planning**

Disaster services; Civil defense; Early warning systems and emergency preparedness for all types of disaster; Emergency weather services; Pollution alerts; Civil disturbances; Ambulance services; Flooding; Disaster relief.

See also 43D, 44, and 91F.

For military passive defense systems, see also 74I.

For personnel detection, see also 63G.

**91J-Economic Studies**

Economic analyses; Economic development; Industrial development; Economic impacts of development; Population-economy-income studies; Employment and earnings; Property values; Commercial area studies.

See also 43B and 96.

For government financial operations, use 43A, 70F, 91G, and 91H.

**91K-Social Services**

Child care; Family and youth counseling; Social rehabilitation; Foster homes and adoption; Welfare and public assistance; Financial assistance; Food stamp services; Employment services; Legal services.

See also 43C, 91F, and 92C.



# NTIS Subject Categories

## Numerical Listing of Major Categories

### Appendix D

Primary category titles arranged by subject category code. This list will assist you in using the cross reference category codes provided in many of the descriptions.

- |  |   |
|--|---|
| <ul style="list-style-type: none"> <li>41 Manufacturing Technology</li> <li>43 Problem Solving Information for State &amp; Local Governments</li> <li>44 Health Care</li> <li>45 Communications</li> <li>46 Physics</li> <li>47 Ocean Sciences &amp; Technology</li> <li>48 Natural Resources &amp; Earth Sciences</li> <li>49 Electrotechnology</li> <li>50 Civil Engineering</li> <li>51 Aeronautics &amp; Aerodynamics</li> <li>54 Astronomy &amp; Astrophysics</li> <li>55 Atmospheric Sciences</li> <li>57 Medicine &amp; Biology</li> <li>62 Computers, Control &amp; Information Theory</li> <li>63 Detection &amp; Countermeasures</li> <li>68 Environmental Pollution &amp; Control</li> <li>70 Administration &amp; Management</li> <li>71 Materials Sciences</li> <li>72 Mathematical Sciences</li> <li>74 Military Sciences</li> </ul> | <ul style="list-style-type: none"> <li>75 Missile Technology</li> <li>76 Navigation, Guidance &amp; Control</li> <li>77 Nuclear Science &amp; Technology</li> <li>79 Ordnance</li> <li>81 Combustion, Engines, &amp; Propellants</li> <li>82 Photography &amp; Recording Devices</li> <li>84 Space Technology</li> <li>85 Transportation</li> <li>88 Library &amp; Information Sciences</li> <li>89 Building Industry Technology</li> <li>90 Government Inventions for Licensing</li> <li>91 Urban &amp; Regional Technology &amp; Development</li> <li>92 Behavior &amp; Society</li> <li>94 Industrial &amp; Mechanical Engineering</li> <li>95 Biomedical Technology &amp; Human Factors Engineering</li> <li>96 Business &amp; Economics</li> <li>97 Energy</li> <li>98 Agriculture &amp; Food</li> <li>99 Chemistry</li> </ul> |
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# NTIS Subject Categories

## Numerical Listing with Scope Descriptions

### Appendix E

#### 41-MANUFACTURING TECHNOLOGY

##### 410-General

Includes mechanical elements; Pipes; Tubes; Levers; Cams; Springs; Clutches; Gears; Valves; Filters; Containers and packing materials; Refrigeration systems and equipment; Industrial furnaces and boilers; Heat exchangers; Heat pumps; Heat pipes; Energy management, economics, and financing; International issues.

See also 94O and 97G.

For engine components, use 81.

For fuel tanks, use 81C.

For cooling towers, use 97J.

##### 41A-Computer Aided Design (CAD)

Application of computer hardware and software (programs) to enhance the design, computations, simulation, analysis and modeling, presentations, graphics, drafting, data base creation and human-machine interface, associated with the creation of engineering design specifications.

See also 94A.

##### 41B-Computer Aided Manufacturing (CAM)

Application of computer hardware and software (programs) to enhance materials planning, processing and handling, tooling; Assembly; Quality and reliability control; Inspection; Tests; Scheduling and control; Facilities and equipment maintenance; Group technology applications; Inventory control (raw material, in process and finished); Numerical controls and automation; The creation of Direct Numerical Control (DNC) and Computer Numerical Control (CNC) manufacturing cells and systems.

See also 94A and 94G.

##### 41C-Robotics/Robots

Application of computer hardware and software, controls, sensors, electromechanical and hydro-mechanical devices, to the creation of robots and the application of robots to all facets of manufacturing. Study of biological processes in order to develop engineering systems; Pattern recognition systems based on biological models. Includes feature extraction; Image enhancement; Image restoration; Scene analysis; Character recognition.

See also 95F and 62F.

##### 41D-Productivity

Productivity of employees, management, and services; Improving quality of worklife; Measurement of productivity efficiency and effectiveness; Employee attitudes and motivation; Manpower utilization and performance improvement, job satisfaction, job security; Labor-management, job redesign; Alternative work schedules; Incentive plans; Productivity barriers including regulation, obsolete practices; Paperwork, and financing methods.

See also 70G and 70D.

##### 41E-Manufacturing, Planning, Processing & Control

Fabrication, assembling, cleaning, and finishing; Industrial and manufacturing processes (limited to in-depth studies that directly discuss specific processes); Materials forming and machining; Heat treatment; Fabrication and manufacturing; Layout; Coating processes; Materials handling and control, including palletizing, conveying, warehousing, storing, containerization, and packaging; Time and motion studies; Scheduling; Production controls and programming; Modeling techniques and program controls; Inventory management.

See also 94A.

For the beneficiation and processing of minerals, use 48A.

For chemical engineering and processing, use 99B.

For computer-aided manufacturing, use 41B and 94G.

For lasers used in manufacturing, use 41M.

For processing and packaging of food, use 98H.

For production of materials, use 71.

##### 41F-Joining

Bonding and joining including gluing, welding, soldering, brazing, and fastening; Joints and fasteners; Physical, mechanical, and structural properties of adhesives, sealants, glue, binders, seals, and gaskets.

See also 94G, 94O General, and 71B.

##### 41G-Quality Control & Reliability

Tolerance allocation; Maintainability requirements; Probability of satisfactory performance of components and equipment; Inspection methods; Reliability theory; Quality assurance; Nondestructive testing having industrial application; Ultrasonic, radiographic, hydrostatic, magnetic, and optical nondestructive techniques and equipment; Nondestructive testing of flaws, thickness, opacity, strength; Destructive industrial testing; Metrology.

See also 94B, 94J, and 94O General.

##### 41H-Plant Design & Maintenance

Site selection; Plant design; Maintenance Management; Scheduled, routine, and corrective maintenance; Security.

See also 94C.

##### 41I-Job Environment

Industrial hygiene and occupational safety and health. See also 57U, 68G, and 44G. Workplace layout and design; Human factors engineering; Includes Industrial psychology and Industrial sociology; Worker interactions.

See also 94D and 95D.

Includes environmental engineering equipment related to industrial use. See also 97J, 89B, and 94E.

For mine safety, use 48A.

For ordnance safety, use 79A.

For nuclear radiation safety, use 77.

For transportation safety, use 85D.

##### 41J-Tooling, Machinery, & Tools

Machine subassemblies; Tools; Machinery including hoists, conveyors, and pumps; Design, production performance, and testing of hydraulic and pneumatic systems, accumulators, actuators, compressors and distribution equipment; Fluidic and fluoric devices; Ergonomics interaction of man and equipment in terms of subsystem and system performance requirements and evaluation; Man-machine systems and human factors engineering.

See also 94F, 94I, 94D, and 95D.

For hydraulic fluids, use 71K.

**41K-Engineering Materials**

Performance; Properties, fabrication and manufacturing methods of ceramics, coatings and composite materials including ceramic coatings, ceramic fibers, corrosion resistant coatings, reinforced plastics, graphite or carbon composites, laminates; Metal matrix composites, and fiber and particulate composites.

See also 71B, 71D, and 71F.

**41L-Tribology**

Friction, lubrication and wear, including bearings; Unwanted chemical reaction effects on metals, corrosion of metals and corrosion resistant coatings; Lubricants.

See also 71L, 71G, and 71K.

**41M-Optics & Lasers**

Design and performance of optical equipment for use in manufacturing applications. Includes laser applications such as laser annealing, cutting, drilling, and welding.

See also 46C.

**41N-Computer Software**

Computer programming; Programming languages; Compilers; Data base management systems; CAD/CAM robotics.

See also 62B.

**41O-Domestic Commerce, Marketing, & Economics**

Economic impacts on industries; Productivity; Wage surveys; Domestic market surveys.

See also 96A.

**41P-Research Program Administration & Technology Transfer**

Research needs; Technology transfer and forecasting.

See also 70E.

**43-PROBLEM SOLVING INFORMATION FOR STATE & LOCAL GOVERNMENTS****430-General**

Includes internal government administration; State programs; Criminal justice, corrections planning, and administration.

**43A-Finance**

Taxation; Revenue; Budgeting; Revenue sharing; Financing; Allocation.

See also 91G and 91H.

For commercial banking and finance operations, use 96F.

**43B-Economic & Community Development**

Land use planning; Urban renewal; Economic effects; Economic planning and development; Recreation planning and development; Economic readjustment.

See also 91J and 96A.

**43C-Human Resources**

Education; Social services; Health care services; Manpower.

See also 91K and 92C.

**43D-Police, Fire, & Emergency Services**

Police and fire services and administration; Disaster services; Civil defense; Emergency weather services, Pollution alerts; Civil disturbances; Ambulance services; Disaster relief.

See also 91C and 91I.

**43E-Energy**

Management and planning on energy resources, use and production; Government administration and forecasting.

See also 97.

**43F-Environment**

Air, water, noise, waste management and planning; Monitoring services.

See also 68.

**43G-Transportation**

Planning for modes of public, private, and cargo transportation; Highway planning, Parking; Traffic engineering.

See also 85 and 91B.

**44-HEALTH CARE****440-General****44A-Planning Methodology**

Health planning theory including methods, tactics, techniques and policies; Evaluation of planning theories and processes.

**44B-Agency Administrative & Financial Management**

Management practices and policies regarding technical assistance, evaluation of health care agency activities, public relations; Financial management and accounting methods.

**44C-Community & Population Characteristics**

Data and numerical information including health status, quality of care, malpractice, health care needs/demands; Health care utilization, health care cost, vital statistics; Demographic information, economic, environmental, nutritional, and societal factors affecting health, and health resource distribution.

**44D-Health Care Assessment & Quality Assurance**

Financial feasibility review, economic impact review, and project review; Certificate of need theory; Health manpower education institutional accreditation; Judiciary procedures, review, and assessment; Quality assurance theory; Certificatory methodology; Health manpower proficiency testing, and public health education evaluation; Classification of health care facilities and health care personnel.

**44E-Health Care Measurement Methodology**

Measurement of health status, quality of care, health facility supply, health manpower supply, proficiency and productivity, and health care costs; Health care needs/demands and utilization measurement.

See also 44L, 44N, and 44Q.

**44F-Health Care Forecasting Methodology**

Projecting health care needs/demands and health care utilization; Health care facility supply; Health manpower supply; Health care costs; Home health care; Cross-impact projections.

**44G-Environmental & Occupational Factors**

Environmental factors affecting health including housing, sanitation, water pollution, solid waste pollution, noise pollution, disease vectors, safety hazards, and occupational and industrial hazards; Overpopulation; Health facility environmental considerations and environmental impact; Energy sources in the health field.

See also 57U and 68G.

#### **44H-Health Care Technology**

Descriptions and applications of new health care technology and equipment; Ailment prevention techniques, and technology regarding diagnosis, therapy, rehabilitation, and food and nutrition; Health care equipment and facility design and performance considerations.

See also 57 and 95.

#### **44J-Health Delivery Plans, Projects & Studies**

Plans, projects, and studies related to the institutional delivery of health services including state/local health plans, state/local medical facility plans, plans for specific health services, and health delivery feasibility studies.

#### **44K-Health Services**

Personal and public health services, patient care, and maintenance of an individual's health status including hospital services acute in-patient services, long-term inpatient services, nursing home services, emergency services, public health services, mental services, nursing services, dental services, and medically-related social services including institution discharge services.

#### **44L-Health Care Needs & Demands**

Measurement of health care needs/demands, hospital care, acute in-patient care, long-term in patient care, nursing home care, medical care, mental care, nursing care, dental care, and health insurance; Home health care; Measurements of health manpower requirements/demands.

See also 44E.

#### **44M-Health Resources**

Surveys, reports, and studies related to specific health care resources including manpower, facilities, sources of financing, and government and private health-related organizations, agencies and individuals.

#### **44N-Health Care Utilization**

Measurements regarding utilization of health resources including manpower, ambulatory care, emergency care, public health care, medical care, mental care, nursing care, dental care, health insurance, health care facilities, and home health care.

See also 44E and 44L.

#### **44P-Health Education & Manpower Training**

Health manpower education including curricula and costs; Health manpower education facility needs/demands; Institutional financing; Financing for health related educational institutions; Student recruiting and retention methods; Continuing education; Career guidance and career advancement; Consumer health education and public health education methods.

#### **44Q-Health-Related Costs**

Health care costs, indexes, projections, in-patient care costs, acute in-patient care costs, long-term care costs, nursing home care costs, ambulatory care costs, emergency care costs, public health care costs, medical care costs; Insurance costs; Manpower income; Equipment costs; Facility utilization and construction costs; Ailment costs including preventive medicine costs and injury costs; Transportation costs including emergency transportation costs.

#### **44R-Economics & Sociology**

Discussions of economic and sociological factors and theories relevant to health care.

#### **44S-Legislation & Regulations**

Laws, bills, regulations, and model legislation. Includes certificate of need, health insurance certification, health manpower licensing, health facility licensing, health manpower employment, and support regarding health manpower education.

#### **44T-Data & Information Systems**

Techniques regarding information systems including document sources, acquisition, surrogation, and storage; Information retrieval; Data systems, Data gathering; Data processing; Data processing hardware; Information system feasibility studies, and confidentiality of information.

#### **44U-Health Care Delivery Organization & Administration**

Hospital and medical practice administration and management; Organizational structure of health services; Management policies and practices regarding personnel, community participation and relations, and coordination with other agencies; Financial management and accounting methods; Financing of health delivery and facilities; Reporting methods and requirements.

### **45-COMMUNICATION**

#### **450-General**

##### **45A-Policies, Regulations, & Studies**

Licensing; Legislation; National policies and Federal regulatory controls; Frequency management; Broadcasting standards; Time signals, etc.

##### **45B-Radio & Television Equipment**

Design and maintenance of radio and television transmitting and receiving equipment only.

See also 51E.

##### **45C-Common Carrier & Satellite**

All communication equipment except radio and television. Optical, radio, microwave, wire, and acoustic communication; Telephone, telemeter, telegraph, television, and radio communication systems; Computer network communications; Digital communication; Intercommunication systems; Optical scanning.

For information systems, see also 88B.

For design and construction of communication satellites, see also 84G.

##### **45D-Sociopolitical**

Propaganda; Social communication; Sign language, Effects of communication on society and behavior; Postal service; Mass media communication.

##### **45E-Graphics**

Publishing; Printing; Graphic arts; Reprography; Xerography; Facsimile; Desktop publishing.

##### **45F-Verbal**

Research and development in vocal communication; Speech intelligibility; Speech recognition.

##### **45G-Communication & Information Theory**

Theoretical studies relating to the measurement and transmission of information in a communication channel. Includes coding theory, information capacity, detection of signals in noise.

See also 62E.

**46-Physics****460-General**

Includes electron and X-ray optics; Thermodynamics; Nuclear physics; elementary particles; Atomic and molecular physics.

**46A-Acoustics**

Generation and transmission of sound through various media or enclosures. Includes ultrasonic and infrasonic radiation.

See also 63A.

**46B-Fluid Mechanics**

Theoretical and experimental studies of the dynamics and statics of fluids and of relative motion between fluids and solid bodies; Aerodynamics and hydrodynamics; Water tunnel studies and equipment.

For wind tunnel equipment and facilities, use 51F.

For operational applications, use 51A, 75E, and 84D.

For plasma physics, use 46G.

**46C-Optics & Lasers**

Generation and propagation of electromagnetic waves in the infrared, visible, and ultraviolet region of the spectrum; Theory; Design and performance of optical equipment; Lasers and masers.

**46D-Solid State Physics**

Physical properties of solids as related to their structure. Fundamental research and theoretical studies on semiconductors, superconductors, structure of solids. Includes crystallography and superconductivity.

For semiconductor devices, use 49H.

For structural mechanics, use 46E.

For studies on ceramics, coatings, composite materials, metals, and alloys, use 71.

**46E-Structural Mechanics**

Dynamics and statics of solid bodies; Kinematics; Shock and vibration.

**46G-Plasma Physics**

Properties and actions of plasmas, including magnetohydrodynamics, pinch effect, plasma oscillations, plasma jets; Plasma diagnostics; Plasma dynamics. Plasmas in thermonuclear devices.

See also 77A.

For MHD generators, use 97O.

For astrophysics, use 54C.

For aeronomy, use 55A.

**46H-Radiofrequency Waves**

Generation and propagation of radiofrequency waves.

For communication systems, techniques, equipment, etc., use 45.

For radiofrequency detection, use 63H.

**47-OCEAN SCIENCES & TECHNOLOGY****470-General**

Includes breakwaters; Onshore and offshore facilities; Ocean dredging operations; Beach erosion; Harbor engineering; Ocean mining; Anchors; Buoys; Seakeeping; Diving operations and equipment; Decompression equipment.

See also 50B, 47H, and 95E.

**47A-Marine Engineering**

Design, construction, and maintenance of ships, boats, and related equipment; Salvage operations; Naval architecture; Shipyards and shipbuilding; Submarines; Shipborne containerization.

See also 85G.

**47B-Dynamic Oceanography**

Ocean waves; Sea level changes; Ocean currents; Ocean tides; Littoral transport; Sea ice movement.

**47C-Physical & Chemical Oceanography**

Physical and chemical properties of sea water, the ocean bottom, and estuaries; Sea ice.

For glaciers and fresh water ice, use 48H.

**47D-Biological Oceanography**

Plant and animal life in the marine environment; Biological fouling; Marine ecology; Biological aspects of mariculture; Use of marine organisms as bioassay systems; Marine aspects of estuaries; Marine biology of anadromous fishes.

See also 57C, 57H, 57K, 57F, 57Z, and 98F.

**47E-Marine Geophysics & Geology**

Geophysical and geological studies and surveys as applied to a marine environment; Plate tectonics; Sea floor spreading; Continental drift.

See also 48F.

**47F-Oceanographic Vessels, Instruments, & Platforms**

Instrumentation and equipment to collect and process oceanographic data; Remote sensors.

**47G-Hydrography**

Hydrographic surveying; Ocean bottom topography; Bathymetry.

**47H-Underwater Construction & Habitats**

Closed environments; Underwater work and construction; Underwater construction equipment.

See also 47Gen or 95E.

**48-NATURAL RESOURCES & EARTH SCIENCES****480-General****48A-Mineral Industries**

Industries and their processes that exploit metallic and nonmetallic, fuel and nonfuel resources. Includes coal mining, mining wastes, and acid mine drainage; Coal preparation; Petroleum exploration, drilling, and production; Metals exploration and mining; Exploration geophysics and seismology; Reserves; Mine safety; Mineral economics; Underwater and continental shelf mining; Natural resources studies (excluding Earth Resource Satellite Surveys).

If energy source production related, use 97.

For petroleum refining, use 97K and 99B.

**48B-Natural Resource Management**

Conservation and management of natural resources, including land and soil, water, forest, grassland, and other vegetation; Fish and wildlife management; Mineral management; Policies and legislation including game laws and licensing; Water resource management; Water supply; Deforestation; Forest fire prevention.

See also 98F, 48A, 48C, and 48D.



**48C-Natural Resource Surveys**

Use of scientific satellites, aerial photography, and other remote sensing techniques to scan the earth's surface in data gathering experiments on soils, mineral resources, hydrology, animals, forests, and other resources; Surveying techniques such as image processing, photointerpretation, and pattern recognition.

For agricultural resource surveys, use 98G.

For equipment studies, use 63.

**48D-Forestry**

Forest description and measurement; Forest influences; Forest protection and management; Harvesting, logging, sawmills, and transportation; Silviculture; Forest nurseries; Afforestation reforestation, and deforestation; Forest fires and prevention.

For wood utilization, use 71R.

**48E-Soil Sciences**

Soil biology, chemistry, moisture, mineralogy, classification, surveys; Soil erosion and its prevention; Land reclamation, terracing, contouring, polders, tillage, and fertility; Soil banks.

For irrigation, use 98C.

For mechanical and engineering properties, use 50D.

**48F-Geology & Geophysics**

Structure, properties, and classification of rocks; Paleontology; Stratigraphy; Geodesy; Structural geology; Engineering geology; Vulcanology; Petrology; Petrography; Tectonics.

For astrogeology, use 54A.

For geological studies relating to energy or mineral reserves, use 97A and 48A respectively.

For marine geology and geophysics, use 47E.

**48G-Hydrology & Limnology**

Properties, distribution, and circulation of fresh water, including its surface and underground occurrence; Physical and chemical conditions in fresh water bodies; Eutrophication; Chemical-biological interrelationships; Water runoff; Water losses; Ground water; Streams; Aquifers.

For studies of estuaries or sea water, use 47.

**48H-Snow, Ice, & Permafrost**

Physical characteristics including trafficability, stability, and mechanical properties; Glaciology.

For sea ice, use 47C, and for sea ice movement, use 47B.

**48I-Cartography**

Map making; Photogrammetry; Terrain models; Topography. Geographic information systems; Cartography; Actual physical processes, procedures, and methods of map making.

**49-ELECTROTECHNOLOGY****490-General**

Includes standards, measurements, and instrumentation not applied to any other subcategories.

**49A-Antennas**

Antennas; Antenna theory; Antenna radiation patterns; Radomes.

**49B-Circuits**

Circuit theory; Network analysis; Filters; Oscillators; Logic circuits; Printed circuits; Electronic modules; Commutators; Power supply circuits; Waveform generators; Analog to digital converters; Phase locked systems.

For integrated circuits, use 49H.

**49C-Electromechanical Devices**

Electric motors; Relays; Mechanical switches; Connectors; Circuit breakers; Electric fuses.

**49D-Electron Tubes**

All electron tubes except those in 49E.

**49E-Optoelectronic Devices & Systems**

Display systems; Phototubes; Image tubes; Cathode ray tubes; Electroluminescent panels; Light emitting diodes; Photodiodes; Phototransistors; Magneto-optics; Electro-optics; Optical detectors, including infrared and ultraviolet detectors.

See also 63C and 63F.

For solar cells, see also 97N.

For lasers, use 46C.

**49F-Power & Signal Transmission Devices**

Transmission lines; Electric wire and cable; Waveguides; Fiber optics transmission lines.

**49G-Resistive, Capacitive, & Inductive Components**

Resistors; Capacitors; Inductors; Transformers; Electromagnets; Potentiometers; Thermistors; Delay lines; Transducers; Crystal resonators. Includes miscellaneous and basic components.

**49H-Semiconductor Devices**

Transistors; Semiconductor diodes; Integrated circuits.

For photodiodes, phototransistors, light emitting diodes, and optical detectors, use 49E.

**50-CIVIL ENGINEERING****500-General****50A-Highway Engineering**

Construction of roads and highways; Highway and rights-of-way maintenance including weed control; Bridges and bridge systems; Highway paints and markings; Highway and road signs; Beautification; Slope stability and soil subbases.

**50B-Civil Engineering**

Dredging; Dams; Water purification; Reservoir engineering; Flood control; Sewers; Waterway engineering; Runway construction; Shore protection; Breakwaters; Harbor engineering; Tunneling.

See also 47.

For sewage treatment, use 68D.

For building construction, use 89.

For oil and gas reservoir engineering, use 97 or 48A.

**50C-Construction Equipment, Materials, & Supplies**

Excavation and earth moving equipment; Hoisting and conveying equipment; Concrete and cement.

See also 89G.

For properties of concrete and cement, see also 71D.

**50D-Soil & Rock Mechanics**

Physical properties of soil and rock for utilization in engineering; Landslides; Soil stabilization.

For soil sciences, use 48E.

For soil conservation, use 48B.

For geology and geophysics, use 48F.

**51-AERONAUTICS & AERODYNAMICS****510-General**

Includes landing mats.

**51A-Aerodynamics**

Aerodynamic characteristics and problems of bodies as they are affected by the dynamics of phenomena relating to boundary layer, lift, drag, laminar and turbulent flow, compressible flow, lift, aerodynamic heating, vortex flow, wake, etc. in aerodynamic regimes. Includes aircraft, ground vehicles, and structures.

See also 46B.

For missile reentry dynamics, use 75E.

For spacecraft reentry dynamics, use 84D.

**51B-Aeronautics**

Aircraft operations such as takeoff and landing, all-weather and night flight, taxiing, approach, letdown, in-flight refueling, etc. Includes aviation accidents.

**51C-Aircraft**

Design, production, and maintenance of aircraft, aircraft components and equipment. Structural studies of airframes, bodies, wings, fuselages; Military and commercial aircraft; Balloons (excludes meteorological balloons); Air cushion vehicles (excludes tracked vehicles).

See also 85A and 81D.

For meteorological balloons, use 55D.

For tracked air cushion vehicles, use 85C.

For electronic equipment, use 51E.

**51D-Parachutes & Decelerators**

Deployable devices and structures to induce drag and deceleration of aircraft, spacecraft, and test vehicles such as rocket sleds.

**51E-Avionics**

Airborne electronic equipment. Includes electronic equipment used for communications; Navigation; Control systems; Onboard air traffic control; Detection.

See also 45, 49, 63, and 76.

**51F-Test Facilities & Equipment**

Wind tunnels; Simulators; Flight simulators.

For flight simulators used for training, use 92A.

**54-ASTRONOMY & ASTROPHYSICS****540-General****54A-Astrogeology**

Studies of the structure and composition of planets and other bodies in the solar system.

For geology and geophysics, see also 48F.

**54B-Astronomy & Celestial Mechanics**

Positions and motions of the celestial bodies; Ephemerides, Eclipses.

**54C-Astrophysics**

Physical and chemical aspects of celestial bodies, their origin and evolution. Includes astronomical spectroscopy, radio astronomy, solar structure, and planetary atmospheres.

**54D-Cosmic Ray Research**

Detection and analysis of cosmic rays.

**55-ATMOSPHERIC SCIENCES****550-General****55A-Aeronomy**

Physics and chemistry of the upper atmosphere; Composition; Chemical reactions; Aurora; Airglow; Solar-terrestrial relationships.

For cosmic ray research, use 54D.

**55B-Dynamic Meteorology**

Studies of atmospheric motions; Atmospheric diffusion models; Atmospheric circulation.

For air pollution movement studies, use 68A.

**55C-Meteorological Data Collection, Analysis, & Weather Forecasting**

Climatology; Satellite meteorology; Weather prediction; Ice forecasting.

**55D-Meteorological Instruments & Instrument Platforms**

Instruments used to record meteorological parameters; Meteorological balloons; Weather stations; Sounding rockets; Remote sensors.

**55E-Physical Meteorology**

Acoustical, electrical, optical, and thermodynamic properties of the atmosphere; Cloud physics; Precipitation theory; Global warming.

See also 68A.

**55F-Weather Modification**

Change of weather conditions through artificial means; Fog dispersal; Artificial precipitation.

**57-MEDICINE & BIOLOGY****570-General****57A-Anatomy**

Descriptive and comparative anatomy of humans; Anthropometry; Dissection; Neuroanatomy; Morphology.

For plant anatomy, use 57C.

For animal anatomy, use 57Z.

**57B-Biochemistry**

Studies of the chemical processes which take place in biological systems. Identification and measurement of biochemical substances and methods of analysis, including assaying.

See also 57F, 57L, 57Q, and 99A.

For measurement of biochemical substances for clinical diagnoses, use 57D.

**57C-Botany**

Study of macroscopic and microscopic plants; Plant anatomy, physiology, pathology, and taxonomy; Phytotoxicity; Includes algae and diatoms.

See also 57H, 57K, 57Y, and 98D.

**57D-Clinical Chemistry**

Techniques and instrumentation for chemical analysis of body fluids, including blood, and tissues for clinical diagnoses.

See also 99A.

**57E-Clinical Medicine**

Prevention, diagnosis, and therapy of diseases; Nuclear medicine; Experimental medicine; Clinical protocols.

See also 57J, 57O, and 57X.

For veterinary medicine, use 98E.

For health care services, use 44.

For epidemiology and disease control, use 57U.

**57F-Cytology, Genetics, & Molecular Biology**

Origin, structure, and functions of living cells and cell components; Hereditary diseases; Use of chemistry and physics to study biological phenomena on the molecular level; Structure and function of biological macromolecules, e.g. proteins and nucleic acids.

See also 57B.

**57G-Dentistry**

Prevention, diagnosis, and treatment of diseases of the teeth, oral cavity, and associated parts; Oral hygiene.

For dental materials and equipment, use 95C.

For dental prosthetics, use 95A.

For dental services, use 44.

**57H-Ecology**

Interrelationships of organisms and their environment; Animal, plant, and human ecology; Marine, fresh water, and terrestrial ecology; Ecosystems; Adaptation; Acclimatization; Natural selection; Species diversity; Food chains; Energy balance; Ecological succession; Effects of polluted environments on organisms; Biological productivity.

See also 47D, 48B, 48G, 57C, 57Y, 57Z, 68, 98D, and 98B.

For effects of extreme environments or stimuli on humans, use 57W.

For the interrelationships of humans and their social environments, use 92.

For the effects of industrial environments on humans, use 57U.

**57I-Electrophysiology**

Electrical activity associated with living organisms and life processes; Electrophysiologic recording including electrocardiography, electroencephalography, and electromyography; Neural transmission; Intracellular potential; Bioelectricity; Bioluminescence; Responses of organisms to electrical stimulation.

**57J-Immunology**

Mechanisms of immune responses; Antigens and antibodies; Vaccines; Immune serums; Immunization; Immunopathology; Immunohematology; Immunochemistry; Serology; Immunity; Allergy; Histocompatibility; Autoimmune diseases. HIV/AIDS.

See also 57E and 57K.

**57K-Microbiology**

Studies of microscopic plants and animals; Vaccine and interferon production; Microbial metabolism and biochemistry.

For diagnosis and therapy of infectious diseases, use 57E.

For disease control and epidemiology, use 57U.

For biotechnology applications, see also field of application.

**57L-Nutrition**

Processes by which humans assimilate and utilize food substances; Experimental nutrition; Nutritive value of foods; Malnutrition; Diet; Food habits; Nutrition surveys; Nutritional requirements; Clinical nutrition.

For food processing, use 98H.

For animal nutrition related to animal husbandry, veterinary medicine or zoology, use 98E or 57Z.

**57M-Occupational Therapy, Physical Therapy, & Rehabilitation**

Restoration of normal form and function after injury or physical illness; Occupational therapy; Physical therapy; Vocational rehabilitation.

See also 44K, 92A, 95A.

For mental rehabilitation, use 57T.

For social rehabilitation, use 92C and 91K.

For rehabilitation centers, use 44K.

**57N-Parasitology**

Parasites and parasitism; Host-parasite interactions; Vectors of parasites; Parasitic diseases; Life cycles of parasites.

See also 57H, 57K, and 57P.

**57O-Pathology**

Studies of the structural and functional changes in tissues and organs which cause or are caused by diseases, trauma or injuries; Gross pathology; Histopathology; Cytopathology; Pathophysiology; Comparative and experimental pathology; Histological techniques; Autopsy.

For plant diseases, use 98D.

For animal diseases, use 98E.

For diagnosis and treatment of diseases, use 57E.

For immunopathology, use 57J.

**57P-Pest Control**

Agents and methods for the control of plant and animal pests; Pesticides, algicides, herbicides, insecticides, molluscicides, fungicides, rodenticides, etc.; Repellants and attractants; Fumigation and extermination; Traps; Biological pest control.

See also 68E and 98C.

For ecological aspects of pest control, use 57H.

**57Q-Pharmacology & Pharmacological Chemistry**

Synthesis, composition, properties, and effects of drugs; Pharmacy, Pharmacodynamics.

See also 57Y.

For social effects of drugs, use 91C and 92C.

For radiopharmaceuticals, use 57V.

For business studies of the drug industry, use 96A.

**57S-Physiology**

Functions of the human organism and its parts and comparative physiology; Metabolism; Endocrinology; Neurophysiology; Respiration; Biological rhythms; Growth; Aging; Regeneration.

See also 57B, 57F, 57J, and 57L.

For plant physiology, use 57C.

For animal physiology, use 57Z and 98E.

For psychophysiology, use 57T and 92B.

For electrophysiology, use 57I.

For pathophysiology, use 57O.

For stress physiology, use 57W.

**57T-Psychiatry**

Prevention, diagnosis, and treatment of mental, emotional, and behavioral disorders; Psychopathology; Psychoanalysis; Neuropsychiatry; Orthopsychiatry; Psychotherapy; Psychophysiology; Psychophysics.

For psychological mechanisms and processes, use 92B.

**57U-Public Health & Industrial Medicine**

Protection and improvement of community health; Effects of environments on public health; School and public health programs, services, and education; Health screening; Health statistics; Epidemiology; Toxic and infectious disease control; Preventive medicine; Hygiene and sanitation; Drinking water quality; Industrial hygiene and medicine; Safety engineering; Occupational safety and health; Industrial safety and detection equipment; Site-specific investigations.

See also 94D, 94H, 41I and 68G.

For occupational and for occupational and environmental factors related to health planning, use 44G.

**57V-Radiobiology**

Biological effects of radiation; Dosimetry; Health physics; Radiation sickness and injury; Radiation hazards; Radiation protection; Radiopharmaceuticals. Includes electromagnetic, ultrasonic, and particle radiation.

See also 68F and 99E.

For radioecology, use 57H.

For nuclear medicine, radiology, and radiotherapy, use 57E.

**57W-Stress Physiology**

Effects of extreme environments or stimuli on human biological processes; Physiological effects of motion, gravity, sound, temperature, electromagnetic, fields, pressure, sensory deprivation, and fatigue; Acclimatization. Includes aerospace and underwater medicine.

See also 51B, 57H, and 84.

For plants, use 57C.

For animals, use 57Z.

For stress psychology, use 92B or 57T.

**57X-Surgery**

Treatment of diseases, injuries, and deformities by manual or operative methods; Organ and tissue transplantation; Pre- and post-management of surgical patients; Experimental surgery.

See also 95A and 95B.

For dental surgery, use 57G.

For histocompatibility, use 57J.

**57Y-Toxicology**

Study of the adverse effects of substances on biological systems and the diagnosis and treatment of toxic diseases; Toxicity studies; Risk assessment of chemicals; Antidotes.

See also 57C, 57Q, 57S and 57Z.

**57Z-Zoology**

Animal anatomy and physiology; Natural history; Animal behavior; Taxonomy.

See also 47D, 48B, 57Y, and 98F.

For animal models used in biomedical research, use the research discipline.

For laboratory and domesticated animal care, or animal diseases, use 98E.

**62-COMPUTERS, CONTROL & INFORMATION THEORY****620-General**

Includes computer security; Artificial intelligence; Signal processing (unapplied).

**62A-Computer Hardware**

Design and development of computers and peripheral equipment, including analog computers, digital computers, hybrid computers, special purpose computers, minicomputers, microcomputers; Computer accessories, supplies and installation; Logic circuits; Computer architecture; Computer network hardware.

For computer hardware applied to a specific application, see the field of application.

For Very Large Scale Integration (VLSI), use 49H.

**62B-Computer Software**

Computer programming; Programming languages; Compilers; Database management systems; Software tools; Software reliability; Computer graphics.

For computer software and database development applied to a specific application, see the field of application.

For CAD/CAM, use 41A and 41B.

**62C-Control Systems & Control Theory**

Theoretical studies of open-loop and closed-loop control systems; Automatic control systems; Principles including adaptive, continuous, digital, distributed parameter, linear, multivariable, nonlinear, optional, predictive, and proportional; Process controllers.

See also 720 General.

For control systems applied to a specific application, see the field of application.

**62D-Information Processing Standards**

Standards for the use of automatic data processing equipment and systems. Includes standards for hardware, software, applications, and data; Federal Information Processing Standards (FIPS).

**62E-Information Theory**

Theoretical studies relating to the measurement and transmission of information in a communication channel, including coding theory, information capacity, and detection of signals in noise.

See also 45G.

**62F-Pattern Recognition & Image Processing**

Includes feature extraction; Image enhancement; Image restoration; Scene analysis; Character recognition; Barcoding; Computer vision.

**62R-Applications Software****62S-Data Files****63-DETECTION & COUNTERMEASURES****630-General**

Automated access control systems.

For industrial security, see also 940 General.

**63A-Acoustic Detection**

Techniques and equipment used for the detection and tracking of objects by means of sound waves, including ultrasonic and infrasonic radiation; Sonar.

For acoustic testing, use 94.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 54, 47, 57, 41, and 94, respectively.



### **63B-Electromagnetic & Acoustic Countermeasures**

Interception, jamming, antijamming, and deception of acoustic and electromagnetic signals; Techniques to nullify the use of detection, surveillance, guidance, and communication systems; Radar jamming; Chaff; Counter-countermeasures.

See also 74.

### **63C-Infrared & Ultraviolet Detection**

Techniques and equipment for the detection and tracking of objects by infrared and ultraviolet radiation; Infrared night vision devices; Infrared homing.

See also 76B.

For earth resource surveys, use 48C and 98G.

For mapping, use 48I.

For photography, use 82B.

For nondestructive testing, use 94J.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 57, 41, and 94, respectively.

### **63D-Magnetic Detection**

Techniques and equipment for the detection of objects by means of magnetic fields.

For geomagnetism, use 48.

### **63E-Nuclear Explosion Detection**

Techniques and equipment for the detection of nuclear explosions at high altitude, underground, and in space. Includes the use of shock waves, earth movement, and measurement of nuclear radiation levels.

See also other applicable subcategories in 63, especially 63I.

### **63F-Optical Detection**

Techniques and equipment for the detection by means of light. Includes the use of binoculars, periscopes, telescopes, and night vision devices for object detection, and smoke particle detectors.

See also 46C.

For detection using only infrared or ultraviolet radiation, use 63C.

For earth resources surveys, use 48C and 98G.

For photography, use 82B.

For detection techniques applied to chemistry, meteorology, astronomy, oceanography, medicine, and manufacturing, use 99, 55, 54, 47, 41, and 94, respectively.

### **63G-Personnel Detection**

Techniques and equipment for the detection of personnel. Includes the use of acoustic, seismic, olfactory, chemical, and optical detectors; Antiintrusion devices; Motion detectors; Security devices.

For military passive defense systems, see also 74I.

### **63H-Radiofrequency Detection**

Techniques and equipment for the detection and tracking by means of radiofrequency waves; Radar; Microwave detection.

See also 76.

For mapping, use 48I.

For detection techniques applied to meteorology, astronomy, oceanography, medicine, and manufacturing, use 55, 54, 57, 41, and 94 respectively.

### **63I-Seismic Detection**

Techniques and equipment for the detection of objects by means of seismic waves.

For earthquake detection, use 48F.

For seismic prospecting, use 48A.

## **68-ENVIRONMENTAL POLLUTION & CONTROL**

### **680-General**

Any study covering multiple types of pollution. Includes broad pollution studies, such as life-cycle analysis of wastes.

### **68A-Air Pollution & Control**

Air pollution from flue gases, exhaust gases, odors, dust, smog, microorganisms, etc.; Control techniques and equipment; Sampling and analytical techniques, and equipment; Waste gas recovery; Biological and ecological effects; Air pollution chemistry; Acid precipitation; Atmospheric motion; Laws, legislation, and regulations; Public administration; Economics; Land use.

See also 43F, 91A, 57, 85, 81, 99A, 99B, and 97R.

For effects on human health, use 68G.

For pesticides and radioactive contaminants, use 68E and 68F respectively.

### **68B-Noise Pollution & Control**

Pollution in the environment by noise from any source including engine noise, traffic and transportation noise, machinery noise, industrial noise, urban noise, sonic boom; Theory and devices for control; Biological and ecological effects; Noise detection; Building technology; Laws, legislation, and regulations; Public administration; Land use.

See also 41I, 43F, 91A, 46A, 57, 85, 89, 94D, and 97R.

For effects on human health, use 68G.

### **68C-Solid Wastes Pollution & Control**

Pollution by solid wastes including garbage, scrap, junked automobiles, spoil, sludge, containers; Disposal methods such as composts or land application, injection wells, incineration, sanitary landfills; Mining wastes; Processing for separation and materials recovery; Solid waste utilization; Recycling; Biological and ecological effects; Superfund (Records of Decision, etc.); SITE technology; Laws, legislation, and regulations; Public administration; Economics; Land use. Includes disposal of concentrated or pure liquids such as brines, oils, chemicals, and hazardous materials.

See also 43F, 91A, 57, 99B, and 97R.

For effects on human health, use 68G.

For the disposal of pesticides and radioactive contaminants, use 68E and 68F.

For the controlled disposal of radioactive wastes from nuclear reactors, use 77G.

### **68D-Water Pollution & Control**

Pollution by municipal wastes, agricultural wastes, industrial wastes, mine wastes, radioactive contaminants; Chemistry and analysis of pollutants; Thermal pollution; Oil pollution; Control techniques and equipment; Sewage treatment; Industrial waste water pretreatment; Hydrology and limnology; Biological and ecological effects; Waste water reuse; Laws, legislation, and regulations; Public administration; Economics; Land use.

See also 43F, 91A, 47, 48G, 57, 97R, 98, 99A, and 99B.

For effects on human health, use 68G.

For pollution by pesticides and radioactive contaminants, use 68E and 68F respectively.

For the design and construction of sewers, and drinking water treatment, use 50B.



### 68E-Pesticides Pollution & Control

Pollution by insecticides, herbicides, fungicides, rodenticides; Residues; Decomposition studies; Analysis and detection; Soil chemistry and biology; Adverse biological effects; Ecology; Laws, legislation, and regulations; Public administration; Economics.

See also 57, 68A, 68C, 68D, 43F, 91A, 98, and 99A.

For effects on human health, use 68G.

### 68F-Radiation Pollution & Control

Involves pollution of the environment by particle and electromagnetic radiation from natural and synthetic sources, including neutrons, X-rays, ultraviolet radiation, microwaves, alpha particles; Radon; Sampling and analytical techniques; Fallout; Biological and ecological effects; Laws, legislation, and regulations; Public administration; Economics.

See also 57, 68A, 68C, 68D, 91A, 97R.

For effects on human health, use 68G.

For the controlled disposal of radioactive wastes from nuclear reactors, use 77G.

### 68G-Environmental Health & Safety

Effects of pollution on public health and safety; Toxicology; Industrial health; Physiology; Psychology; Clinical medicine; Radiobiology; Animals used as research experimental models.

See also 41I, 57, 44G, 68A, 68B, 68C, 68D, 91A, 43F, 94D, and 97R.

### 68H-Environmental Impact Statements

Only actual draft and final statements are posted in this subcategory. Environmental impact statements describing national effects are posted here and to other appropriate subcategories.

For studies about environmental impact statements, use 680 General.

## 70-ADMINISTRATION & MANAGEMENT

### 700-General

Organizational structure and organization theory.

### 70A-Inventory Control

Inventory analysis; Inventory models; Obsolescence; Repair-replacement tradeoffs; Spare parts; Stock level control; Usage prediction; Warehouse automation; Stockpiling.

### 70B-Management Practice

Theory and concepts of management including record keeping, planning, scheduling, organization, coordination, decision making, policy making; Productivity management; Cost effectiveness; Systems management; Contact management; Management methods (PERT, PPB, etc.); Management games. Applied studies are classified in the application.

For research management, use 70E.

### 70C-Management Information Systems

Information systems which include data collection, data processing, and information delivery for use in decision making an evaluation by managers; Manual and automated systems.

See also 88B.

### 70D-Personnel Management, Labor Relations & Manpower Studies

Selection, recruitment, management, utilization, and evaluation of personnel; Job descriptions; Job analysis; Salary administration; Labor supply; Labor unions; Arbitration and bargaining; Industrial relations; Fringe benefits, and incentives; Manpower allocation requirements and utilization.

For library and information science personnel, use 88D.

For health personnel, use 44P.

### 70E-Research Program Administration & Technology Transfer

Research management, development, and forecasting; Research contract management; Research needs; Technology transfer and forecasting. Excludes research methods per se. Studies of specific programs are excluded unless they discuss a program at the national level, technology innovation, or trends and impacts of new technology.

### 70F-Public Administration & Government

National, state, and local government structure, operation, and administration. Operations of government agencies and their interactions; Intergovernmental relations.

See also 43, 91G, and 91H.

### 70G-Productivity

Productivity of businesses, government, employees, management, and services; Improving quality of work life; Measurement of productivity efficiency and effectiveness; Employee attitudes and motivation, manpower utilization and performance improvement, job satisfaction, job security; Labor-management cooperation, joint committees participative management, job redesign; Alternative work schedules; Incentive plans. Productivity barriers including regulations, obsolete practices, paperwork, and financing methods.

See also 70B, 70D, 70F, 96A, and 96G.

For specific applications of productivity to manufacturing, use 41D and 94.

## 71-MATERIALS SCIENCES

### 710-General

Advanced materials.

See also 41K.

### 71A-Ablative Materials & Ablation

Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Ablation processes and chemistry; Reentry vehicle heat shields.

For production planning, use 41 and 94.

### 71B-Adhesives & Sealants

Adhesives; Glues; Binders; Sealants; Seals; Gaskets; Physical, mechanical, and structural properties; Performance; Fabrication and manufacturing; Equipment directly related to processing.

See also 71L and 94G.

For concrete cements, use 50C and 89G.

For propellant binders, use 79A and 81H.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

### 71C-Carbon & Graphite

Carbon and graphite fibers and textiles; Charcoal; Carbon black; Carbon and graphite coatings; Industrial diamonds; Physical, mechanical, and structural properties; Performance, fabrication and manufacturing methods; Equipment directly related to processing.

See also 71A, 71E, 71F, 71I, 71L, and 94G.

For carbon and graphite composites, use 71F.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71D-Ceramics, Refractories, & Glass**

Glasses; Brick; Porcelain; Ceramic coatings; Ceramic fibers;  
Physical, mechanical, and structural properties; Performance;  
Fabrication and manufacturing; Equipment directly related to  
processing; Studies of individual structural members; Cement  
properties.

See also 71E, 71I, 71L, and 94G.

For concrete and cement used as building materials, use 50C and 89G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71E-Coatings, Colorants, & Finishes**

Paints and primers; Varnishes; Corrosion resistant coatings; Coating  
pigments; Carbon, ceramic, plastic, rubber and metal coatings;  
Physical, mechanical and structural properties; Performance;  
Fabrication and manufacturing methods; Equipment directly  
related to processing; Electroplating; Electrodeposition; Flame  
and plasma spraying; Vapor deposition.

See also 71G, 71L, and 94G.

For surface treatment not involved with coatings, use 94G.

For dielectric and semiconducting films, use 46 and 49.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71F-Composite Materials**

Materials composed of two or more physically distinct constituents;  
Reinforced plastics, graphite or carbon composites; Laminates;  
Metal matrix composites; Fiber and particulate composites;  
Physical, mechanical, and structural properties; Performance;  
Fabrication and manufacturing methods; Equipment directly  
related to processing; Studies of individual structural members.

See also 71L and 94G.

For wood composites, use 71R.

For concrete and reinforced concrete, use 50C and 89G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71G-Corrosion & Corrosion Inhibition**

Unwanted chemical reaction effects on metals; Corrosion of metals;  
Rusting; Corrosion inhibitors; Corrosion resistant coatings; Cor-  
rosion electrochemistry.

See also 71E and 71L.

For concrete corrosion, use 50C and 89G.

**71H-Elastomers**

Rubbers; Additives; Curing agents; Elastomer polymerization;  
Physical, chemical, mechanical, and structural properties; Per-  
formance; Fabrication and manufacturing methods; Equipment  
directly related to processing; Studies of individual structural  
members.

See also 71E, 71I, 71L, 94G, and 99C.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71I-Fibers & Textiles**

Glass, carbon, ceramic, metal, and polymeric fibers; Threads,  
yarns, textile, and fiber finishing, including dyeing and sizing;  
Physical, chemical, mechanical, and structural properties;

Performance; Fabrication and manufacturing methods;  
Equipment directly related to processing; Studies of individual  
structural members; Flame resistance.

See also 71L and 94G.

For fiber composites, use 71F.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71J-Iron & Iron Alloys**

Includes steels or alloys containing more than 50% iron. Coatings;  
Fibers; Extractive metallurgy; Refining; Embrittlement; Physi-  
cal, mechanical, and structural properties; Microstructure; Phase  
studies; Performance; Fabrication and manufacturing methods;  
Equipment directly related to processing; Studies of individual  
structural members.

See also 71E, 71I, and 71L.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71K-Lubricants & Hydraulic Fluids**

Solid and liquid lubricants; Additives; Greases;  
Drilling fluids; Brake fluids; Physical, chemical, mechanical and  
structural properties; Performance; Manufacturing; Equipment  
directly related to processing; Chemical synthesis.

See also 71L and 41L.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71L-Materials Degradation & Fouling**

Aging; Erosion and cavitation erosion; Wear; Weathering; Decay;  
Effects of radiation on materials; Biodeterioration, including  
fungus deterioration.

See also 71C, 71D, 71F, 71H, 71I, 71J, 71K, 71N, and 71R.

For nuclear reactor materials degradation, see also 77I or 77J. If  
concerned with nuclear propulsion, use 81I.

**71M-Miscellaneous Materials**

Materials not included in another group, including leather, fur,  
refrigerants, and waxes; Physical, mechanical, and structural  
properties; Performance; Fabrication and manufacturing  
methods; Equipment directly related to processing; Studies of  
individual structural members.

See also 94G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

**71N-Nonferrous Metals & Alloys**

Includes studies not specifying the type of metal. Coatings; Fibers;  
Extractive metallurgy; Refining; Embrittlement; Physical,  
mechanical, and structural properties; Microstructure; Phase  
studies; Performance; Fabrication and manufacturing methods;  
Equipment directly related to processing; studies of individual  
structural members.

See also 71E, 71I, and 71L.

For metal fabrication, use 94G.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

### **710-Plastics**

Additives; Curing agents; Plastic coatings; Plastic polymerization; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71L, 94G, and 99C.

For plastic composites, use 71F.

For polymeric fibers, use 71I.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

### **71P-Refractory Metals & Alloys**

Includes only the following metals and alloys having more than 50% of these metals: iridium, molybdenum, niobium (columbium), osmium, rhenium, tantalum, and tungsten. Coatings; Fibers; Extractive metallurgy; Refining; Embrittlement; Physical, mechanical, and structural properties; Microstructure; Phase studies; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 71E, 71I, and 71L.

For metal fabrication, use 94G.

For corrosion, use 71G.

For beneficiation, use 48A.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

### **71Q-Solvents, Cleaners, & Abrasives**

Cleaning compositions; Solvents; Detergents; Soaps and abrasives; Cleaning action of these materials; Physical and chemical properties; Performance; Manufacturing; Equipment directly related to processing.

For cleaning techniques, use 94G.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

### **71R-Wood & Paper Products**

Sawing and milling; Lumbering; Plywood, particle and fiber board; Wood product fabrication; Pulp, papermaking, and conversion processes; Physical, chemical, mechanical, and structural properties; Performance; Fabrication and manufacturing methods; Equipment directly related to processing; Studies of individual structural members.

See also 94G.

For forestry and tree production, use 48D.

For pollution studies, use 68.

For industry economics and marketing, use 96.

For production planning, use 41 and 94.

## **72-MATHEMATICAL SCIENCES**

### **720-General**

#### **72B-Algebra, Analysis, Geometry, & Mathematical Logic**

Algebra and number theory, including field theory (algebra), group theory, ring theory; Analysis, including calculus of variations, complex variables, differential equations, Fourier analysis, functional analysis, functions (mathematics), measure, and integration; Geometry, tensor analysis, and topology; Mathematical logic, including foundations of mathematics, lattices (mathematics), metamathematics, and set theory.

For applications of mathematics, see the appropriate category of application.

#### **72E-Operations Research**

Game theory; Queuing theory; Management games; Mathematical models; Mathematical programming, Network flows; Search theory.

See also Managerial practice, 70B.

For operations research applied to a specific application, see the field of application.

#### **72F-Statistical Analysis**

Analysis of variance; Correlations techniques; Discriminate analysis; Distribution theory; Experimental design; Factor analysis; Nonparametric statistics; Probability theory; Regression analysis; Statistical decision theory; Statistical inference; Statistical tests; Stochastic processes.

For statistical analysis applied to a specific application, see the field of application.

## **74-MILITARY SCIENCES**

### **740-General**

#### **74A-Antiaircraft Defense Systems**

Tactical and terminal countermeasures against attacking aircraft that includes tracking and computing equipment, antiaircraft guns, rockets, and missiles.

For specific missiles and rockets, use 75.

#### **74B-Antimissile Defense Systems**

Point and terminal defense and countermeasures against air-, surface-, or underwater-launched missiles, bombardment satellites. Includes land based and shipborne tracking and computing systems; Strategic Defense Initiatives (SDI), Star Wars; ballistic missile defense.

#### **74C-Antisubmarine Warfare**

Operations conducted against submarines, their supporting forces and operating bases. Include air, surface, and underwater operations.

See also 63.

#### **74D-Chemical, Biological, & Radiological Warfare**

Design, development, and utilization of chemical, biological, and radiological weapons; Production, generation, and stability of lethal and nonlethal agents; Biological agents including anticrop and defoliating agents.

For nuclear weapons, use 74H.

**74E-Logistics, Military Facilities, & Supplies**

Procurement, storage, distribution, issue, repair, replacement of military equipment; Deployment of troops and cargo; Industrial mobilization; stock level controls and inventory techniques; Defense conversion; Downsizing; Base closures; Force reduction; Dual Use Technology; Continuous Acquisition and Life-cycle Support (CALS), formerly Computer Aided Acquisition and Logistics Support.

For related civilian studies, use 70 and 94.

**74F-Military Intelligence**

Techniques for collecting, evaluating, and disseminating information concerning foreign nations. Includes damage assessment; Surveillance and reconnaissance systems.

**74G-Military Operations, Strategy, & Tactics**

Joint and combined operations, campaigns, battles, invasions, theater operations; Planning analysis, appraisal, and threat evaluation; Methods of attack and support; Armed Forces maneuvers; Limited and unconventional warfare; Sabotage, insurgency, and counterinsurgency; Guerrilla warfare; Psychological and cold warfare.

**74H-Nuclear Warfare**

Design, development, and applications of nuclear weapons and devices; Studies of the physical effects of nuclear weapons; Arms control.

For nuclear guided missile warheads, use 75F.

**74I-Passive Defense Systems**

Systems, structures, and devices to provide area monitoring security and denial. Includes camouflage, barbed wire, minefields, warning systems, barriers, and other anti-intrusion devices.

For civil defense, see also 91I.

For personnel detection, see also 63G.

**75-MISSILE TECHNOLOGY****750-General****75A-Air & Space-Launched Missiles**

Design, construction and performance of missiles launched from aircraft or spacecraft.

**75B-Missile Guidance & Control Systems**

Techniques for guidance and control of missiles from launching to impact. Includes optical guidance, television guidance, wire guidance, preset and terminal guidance, inertial guidance, command guidance, and homing guidance.

**75C-Missile Launching & Support Systems**

Missile handling and launching. Includes transportation, storage, and preparation for launching; Air, space, surface, and underwater launching and support equipment and techniques; Checkout equipment and procedures; Guided missile ranges.

**75D-Missile Tracking Systems**

Techniques and systems for tracking missiles as defensive measures. Can be from surface installations or air and spaceborne platforms.

For antimissile defense systems, use 74B.

**75E-Missile Trajectories & Reentry Dynamics**

Determination, analysis, and processing of missile trajectory data; Flight path analysis; Impact prediction; Atmospheric reentry. Includes aerodynamic studies.

For spacecraft reentry, use 84D.

**75F-Missile Warheads & Fuses**

Design and performance of all types of missile warheads and fuzes-chemical, biological, nuclear and explosive.

For rockets, use 79H.

**75G-Surface-Launched Missiles**

Design, construction, and performance of missiles launched from the ground, surface platforms, vehicles, silos, and surface ships.

**75H-Underwater-Launched Missiles**

Design, construction, and performance of missiles launched from underwater.

**76-NAVIGATION, GUIDANCE, & CONTROL****760-General****76A-Control Devices & Equipment**

Navigation and guidance control equipment.

See also 76C.

**76B-Guidance Systems**

Design, development, and performance of complete guidance systems. Includes integration of specific components and subsystems necessary to assure course positioning.

**76C-Navigation & Guidance System Components**

Navigation computers; Gyros, radiators, sensors, indicators, etc., used in navigation of aircraft, ships, spacecraft, and ground vehicles.

**76D-Navigation Systems**

Design, development, and performance of complete navigation systems; Integration of specific components and subsystems necessary in direction finding (position, distance, and course of travel); Global navigation systems.

See also 85F.

**77-NUCLEAR SCIENCE & TECHNOLOGY****770-General**

Includes nuclear materials management, safeguards, accounting methods.

See also 77I.

**77A-Fusion Devices (Thermonuclear)**

Theory, design, construction, and operation of devices for producing controlled thermonuclear fusion reactions; Nuclear fusion reactor materials and fuels.

For plasma studies in thermonuclear devices, see also 46G.

**77B-Isotopes**

Identification, separation, and concentration of radioactive isotopes. Includes isotopic irradiation devices.

For radioactive isotopes polluting the environment, use 68F.

For the use of isotopes in labeling chemical reactions, use 99F.

For the use of isotopes in medical/biological applications, use 57.

**77C-Nuclear Auxiliary Power Systems**

SNAP technology, both isotopic and reactor; Isotopic power supplies; Small scale electricity generation by nuclear means.

For nuclear propulsion, see the field of application.



**77D-Nuclear Explosions & Devices**

Explosion effects, including shock waves, ground motion, electromagnetic pulses, primary radiation, injection of charged particles into radiation belts; Testing of nuclear devices (including nuclear simulation using chemical explosives); Peaceful applications (e.g., Plowshare).

For effects on communications and electronics systems, see the field of application.

For military applications, use 74H.

**77E-Nuclear Instrumentation**

Nuclear radiation detection and measurement devices and systems; Beta particle detectors.

For X-ray detectors, use 46Gen.

For health physics instrumentation, use 57V.

**77F-Radiation Shielding, Protection, & Safety**

Shielding design, nuclear radiation transport properties of materials, decontamination; Container design and transportation requirements for radioactive materials; Fallout shelters.

See also 91I.

**77G-Radioactive Wastes & Radioactivity**

Separation, processing, handling, storage, disposal, and reuse of radioactive wastes; Radioactive fallout; Fission products; Man-made or natural radioactivity; Decommissioning.

For radiation pollution, use 68F.

**77H-Reactor Engineering & Nuclear Power Plants**

Engineering related directly to the design, safety, and operation of a reactor; Research and test reactors. Integrated assemblage, including reactor and turbogenerator equipment, plus control and regulatory devices of a nuclear power plant, either mobile or stationary; Includes site selection and feasibility studies; Engineering aspects of reactor accidents.

See also 77C.

For critical assemblies and reactor simulation, use 77K.

**77I-Reactor Fuels & Fuel Processing**

Production, testing, design, or reclamation of nuclear fuel materials, reactor fuel elements (includes cladding) and fuel assemblies. Includes nuclear fuel cycle studies for nuclear materials management; Nuclear fuel reprocessing.

For processing of nonrecoverable fuel materials and fuel contaminants, use 77G.

**77J-Reactor Materials**

Production, testing, design, or reclamation of coolants, control materials, moderators, structural materials such as pipe materials; Shielding materials, and steels. Includes fabricated elements or assemblies and specific configurations.

For the effects of radiation on materials, see also 71L or 71J.

For fuel materials, cladding, or fuel assemblies, use 77I. Excludes power generating equipment and nuclear fusion reactor materials.

**77K-Reactor Physics**

Reactor kinetics, reactor theory, neutron transport theory, and criticality. Includes critical assemblies and reactor simulators.

**79-ORDNANCE****790-General****79A-Ammunition, Explosives, & Pyrotechnics**

Projectiles, fuzes, demolition explosives, detonators, grenades, land mines, high explosives, primers, powder and liquid propellants, flame throwers, and equipment for handling these items; Production, performance, storage stability of incendiaries, pyrotechnics, screening agents (smokes), etc.

For nuclear weapons, use 74H.

For rocket propellants, use 81.

**79B-Armor**

Design, testing, and performance of armor and armor plate including bullet proof, flak proof, explosion proof, and fragment proof devices and related equipment.

For other types of protective devices, see the application.

**79C-Bombs**

High-explosive, fragmentation, antipersonnel, armor piercing, incendiary, napalm, general purpose, and similar types of bombs; Bomb handling equipment; Storage.

For bomb directors and bomb release mechanisms, use 79F; For nuclear bombs, use 74H.

**79D-Combat Vehicles**

Military vehicles including armored wheeled and track-laying vehicles, tanks and reconnaissance vehicles, trucks, gun carriers; Components and accessories.

**79E-Detonations, Explosion Effects, & Ballistics**

Explosion effects (except nuclear) such as blast, shock waves, detonation waves, cratering, earth motion or movement, heat, etc.; Interior, exterior, and terminal ballistics; The study of motion, behavior, and aerodynamics of projectiles thrown or launched by ordnance projectors; Includes target vulnerability and damage assessment studies, weapons effects.

For nuclear explosion effects, use 77D.

**79F-Fire Control & Bombing Systems**

Fire control computers, sights, directors, range finders, gunlaying, bombing radar systems, boresighting, bomb releases, and other devices used specifically for directing the firing of weapons or the dropping of bombs.

**79G-Guns**

Small arms, automatic weapons, antipersonnel weapons, recoilless weapons, mortars, artillery and naval guns, their accessories and components; Gun carriages, gun mounts, remote control equipment, etc.

For ballistic studies, use 79E.

For gun control, social violence, use 92C or 43.

**79H-Rockets**

Unguided, self-propelled projectiles whose trajectory or course cannot be altered after launch; Ground launched, air launched, or ship launched rockets, launchers, and launch support equipment.

For sounding rockets, use 55D.

**79I-Underwater Ordnance**

Torpedoes, submarine mines, depth charges, hydrobombs, anti-submarine ammunition, etc.; Launching devices and support equipment.



**81-COMBUSTION, ENGINES, & PROPELLANTS****810-General****81A-Combustion & Ignition**

Autoignition, ignition, and combustion. Includes flame studies; Combustion products studies; Ignition systems; Combustion chemistry; Flammability studies.

See also 89 and 94H.

**81B-Electric & Ion Propulsion**

All types of engines deriving power from free ions and electrons. Includes ion, plasma, and arc jet systems; Propulsion by means of solar wind; Laser propulsion.

For electrically propelled surface vehicles, use 85.

**81C-Fuel & Propellant Tanks**

Design, performance, and testing of fuel and propellant tanks including those for automobiles, petroleum products, and rocket propellants.

**81D-Jet & Gas Turbine Engines**

Design, performance, and testing of all types of jet and gas turbine engines, their components, engine nozzles. Includes Ramjet, Scramjet, and Turbofan engines, and hydroduct and turbomachinery as well as nonpropulsive turbines.

See also 97L and 51C.

**81G-Rocket Engines & Motors**

Design, performance, and testing of rocket engines and motors and their components.

**81H-Rocket Propellants**

Production, handling, stability, and performance of liquid, solid, thixotropic, and exotic propellants. Includes fuels, oxidizers, additives, and binders.

For combustion and ignition, use 81A.

**81I-Nuclear Propulsion**

Design, performance, and testing of nuclear engines for surface, air, and space propulsion.

See also 85.

**81J-Reciprocation & Rotating Combustion Engines**

Design, performance, and testing of reciprocating and rotating engines of various configurations for all types of propulsion. Includes internal and external combustion engines; Engine exhaust systems; Engine air systems components; Engine structures; Stirling and diesel engines.

See also 97L and 85H.

**82-PHOTOGRAPHY & RECORDING DEVICES****820-General****82A-Holography**

Techniques, materials, and uses of holography and holograms; Acoustic holography.

See also 46C.

**82B-Photographic Techniques & Equipment**

Photographic techniques, including aerial photography, color photography, astronomical photography, cinematography, photomicrography, Schlieren photography; Cameras, lenses, shutters, projectors, photographic processes, and materials; Microphotography, Photographic copying; Direct recording and reproduction of visual images; Copying, reproduction and

replication techniques; Thermography; Lithography, and related arts; Graphic arts, illustrating, visual design.

For photogrammetry, use 48I.

**82C-Recording Devices**

Techniques and devices for recording other than visual images.

Includes disk, magnetic, thermoplastic, electrostatic recording systems, CD-ROM, and playback equipment such as record players, tape recorders, etc.

**84-SPACE TECHNOLOGY****840-General**

Extraterrestrial biology, chemistry, and medicine.

**84A-Astronautics**

Space missions; Projects and logistics; Orbital rendezvous; Space exploration; Spacecraft operating problems; Extravehicular activity.

**84B-Extraterrestrial Exploration**

Space probe exploration; Space landings; Space construction and maintenance; Extravehicular activity on other planets.

**84C-Manned Spacecraft**

Design and construction of manned spacecraft, space stations, aerospace planes and their components.

**84D-Spacecraft Trajectories & Flight Mechanics**

Determination, analysis, processing of spacecraft trajectory data; Space mechanics; Orbital calculations; Flight path analysis; Atmosphere entry; Reentry dynamics.

**84E-Space Launch Vehicles & Support Equipment**

Handling and launching, including transportation, storage, preparation for launching, countdown, launching equipment, checkout equipment, ground support equipment, and information systems; Spacecraft tracking systems; Tracking networks; Recovery support.

**84F-Space Safety**

Safety measures and devices directed toward reducing the hazards of spaceflight.

**84G-Unmanned Spacecraft**

Design and construction of unmanned spacecraft, including space probes, scientific satellites, military satellites, communication satellites, reconnaissance satellites, and navigational satellites.

For satellites applied to a specific application, see the field of application.

**85-TRANSPORTATION****850-General****85A-Air Transportation**

Operation of systems for transport by air; Civil aviation; Airports and airport access; Airline operations; Air routing; Air traffic control systems; Multimodal systems; Aviation safety and aviation accidents; Aircraft fires; Aircraft fuel fires.

See also 43G, 74E, 76, 85D, and 91B.

For design of aircraft and components, use 51 and 81.

For runway construction and design, use 50B.

**85C-Metropolitan Rail Transportation**

Urban rail transit; Underground and above-ground rapid transit railways, including subways; Automated guideway transit systems; Tracked air cushion vehicles.

See also 85I and 91B.

**85D-Transportation Safety**

Safety and accidents involving air, land, and water transportation; Accident studies and prevention; Alcohol related studies; Break-away barriers and structures; Standards and testing of components and equipment; Crashworthiness; Traffic safety; Collision research; Safety equipment and devices.

See also 91B.

For pipeline accidents, use 85E.

**85E-Pipeline Transportation**

Transportation of liquids, gases, and slurries throughlong-distance pipelines; Accidents and safety.

**85F-Global Navigation Systems**

Worldwide navigational aids to transportation; Global positioning system (GPS).

See also 76D.

**85G-Marine & Waterway Transportation**

Shipping; Safety and accidents; Safety equipment; Cargo handling and equipment; Cargo movement; Passenger movement; Traffic control; Boating; Trade routes; Shipborne containerization.

See also 43G, 74E, 76, and 85D.

For marine engineering, use 47A.

For waterway engineering, use 50B.

**85H-Road Transportation**

Passenger and cargo movement; Design and standards for vehicles and components; Motor vehicle engine studies; Safety engineering; Safety devices; Traffic and road safety; Collision research; Accident studies; Highway traffic; Traffic engineering; Passenger and cargo vehicles; Trailers; Motorcycles; Bicycles and bikeways; Hiking trails.

See also 43G, 50A, 74E, 81J, 85D, and 91B.

**85I-Railroad Transportation**

Safety and accidents; Safety equipment; Cargo handling and equipment; Cargo movement; Passenger movement; Traffic control; Terminals; Amtrak; Track studies; Rolling stock; Scheduling; Railroad engineering and equipment.

See also 43G, 85D, and 91B.

**88-LIBRARY & INFORMATION SCIENCES****880-General**

Includes general studies about microforms; Film readers; Copyrights; Privacy Act; Report writing.

**88A-Operations & Planning**

Acquisitions, classification, cataloging, abstracting, and indexing; Circulation and reference systems; Information services; Interlibrary loans; Distribution; Manual and computerized information retrieval; Individual libraries and information center.

For library or information networks, use 88B.

**88B-Information Systems**

Library and information networks; Operations and planning of these systems; File maintenance and management; Database management; Information superhighway, National Information Infrastructure; Applied information systems (Management, medical, transportation, etc.)

See also 44T, 62, and 70C.

For database management, use 62B.

For communications and computer networks, use 45C.

For geographic information systems, see 48I.

**88C-Marketing & User Services**

User needs, surveys; Promotions; Fees.

**88D-Personnel**

Training and education; Selection; Management; Performance; Schools and accreditation.

See also 70D.

**88E-Reference Materials**

Bibliographies; Directories; Glossaries; Catalogs; Thesauri; Indexes; Abstract and title periodicals.

**89-BUILDING INDUSTRY TECHNOLOGY**

Includes fires in buildings.

**890-General**

Includes fires in buildings.

**89B-Architectural Design & Environmental Engineering**

Architecture; Human engineering; Site surveys; Interior design; Lighting; Heating, ventilating, and air conditioning; Heat loss studies. Includes environmental engineering equipment.

See also 97J and 94E.

**89C-Construction Management & Techniques**

Excavation; Fabrication (presite and onsite); Construction techniques; Reconstruction; Management including planning, manpower, and labor studies.

**89D-Structural Analyses**

Dynamics and statics of structures and structural members including kinetics, kinematics, vibration and stress analyses; Induced environmental stresses including earthquakes, wind, and flood; Foundation stresses; Soil-structure interactions.

**89E-Building Standards & Codes**

Standards and codes for buildings, equipment, components, and materials.

**89G-Construction Materials, Components, & Equipment**

Plumbing; Wiring; Insulation; Doors and windows; Walls; Joints; Beams; Construction equipment such as bulldozers and cranes. Includes flammability and fire studies. Cement and concrete.

See also 50C.

For cement properties, see also 71D.

**89H-Building Equipment, Furnishings, & Maintenance**

Equipment including security alarms (i.e. Burglar alarms), elevators, and fire safety devices; Furnishings, including major household appliances, rugs, and furniture; Maintenance, including repair, pest control, and cleaning.

For environmental engineering equipment, use 89B.

**90-GOVERNMENT INVENTIONS FOR LICENSING**

For patents and patent applications only (will be labeled as such in the report title); Not for bibliographies.

**900-General**

Computer software.

**90A-Mechanical Devices & Equipment**

Devices and equipment for fuel ignition; Heating, illumination, and refrigeration; Cleaning; Printing; Product handling and transportation; Sprinklers; Fire extinguishers; Safety; Motor and other land vehicles; Earthworking and excavating; Tools; Jacks; Hydraulic and pneumatic systems; Power transmissions; Couplings, fasteners, and joints; Piping; Drilling and mining; Separators; Locks; Sewing machines; Winding and reeling; etc.

For metal shaping and forming, use 90E.

For medical equipment, use 90D.

**90B-Chemistry**

Organic and inorganic compounds; Batteries; Electrochemistry; Hydrocarbons; Lubricating compositions; Propellants and rocket fuels; Acids; Polymers; Plastics; Inks; Bleaching; Dyeing; Fertilizers; Food fermentation; Sugar and starch; Paper making; Textiles; Paints; Coatings (except metal coatings); Chemical reactors; etc.

**90C-Nuclear Technology**

Reactors; Radioactive materials; Nuclear instrumentation; Nuclear radiation safety; Nuclear power plants and reactor engineering; Nuclear fusion; Particle accelerators; Plasma devices; etc.

**90D-Biology & Medicine**

Drugs; Cosmetics; Prosthetics; Medical equipment; Pesticide biology; Biological laboratory equipment; Life support equipment.

**90E-Metallurgy**

Metal stock; Metal coatings; Molding, shaping, and treating processes; Laminating; Glasses; Material shaping; Sheet metal and wire working; Bonding and joining; Cutlery; etc.

For use of mechanical equipment, use 90A.

**90F-Electrotechnology**

Antennas, circuits, and electromechanical devices; Electron tubes; Optoelectronic devices; Power and signal transmission devices; Resistive, capacitive and inductive components; Semiconductor devices; Information transmission, storage, and retrieval; Communications; etc.

**90G-Instruments**

Photographic equipment; Measuring and testing instruments and equipments; Acoustic devices; Etc.

For nuclear instruments, use 90C.

**90H-Optics & Lasers**

Optical materials, components, equipment, and systems; Infrared, visible, ultraviolet, and X-ray lasers; Masers.

**90I-Ordnance**

Production and performance of projectiles, fuzes, explosive materials, pyrotechnics, and weapon systems (not limited to military applications); Ordnance storage systems; Fire control systems; Weapons delivery systems; Missiles, rockets, and propellants directly related thereto; Weapons carriers (tanks, aircraft ships, etc); Guns; Laser weapons; Bombs.

**90J-Food Technology**

Pasteurizing, curing, canning, dehydrating, freezing, irradiation, freeze drying, etc., of foods and other agricultural products; Sanitation and fumigation of products; Food additives and preservatives; Analysis and inspection of products; Storage, packaging, and display of products; Cooking devices.

For food fermentation, use 90B.

**91-URBAN & REGIONAL TECHNOLOGY & DEVELOPMENT****910-General**

Includes energy studies.

**91A-Environmental Management & Planning**

Air, water, noise, and waste management and control; Monitoring services; Solid wastes and recycling; Solid waste landfills; Water quality management; Environmental surveys; Design and operation of sewer systems (combined, etc.); Water supplies and services; Excludes natural resource management.

See also 68 and 43F.

**91B-Transportation & Traffic Planning**

Planning for modes of public and private, passenger and cargo transportation; Travel patterns and demand; Parking; Traffic engineering, traffic flow and control; Traffic surveys; Highway and street services; Rapid transit systems; Passenger transportation and planning; Pedestrian movement.

See also 43G and 85.

**91C-Fire Services, Law Enforcement, & Criminal Justice**

Fire, police, and court services and their administration; Law enforcement and criminal justice; Crime and fire prevention; Personnel recruitment, training, and utilization; Parole; Work release; Correctional institutions.

See also 43D.

For criminal justice and corrections, see also 43Gen.

**91D-Communications**

Use and planning of communications; Mass media, emergency communications, public information.

See also 45.

**91E-Housing**

Surveys and assessments of existing housing; Planning and development; Building codes; Housing needs; Housing renovation; Public housing.

For design, architectural, or construction related studies, see also 89.

**91F-Health Services**

Urban health services; Emergency medical services; Mental health services; Nursing homes; Ambulatory health services; Hospital services; Public health access.

See also 43C, 43D, 44 and 91I.

**91G-Urban Administration & Planning**

General administration and planning; Feasibility studies; Appraisal of real property; Taxation; Land use and zoning; Urban revitalization; Financing.

See also 43 and 70F.

## 91H-Regional Administration & Planning

General administration and planning for county and regional areas that may also contain urban or urbanized areas; Intergovernmental relations and interactions (State, County, Local); Land use and zoning.

See also 43 and 70F.

For state government administration and planning, use 43.

## 91I-Emergency Services & Planning

Disaster services; Civil defense; Early warning systems and emergency preparedness for all types of disaster; Emergency weather services; Pollution alerts; Civil disturbances; Ambulance services; Flooding; Disaster relief.

See also 43D, 44, and 91F.

For military passive defense systems, see also 74I.

For personnel detection, see also 63G.

## 91J-Economic Studies

Economic analyses; Economic development; Industrial development; Economic impacts of development; Population-economy-income studies; Employment and earnings; Property values; Commercial area studies.

See also 43B and 96.

For government financial operations, use 43A, 70F, 91G, and 91H.

## 91K-Social Services

Child care; Family and youth counseling; Social rehabilitation; Foster homes and adoption; Welfare and public assistance; Financial assistance; Food stamp services; Employment services; Legal services.

See also 43C, 91F, and 92C.

## 91L-Recreation

Planning and administration; Facilities; Public opinion; Economic and social aspects; Safety aspects; Use of recreational vehicles; Cultural activities; Sports; Parks, including national parks.

# 92-BEHAVIOR & SOCIETY

## 920-General

Includes general overall census studies; Political science.

## 92A-Job Training & Career Development

Vocational training; On-the-job training; Retraining; Vocational rehabilitation; Use and design of training simulators (including flight simulators) and equipment; Instructional aids; Professional development; Career development.

For curriculum development, use 92D.

## 92B-Psychology

Human behavior; Personality; Intelligence; Learning ability; Judgment; Motivation; Perception; Job satisfaction; Leadership characteristics; Psychometrics; Adaptability; Social, industrial, group, organizational, interpersonal, and experimental psychology; Clinical psychology; Physiological psychology.

For the measurement of hearing, vision, heart rate, respiration and other physiological responses as related to behavior, use 57T or 57W.

## 92C-Social Concerns

Sociology and sociometrics; Race relations; Age group and minority group studies; Social rehabilitation of drug abusers, alcoholics, physically, emotionally, and mentally handicapped, offenders, etc.; Cultural and economic deprivation; Social discrimination; Immigration; Demography; Social services, including child care, welfare, counseling, financial assistance, and employment and unemployment services; Attitude studies.

See also 43C, 44, and 91K.

## 92D-Education, Law, & Humanities

Formal education; School systems; Educational administration; Curricula; Instructional devices and materials, including audiovisual; Teaching methods; Computer-assisted instruction; Laws; Linguistics; Machine translation; Fine arts; Archaeology; History; Anthropology; Humanities; Religion.

## 92E-International Relations

Political and social indicators; Crises and crisis management; Conflict analysis; Foreign aid; Foreign policy and foreign affairs; International political science; Disarmament and arms control; Espionage; Includes international relationships concerning territorial seas, fishing, extradition, and natural resources.

See also 74H.

For international commerce, use 96C.

# 94-INDUSTRIAL & MECHANICAL ENGINEERING

## 940-General

Includes bearings; Mechanical elements; Pipes; Tubes; Levers; Cams; Springs; Mechanical joints; Containers and packing materials; Refrigeration systems and equipment; Industrial furnaces and boilers; Heat exchangers; Heat pumps; Heat pipes; Industrial security; Metrology.

For rocket engine components, use 81G; For fuel tanks, use 81C;

For cooling towers, use 97J; For nuclear security, use 77Gen.

## 94A-Production Planning & Process Controls

Materials control; Numerical control and automation; Time and motion studies; Scheduling; Production controls and programming; Modeling techniques and program controls; Inventory management.

See also 44A, 41A and 41B.

## 94B-Quality Control & Reliability

Tolerances allocations; Maintainability requirements; Probability of satisfactory performance of components and equipment; Inspection methods; Destructive industrial testing; Reliability theory; Quality assurance.

See also 41E and 41G.

## 94C-Plant Design & Maintenance

Site selection; Plant design; Layout; Maintenance management; Scheduled, routine, and corrective maintenance.

See also 41H.

## 94D-Job Environment

Industrial hygiene and occupational diseases and injuries in settings such as factories, and office and commercial buildings; Industrial psychology; Industrial sociology; Workplace layout and design; Worker interactions.

See also 44G, 57U, 41I, and 92B.

For industrial safety engineering and accident prevention, use 94H.

## 94E-Environmental Engineering

Lighting; Heating; Ventilating; Air conditioning. Includes environmental engineering equipment related to industrial use. Excludes pollution control.

See also 41I, 89B and 97J.

## 94F-Tooling, Machinery, & Tools

Machine subassemblies; Robots; Robotics; Tools; Machinery, including hoists, conveyors and pumps.

See also 41C and 41J.



**94G-Manufacturing Processes & Materials Handling**

Fabrication, assembling, cleaning, and finishing; Industrial and manufacturing processes (limited to in-depth studies that directly discuss specific processes); Bonding and joining, including gluing, welding, soldering, and brazing; Materials forming and machining; Heat treatment; Coating processes; Materials handling, including palletizing, conveying, warehousing, storing, containerization, and packaging.

See also 71, 41B, 41E, and 41F.

For processing and packaging of food, use 98H.

For production of materials, use 71.

For chemical engineering and processing, use 99B.

For the beneficiation and processing of minerals, use 48A.

**94H-Industrial Safety Engineering**

Accident prevention; Safety measures; Fire prevention; Warning systems; Safety equipment, structures, and clothing.

For industrial safety engineering applied to a specific application, use the field of application.

**94I-Hydraulic & Pneumatic Equipment**

Design, production, performance, and testing of hydraulic and pneumatic systems, accumulators, actuators, compressors, and distribution equipment; Fluidic and fluoric devices.

See also 41J.

For hydraulic fluids, see 71K.

**94J-Nondestructive Testing**

Nondestructive testing having industrial application; Ultrasonic, radiographic, hydrostatic, magnetic, and optical nondestructive techniques and equipment; Nondestructive testing of flaws, thickness, opacity, strength.

For destructive industrial testing, use 94B.

**94K-Laboratory & Test Facility Design & Operation**

Measuring, testing, and simulation devices. Includes laboratories, test facilities, and test equipment measuring testing and simulation. If the test facility, equipment, etc. is applied to a specific application, use the field of application.

**95-BIOMEDICAL TECHNOLOGY & HUMAN FACTORS ENGINEERING****950-General****95A-Prosthetics & Mechanical Organs**

Includes materials and equipment going into human bodies, enabling them to function properly, either temporarily or permanently. Artificial limbs and limb braces; Facial prosthetics, including artificial eyes; Dental prosthetics; Mechanical organs and mechanical hearts; Circulatory assist devices; Artificial kidneys, etc.; Biocompatible materials including tissue adhesives, tissue compatible materials, and antithrombogenic materials.

For prosthodontics, use 57G.

**95B-Tissue Preservation & Storage**

Preservation of organs, tissue, and blood for transplantation or transfusion to living organs;

Blood and tissue banks; Properties and evaluation of preserved and stored materials.

See also 57J, 57S, and 57X.

**95C-Biomedical Instrumentation & Bioengineering**

Includes materials and equipment used to monitor human body functions. Design, use, and performance of biomedical equipment; Biotelemetry including biotelemetry transducer and transmitter equipment; Hospital equipment and supplies; Dental materials and equipment; Equipment for physiological monitoring; Diagnostic equipment; Biomedical laboratory equipment.

See also 95A.

**95D-Human Factors Engineering**

Design of tools, instruments, equipment, and machinery with emphasis on optimum utilization by humans; Habitability of work and living space; Ergonomics; Interaction of man and equipment in terms of subsystem and system performance requirements and evaluation. Encompasses manual controls, tactical kinesthesia, and other human sensory modalities involved in operation of equipment and understanding of personnel subsystems; Man-machine systems. Includes anthropometric studies, protective equipment, protective clothing, and life support systems.

**95E-Life Support Systems**

Equipment and techniques for sustaining life in foreign environments, such as space, underground, and underwater; Closed ecological systems (includes pressure suits, diving gear, and breathing apparatus).

See also 95D.

**95F-Bionics & Artificial Intelligence**

Study of biological processes in order to develop engineering systems; Simulation of biological processes; Comparative studies of control systems formed by the brain and nervous system; Pattern recognition systems based on biological modes; Biological applications of information theory; Cybernetics.

**95G-Protective Equipment**

Equipment providing protection against such environmental elements as heat, cold, noise, machinery, and radiation.

For equipment and techniques for sustaining life in environments where normal respiration is not possible, use 95E.

**96-BUSINESS & ECONOMICS****960-General**

Includes economic theory; Business and economic census studies; Insurance not covered by another subcategory; Small businesses.

**96A-Domestic Commerce, Marketing, & Economics**

National and state-level studies; Industrial costs and economics; Economic impact of industries; Economic impacts on industries; Industrial statistics; Agricultural economics; Productivity; Labor supply and demand; Labor costs and economics; Inflation; Economic aspects of unemployment; Employment and unemployment statistics; Wage surveys; United States commerce; Wholesale and retail trade; Domestic market surveys; Business, personal, and property taxes; Income tax data; Franchising.

See also 43B, 70D, 91J, and 98B.

For studies of individual plants or operations, see the field of application.

For economic impacts of individual plants or operations, see the field of application.

For regional development, use 43B and 91J.



**96C-International Commerce, Marketing, & Economics**

Foreign market surveys and research; International trade; Imports and exports; Customs and tariffs; Multinational businesses; Trends and forecasting.

For international finance, use 96F.

**96D-Consumer Affairs**

Consumer problems and protection; Truth in advertising; Commercial psychology; Product maintenance and reliability problems; Home appliances safety; Product comparison studies; Flammability studies; Motor vehicle recalls.

**96E-Minority Enterprises**

Minority owned and operated businesses; Business training of minority groups; Franchising; Equal opportunities in business.

**96F-Banking & Finance**

Investments; Credit; Banks and trust companies; Mortgage finance; Savings and loan associations; Security and commodity brokerage; Balance of payments; Gold and silver movement; Cash flow; Regulations; International finance.

For government financial operations, use 43A, 70F, 91G, and/or 91H.

**96G-Foreign Industry Economic Development**

Private and governmental industrial and economic development in foreign countries including industrialized and developing countries; International technology transfer; For foreign market surveys and international trade, use 96C.

**96H-Foreign Business & Economics**

Foreign and developing countries; Businesses, economic conditions and socioeconomics.

For foreign market surveys and international trade, use 96C.

For social concerns related to economics, see also 92C.

**97-ENERGY****970-General**

Includes energy source development.

**97A-Reserves**

Natural reserves; Fuel stockpiles; Mineral and fossil fuel deposits including coal, uranium, petroleum, natural gas, geothermal, peat, and oil shale; Water power potential; Site studies of wind power potential and solar radiation availability.

For individual mine studies, use 48A.

**97B-Energy Use, Supply, & Demand**

Electric power and fuel consumption and requirements; Supply and demand; Heat use, supply, and demand.

**97E-Electric Power Transmission**

Electric power distribution; Electric transmission lines and substations; Electric power pools; Wireless energy transmission.

**97F-Fuel Conversion Processes**

Methods to convert a fuel to a different chemical form including coal gasification and liquefaction; Upgrading fuels by chemical synthesis.

For petroleum refining, oil shale retorting and refining, use 97K and 99B; For environmental studies, use 97R.

**97G-Policies, Regulations & Studies**

Energy conservation; Licensing; Legislation; Government policies and regulatory controls; Energy goals; Research needs; Energy management, economics, and financing; Depletion allowances and leasing policies; Rates and energy models; Energy shortages; International issues.

**97I-Electric Power Production**

Design and operation of electric power plants; Commercial, industrial, and residential electric power production; Site surveys; Large-scale nuclear, hydro, solar, geothermal, and fossil fuel electric power plants; Power plant boilers.

*Note: Usually restricted to large-scale electric power production.*

For small-scale electric power production, use 97N, 97O, or 97P.

For pollution control and environmental impact, use 68 and 97R.

For some nuclear power plant studies, use 77 and 97Q. (97Q should be those that are most pertinent to the use of nuclear technology for energy production.)

**97J-Heating & Cooling Systems**

Design and operation of space heating and cooling systems and equipment; Furnace and boiler studies when related to energy conservation and energy use; Cooling towers; MIUS technology; Total energy systems.

See also 97N.

**97K-Fuels**

Production, performance, properties, storage, prices, and transportation of all types of solid, liquid, and gaseous fuels; Chemical composition of fuels; Fuel compatibility; Hydrogen production; Refuse derived fuels; Fuel desulfurization; Oil shale retorting; Petroleum refining; Fuel additives; Growing plants for fuels; Bioconversion and biomass plantations.

See also 48D and 97N.

For fuel tanks, use 81C.

For nuclear fuels, use 77I.

For fuel conversion, use 97F.

For rocket fuels, use 81H.

For supply and demand, use 97B.

For oil and gas drilling and recovery, coal mining and other energy related mining studies, use 48A.

**97L-Engine Studies (Energy Related)**

Operation and design of engines when related to energy conservation and energy use. Covers turbine, rotary, and reciprocating engines.

See also 81.

**97M-Batteries & Components**

Electrochemical batteries of all types including alkaline cells, dry cells, metal-air batteries, primary cells, reserve batteries, storage batteries, thermal batteries, wet cells; Battery containers, depolarizers, electrodes, electrolytes, separators, and other components and materials; Battery chargers and testers; Battery electrochemistry.

For thermoelectric and thermionic batteries, use 97O.

**97N-Solar Energy**

Solar collectors, concentrators, and absorbers; Solar cells; Solar cookers, dryers, furnaces, generators; Solar heat engines; Solar heating and cooling systems; Solar power plants; Solar stills; Solar water heaters; Solar heat storage systems; Solar water pumps; Solar sea power plants; Orbital solar power plants; Optical coatings and filters for solar devices; Solar energy policies, use, supply, trends, and economics.

**970-Miscellaneous Energy Conversion & Storage**

Fuel cells; Magnetohydrodynamics; Experimental electric generators; Turbogenerators; Heat storage; Compressed air energy storage; Mechanical conversion; Thermoelectric and thermionic conversion; Photovoltaic conversion (excludes solar cells); Wind power; Tidal power; Nuclear fusion power plants.

For commercial, industrial, and residential use of energy conversion and storage devices, use 97I or 97J.

**97P-Geothermal Energy**

Geothermal exploration and prospecting methods and equipment; Geothermal resources; Geothermal energy conversion; Geology applied to geothermal systems; Drilling; Reservoirs; Extraction; Site selection; Geothermal power plants; Corrosion studies; Materials used in geothermal systems.

**97Q-Selected Studies In Nuclear Technology**

Reports assigned to this subcategory are selected for their broad interest to users in the nuclear energy field.

For other nuclear energy subcategories, use 77.

**97R-Environmental Studies**

Air, noise, water, and solid waste pollution and pollution control from energy resource development, fuel production, energy production, and energy use; Environmental impacts of energy production and use.

See also 68.

**98-AGRICULTURE & FOOD****980-General****98A-Agricultural Chemistry**

The application of chemistry and chemical analysis to agriculture; Fertilizer production; Soil chemistry; Chemistry of feeding stuffs; Crop chemistry; Biochemical studies.

For food chemistry, use 98H.

**98B-Agricultural Economics**

Economics conditions, markets, subsidies, and policies affecting agriculture; Farm management and finance; Land and labor economics; Prices and price control.

See also 96C.

**98C-Agricultural Equipment, Facilities, & Operations**

Agricultural engineering; Agricultural machinery and tools; Seed preservation; Planting, fertilizing, mulching, weeding, and harvesting; Pest and disease control techniques and equipment; Crop protection; Crop drying and storage; Farm water supplies; Irrigation systems; Farm safety; Farm construction and operation.

For pest control, see also 57P.

For food processing, use 98H.

**98D-Agronomy, Horticulture, & Plant Pathology**

Field crop production; Cultivation of orchards, gardens and nurseries; Plant biology; Plant breeding, propagation, and hybridizing; Hydroponics.

See also 57C.

**98E-Animal Husbandry & Veterinary Medicine**

Production and care of domestic and wild animals; Breeding, feeding, management, rearing, testing, and training; Pets; Animal pathology; Toxic effects on domestic animals; Animal quarantine; Disease resistance, control and treatment; Breeding, care, and utilization of laboratory animals.

See also 57Z.

**98F-Fisheries & Aquaculture**

Fishing, fishing equipment, and shipboard processing of fisheries products; Cultivation of fishes, shellfish, and algae in fresh or salt water for commercial or recreational use; Use of fish ladders and weirs; Sport fishing.

See also 47D, 48B, and 57Z.

For fish processing, use 98H.

**98G-Agriculture Resource Surveys**

Surveys to scan crop yields, soil moisture content, crop diseases, and forest diseases. Includes fishery surveys; Satellite and aerial surveys.

**98H-Food Technology**

Pasteurizing, curing, canning, dehydrating, freezing, irradiation, freeze drying, etc., of foods and other agricultural products; Sanitation and fumigation of products; Food additives and preservatives; Analysis and inspection of products; Storage, packaging, and display of products; Kitchen and cooking equipment.

For biochemical studies of foods, see also 57B.

**99-CHEMISTRY****990-General****99A-Analytical Chemistry**

Techniques and instrumentation for the separation and analysis of individual compounds or specific groups or compounds, both inorganic and organic. Includes qualitative, quantitative, volumetric, gravimetric, optical, spectroscopic; electrochemical, ion exchange, chromatographic analysis; Test methods; Forensic chemistry; Data interpretation; Routine analysis or experimental results.

**99B-Industrial Chemistry & Chemical Process Engineering**

Techniques, processes, unit operations, and plant equipment that apply to chemical manufacturing, processing, transportation, and storage; Petroleum refining; Desalination technology; Pollution control equipment; Process control technology; Process engineering; Chemical reactors.

For coal gasification and liquefaction processes, see also 97F and 97K.

For specific environmental pollution control, see also 68.

For water purification, see also 50B and 68D.

**99C-Polymer Chemistry**

Synthesis, properties, reactions and theories of polymers and copolymers. Includes all types of polymerization, curing, crosslinking, reaction kinetics, etc.

For mechanical properties of polymers, use 71O and 71H.

**99D-Basic & Synthetic Chemistry**

Synthesis, properties, and reactions of inorganic and organic compounds; Studies of individual or specific groups of chemical elements; Molecular structure; Stereochemistry.

For chemical reaction mechanisms between atoms, ions, or molecules, see also 99F.

For spectrum analysis of compounds, use 99A and 99F.

**99E-Photochemistry & Radiation Chemistry**

Studies involving the interrelationships of electromagnetic or particle radiation and chemical reactions; Studies of radioactive elements and their reactions; Radiochemistry; Photochemical reactions.

See also 55A and 68A.

**99F-Physical & Theoretical Chemistry**

Physical chemistry; Thermodynamics; Thermochemistry; Colloids and gels; Surface chemistry; Catalysis and catalysts; Electrochemistry; Solutions; Chemical equilibria; Membranes; Reaction kinetics; Quantum mechanics; The mathematical determination of atomic or molecular orbitals, energy levels, or properties; The application of mathematics to chemical systems and electronic spectra, excluding routine analysis or experimental results; Molecular spectra interpretation; Chemical reaction mechanisms in the gas, liquid, or solid phase between atoms, ions, or molecules; Atomic and molecular energy studies; Phase studies of nonmetallic systems; Isotherms; Crystallography.

For advanced materials, use 71Gen or the field of application.

For solid state physics, use 46D.

For thermodynamics, see also 460 General.

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# A Cementation Process for Minerals Recovery from Salton Sea Geothermal Brines

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# A Cementation Process for Minerals Recovery from Salton Sea Geothermal Brines

## Abstract

The potential for minerals recovery from a 1000-MWe combined geothermal power and minerals recovery plant in the Salton Sea is examined. While the possible value of minerals recovered would substantially exceed the revenue from power production, information is insufficient to carry out a detailed economic analysis. The recovery of precious metals—silver, gold, and platinum—is the most important factor in determining the economics of a minerals recovery plant; however, the precious metals content of the brines is not certain. Such a power plant could recover 14-31% of the U.S. demand for manganese and substantial amounts of zinc and lead. Previous work on minerals extraction from Salton Sea brines is also reviewed and a new process, based on a fluidized-bed cementation reaction with metallic iron, is proposed. This process would recover the precious metals, lead, and tin present in the brines.

## Introduction

Brines from various sources are being used worldwide as sources for a variety of minerals. While the potential use of geothermal brines for simultaneous energy and minerals production has not been explored in detail, potassium chloride has been recovered from salts in the evaporation ponds at the Cerro Prieto, Mexico, geothermal plant<sup>1</sup> and the U.S. Bureau of Mines has sponsored two experimental programs on minerals extraction from brines in the Salton Sea Geothermal Field, California.

The brines in the Salton Sea KGRA (Known Geothermal Resource Area), also called Niland brines, are particularly interesting for combined energy and minerals recovery because of their high temperature, high salinity, and the fact that some processing would be required for brine reinjection regardless of minerals recovery.

The amounts of electrical energy recoverable from the Salton Sea have been estimated to lie between 1100 and 8700 MWe for 20 years.<sup>2</sup> For a combined geothermal power-minerals recovery plant, the revenue from the minerals recovered can substantially exceed the revenue from power

production. A 1000-MWe power plant could recover 14-31% of the U.S. demand for manganese,<sup>3</sup> together with significant quantities of zinc and lead. The potential for lithium recovery is very large; one such 1000-MWe plant could recover between 31 and 65 thousand metric tons of lithium per year (metal equivalent), compared to the 1980 total world sales of about 7.2 thousand metric tons.<sup>4</sup> The value of minerals potentially recoverable cannot be estimated accurately, however, because of variability in the chemical analysis of brines collected from any one well, as well as differences in the chemical composition of brines from neighboring wells. Further, the most valuable elements in the brines could well be the precious metals—gold, platinum, and silver, but those are present in trace amounts and the uncertainty in the chemical analysis of the brines, together with the variability in reported brine compositions, does not allow for good estimates. However, it is significant that both silver and gold have been reported as minor components of the scales obtained from Salton Sea high-temperature brines.<sup>5-8</sup>

## Chemical Composition of Salton Sea Geothermal Brines

A number of studies have been made of the chemical composition of Salton Sea brines. For

the purposes of this report, analyses of brines from the Magmamax No. 1 and Sinclair No. 4

wells will be considered representative and will be used to estimate the potential for minerals production for a combined geothermal power-minerals recovery plant. The choice of these two wells is arbitrary, but the properties of their brines have been studied in some detail.<sup>5,9,10</sup> Although other wells in the area show equal or greater mineral contents, there are substantial differences in the trace-element composition from relatively closely spaced wells. The locations of these and other wells in the Salton Sea KGRA are shown in Figs. 1 and 2 (see Ref. 2).

The total dissolved solids, chloride concentration, and density of brine change with well flow

rate. The reasons for these changes are not well understood, but are likely the result of transient effects during unsteady state operation and, perhaps, of larger inflows of deeper, more-concentrated brines as flow rates increase. The large variability in chemical analyses reported for the Magmamax No. 1 well is shown in Table 1 for some Lawrence Livermore National Laboratory (LLNL)<sup>5,10</sup> data; the range of values in the compilation of Cosner and Apps<sup>9</sup> is even larger.

The chemical composition of the brines is so complex that systematic analytical errors can easily obtain. Thus the barium concentrations given in Table 1 were shown to be in error because of

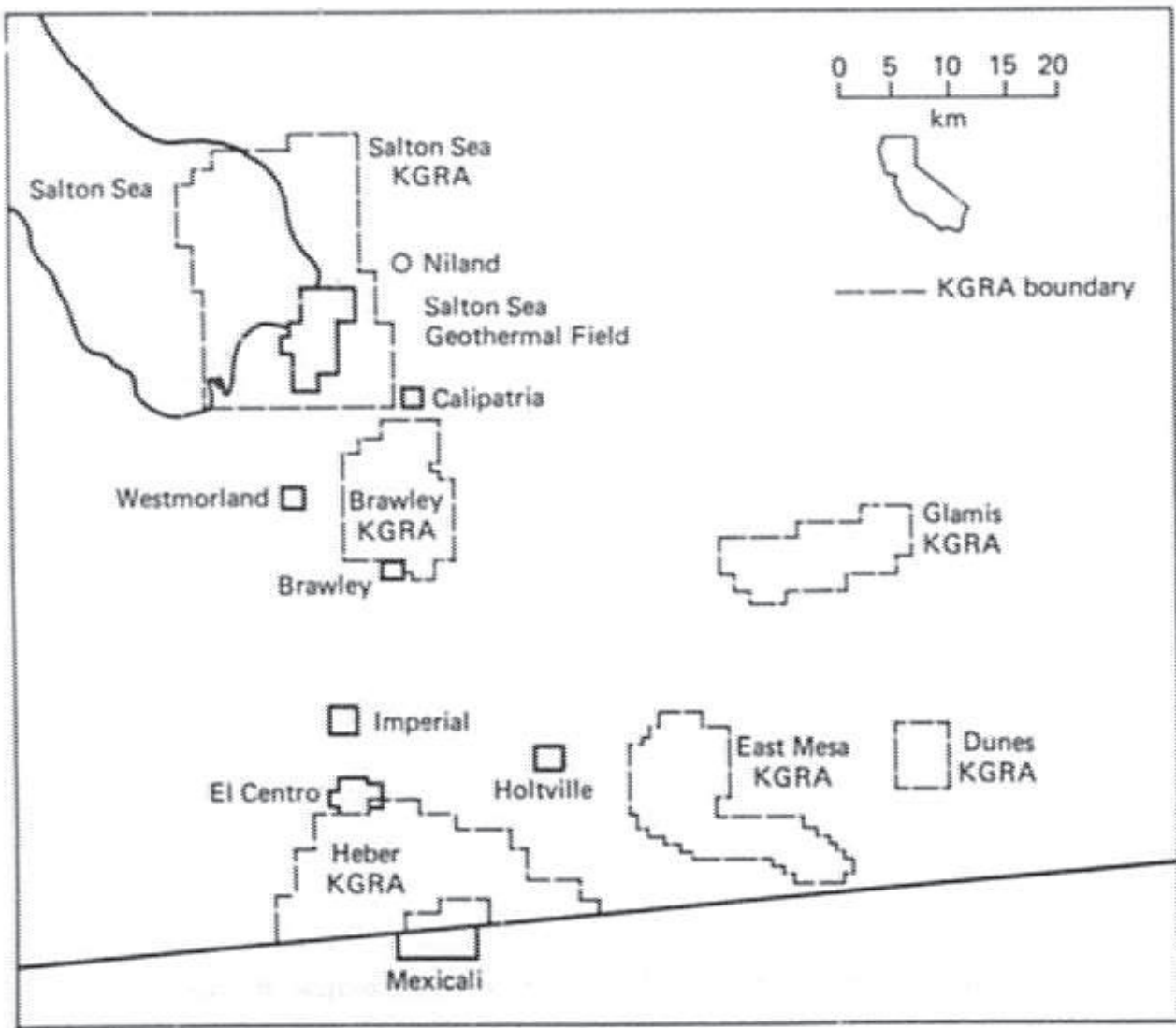


Figure 1. Map of the Imperial Valley, showing Known Geothermal Resource Areas (KGRA) and the Salton Sea Geothermal Field.



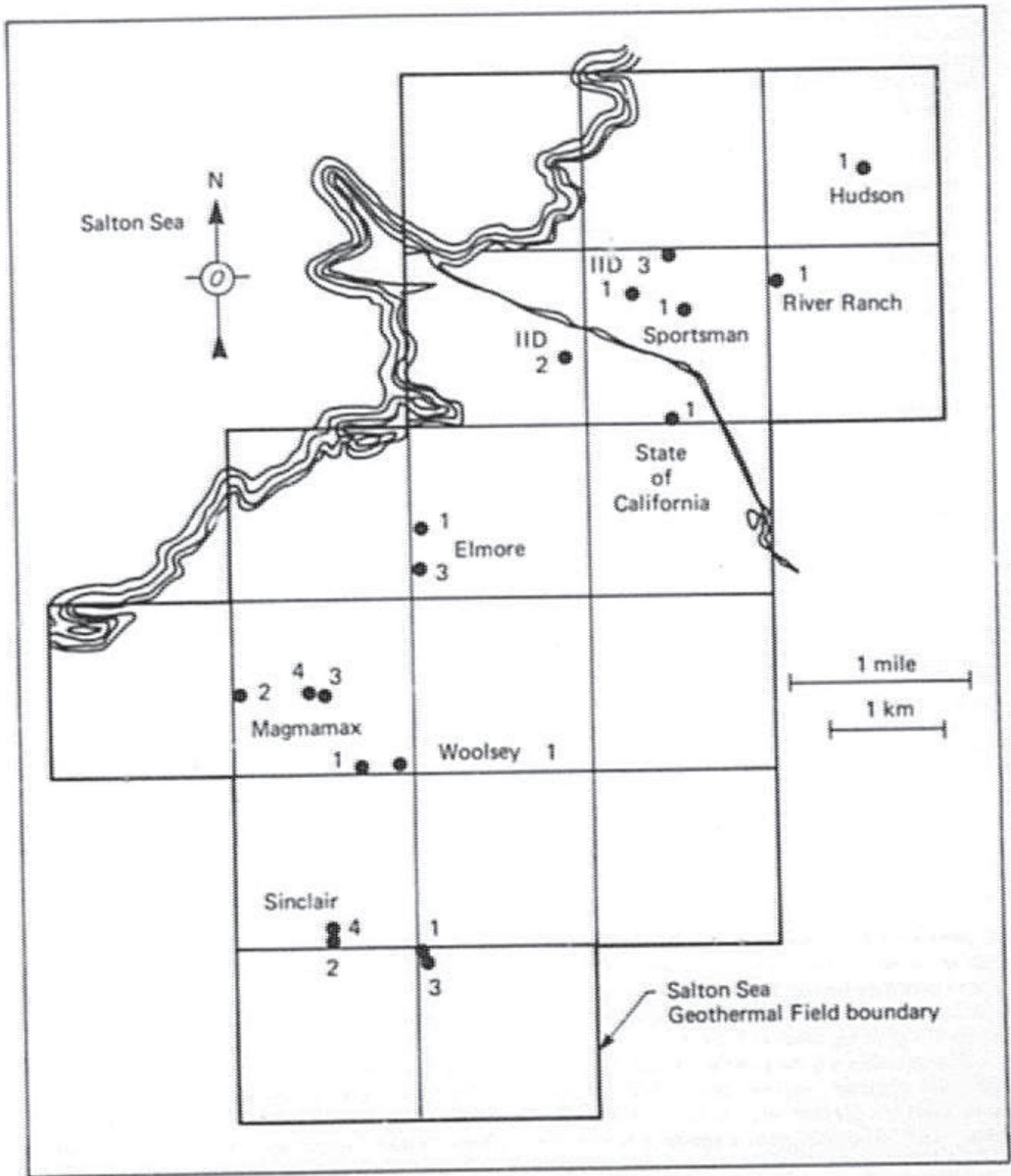


Figure 2. Well locations in the Salton Sea Geothermal Field.

Table 1. Changes in brine composition during production of Magmamax No. 1.

	Date taken (1976)				
	6/29	6/30	8/08	8/10	8/10
Temperature (°C)	200	214	230	215	215
Pressure	225	240	320	235	235
Composition (ppm by weight)					
Lithium	—	—	128	135	141
Sodium	40 900	42 100	41 200	42 700	42 000
Silicon	181	187	190	200	202
Potassium	6 400	7 000	6 600	6 500	5 600
Iron	202	161	199	180	256
Copper	1	1	1	1	1
Rubidium	—	—	—	—	64
Barium	54	85	115	118	118
Magnesium	125	125	95	99	80
Zinc	188	183	275	285	361
Strontium	—	—	360	373	388
Tin	23	23	—	—	—
Aluminum	—	—	—	1	1
Chlorine	101 000	105 000	111 000	112 000	121 000
Calcium	17 400	16 900	17 900	18 200	20 000
Manganese	502	494	565	570	690
Antimony	4	4	—	—	—
Lead	22	22	60	59	78
NH <sub>3</sub>	—	—	—	—	30-60
CO <sub>2</sub>	—	—	—	—	1-2 (wt%)
H <sub>2</sub> S	—	—	—	—	10-30
pH	—	5.7	5.8	6.1	5.2
Oxidation-reduction potential (mV vs H <sub>2</sub> )	—	—	192	177	237
Density (g/cm <sup>3</sup> )	1.12	1.12	1.13	1.14	1.15
Total solids (g/kg brine) by evaporation	169	171	197	196	208

the precipitation of barium sulfate before sample analysis. A special sample was obtained and handled to minimize barium sulfate precipitation, and a barium content of 290 ppm was measured<sup>5</sup> vs the 80-125 ppm reported in Table 1.

The situation for the precious metals—silver, gold, and platinum—is even more difficult because they are present only in trace concentrations.<sup>11</sup> LLNL commissioned a special analysis at Ledoux Laboratories, Teaneck, New Jersey, which specializes in precious metals assays. Ledoux, using the fire-assay method of analysis, reported 0.5-0.7 ppm silver, 0.1 ppm gold, and 0.06 ppm platinum. The fire-assay method, a molten-salt extraction process performed on a sample of about 200 g of

salts obtained by evaporating the brine, is very selective and is considered a standard for ore analysis. The silver analysis agrees with the values reported by Cosner and Apps.<sup>9</sup> However, a recent study at SRI International<sup>12</sup> indicates that silver analyses obtained by atomic absorption spectroscopy can be biased by matrix interferences. Using an extraction technique followed by flame atomic absorption, SRI researchers found 0.02 ppm silver in Niland brines (San Diego Gas and Electric Geothermal Loop Experiment Facility, GLEF) stored at room temperature in plastic containers. This value should be compared to the 0.48 ppm they had obtained in the initial analysis. However, none of the above analyses reflects the



Table 2. "Typical" analysis for Magmamax No. 1 and Sinclair No. 4 brines.

	Magmamax 1	Sinclair 4
Total solids (g/l)	190	294
pH	5.6	5.2
Eh (vs NHE)	0.18	0.18
Composition (ppm by weight)		
SiO <sub>2</sub>	200	506
NH <sub>3</sub>	45	440
Li	117	245
K	8 500	14 300
Rb	56	25
Mg	75	68
Sr	366	600
Ba	290	—
Mn	565	1 260
Fe	422	1 300
Co	0.3	—
Mo	4	—
Cu	0.8	3
Zn	226	500
B	10	300
Sn	23	—
Pb	70	90
As	0.2	7
Sb	4	—
Bi	5	—
Se	6	2.5
Ag	0.5	0.5
Au	0.1	0.1
Pt	0.06	0.06

composition of the wellhead brines; the systematic variation in scale compositions described below indicates that some metals, particularly silver and lead, are more concentrated in the wellhead brine than in the aged, post-flash brines.

The total salt concentration of the brine is reflected very accurately by its density, and there is an almost perfect correlation between density and chloride concentration. Chloride concentrations tend to reflect the variation in relative concentration of most minor brine constituents. The

solubility of silica is lower in the more-concentrated brines.<sup>6</sup>

For the purposes of this study, and somewhat arbitrarily, "typical" post-flash brine compositions for room-temperature, aged brines from the Magmamax No. 1 and Sinclair No. 4 wells were developed by averaging the available chemical analyses and, in some cases, selecting "best" values. These "typical" analyses are shown in Table 2. The Ledoux values for silver, gold, and platinum are also included.

## Chemical Composition of Scales

The substantial amount of scale deposited by Salton Sea brines during equipment operation has been a major impediment to the development of geothermal energy in the area. Brine from the Magmamax No. 1 well gave rise to scaling rates as

high as 1 mil/h in the San Diego Gas and Electric Geothermal Loop Experiment Facility. The composition of some of those scales is discussed below. The chemical compositions of scales from other wells in the area have also been reported;

Table 3. Analyses<sup>5</sup> of scale from Magmamax No. 1 wellhead and the LLNL four-stage flash system after about 720 h of operation.

Element	Composition, wt%							
	Wellhead, 220°C	Separated unmodified brine, 200–220°C	2nd-stage brine, 150°C	2nd-stage steam, 150°C	3rd-stage brine, 125°C	3rd-stage steam, 125°C	4th-stage brine, 110°C	Delay line, 85°C
Si as SiO <sub>2</sub>	2	27	60	27	64	64	49	39
Li	a	0.1	0.03	0.1	0.03	0.01	0.01	0.1
Na	a	10	3	1	3	3	1	20
K	<0.5	1.6	1.3	1.5	0.64	0.22	0.8	1.4
Rb	<0.1	0.01	0.02	0.02	0.007	0.004	0.003	0.01
Be	a	0.0003	0.001	0.0006	0.0003	0.0003	0.002	0.0001
Mg	a	0.2	0.02	0.02	0.02	0.05	0.03	0.02
Ca	2	4.2	2.0	1.2	2.7	2.9	26	6.1
Sr	trace	0.06	0.04	0.01	0.22	0.03	0.12	0.40
Ba	<0.5	<0.1	<0.1	<0.1	3.5	0.32	1.2	5.3
B	a	0.03	0.03	0.2	0.03	0.05	0.1	0.05
Al	a	0.1	0.3	2	0.1	0.2	0.2	0.02
Y	<1	<0.005	0.01	0.1	<0.005	<0.005	0.02	<0.005
S	12	2.4	<1.0	<1.0	<1.0	<1.0	1.5	2.3
As	a	0.15	0.32	0.97	0.21	0.45	0.07	0.11
Se	trace	0.019	0.22	0.65	0.11	0.27	0.069	0.083
Ti	0.03	<0.05	<0.05	<0.05	<0.5	<0.05	<0.2	<0.8
Cr	0.09	<0.02	0.03	0.34	<0.2	<0.01	<0.05	<0.3
Mn	0.03	0.67	0.21	0.27	0.12	0.12	0.03	0.12
Fe	0.7	22	7.1	14	2.4	6.0	1.4	0.59
Ni	0.01	<0.01	0.19	1.7	0.07	0.16	0.05	<0.01
Mo	a	<0.002	<0.002	0.004	<0.002	<0.002	<0.002	<0.002
Ag	0.34	0.008	0.028	0.11	0.024	0.056	0.01	0.012
Cu	0.02	1.0	0.4	0.5	0.2	0.6	0.15	0.08
Zn	0.07	0.11	0.04	0.03	0.06	0.09	0.02	0.08
Pb	76	1.3	0.16	0.08	0.55	0.90	0.21	0.25
Cl	a	7.9	9.9	1.7	7.7	4.3	3.2	18
Br	a	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F	a	a	a	a	a	a	26	a

<sup>a</sup>Not determined.

for example, Skinner<sup>2</sup> reports that six to eight tons of scale were collected during a three-month test of the No. 1 Imperial Irrigation District (IID No. 1) well. This scale contained "approximately 20% copper and precious metal values of several hundred ounces of silver plus one tenth of an ounce of gold per ton."

The LLNL Geothermal Program was carried out at the Magmamax No. 1 well, adjacent to the GLEF. A substantial part of the program was devoted to developing an understanding of brine chemistry and to methods for preventing scale deposition, as well as to brine treatment before reinjection.<sup>5,7,10,13-18</sup>

Suspended solids (about 7 ppm<sup>10</sup>) collected at the wellhead of Magmamax No. 1 well were

found to be almost pure lead sulfide.<sup>13</sup> Substantial changes in scale composition were found as the brine flowed from the wellhead through the different stages of the LLNL four-stage system.

The scale compositions reported by Harrar et al.<sup>5</sup> are given in Table 3. Various compounds tend to precipitate preferentially at different points in the equipment, depending on respective temperatures, the concentration of such reactive volatile species as H<sub>2</sub>S and CO<sub>2</sub>, and residence times.

Thus copper content was highest in the 200–220°C scales from the first-stage separator, and scale from the fourth-stage separator contained 26% fluorine as apatite (CaF<sub>2</sub>). While the high-temperature wellhead scale contained only



4%  $\text{SiO}_2$ , lower-temperature scales contained up to 64% silica. Analysis of the scales obtained by LLNL during the nozzle expansion tests indicated that the primary metal sulfides were  $\text{PbS}$ ,  $\text{CuFeS}_2$ ,  $\text{ZnS}$ , and  $\text{Cu}_2\text{S}$ ; the silver content increased downstream of the throat region and reached a maximum value of 1 wt% adjacent to the nozzle exhaust.<sup>10</sup> The wellhead (220°C) scale contained approximately 88% lead sulfide and 0.34% silver; however, the silver content of the lower-temperature scales in Table 3 is almost negligible. Similar results were reported by Carter and McCawley.<sup>19</sup> In the case of silver, the higher concentration in the wellhead scales is probably due to the initial cooling in the presence of  $\text{H}_2\text{S}$ ; how-

ever, metallic silver has also been reported. The high silver content of the wellhead scales implies that, unless precipitation is prevented, a process aimed at recovering the silver should interact with wellhead brines and scales.

Reduction of the rate of scale deposition in process equipment was an important part of LLNL's program.<sup>10,15,16</sup> Large reductions in the rate of suspended solids production were obtained by acidification with HCl, as well as by the addition of a variety of organic compounds. The reduction in the rate of scale deposition by additions of HCl is shown in Fig. 3 for 85°C brines, and the amounts of acid required are shown in Fig. 4. However, the reported increases in the corrosion rates on carbon steels were of concern; corrosion of mild steels will be discussed later in this report.

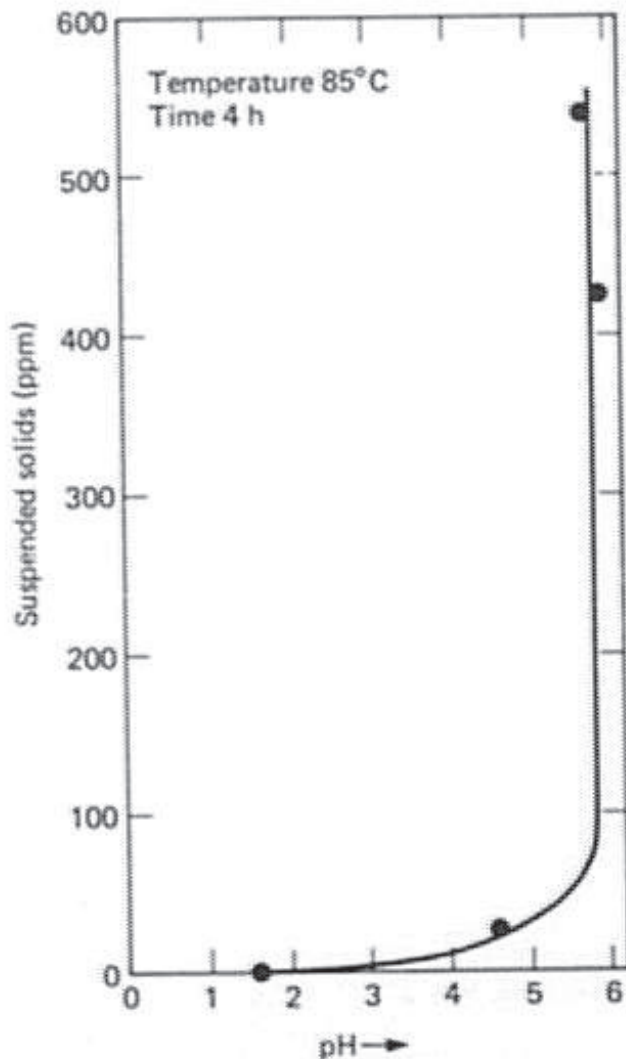


Figure 3. Suspended solids production in separated Magmamax No. 1 brine, as a function of pH.

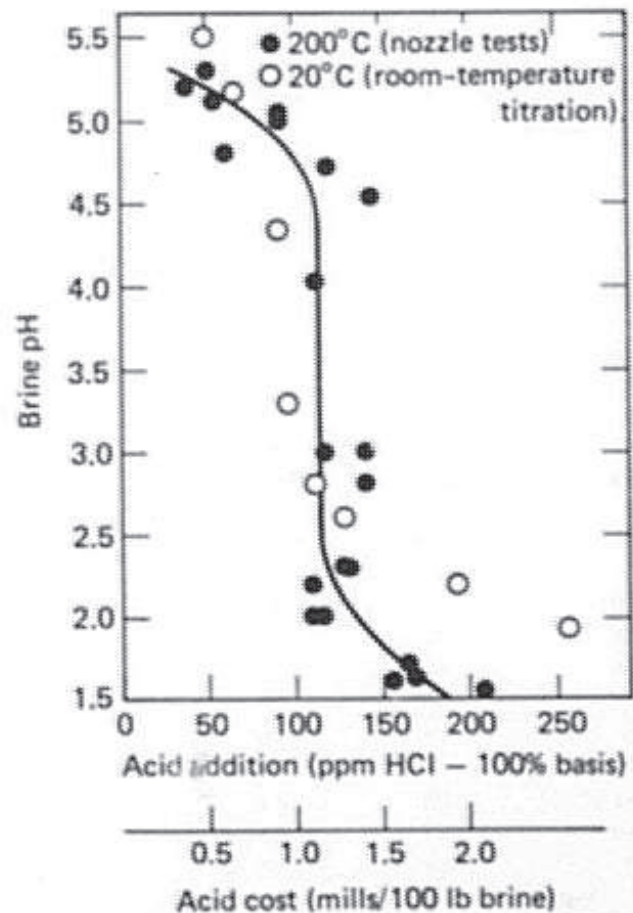


Figure 4. Acid-consumption measurements for pH control (separated Magmamax No. 1 brine).



## Potential for Minerals Recovery from Salton Sea Geothermal Brines

The possibility of minerals recovery from geothermal brines has been widely acknowledged; however, there are few detailed published studies on the subject. Werner,<sup>20</sup> Barnea,<sup>21</sup> and Blake<sup>22</sup> surveyed the minerals potential of geothermal brines and allude to some problems in the development of this resource. The U.S. Bureau of Mines has sponsored the only detailed published studies. Berthold et al. of Hazen Research<sup>23</sup> performed a more-detailed study in which a large number of possible processes were illustrated by application to the most common elements present in the brines. The Hazen Research study culminated in the building and operation of a 15-gpm pilot plant at the Salton Sea.<sup>24,25</sup> SRI International explored the possibilities of recovering heavy metals from Salton Sea brines by sulfide precipitation.<sup>12</sup> The results obtained at Hazen Research

and SRI International will be reviewed in more detail later.

The market value of possible products from a 1000-MWe combined geothermal power-minerals recovery plant is larger than the market value of the electric power production. A detailed listing is shown in Table 4.

Table 4 was developed using relatively conservative assumptions:

- The plant would have a 25% downtime, i.e., 6570 operating hours per year.
- Ninety percent of the mineral values in the brine would be recovered.
- Brine reinjection would be considered a basic necessity for long-term operations, with the minerals recovery processes limited to those achievable without evaporation of the brine.

Table 4. Potential minerals recovery from a 1000-MWe geothermal power-minerals recovery plant in the Salton Sea.

Element	Potential minerals recovery (thousand metric tons/yr)		U.S. consumption 1980 estimates (thousand metric tons <sup>b</sup> )	Possible plant product and market value <sup>26,27</sup> (10/30/81)	Market value of possible plant product (\$million/yr)	
	MagmaMax 1	Sinclair 4			MagmaMax 1	Sinclair 4
SiO <sub>2</sub>	53	135	—	Amorphous drying grade 93%, \$31/ton	1.8	4.6
NH <sub>3</sub>	12	117	15 800	Aqueous 29.4% anhydrous basis, \$210/ton	2.7	27.1
Li	31	65	4.7 <sup>a</sup>	Li <sub>2</sub> CO <sub>3</sub> , \$1.41/lb	(511) <sup>c</sup>	(1 075) <sup>c</sup>
Mn	150	335	1 061	Ferromanganese 78%, 0.1% C, \$0.685/lb	290	648
Fe	112 (79) <sup>b</sup>	346 (272) <sup>b</sup>	69 400	Black, magnetic iron oxide, \$0.25/lb	28	97
Cu	0.2	0.8	3 962	Metal, \$0.745/lb	—	—
Zn	60	133	923	Metal, \$0.462/lb	61	135
Sn	6	—	53	Metal, \$6.86/lb	90	—
Pb	18.6	24	1 100	Metal, \$0.36/lb	14.8	19
Se	1.6	0.7	0.4	Metal, \$3.80/lb	13.4	6
Subtotal					502	938
Ag <sup>d</sup>	4.2	4.2	99	Metal, \$9.08/troy oz	38	38
Au <sup>d</sup>	0.8	0.8	3.0	Metal, \$426/troy oz	341	341
Pt <sup>d</sup>	0.5	0.5	2.2 <sup>d</sup>	Metal, \$412/troy oz	206	206
Total					1 087	1 523

<sup>a</sup>Elasticity of lithium market not known.

<sup>b</sup>Iron in excess of that needed for 78% ferromanganese production.

<sup>c</sup>Precious metals production in million troy ounces (31.104 g).

<sup>d</sup>Total consumption, platinum-group metals.



- A net specific energy output (power plant efficiency) of 22 watt hours per kilogram of brine was assumed, corresponding to a brine flow rate of 45 million kilograms per hour. This value of specific energy is appropriate for current double-flash systems, but lower than might be obtained from advanced geothermal power systems.<sup>24</sup>

If electric power sells for six cents per kilowatt hour, the market value of the power is \$394 million per year. The market value of the product slate shown in Table 4 ranges from about \$500 to

\$1500 million per year, depending on the assumptions made about the precious metals content of the brine. The above estimates do not include the value of the lithium chemicals since the potential production is so much larger than the current market.<sup>4</sup>

It is worthwhile noting that manganese production from such a plant could supply 14-31% of the U.S. demand for this strategic material.<sup>3</sup> Substantial amounts of zinc, lead, tin, and selenium could also be recovered.

## Review of Prior Work

### Hazen Research Incorporated

Hazen Research, Incorporated, Golden, Colorado, conducted laboratory<sup>24</sup> and pilot plant tests<sup>25</sup> in the Salton Sea. While the pilot plant was operated successfully, the results are still being analyzed and a final report is not available.

Their laboratory studies using Sinclair No. 4 brines indicated that iron could be separated from manganese, zinc, and lead by selective precipitation of the respective hydrated oxides. Processes for the separation of lithium, barium, and strontium without evaporation of the brine were also explored.

Hazen's process is based on selective precipitation of the hydroxides using lime. They found better separation when the iron was oxidized to the ferric state by sparging air through the brine. Ninety-nine percent of the lithium was recovered as aluminate, and partial recovery of barium was obtained by the addition of gypsum. Recovery of strontium requires evaporation of the brine. In laboratory experiments, Hazen was able to obtain a hydrated magnetic iron oxide containing more than 68% iron and less than 0.1% manganese. The manganese precipitate contained 47.3% manganese, 18.2% zinc, and 2.6% lead with 0.6% iron contamination. Their experiments also indicated that it would be advantageous to remove the silica present in the brine before precipitating the heavy metal hydroxides.

Hazen then designed and operated a 15-gpm pilot plant, using post-flash brine from the GLEF plant of San Diego Gas and Electric at the Magmamax No. 1 well. While their complete design flow sheet with nominal flows and compositions<sup>25</sup> is given in Fig. 5 and Table 5, the actual pilot plant used just one lime-precipitation step in

which a comingled precipitate containing iron, manganese, and zinc was obtained. As mentioned earlier, the results of the pilot plant experiments are not yet available; however, information obtained informally from Mr. L. Schultze of the Reno Metallurgy Research Center, U.S. Bureau of Mines<sup>26</sup> indicated that:

- The Pilot Plant was operated in the spring of 1980, following the original Hazen flow sheet, with minor modifications.
- The silica-separation step was not very effective, and silica was found to contaminate the products.
- The single (bulk) lime-precipitation step allowed them to recover about 90% of the metals of interest, but had difficulty in separating the iron, lead, and zinc into materials pure enough to be of commercial interest. However, the precipitates had aged for about one year before further separation was attempted.
- They used aqueous ammonia and ammonium chloride solutions to separate zinc from the aged, mixed precipitate indicated above; however, they were only able to recover about 50% of the zinc present.
- They obtained good separation of lithium and are investigating means of recycling the aluminum.
- A large number of samples remain to be analyzed.

### SRI International

The process investigated at SRI International,<sup>12</sup> Menlo Park, California, involved precipitation of the more-valuable elements in the brine by use of a sulfiding agent, such as H<sub>2</sub>S, NaHS, or

Na<sub>2</sub>S. SRI performed a number of equilibrium calculations, as well as laboratory experiments, using Magmamax and Woosley brines, including a 14-l/h flow experiment using aged, spent brine from the GLEF. Their "goal was to precipitate essentially all the silver, lead, and zinc, while minimizing the precipitation of iron and manganese and using as little of the sulfide as possible." Their equipment for continuous sulfidation is shown in Fig. 6.

Calculations indicated that the insolubilities of the metal sulfides are in the order Ag, Pb, Zn, Fe, and Mn.

Experimentally, SRI found that lead and silver sulfides can be precipitated preferentially before zinc, iron, and manganese sulfides.

Their small-scale batch experiments, using H<sub>2</sub>S at 100°C and a pH of about 3, indicated that H<sub>2</sub>S at about one atmosphere led to precipitation of about half of the zinc present. However, only

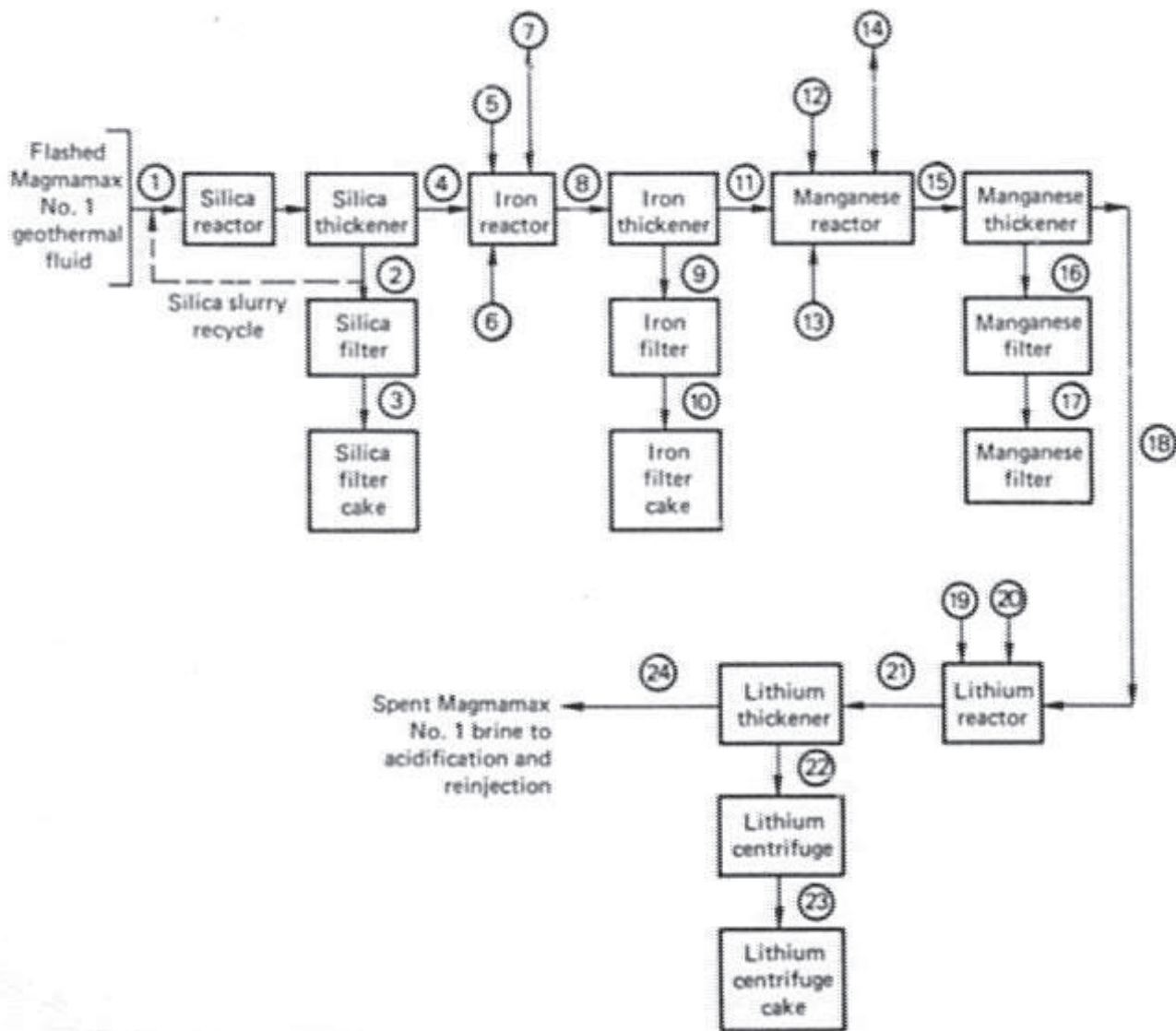


Figure 5. Process materials balance of Magmamax No. 1 brine (Hazen Research).



Table 5. Process flow sheet for Magmamax No. 1 brine (Hazen Research, Inc.).

	Stream No.											
	1	2	3	4	5	6	7	8	9	10	11	12
SiO <sub>2</sub>	230 ppm total 187 ppm solid	1.6 lb/h 10.2 wt%	1.6 lb/h 60 wt%	43 ppm				43 ppm	0.16 lb/h solids		22 ppm	
Fe	255 ppm			255 ppm				255 ppm total	375 lb/h solids		26 ppm	
Zn	333 ppm			333 ppm				333 ppm			333 ppm	
Mn	775 ppm			775 ppm				775 ppm			775 ppm	
Pb	70 ppm			70 ppm				70 ppm	0.13 lb/h solids		56 ppm	
Li	182 ppm			182 ppm				182 ppm			182 ppm	
Inertia	22.1%			22.1%				22.1%			22.1%	
H <sub>2</sub> O	77.7%			77.7%			7 lb/h	77.7%			77.1%	
Specific gravity	1.135	1.20		1.135	1.22			1.14	1.32	1.9	1.13	1.22
Temp. °C	93	93	93	93	25	29	92	92	92	92	92	25
Temp. °F	200	200	200	200	77	85	198	198	198	198	198	77
Flow, gpm	15	0.025		15	0.025			15	0.03		15	0.088
Flow, gph	900	1.5		900	1.50			901	1.8		901	5.25
Flow, cfm	-	-				5.0	6.2					
Flow, lb/h	8523	15.0	2.67	8520	15.3			8528	20	6.8	8508	54
Specific heat Btu/lb °F	0.85	0.78	0.46	0.85	0.77			0.85		0.48	0.85	0.77
Heat Btu/h	1.45 X 10 <sup>6</sup>	2340	2.46	1.45 X 10 <sup>6</sup>	2471			144 X 10 <sup>6</sup>		646	144 X 10 <sup>6</sup>	10,656
Density	9.47 lb/gal	9.99 lb/gal	~50 lb/ft <sup>3</sup>	9.47 lb/gal	10.2 lb/gal			951 lb/gal	11.0 lb/gal	15.8 lb/gal	944 lb/gal	10.2 lb/gal
NH <sub>3</sub>	352 ppm			352 ppm				352 ppm			352 ppm	

Post-flash No. 1  
 Magmamax No. 1  
 Brine Input  
 SiO<sub>2</sub> thickener  
 at 11 wt% solids  
 SiO<sub>2</sub>  
 Filter cake  
 Brine feed  
 to iron reactor  
 40% w/v  
 Ca(OH)<sub>2</sub> slurry  
 Vent gases from  
 iron reactor  
 Iron slurry to  
 thickener  
 Iron thickener  
 at 20 wt% solids  
 Iron filter cake  
 Iron thickener  
 overflow  
 40% w/v  
 Ca(OH)<sub>2</sub> slurry



Table 5. (Continued.)

	Stream No.											
	13	14	15	16	17	18	19	20	21	22	23	24
SiO <sub>2</sub>												
Fe			26 ppm	0.21 lb/h		13 ppm			13 ppm			13 ppm
Zn			333 ppm	4.11 lb/h		17 ppm			17 ppm			17 ppm
Mn			775 ppm	10.06 lb/h		39 ppm			39 ppm			39 ppm
Pb			56 ppm	0.48 lb/h		6 ppm			6 ppm			6 ppm
Li			182 ppm			182 ppm			182 ppm	43 lb/h solids		18 ppm
Inertia			22.1%			22.1%			22.1%			22.1%
H <sub>2</sub> O		20 lb/h	777%			77.8%			77.0%			77.0%
Specific gravity			1.132	1.303	1.86	1.13	1.109	1.315	1.13	1.434	1.86	1.13
Temp. °C	29	90	90	90	90	90	25	25	90	90	90	90
Temp. °F	85	195	195	195	195	195	77	77	195	195	195	195
Flow, gpm			15	0.11		15	0.22	0.05	15.3	0.15	0.1	15
Flow, gph			904	6.8	1.6	902	13.6	2.8	918	9.2	5.8	912
Flow, cfm	12.4	16.0										
Flow, lb/h			8540	74	24.8	8515	126	31	8672	110	78	8594
Specific heat Btu/lb °F			0.85			0.85	0.78	0.57	0.85		0.48	0.85
Heat Btu/h			1.41 X 10 <sup>6</sup>			1.41 X 10 <sup>6</sup>	7568	16,000	1.44 X 10 <sup>6</sup>		7301	1.43 X 10 <sup>6</sup>
Density			9.45 lb/gal	10.9 lb/gal	15.5 lb/gal	9.44 lb/gal	9.24 lb/gal	10.9 lb/gal	9.45 lb/gal	12.0 lb/gal	15.5 lb/gal	9.43 lb/gal
NH <sub>3</sub>		3.0 lb/h	352 ppm			35 ppm			35 ppm			35 ppm
<div> <div>air sparge to manganese reactor incl. ammonia</div> <div>manganese reactor from incl. ammonia</div> <div>manganese slurry to thickener</div> <div>manganese underflow at 20 wt% solids</div> <div>manganese filter cake</div> <div>manganese thickener overflow</div> <div>NaAlO<sub>2</sub> solution 30 wt% NaAlO<sub>2</sub></div> <div>AlCl<sub>3</sub> solution 40 wt% AlCl<sub>3</sub></div> <div>aluminate slurry to thickener</div> <div>aluminate underflow at 39 wt% solids</div> <div>aluminate centrifuge cake</div> <div>lithium aluminate thickener overflow</div> </div>												

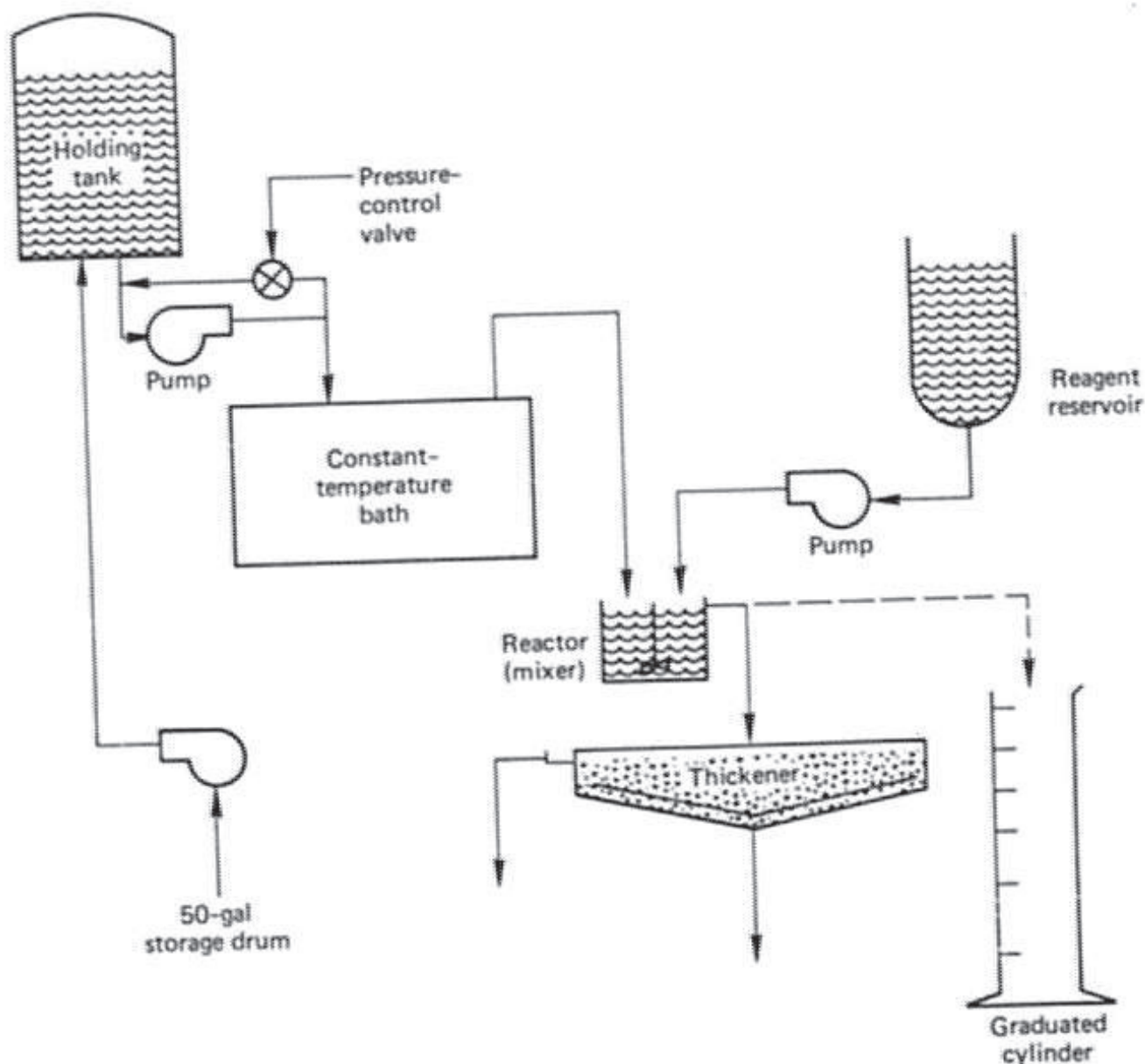


Figure 6. Continuous sulfidation apparatus (SRI International).

about half of the lead precipitated when the  $H_2S$  partial pressure was reduced to about 0.01 atm. Precipitation with hydrogen sulfide is very fast and leads to plugging of the injection nozzle.

These small-scale batch experiments led SRI to use  $Na_2S$  in their flow experiments. Under conditions for 85% Zn recovery, the composition of the precipitates was 31%  $ZnS$ , 5%  $PbS$ , 14%  $MnS$ , and 41% insolubles, most of which was silica. The amounts of precipitated iron and manganese can be reduced by operating at a lower pH; however, this increases the amount of sulfide reagent required. Since substantial silica precipitation occurs

during sulfidation, they concluded that silica had to be removed before sulfidation. Silica scale was particularly evident in their experiments with Niland brine.

SRI did a careful study of analytical techniques for silver in the brines and concluded that standard atomic absorption techniques tend to overestimate the concentration of silver in the brine. They developed a solvent extraction technique using dithizone (diphenylthio-carbazone)—EDTA (ethylenediamine-tetracetic acid)—in chloroform and concluded that the silver content of the aged, spent brine was 0.02 ppm. The silver



content of their sulfide precipitates was only 70 ppm, consistent with the silver content of the lower-temperature scales given in Table 3. This low silver content in the aged, room-temperature brines is to be expected.

## Proposed Cementation Process

Ideally, one would like a process scheme in which successive steps are implemented only if economically desirable, in which materials with the highest value are recovered first, and which provides a reasonable purity for the different products. Smelters usually do not give credit for potential byproducts from an ore. The results obtained by Hazen Research indicate that it would be advantageous to remove the silver, copper, and lead prior to the precipitation of zinc, iron, and manganese, perhaps using a sulfide precipitation or electrolytic separation.

The SRI results indicated that a separation by sulfide precipitation can be used to recover the most valuable elements; however, it leads to a mixed sulfide product. Also, it is somewhat difficult to interact with the wellhead brines, and integration of the silica-removal step with the rest of the process has not been studied.

Hydrogen sulfide added at the wellhead would be flashed at the power plant, leading to possible redissolution of the precipitates; the hydrogen sulfide would become a part of the non-condensable exit gases. However, small-scale experiments demonstrated that the spent brines are effective in scrubbing  $H_2S$  from the noncondensable gases.<sup>28</sup> Thus, this gas could be reacted with the brines leaving the power plant. Precipitation of the wellhead brine with sodium sulfide would lead to gross silica scaling and contamination.

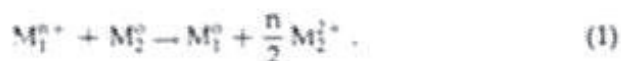
The results of a cursory experiment by Schock and Duba<sup>7</sup> indicate that electrolysis of unacidified brine is not likely to lead to a clean separation since the kinetics of scale precipitation seem to dominate the composition of products deposited in the electrodes, although silver concentrations as high as 2% were obtained in the cathodes. However, controlled potential electrolysis of acidified brine could be a viable process.<sup>30</sup> Since many of the technical issues associated with electrolytic recovery are closely related to the metal cementation process to be outlined below, a research program in this area should include the

They were able to remove about 70% of the lead in Niland brine by cementation on iron turnings, but did not realize the potential of cementation as a separation process.

development of information required for either approach.

Adsorption on activated carbon and selective ion-exchange resins of various kinds is also possible, particularly for the precious metals. However, the untreated brines will deposit scale on the adsorbent and destroy its selectivity.<sup>31</sup> The economics of using a reducing adsorbent, such as Rohm and Haas AMBORANE resins with acidified brine, are likely to be less favorable than alternative processes.

The use of cementation is another alternative. Cementation is used to recover copper from solutions using metallic iron. It also has been applied to the reduction and precipitation of a variety of metals from solution, using metallic iron or zinc as the reducing agent. Electrolysis is another option. The general cementation reaction is:



Cementation of lead from unacidified Salton Sea brines was reported in the SRI study<sup>12</sup>; that from acidified brines was reported by Harrar et al.<sup>32</sup> Exposure of a virgin steel surface to acidified brine at a pH of 2-3 results in nearly complete surface coverage by a deposit consisting of metallic lead, lead carbonate, a copper-rich phase, and lesser amounts of iron corrosion products.

## Cementation Equilibria

Although there are many possible options, the cementation process will be described using metallic iron as the reducing agent. One can obtain approximate values for the equilibrium concentrations in contact with metallic iron. The results of such a calculation, using standard thermodynamic potentials at 25°C and unit activity coefficients, are shown in Table 6. While one should expect essentially complete precipitation



**Table 6. Cementation equilibria. Metallic iron, 25°C, unit activity coefficients.**

Ionic species	Concentration	
	g-mole/l	ppm
Ag <sup>+</sup>	$1.5 \times 10^{20}$	$1.8 \times 10^{12}$
Cu <sup>++</sup>	$1.0 \times 10^{24}$	$7.2 \times 10^{17}$
Pb <sup>++</sup>	$4.5 \times 10^8$	1.0
Sn <sup>++</sup>	$1.0 \times 10^8$	1.4

of silver and copper, the equilibrium concentrations for lead and tin are of the order of 1 ppm by weight. Since the wellhead brines contain hydrogen sulfide (10–30 ppm by weight), some metals in solution will precipitate as sulfides, and the resulting cements are likely to be mixtures of metals and metal sulfides. Table 7 gives an estimate of the metals content of the resulting cements for the Magmamax No. 1 and Sinclair No. 4 wells. The economic value of the cement will depend critically on the precious metals content, but a base is provided by the lead and tin prices.

## Cementation Process Flow Sheet

The recovery of metal values from the Salton Sea brines imposes special requirements on the cementation equipment:

- Since the flows are quite large (171,000 gpm for a 1000-MWe plant) and the solutions very dilute in heavy-metal ions, the process has to be able to handle large flows economically and efficiently.

- The equipment has to be designed to minimize plugging by scales or by the product cement.

- The brine has to be treated to prevent deposition of silica on the metallic iron (or electrodes) used for cementation, the product cement, and the power equipment. The likely optimum treatment is acidification to a pH of about 3.

- The equipment has to be designed to minimize air oxidation of the brine, which would lead to increased iron consumption and premature precipitation of hydrated ferric hydroxides.

Of the various types of equipment used commercially for cementation, the fluidized-bed reactor is probably best suited for application to Salton Sea brines, particularly since it lends itself to large-scale operations. There is also considerable experience available regarding methods for the design of large units. Alternatives to the fluidized-bed reactor include ball mills of various types, such as vibratory mills, the Koppers Tower Mills, etc. Laboratory experiments have been reported on fluidized cathode cementation in a rotating drum.<sup>33</sup>

A preliminary flow sheet for a cementation process using metallic iron as the reducing agent is shown in Fig. 7. It also includes the main features of the Hazen process.

The wellhead brines are acidified and mixed with recycled fines containing metallic iron. The purpose of acidification is to prevent silica from precipitating onto the metallic iron and hindering the cementation process. While the acidified brine is expected to be somewhat more corrosive than untreated brine, acidification of brine was one of the techniques considered in detail by the LLNL geothermal energy program.

**Table 7. Estimated cement composition (%).<sup>a</sup>**

Precious metal	Magmamax 1		Sinclair 4	
	Precious metal included	No precious metal	Precious metal included	No precious metal
Copper	0.7	0.7	2.9	2.9
Lead	64.7	65	87.1	87.7
Tin	19.7	19.8	—	—
Arsenic	0.2	0.2	6.8	6.9
Antimony	3.7	3.8	—	—
Bismuth	4.7	4.7	—	—
Selenium	5.6	5.7	2.4	2.5
Silver	0.5	—	0.5	—
Gold	0.1	—	0.1	—
Platinum	0.06	—	0.06	—
	100	99.9	99.9	100

<sup>a</sup>Given the chemical analysis of Table 2 and the equilibria of Table 6.



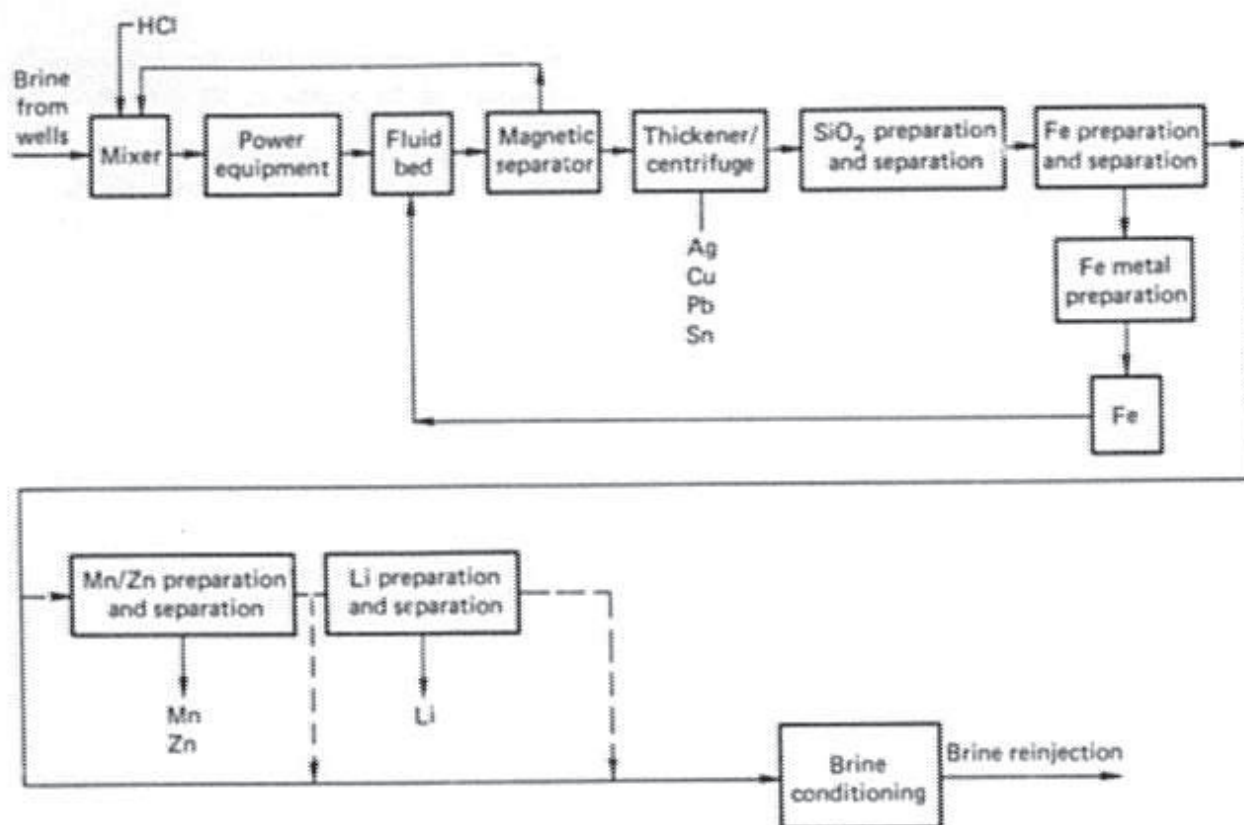


Figure 7. Steps in minerals recovery from Salton Sea brines.

As acidified brine flows through the power equipment, such as two-stage flash, the metallic iron in the fines acts as a nucleation center for the precipitation of supersaturated sulfides and as a reducing agent for the precipitation of metals. Brines leaving the power equipment then enter the fluidized bed(s). While fluidized beds have not been designed in detail, it is likely that the final configuration would involve a number of short, conical fluidized beds operating in series to achieve maximum recovery of precious metal values. Fines elutriated from the fluidized beds proceed to a magnetic separator, where iron containing fines is separated for recycling. The cement then proceeds to separating equipment, which could consist of a combination of thickeners with filters or centrifuges.

Implementation of the rest of the process flow sheet shown in Fig. 7 depends on the relative economics of conducting the different operations. The recovery and reduction of iron used in the cementation step, in particular, is likely to be economically advantageous. While brine treatment will be required before reinjection, the detailed

process to be used will depend on subsequent minerals recovery steps.

One alternative to the Hazen process in the iron-separation step is to attempt precipitation of goethite ( $\text{FeO} \cdot \text{OH}$ ) by air oxidation of the acidified brines before silica removal. It has been reported<sup>34</sup> that goethite can be precipitated by air oxidation of chloride solutions containing iron at a pH of 2.6 and 80°C; the precipitate is reported to be easily filterable. This process step might be carried out before the silica-precipitation step and would be particularly advantageous if recovery of manganese and zinc were not contemplated.

### Corrosion and Cementation Rates

Corrosion of mild steels by Salton Sea brines can be explained by the presence of a small amount of ferric ion and by cementation reactions. Cementation and corrosion involve the same chemical processes. In this section, the maximum



observed corrosion rates will be shown to be compatible with estimates of cementation rates on individual fluidized particles.

Fluidized beds are being used for the cementation of copper<sup>27</sup> and selenium,<sup>35</sup> and there is some information on cementation rates for fluidized particles<sup>36</sup> from copper and nickel sulfate solutions. The cementation reaction rates are a function of ionic diffusion rates and are strongly influenced by the morphology of the deposited cement. The morphology is affected by the deposition conditions: temperature, solution concentration, and thickness of the deposit.<sup>37,38</sup>

Cements deposited from Salton Sea brines will have different characteristics, depending on the local environment. The results reported by Harrar et al.<sup>32</sup> give information about the morphology and composition of cements deposited from 20-h exposures to acidified, effluent 90°C brine. These cements were unusual in that no sulfur was detected on any of the steel surfaces examined, whereas sulfur was a component of all previously analyzed scales. An unexpected feature of the deposits was the presence of single crystals of lead carbonate. Analysis of the surface deposits, using energy dispersive x-ray spectrometry, showed the major constituents to be lead, chloride, and calcium, with smaller quantities of iron, copper, and potassium.

No information is available on diffusion rates for the species of interest in the brines. A value of about  $1 \times 10^{-9}$  m<sup>2</sup>/s was estimated for the M<sup>++</sup> ions in the brines. This value is based on the diffusivities at infinite dilution,<sup>39,40</sup> together with estimates for the effects of the ionic strength of the solution and temperature. This estimate is probably good within a factor of two.

Using the above information, one can estimate cementation rates. For a 2-mm particle fluidized in 100°C brine and the concentration of reducible species given in Table 2 for Magmamax No. 1 brine, the calculated corrosion rate is 1.8 cm/yr (0.7 in./yr).

The observed corrosion rates vary with sample location, pH, temperature, extent of scaling, etc. However, one might expect that the highest observed corrosion rates would obtain at the wellhead. A section of schedule 80, low carbon steel pipe from Magmamax No. 1 wellhead had been exposed intermittently (about 5000 h) to two-phase production fluid over a two-year period. The maximum corrosion was in a broad, 0.150-in.-deep pit and translates to a corrosion rate of about 0.26 in./yr.<sup>41</sup> Other observed corrosion rates are of the order of 80 mils/yr for mild

steel corrosion coupons located near the wellhead.<sup>42</sup>

There are few measurements on acidified brines. The LLNL results<sup>39</sup> at about 90°C, using linear polarization techniques, indicated corrosion rates of about 100 mils/yr at a pH of 3.6 and 250 mils/yr at a pH of 2.3; however, the weight loss on the corrosion specimens indicated much lower weight losses, 9–36 mils per year.

The 15-day laboratory experiments with synthetic brines indicated that corrosion rates were independent of acid concentration for pH larger than about 3. However, observed corrosion rates under those conditions were quite low, on the order of 20 mils/yr,<sup>8</sup> and the amounts of lead in solution were much larger than the amounts of iron dissolved. Possible reasons for the large differences in rates are poor mixing of the brine, leading to a diffusion-controlled process; a thin, semicoherent layer of cement forming, which impeded further cementation, etc.

## Comparison of Cementation with Alternative Processes

As mentioned earlier, Salton Sea brines could be valuable minerals sources if economical processes were available that led to relatively pure "ores" for subsequent processing. Thus, one objective of process development should be separation of the minerals in the brine into "ores" easily amenable to subsequent processing.

Silica control and removal is a key part of any process for handling Salton Sea brines. In this context, LLNL experimental work on brine acidification, the effects of organic additives, and methods for precipitating, thickening, and filtering the silica needs to be considered in any future process design studies.

It is worthwhile comparing the proposed cementation process with previous process concepts. In all cases, most of the process is carried out on spent brines from the power plant. In the cementation process flow sheet (Fig. 7), finely divided iron is introduced into the brine at the wellhead to act as a nucleation source for sulfide precipitates and to recover precious metals. It is likely that silver would have to be periodically "mined" from the scales depositing on the piping if the wellhead brines were not so treated. Cementation fines might also decrease corrosion and scaling on the walls of process equipment, although careful



plant design would be required to minimize erosion by the suspended solids. However, more information on the behavior of acidified wellhead brines is required before a final process flow sheet can be selected.

Electrolysis of the acidified brines will likely recover silver and other precious metals, lead, tin, etc. While the morphology of the deposits and diffusion rates for the ionic species would be the same as in the metal cementation process, electrolysis might be advantageous if the lead cement deposited from the brines is coherent and blocks access to the underlying iron surface. However, large electrode surface areas would be required, and it may be difficult to keep their surfaces relatively clean.

Sulfidation of acidified brine using hydrogen sulfide leads to good separation of silver, lead, and tin from zinc, iron, and manganese. However, it can only be carried out on post-flash brines since the  $H_2S$  would be separated from the brines in the power plant. The  $H_2S$  scavenging experiments of Quong et al.,<sup>29</sup> as well as the experiments at SRI, indicate that this might be a viable process. Sulfidation using sodium sulfide leads to a mixed precipitate containing iron and manganese, in addition to the desired elements. Separation of the minerals after recovery from the brines may be difficult. Handling of silica precipitation and contamination is another problem that has not been examined for either of the above sulfidation alternatives.

The combination of cementation (carried out either by reduction with metallic iron or electrolytically) with a somewhat modified Hazen flow sheet would have the following advantages:

- It would obtain good separation of Ag, Cu, Pb, Sn, etc. from the brines. If economically justified, the controlled potential electrolysis of acidified brine might allow for separation of the precious metals from lead, tin, and copper.
- The resulting silica, iron hydroxides, manganese, and zinc hydroxides will be uncontaminated by the other heavy elements. The concentrations of lead, tin, etc., still in solution after the cementation (Table 6) are lower than those expected from the manganese-hydroxide precipitation step (Table 5, stream 18) of the Hazen process.
- Thus the manganese and zinc mixed hydroxide product is likely to be quite pure. Separation of zinc from manganese in the fresh mixed hydroxides from precipitate is likely to be easy, although the difficulty experienced by the Bureau of Mines with aged precipitate is discouraging.

- If 78% ferromanganese alloy is a desired product, iron-manganese precipitation can probably be adjusted to obtain the desired iron/manganese ratio.

- The process is designed to recover precious metals from wellhead brines.

- The individual process steps after cementation need not be carried out unless the economics are favorable. If manganese and zinc recovery are not required, and it is economically justifiable to produce the iron required for cementation locally, it might be possible to precipitate iron as goethite before silica removal and brine conditioning for reinjection.

## Elements of R&D Program

The main technical uncertainties in the proposed process have to do with the properties and composition of the cement and the proper design of the fluidized bed. The main uncertainties affecting the process economics are related to brine composition and precious metals recovery, although all aspects of the process would have to be optimized.

An R&D program to validate the ideas presented above would consist of the following elements:

1. *Preliminary studies*
  - Develop experimental plan in detail.
  - Obtain reliable precious metals analyses of wellhead and spent brines from at least two wells in the area.
  - Perform preliminary economic analysis, including some variants of the initial flow sheet, Fig. 7.
2. *Laboratory cementation experiments* (to be carried out primarily on acidified brines). Synthetic brines might be very useful for certain aspects of this portion of the program and are required for the laboratory fluidized-bed experiments.
  - Verify equilibrium and transport data at 100°C; estimate 200°C values.
  - Determine electrode potentials in acidified brines.
  - Determine physical characteristics of cement as a function of pH and cement layer thickness.
  - Determine chemical composition of cement for several initial brine compositions.
  - Determine effect on cement of scaling inhibitors other than HCl.

- Attempt goethite precipitation from spent brine.

3. *Laboratory fluidized-bed experiment.* Equipment should be suitable for eventual operation in the field. However, laboratory experiments are likely to require closed-loop recirculation of synthetic brines, with provision for replenishing the metals recovered in the cementation process.

- Design objectives:

- Design field experiment.

- Design trace metal addition and control system.

- Design on-line measurement and controls.

- Design or select commercial magnetic separator, thickeners, etc.

- Data obtained:

- Operating characteristics of fluidized bed.

- Particle-size distribution of cement.

- Equilibrium distribution of iron particles in bed.

- Confirm transport and fluid-flow design parameters.

- Operating characteristics of magnetic separator, thickeners, filters, etc.

4. *Field experiments*

- Design objectives:

- Confirm design parameters with real brine.

- Precious metals recovery from 200°C wellhead brines.

- Iron consumption and ratio of metal to metal sulfide in product cement.

- If goethite precipitation is successful in laboratory experiments, attempt with real brine.

- Erosion by fines.

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