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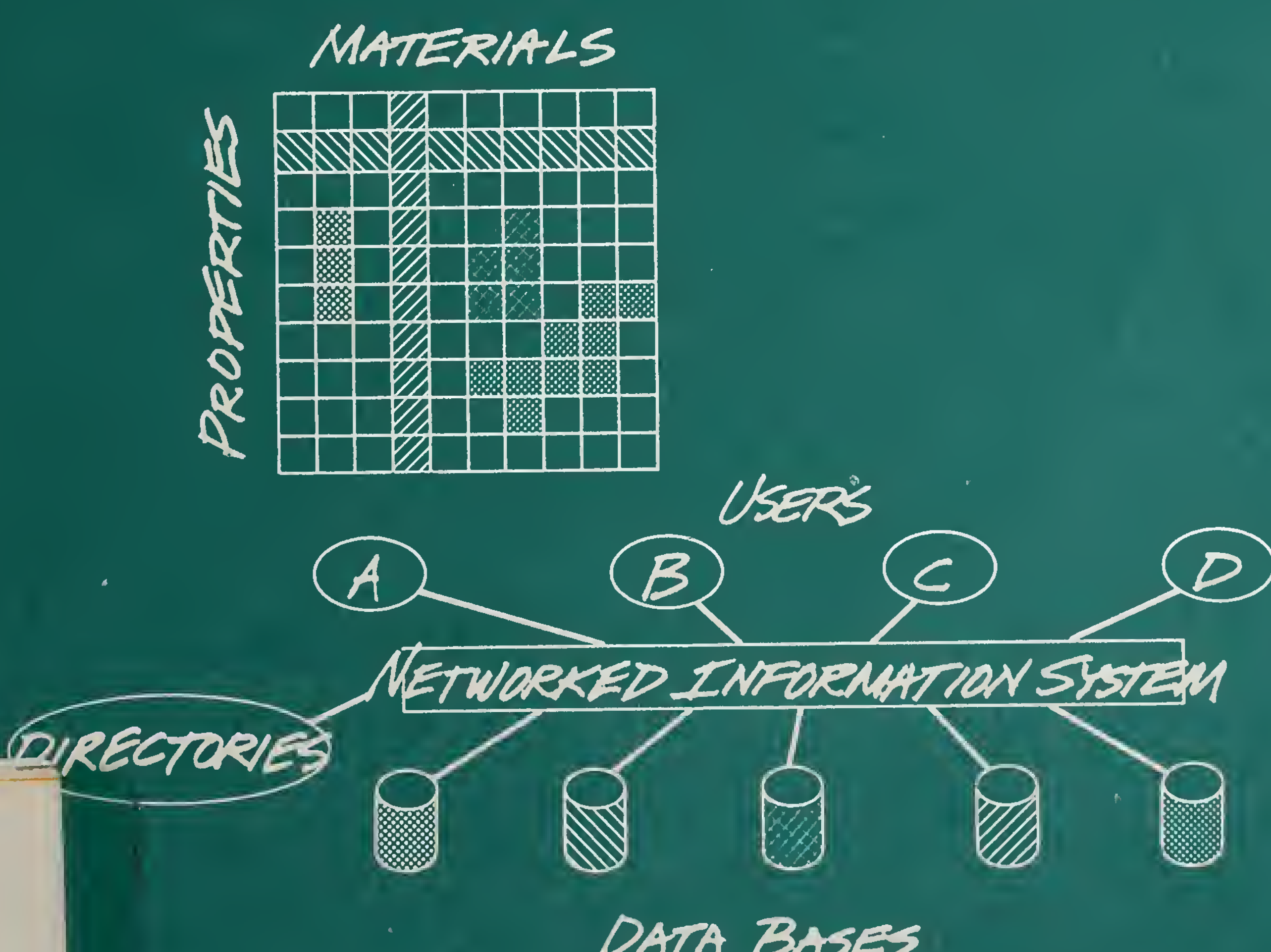
NBS Special Publication 726

Materials Information for Science & Technology (MIST): Project Overview

Grattidge, Westbrook, McCarthy, Northrup, and Rumble



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- Fracture and Deformation[3]
- Polymers
- Metallurgy
- Reactor Radiation

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[1]Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Gaithersburg, MD 20899.

[2]Some divisions within the center are located at Boulder, CO 80303.

Materials Information for Science & Technology (MIST): Project Overview

Phase I and II
and
General Considerations

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November 1986

U.S. Department of Commerce
Malcolm Baldrige, Secretary

National Bureau of Standards
Ernest Ambler, Director

Library of Congress
Catalog Card Number: 86-600590
National Bureau of Standards
Special Publication 726
Natl. Bur. Stand. (U.S.),
Spec. Publ. 726
119 pages (Nov. 1986)
CODEN: XNBSAV

U.S. Government Printing Office
Washington: 1986

For sale by the Superintendent
of Documents,
U.S. Government Printing Office,
Washington, DC 20402

FOREWORD

The National Bureau of Standards and the Department of Energy have embarked on a program to build a demonstration computerized materials data system called Materials Information for Science & Technology (MIST). This report documents the first two phases of the project as well as setting forth many general considerations that will shape later phases. The report, compiled by Sci-Tech Knowledge Systems, Inc., was a joint effort of the people listed below. Comments, suggestions, or questions should be directed to either John Rumble or Clyde Northrup.

August 1986

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ABSTRACT

This report documents the initial phases of the Materials Information for Science and Technology (MIST) project jointly supported by the Department of Energy and the National Bureau of Standards. The purpose of MIST is to demonstrate the power and utility of computer access to materials property data. The initial goals include: to exercise the concept of a computer network of materials databases and to build a demonstration of such a system in a way to be suitable for use as the core of operational systems in the future. Phases I and II are described in detail herein. In addition, a discussion is given of the expected usage of the system.

PART A - Description of Phases I and II

I. INTRODUCTION.

The Materials Information for Science and Technology (MIST) Project is a demonstration of the power and utility of computer access to materials property data. Several years ago, following a series of well-publicized meetings and studies, it became apparent that the time had come to build a prototype system so that the user community could see the advantage of such a system and through feedback sharpen their concept of what such a system should be able to provide.

Consequently, in late 1983, the Office of Standard Reference Data (OSRD) of the National Bureau of Standards (NBS) and the Office of Scientific and Technical Information (OSTI) of the U.S. Department of Energy (DOE) began cooperating to build the MIST demonstration. Within DOE, the MIST Project is one component of a broader Scientific Information Research Program (SIRP).

The MIST Project has two initial goals:

- o To demonstrate the concept of a computer network of materials databases

- o To build a prototype demonstration system in such a way as to be suitable for use as the core of operational systems in the future.

The basic goals of the two sponsoring groups (DOE and NBS) are the same; that is, to provide access to materials information for technical decision-making in the most complete and efficient manner.

However, the emphases and audiences are different:

For OSTI, to meet the DOE mission through provision of supporting technical information activities;

For OSRD, to provide a general data access capability to the technical community at large.

Since the demonstration project started, other groups have begun to participate, albeit often informally. These include the National Materials Property Data Network Inc., known as the MPD Network - a non-profit private-sector effort; the U.S. Army Command (LABCOM); and the NASA Marshall Space Center.

When the project began in 1985, a unique opportunity existed which all the participating groups wished to exploit. User needs had been well identified and enthusiasm was strong among a substantial user community. Equally important, efforts up to that time had not progressed very far. Consequently, the time was ripe for a cooperative concerted effort directed towards the goals outlined above.

THE CONCEPT

The concept of a computerized materials data system has evolved over the last five years as computer technology has improved and as understanding of materials information and its use has increased. The current form of the concept is founded on several basic assumptions:

1. The people who will build machine-readable materials databases are the same as those who currently write books, compile handbooks, etc.

2. Most of these groups will not want to provide access services to users via their own computers; or if they do provide access, will not want to provide the traditional support services that are required with a computer-based product.

3. Most engineers who use materials data currently have to deal with a multiplicity of data sources.

4. Most engineers will soon have a computer equipped with communication hardware and software at their desks which can be used to access external electronic networks.

5. Most people are unwilling to learn to use a large number of computer languages, command systems, file structures, etc.

The concept adopted to meet such broad requirements is often called a GATEWAY system. In this system, a user should ultimately be able to access, via a single telecommunication connection, many databases, even when these databases reside on different computers. Using a single command language, or by menu screens, and through the use of directories, thesauri, etc., users can quickly gain awareness of what data are available. Connection to different desired databases will be handled automatically by the gateway. After data are retrieved, it will be possible for the user to manipulate, analyze, and display them in a uniform way. Eventually it is conceivable that multiple gateways will exist, reflecting the needs of different user groups.

THE CHALLENGES

The concept of gateways to distributed database systems is of interest for many computer applications ranging from the insurance industry to scientific data. Each application must overcome two sets of challenges: (1) linkage of diverse computer software and hardware; and (2) integration of information, especially that produced by different people or organizations.

For material data systems, the major challenges related to the integration of materials information are given in Table I, and in Phases I and II of the MIST project, effort will be concentrated on meeting many of these challenges, as outlined in this overview.

TABLE 1. Challenges in Building Computerized Systems of Materials Data

Building Materials Databases

- Available Tools
- Data Reporting Standards
- Data Dictionary - Including Formats
- Information Capture from Printed Sources
  - Handbooks
  - Tables
  - Graphs
  - Text
  - Ancillary Information
- On-line data entry protocols
  - Keyboard
  - Digitized files
- Quality Assessment
- Auxiliary Data (e.g., citations, people, organizations, thesauri, etc.)

Database Integration - Data and Metadata Considerations

- Intelligent Linkage of Databases
- Materials Equivalency
- Property Equivalency
- Materials Metadata
- Database Directories
- Data Evaluation and Reliability Coding
- Designation of Nonmetallic Materials
- Private Data (Up-Loading and Integration)
- Data Structures
- Data Exchange Formats

Presentation of Materials Data

- User Interfaces
- Full Screen Presentation
- User Guidance
- Easy-to-use Command Language and Menus
- Publication of Printed Sources from Database Files
- Personal Computer Package Distribution (Down-Loading)

This work, however challenging, will not result in a distributed database system per se, since work related to linking different computers and software is not included. See Chapter III (and especially Table 2) below for a more detailed discussion of implementation plans.

II. PURPOSE OF THE PROJECT OVERVIEW

A demonstration project such as MIST cannot simultaneously address all the challenges listed in Table 1. During the initial part of the project, several detailed planning sessions were held to identify the most important challenges and to estimate levels of effort needed to overcome them.

This description of the first phase of the project is intended to define the scope, both in terms of the challenges and goals, as well as in terms of the work program itself. The chapters in Part A outline the goals, challenges, and project participants for Phases I and II; the second part presents general considerations about projected uses and capabilities of the MIST system.

Development of the MIST prototype system includes a strong effort to obtain user input and feedback on all aspects of the system. Well before system development began, one of the first activities undertaken was to collect information from users by way of a questionnaire supplemented by personal interviews and focus group sessions. A copy of the current version of the questionnaire is given in Appendix A. The results from the questionnaire are reflected in the initial system described here, and further user feedback will be incorporated in subsequent revisions. This document, in turn, can be used to:

a) check for possible distortions in the understanding by the system developers of user wants and needs

b) provide a vehicle for feedback from those individuals who may be asked to test the validity and reasonableness of the MIST prototype.

III. OBJECTIVES OF THE SCIENTIFIC INFORMATION RESEARCH PROGRAM (SIRP) AND OF THE MIST PROJECT

A. General

The long-range objective of the Scientific Information Research Program is to ascertain whether a standardized source of factual, scientific information, maintained at distributed sites by local experts, can have a positive impact on the productivity of scientists and engineers. The prototype Materials Information for Science and Technology (MIST) system thus is being developed based on an analysis of how a substantial group of DOE scientists and engineers use computers in their daily work. In order to begin to assess impacts on productivity, the demonstration system needs to be used by a group of users as an everyday tool.

However, it is important to make sure that the initial system will not be judged against a conceptualized full-blown system, but against its stated demonstration goals. The measure of success for MIST should be that an average search for information on specified materials and properties in the system results in full retrieval of the information stored, presented in a format intelligible and convenient to the user. If expanded to a comprehensive database system (in terms of the needs of the user community), it would become the preferred information source because of demonstrated improvements in user productivity.

Because of the complexity of the complete description of engineering materials and their mechanical and corrosion properties, and because existing material databases have user interfaces which neither fully exploit the power of computers nor are particularly attractive in format or convenience, special emphasis has been placed on the challenges related to the materials data content and its organization and use. The aspects of the gateway concept not being considered in phases I and II relate to computer science issues of networking and physically and logically-distributed databases maintained on different kinds of computers. These issues are receiving intense study from other sources. The MIST project will adopt results as developed eleswhere.

Initially, the MIST project will provide access to physical and mechanical properties of metal alloys, the most commonly needed information, as a first step to accessing data on a wide range of properties for all classes of materials. The choice of the class of materials for the initial system was easy. Only for metallic alloys does a critical mass of highly evaluated data exist. Also, the nomenclature and designation of metallic alloys, while still imprecise in many respects, has advanced far enough in standardization to be used in a general access computerized database system.

B. Specific Initial Objectives of Phases I and II

The above considerations led to the following specific initial objectives:

1. Establishment of a User Group

A cohesive user group, drawn from the DOE technical community, would be chosen and involved from the start. This group currently numbers about 30 materials data users associated with design and analysis work at at Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratories. In the Fall of 1984, the needs of this user group were surveyed by questionnaire, [Appendix A], focus group discussions, and personal interviews.

2. Initial implementation of a computer-based "alpha" prototype system, including:

   a. Data on a limited number of alloys taken from a single printed data source, Aerospace Structural Metals Handbook (ASMH).
   b. The data schema would include the majority of mechanical properties included in ASMH but initially, only a representative set of tables and graphs would be entered.
   c. Data entry procedures for both tabular and graphical data would be developed and made available to other Federal Agencies (e.g., NASA).
   d. Access paths for the data system usage would be defined and two or three examples would be implemented.
   e. The SPIRES database system and its associated PRISM software would be used.
   f. The IBM PC family would be the only terminal supported.
   g. A review of Stage I accomplishments, and the plans for Stage II would be held for the user group in February 1986.

3. Revision and extension of the Initial Prototype to include:

   a. Data on ~150 alloys taken from two handbooks -
MIL-HDBK-5
Aerospace Structural Metals Handbook
entered into databases and loaded in the system as distinct databases.
   b. Other data loaded from existing machine-readable sources, as available (e.g., EPRI Pressure Vessel Steels Data, in cooperation with the MPD Network).
   c. A full user interface would be developed covering all defined access paths.
   d. The FORMS software associated with SPIRES would be utilized.
   e. Data from the JANAF thermodynamical tables would be added. (Optional)

f. (Hopeful) Easy graphical display capabilities would be available, possibly as software on the PC.
g. The user community would be extended, possibly to 60 participants.
h. Database schema would be made available to standards groups (e.g., ASTM) and to other database builders (i.e., NMPDN, American Welding Institute, ACS)
i. The capability will have the user community contribute to a "living" database consisting of recent test results. (Optional)
j. Another user meeting would be held in late 1986 or early 1987 to review status and progress.

IV. DETAILED CONTENTS OF THE INITIAL MIST PROTOTYPE SYSTEM

A. IMPLEMENTATION PHASES

As with every project of this complexity, it is important to have a well-defined plan and schedule. For computer projects this is even more critical. The MIST project has been divided into six phases, each addressing issues of increasing difficulty and complexity.

Table 2. Schematic Schedule for Building A Versatile, Distributed Materials Data Network System

Data Phase	Data Sources	Data Structures	Computer Hardware Sites	Computer Hardware Op Systems	DBMS	User Interface
I	1	1	1	1	1	Command
II	Mult	1	1	1	1	Elementary menu
III	Mult	Mult	1	1	1	Combined
IIIa	Mult	Mult	Pass thru	1	1	Simple Gateway
IV	Mult	Mult	Mult	1	1	
V	Mult	Mult	Mult	Mult	1	Enhanced Gateway
VI	Mult	Mult	Mult	Mult	Mult	Full Gateway

During the first phase, the emphasis was on determining what information was needed and how it could be configured to impact user productivity (essentially, an intense market survey plus database schema development). The initial focus was on developing flexible and extensible data structures which could facilitate storage, retrieval, display and downloading of data for a representative set of selected materials from one printed data source, along with revisions and comments on data extracted from that source.

A schematic representation of this simple initial architecture is shown in figure 1.

In the second phase, data from additional sources will be digitized and incorporated into the system. While these subsets will utilize essentially the same data structures as phase I, data files from those sources will be logically separate.

Phases I and II only go part of the way toward building the core system which can be used as the basis of a fully operational system. Other work would include:

1. East database loading capability
2. Establishment of multiple computer sites
   a. First, using the SPIRES system
   b. Second, adding communications capability to link one or more DBMS on remote computers

3. Enhanced graphical display capabilities
4. Linkage to a statistical package for data analysis and presentation
5. Portability of SPIRES by release of a C language PC version which will allow distribution of database capability between a gateway and a PC, as well as other mainframes
6. Additional databases covering more materials and properties
7. Extension of metadata and designation systems to nonmetallic materials

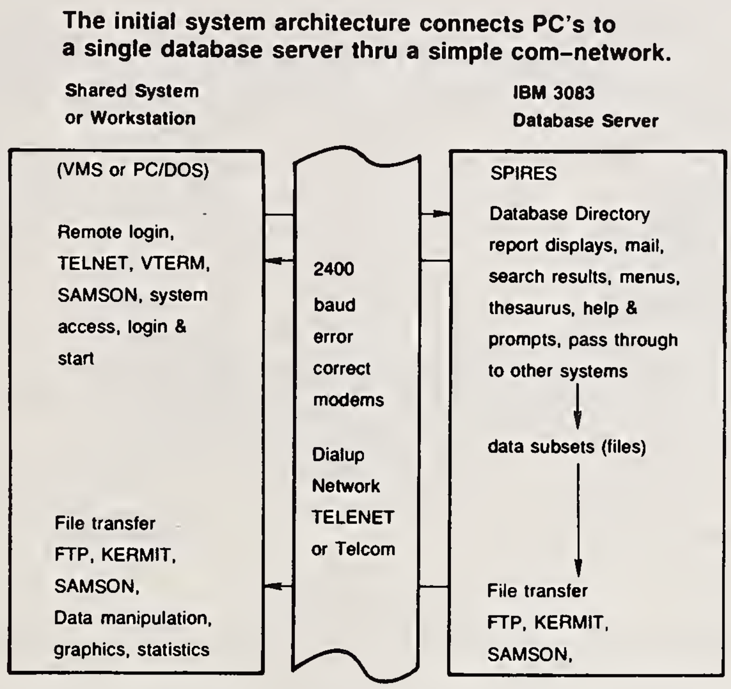

Figure 1
Initial MIST Architecture

Some of this work will naturally be supported by those groups who plan to offer on-line services. It is imagined that this project will also continue to attack these problems as resources permit.

In phase three, additional data sources will be added, some of which, because of their different subject coverage, will require substantially modified data structures. At this point, it is envisioned that the MIST system will still reside at a single site on a single type of mainframe, and use one type of database management system to connect logically distinct materials databases. A possible extension of this third phase may be to develop a simple gateway or "pass through" capability that will provide users with a catalog of other accessible databases and perhaps assist in making connections to other systems.

The fourth phase will emphasize development of a gateway capability to link databases residing at multiple sites but running on the same DBMS on similar hardware and operating systems. The goal at this stage will be a distributed but homogeneous MIST system with remote databases and metadata.

A schematic representation of phase four is shown in figure 2.

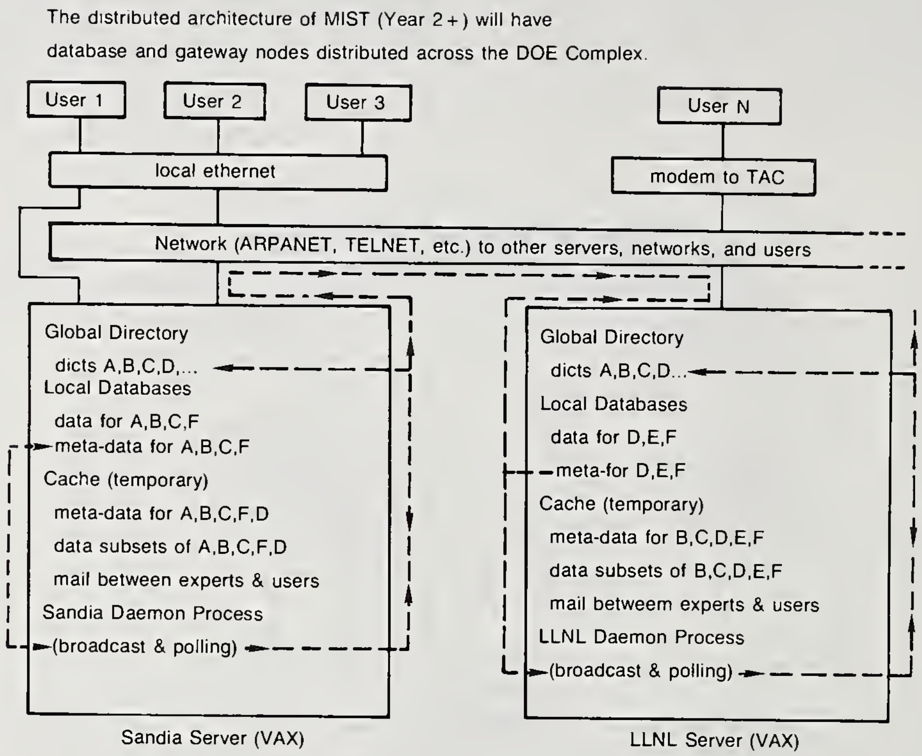

Figure 2
Distributed Architecture (Year 2+)

The fifth phase will extend MIST to different distributed sites running different types of hardware and operating systems, but still relying on a single data management system to provide uniformity over the diverse sites.

In the sixth and final phase, the ultimate goal is to provide multiple gateways linked to different databases built on different types of database management systems and residing on different hardware and operating systems. As figure 3 shows, this phase will involve much greater complexity because of the need to provide translation and mapping facilities for (1) metadata maintenance, (2) query translation and decomposition, (3) different types of systems interactions, (4) merging of heterogeneous output formats and (5) different types of networks.

The MIST system should ultimately have an Intelligent Gateway.

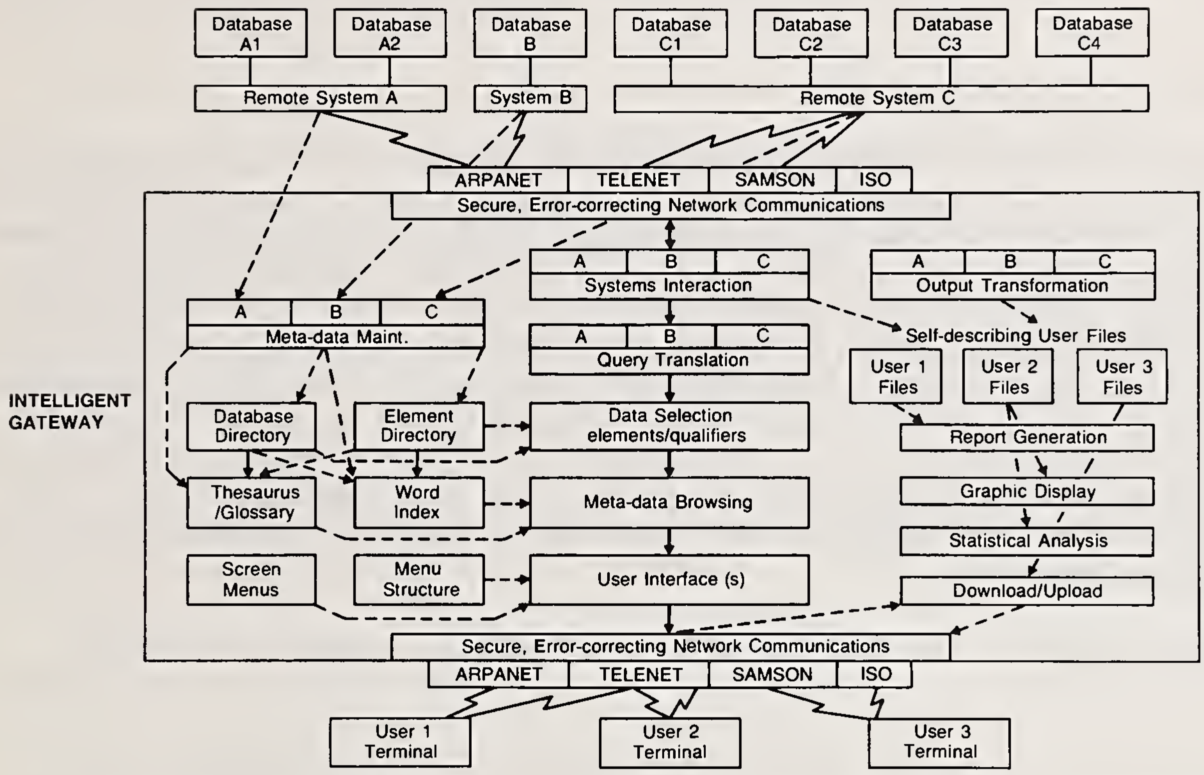

Figure 3
Distributed Materials Data System Components

Because work is going on in other forums related to items on the right hand side of Table 2, especially computer networking and DBMS↔DBMS interfaces, the MIST project anticipates utilizing capabilities generated by others when the later phases are started.

Phases I and II

The result of phase I was demonstrated at a set of user meetings held in February 1986, and Stage II is scheduled for completion in late 1986 or early 1987. However, recognizing the ambitious nature of the work required, progress on this project is highly dependent on the availability of adequate funding. Consequently, even within this schedule, the completion dates or even the work itself may change because of circumstances beyond the participants' control.

B. PHASE I

1) General Strategy

Phase I of the Prototype System includes data on a small set of alloys from a single source, Aerospace Structural Metals Handbook (ASMH). The materials are popular alloys for which there is considerable coverage in at least two of the three principal source handbooks (ASMH, SAH, and MIL HDBK-5). (See Appendix B). Consideration of the characteristics of the particular alloys defined the pertinent application areas, which in turn generated the lists of required properties. (Appendix C). Initial emphasis was on including those properties which could be represented quantitatively and hence rigorously compared. However, the database structure being developed will also accommodate qualitative descriptions and comparisons of nonnumeric values of properties, where appropriate.

Taken together, the initial alloys-properties matrix was chosen so as to:

a) serve as a test-bed for the general database schema

b) permit exercise of the Phase I prototype by the user group with meaningful comparison and other manipulation procedures.

2) Scope of Materials and Properties

a) Materials

The initial materials group consisted of a set of 5 alloys chosen by consensus based on input from the user group, the technical officer, and the contractors. Each material selected has been identified by its UNS number as well as by common names, trade association designations, etc. The common names of chosen materials are:

304
316
4340
17-4PH
A356

A listing of Designation Cross Reference Data for these materials is given in Appendix D.

b) Application Areas

The initial application areas, with associated required properties, were confined to those pertinent to structural and heat transfer applications. Extension beyond those application areas is contemplated for later stages of the project. The user-identified application areas are listed in Appendix E.

c) Properties

The properties to be included for each alloy numbered initially no more than 60 individual parameters determined as described above. The chosen properties are listed in Appendix F. No attempt was made at this stage to record electronically all information found in the chosen source handbook (ASMH). Rather, only data for the required properties on the property list were captured insofar as possible. Generation of a cumulative existence table for the materials-properties-sources, including notations of any omissions, was an important requirement.

Existence matrices that identify for which materials specific property data exist in ASMH are listed in Appendix G for the different materials.

3) Auxiliary Information

a) Independent Variables

A particular problem was the decision as to which of the many effects of independent variables on a sought property would be captured for the Phase I system. Realizing that the initial objective was to exercise the database structure and expose the user group to some of the system's functionalities, the initial data set was restricted to be broadly representative and as a result did not include all data provided in ASMH for all selected properties and all independent variables. A current list of included independent variables is given in Appendix H.

b) Potential Constraining Properties

An additional feature in MIST beyond just the data from ASMH is that special attention is drawn to any property or properties of a material which constitute(s) a possible limitation to certain applications of that material, either from behavior or from restricted availability. This parameter has been termed in MIST "potential constraining properties." As indicated above, these may or may not be application-specific. The existence of these types of data for a material can be highlighted during data display and presentation.

c) Data Qualifiers

Data values to be incorporated from the reference source may be qualified by the following elements:

revision date - date of last entry/update
value type - typical, max, min, etc.
capture method - keyed, digitized from graphical image, etc.
reliability code - preferred or blank.
data quality indicator - limited use, qualified, highly qualified (also total data quality "score card").

Specifics for some of these guidelines will not be completed during Phases I and II of the prototype, but the database schema will accommodate subsequent incremental additions and extensions.

A more complete discussion of data quality indicators and their treatment in MIST is covered in Section X.

d) Glossary and Thesaurus

A list of all the unique terms for materials, properties, units, and other descriptors was generated for all data added to MIST. For all these terms, referenced definitions were compiled, allowable units and conversion factors specified, and synonyms, abbreviations, and symbols listed. The terms of this thesaurus/glossary serve as controls for validating terms and units during data entry and searching for MIST databases as well as a reference source for MIST users.

4) Information Organization

A database schema was designed to accommodate essentially all the features necessary for entering data for the 5 alloys from ASMH in a way that could easily be extended to an unlimited set of additional materials, properties, and independent variables. This included notes, cross-references, various data formats, etc. For further details, see Section VI below on MIST System Architecture.

B. PHASE II

1) General Strategy

The principal elements of the strategy for the second phase of the MIST project will be to develop a full user interface; to enlarge the content and scope of the database; to include data from data sources other than ASMH; to extend coverage to a more diverse array of materials and properties; and to expand the manipulation capabilities offered the user.

The following goals are proposed for Phase II:

- o A well-developed user interface with good data manipulation and display functions
- o A revised version of the data schema capable of supporting multiple databases
- o Multiple data sources including at least two printed and one machine-readable

2) User Interface

First and foremost, an attractive, easy-to-use interface must be developed that reflects the needs of the materials community. This includes a fully-developed navigation through the system, complete definition of all screens and their implementation, and system help aids, all taking advantage of the power of the IBM PC, XT, or AT. The goal is simple: to seduce the potential users, to have them say "That's exactly what I want." Since statistical manipulation, report generation, and especially graphical display are so important, these must be included, either at the workstation or on the mainframe as best practicable.

3) Data Schema

The data schema for mechanical properties must be finalized as much as possible so that data entry rules and manuals can be widely distributed. This recognizes that some changes need to be made because of existing computerized files. These changes need to be identified and made as close as possible to the beginning of Phase II so that data loading may go forward routinely.

4) Data Loading

It is important to get enough data into the system so that users will find it advantageous to turn to the system because they know they will find useful information and so that the data schema and structures can be fully exercised. Because resources are limited, actual data entry will be separated in Phase II of this project from other work. In addition, the data entry manual presently in draft form must be completed.

However, loading of the databases into the SPIRES system will be an important part, especially development of procedures to make such loading as smooth and efficient as possible. It is hoped that data from two printed sources and one or two existing machine-readable sources can be loaded. Additional existing machine-readable sources may also be added. These sources include:

Printed
o MIL-HDBK-5 (NBS)
o Aerospace Structural Metals Handbook (NBS)

Computerized
o EPRI Database on Pressure Vessel Steels (MPD Network)
o Strain-hardening Database (DOE)

The groups in parentheses will be responsible for providing the final machine-readable copy to be loaded into the system.

5) Scope of Materials and Properties

The initial materials list will be extended to a wider range of alloys, chosen so as to expose new application areas and new properties. The current list includes 172 selected alloys. Appendices I and J indicate the existence of source data for those particular alloys in the identified printed sources.

Extension of the properties coverage will be governed by the requirements of new materials, application areas, additional data sources, and recognition of user group requests. Modest extension of the effects of independent variables will be made, primarily to test further the functionality of the data structure architecture at this stage of development.

Provision will also be considered for calculating derived properties from basic data by stored algorithms. If possible, one example will be provided for Phase II. Appendix K lists the derived properties to be considered for inclusion.

6) Metadata Considerations

Expansion of the list of metadata elements, definitions, abbreviations, symbols, etc. will be required because of the extension of coverage to additional materials and properties. Increasingly, it will be desirable to develop and present hierarchical structures covering the various families of metadata elements and reflecting the different data organization of the various data sources.

7) SPIRES Enhancements

Assuming that the PRISM full-screen menu development software is now released, the primary needs for enhancements to SPIRES are related to development of a C language version and to an easy-to-use interface to graphics software. The C language version is necessary for compatible database management on VAX's and IBM PC's. While completion of this version to be done by Stanford is scheduled for 1987, it is important to progress as quickly as possible.

Graphical display of materials data is so fundamental to its use that good graphics is mandatory for acceptance of any system. This will be addressed in work on the User Interface, but it may be necessary to improve SPIRES capability to interface with graphics packages. This work has to be completed in Phase II.

8) Information Organization

It is recognized that, as soon as possible, the system should provide the capability for users to input their own data into the system for manipulation and comparison purposes. If resources permit, this will be done in Phase II.

9) Manuals

Two manuals, one for users and the other for data entry, will be produced.

V. PROJECT ELEMENTS

A. Project Participants

Funding and institutional support for this work has come from a variety of sources, including:

- National Bureau of Standards - Office of Standard Reference Data
- Dept. of Energy - Office of Scientific and Technical Information (OSTI)
- NASA - Marshall Space Flight Center
- U.S. Army - AML LABCOM
- Lawrence Livermore National Laboratory (LLNL)
- Sandia National Laboratories (SNL)
- Los Alamos National Laboratory (LANL)

Major Phase I work has been done, under grants from NBS, OSTI, and Sandia, by three groups:

- Lawrence Berkeley Laboratory, Computer Science Research Dept. - Berkeley, California (LBL)
- Sci-Tech Knowledge Systems, Inc. - Scotia, NY (KSI)
- Battelle Columbus Division - Columbus, OH (BCD)

Additional work for Phase I has been done under grants from NBS by:

- Stanford University, Information Technology Services -Palo Alto, CA (ITS)
- Aaron Marcus and Associates, - Berkeley, CA (AMA)

B. Data Sources

To avoid problems of ending up with a system which contains data of dubious quality, it was decided that two high-quality databases would be built from existing high-quality handbooks, Military Handbook 5 (MIL-HDBK-5) and the Aerospace Structural Metals Handbook (ASMH). Initially the databases would be created as separate entities so that problems involving linking separate databases could be addressed, even though the data drawn from the different sources would be stored in similar formats on the same machine.

C. Categories of Users and their Requirements

The users of a materials database can be divided into several groupings according to functional activities, engineering discipline, or applications. Questionnaires from the initial DOE user group yielded the following background data on the types of activity. (The groupings have also been identified from other user surveys of a more general nature):

1. Functional Activities

   - Engineering Design
   - Materials Selection
   - Engineering Analysis
   - Quality Control
   - Purchasing
   - Maintenance/Service
   - Data Analysis

2. Disciplines

   - Mechanical Engineering
   - Materials Engineering
   - Electrical Engineering
   - Chemical Engineering
   - Nuclear Engineering

3. Specific Applications Involving Materials Data
   (Ranked by relative user interest)

   Stress Analysis
   Thermal Analysis
   Solid Modelling
   Material Selection
   Fatigue Analysis
   Material Specification Development
   Part/Subcomponent Design
   Component Design
   System/Multicomponent Design

   Others:
   (Identified by individuals)

   Tool Design
   Mechanical Testing
   Material Testing
   Reliability Analysis
   Maintenance Analysis
   Data Analysis

Some users may require capabilities for one or another of these purposes exclusively, while others will wish at times to use a mix of them. The system will be structured so as ultimately to serve all of these purposes, but with minimal capabilities initially. However, it will be noted that the wide range of user activities implies many different motivations for accessing the database, and it needs to be recognized that the many different user backgrounds and needs may require different or alternative forms of screen presentation and content, but preferably with standard formats.

D. The User Group

A rapidly increasing amount of the technical work in DOE Laboratories is being performed by scientists and engineers using computers. Selected staff members and first-level supervisors at Los Alamos National Laboratory (LANL), Lawrence Livermore Laboratory (LLNL), and Sandia National Laboratories (SNL) constitute the initial user group and have helped define and develop the MIST database system. Members of the initial user group use computers in their daily work and represent diverse organizations that need information on materials properties to solve their problems.

Because of their previous experience with computers, the user group was enthusiastic about the prospects for the project and felt their productivity would indeed increase if a "corporate information system" for DOE could be established. However, in spite of their frequent use of computers, most users did not consider themselves to be computer scientists and, in general, they did not want to have to learn more about a computer system than necessary to solve their problems. As a consequence, because the users come from diverse backgrounds, a minimum of technical jargon should be included in the system, and HELP fields should be readily available to clarify technical terms and definitions.

E. Computing Facilities

Phase I work is being performed on computers at Lawrence Berkeley Laboratory, Stanford University Information Technology Services, Sci-Tech Knowledge Systems Inc., and Battelle Columbus Division. Communications are being conducted through ARPANET, and also are possible through Telenet and Tymnet, as well as by direct dial-in.

VI. MIST PROTOTYPE SYSTEM ARCHITECTURE

This section briefly describes the software, hardware, and network communications on which the current MIST prototype is being built. It also outlines how various types of information are organized in the initial MIST project.

SPIRES DBMS

The initial MIST project is being implemented on SPIRES, a general-purpose database management system developed and supported by Stanford University. SPIRES was chosen because of its unique combination of capabilities for textual as well as numeric data, its proven ability to handle large numbers of simultaneous users and transactions, its flexibility and extensibility, and its history of support for innovative applications. SPIRES is a mature fourth-generation system with full data management capabilities, including schema definition and control, report generation, design of full-screen forms, on-line documentation, interactive exec language, comprehensive security mechanisms down to the individual element value level, data integrity and recovery, and an extensive library of standard processing procedures for input validation, encoding, automatic indexing, query translation, and output formatting.

SPIRES runs at over thirty installations outside Stanford. Member organizations help provide support and development direction through the SPIRES Consortium, which includes universities such as Harvard, Princeton, and Michigan, as well as several federal organizations such as the NASA Goddard Spaceflight Center and the U.S. Information Agency.

Hardware and Network Communications

The primary MIST prototype project is running on an IBM 3084 under STS at the Stanford University's Information Technology Services (ITS). Another developmental version of the system is running on an IBM 3082 under VM/CMS at the University of California, Berkeley. Users can access the Stanford system via ARPANET, TELENET, and TYMNET, as well as via commercial telephone lines. For fastest response time and use of the full screen PRISM interface, direct connection using a 2400 baud modem with the MNP error-correcting protocol over standard telephone lines gives the best results--though slower speed connections and a line-oriented interface are also available. Users can invoke one of several electronic mail interfaces to send mail to anyone accessible via ARPANET, BITNET, or other networks accessible from those.

Major Data Entities

Engineering and scientific information currently included in MIST can be classified into seven broad types of **entities**: (1) Databases, (2) Exhibits, (3) Data, (4) Terms, (5) Citations, (6) People, and (7) Software.

Databases refer to the database sources incorporated, currently a single one (ASMH), but anticipated to be extended to multiple sources in the future.

Exhibits are source tables, figures, paragraphs, and datasets from printed publications and/or experiments from which the data were obtained.

Data refer to a canonical representation of data extracted from these different types of **exhibits.** Each **data** record pertains to a single set of properties for a single material or a set of materials, sharing a common set of independent variables within the context of a single **exhibit.**

MIST **Terms** is a central thesaurus and glossary for resolving the multiplicity of names, definitions, etc., of materials science and engineering.

It includes definitions for words, phrases, or symbols associated with all materials, properties, independent variables, specifications, measurement units, test methods, organizations, etc., included in the database.

Citations are bibliographic information on source articles, reports, references, etc., which may be linked to specific datasets, exhibits, databases, terms, people, software, and other citations.

People includes information such as telephone numbers, electronic mail addresses, etc., for experts, data reviewers, users, and SIRP Task Group members.

Software includes selected application and manipulation computer programs, subroutines, etc., which may be of use to material scientists and engineers. This file will facilitate the contribution of software from individual users as well as access to the latest version of such software and associated documentation by other users.

Linkages and Relationships between Entities

The MIST project provides extensive linkages between different types of entities during input, user searches, and output display. For example, names of databases, materials, properties, and measurement units are all automatically verified against the MIST thesaurus as a part of standard data entry procedures. All basic descriptive information about a particular material or property contained in the thesaurus is automatically available to users at search or output time as well. When the name of a person is included as part of a data record, users can automatically access additional information (e.g., electronic mail address, telephone number, etc.) from the "person" record corresponding to that same name. Since related types of entities and databases contain comparable key fields (as enforced by the thesaurus of names, terms, etc.), users can make ad hoc connections between different types of data as the need arises.

Data Elements (Field Characteristics)

Information about each entity instance (data record for that type of entity) is contained in discrete data elements (data fields) within MIST. Some data elements are mandatory (e.g., last name for a person record), while others are optional (e.g., name of one or more experts associated with a particular database record). Even graphs are broken down into over thirty distinct types of information components (e.g., scale type, variable, measurement units, caption, etc., for each axis, plus symbol, caption, footnotes, etc., for each curve or set of data points) as well as the numeric X-Y points themselves. Breaking down such information into small discrete parts facilitates data entry validation, indexing, searching, and flexible output display. SPIRES permits addition of new data elements to the database definition for each type of entity, so new types of information can be added as necessary and the types of information for any given entity can evolve gradually without having to reload entire databases when changes are made.

For each data element, MIST also contains additional metadata describing automatic input validation checking procedures, index processing procedures, default output format specifications, storage requirements, data type, short label for standard reports, full description for user help and documentation, etc. All of this metadata is systematically organized within SPIRES file definition records, which are themselves searchable, updatable, etc., by authorized project staff using the same mechanisms for searching, updating, and display as for standard data records.

Detailed information for every data element in every type of entity in MIST is summarized in the appendix and will be documented further in the Data Entry Manual scheduled for the end of Phase II.

VII. IMPACT OF THE MIST PROJECT ON USERS

The MIST Demonstration Project is a natural result of the pressures of contemporary technology which compel consideration of the benefits of computerizing well-used, frequently updated, scientific data sets. Computerization, however, requires more than the translation of data from a printed medium into an electronic medium. Some of the impacts often associated with computerization in general, and which seem to be important for MIST, are:

- Users may have higher expectations from computerized data systems than from printed data compilations.

- Computerized data systems allow users more flexibility to review and compare data.

  One of the advantages of the use of computers is that in computerized information systems, data can be collected and then recombined in many different ways under user control. In any printed handbook the available data are often presented in the limited context of a well-packed page. This is particularly the case with respect to data values embedded in text, tables, and graphs. In MIST, information will be disaggregated in the sense that individual pieces of information or data about a subject of interest can be displayed on a terminal screen in isolation. However, the capability will also exist for the user to display the data in a different context, such as the format that appeared in the original source (e.g., a graph, table, or paragraph) or one in which comparable data for several materials can be viewed simultaneously on a single display. The wide variety of MIST output options, both CRT and printed, will cause many users to become more conscious of what they are viewing and, in some instances, to be more critical of problems which they detect in the data themselves and in the way the data are presented.

- The need for a local interface

  The increasing availability of computer-aided facilities within the nation's laboratories and manufacturing components to support engineering, manufacturing, and purchasing leads to the expectation that MIST will directly interface certain local computerized functions and systems at the individual user level. When completed, MIST should be able to support local computerized applications, functions, and systems with comprehensive machine-readable databases, which in turn will enhance their further utility for computer-aided engineering, manufacturing, and purchasing.

The availability of on-line computer HELP messages invariably results in the opportunity to perform these tasks with increased precision and effectiveness. This in turn places requirements on the accuracy and completeness of the data being supplied.

- The need for a comprehensive, consistent, and versatile data structure

    The diversity of data presentation formats in the printed data sources also affects the ease with which data from different sources can be combined within one computerized information system. Great attention is being paid in the MIST development to ensure that the system includes accurate and consistent data organizing procedures so that similar data from separate sources are linkable within the system but dissimilar data are maintained separate.

VIII. REPORTING

The following reports are scheduled to be completed:

Phase I

Project Overview - Phase I Report and Phase II Plans

Phase II

User Manual
Data Entry Manual
Project Overview - Phase II Report and Phase III Plans

A description of these follows.

<u>Project Overview</u>

This document provides a portrait of the MIST system which is independent of specific choices of hardware, software, and system architecture. This portrait is developed, to the maximum extent feasible, in non-data-processing terminology and concepts so that it can be fully comprehensible to the intended users/customers of MIST. Its principal contents are:

- A fully shared understanding on the parts of the MIST users/customers and the designers/developers regarding the capabilities of MIST at the various phases of system development.

- A basis for the preparation of detailed design specifications for each major phase of the development of MIST.

- A basis for the communication of functional specification changes resulting from:

  - Newly formulated requirements
  - Newly available technological opportunities
  - Increased understanding of the implications of design decisions
  - Redefinition of opportunities and constraints based on resources.

- A basis for the user/customer to perform acceptance testing of each phase of the development of MIST.

User Manual

A guide to users for using the MIST system that will include explanations of all features of the MIST database and the various user-controllable capabilities available to users, including types of searches and options for output display.

Data Entry Manual

This manual will document the structures and procedures to capture data from the various data sources, whether the source of the data be from paragraphs, tables, or graphs. In particular, the procedures must recognize the interrelation of the various record types in preparing complete and consistent data records. The data record structures will be useful in building mechanical property databases consistent with the MIST system. In addition, the data record structure can be used to capture all information relevant to mechanical properties regardless of which database system will be used.

IX. EVALUATION, TESTING, AND FEEDBACK

A project this broad in scope requires evaluation and testing activities for each phase if the system is to develop to fulfill user needs. The following program of evaluation, testing, and feedback is planned:

1) A set of user-coordinators will be identified at each user site, whose function will be to provide close user support as well as guidance to the SIRP Task Group, especially in the early stages. These users will receive extra training to ensure their awareness of the system's potential and functionalities and their capability to coordinate the feedback from users at their site.

2) Users agree that a system log of user interactions will be taken throughout the initial phases. This copy will provide system designers with important feedback on how users are interacting with the system.

3) A user evaluation screen will be available to users upon exiting from each session for their input to identify the relative success of the session and to collect comments for changes or improvements. If possible, the capability for users to insert comments at any point in a session without resulting in a session interruption will be available.

4) Discussion sessions will be held with users and led by user coordinators to pinpoint user reactions and proposals for system extensions or alternative processing capabilities.

5) Users meetings will be held so that users can be fully apprised of system changes and their reactions to new or additional features.

PART B - General Considerations

X. PROJECTED USES OF THE MIST DATABASE

A. Survey and Focus Group Meetings

A detailed survey form was developed by the SIRP Task Group in conjunction with the Berkeley Survey Research Center (SRC). The objective of the survey was to identify the specific factual information needed by the user group, important functional capabilities users want, and the kinds of computer hardware and software they currently have. Members of the SIRP Task Group and the SRC staff met with the user group in focus discussion groups and completed the questionnaire in the Fall of 1984.

The focus group meetings allowed the SIRP Task Group to hear how DOE staff members presently go about their problem-solving processes. They also allowed the users to discuss changes that could make them more productive. At the meetings, the SIRP Task Group learned that currently poor access and inadequate sharing of technical information on a timely basis were causing substantial delays and reducing the reliability of analyses.

The users asked that the SIRP system be an enhanced communications system that connected them to factual data which could be downloaded to their terminals both for analysis as well as for use in other software. Also the system should identify experts who could be contacted directly concerning the data and users' needs. The group wanted multiple access paths to the data to be available (for the expert and non-expert) with more menus presented to the non-experts to guide them to the appropriate data.

B. Approaches to Data Usage

Three approaches were requested by the users:

1. Browsing through the data

2. Locating specific information for one or more specified materials

3. Locating materials that satisfy a given set of constraints

Initially, many users want to browse through the available data and try out the functions of the system. This experience approach appears to be a general learning mode for the users, initially increasing their familiarity with the data and ultimately speeding up their use of the system. To be effective, this approach requires substantial investments in a thesaurus, glossary, and HELP files. An electronic mail communications path back to the system manager or an individual expert responsible for a particular data subset is important to allow the browser to easily provide timely comments.

Users indicated that they often need to locate specific data, compare values, analyze trends, etc.. They identified needs for graphical and statistical plotting routines, and they want to be able to download data to their terminals for use in other software analysis and applications programs. They want a system that almost always finds data being sought. This means there must be clear identification of the data being maintained in the system, and as soon as possible, the quantity and breadth of data in MIST should be increased to cover most of DOE activities.

When users seek specific data, they usually have immediate applications requiring analysis or decision making, and are not patient in waiting for the data to be acquired by conventional library approaches. Increased speed in getting access to data values is one of the principal attractions of a computerized data system. This need for speed in locating data in a computer-based system means that careful attention must be given to search paths. Eventually, adaptive search paths may be associated with particular users to help speed the retrieval of data. Typically, users are seeking numeric data, that is, quantitative information. However, they recognize that associated qualitative descriptions are also necessary in order to assure that the data being supplied are appropriate to the problem.

C. The User Workstation

Members of the user group had access to IBM PC/XT/AT computer terminals, and therefore initially those are the de facto standard terminals being supported by the MIST system. The breadth of scientific information that users need suggests a software capability resident on their terminals that would result in a flexible workstation environment. The workstation, at a minimum, would provide a multitasking environment that could:

1) Incorporate a communications package that would connect the terminal to the MIST gateway,

2) Provide an initial menu set to allow easy interaction with the MIST mainframe computer,

3) Allow appropriate functional software associated with a particular database to be downloaded to the terminal for more rapid off-line transfer and processing of the data (ie. menus specific to the database, graphics, statistical analysis, common theoretical analyses),

4) Permit easy data format control when the data are to be used in conjunction with other application-type software.

D. Data Quality Indicators

User group members strongly urged that the quality of data being supplied to users should be explicitly indicated. Many have also requested that measures of uncertainty associated with data values be stated. After reviewing how engineers and scientists use the information they have now, it appears that the best approach may be to provide a reasonably detailed "pedigree" for each dataset, along with a brief summary quality indicator.

Such a pedigree can also serve as "score card" to guide subsequent upgrading of selected data subsets.

At this stage of development of the MIST project, the SIRP Task Group is working with other groups interested in data quality indicators to establish a general set of guidelines to indicate different aspects of data quality. The model that is emerging identifies three general levels of data quality, each of which is characterized by several specific criteria as described below. The three general levels of data quality are:

Limited Use Data
Qualified Data
Highly Qualified Data

Discussions with users confirmed that a minimum "threshold" for data quality should be met before data are allowed into the system. Data that satisfy these entry criteria, but which could not meet the criteria required for the next level of data quality, have been termed "Limited Use Data".

At the opposite extreme, from the standpoint of maximum scientific and engineering integrity, a much more stringent list of requirements were proposed, all of which seemed essential for critical applications. Data that satisfied these criteria could be termed "Highly Qualified Data".

It was recognized that for many typical applications, a smaller or more relaxed set of criteria would be sufficient, and this level was termed "Qualified Data". The definition for "Qualified Data" may be somewhat arbitrary, so users will also have access to the detailed "scorecard", so they can assess the adequacy of the data for their specific applications.

E. Recommended Quality Indicators for Data in MIST

Users seem to generally support the data quality concepts developed by the Department of Defense MIL-HDBK-5 Coordination Committee, so data quality criteria proposed for the MIST project follow many of the existing quality indicator standards of that Committee. Quality standards from existing reference sources will be "grandfathered" into the MIST project.

Within each general level of data quality, specific data quality standards currently proposed for the MIST project are as follows:

A. Limited Use Data:

1. Data are traceable to an individual, organization, or reference (both the data "Source" and "Digitizer" are identified)

2. After independent review, an identifiable authority approved the digitized version for inclusion in the database.

3. Basis of the data is identified

   a. experimental measurements,
   b. derived data - specify theoretical basis and data,
   c. estimated data

4. Type of data is indicated

   a. original point values,
   b. analyzed data,
      i. standard fit - specify fit and data;
      ii. fit unknown

B. Qualified Data:

5. Number of measurements & data sets stated.

6. Nominal confidence limits estimated (i.e., .90, .95, n).

7. Traceable materials specification assures reproducibility.

8. Testing methods are specified and conform to a standard.

9. Data are traceable to a testing/data generating organization or individual.

C. Highly Qualified Data:

10. High confidence limits determined (i.e., .99, .95, n).

11. Perform minimum number of individual measurements (i.e., 100)
    - from minimum number of sample lots (i.e., 10)
    - from multiple suppliers (if appropriate).

12. Data determined for each variable (i.e., form, processing condition, size, etc.) that significantly affects the property.

13. Independent testing (other than the producer & preferably by several testing labs) performed.

14. A second, independent evaluation (evaluator identified)

15. All features explainable.

16. Producer(s) identified.

To proceed to the next higher level, all of the criteria for the lower level(s) must have been met or exceeded.

"Limited Use Data" will probably be the most common entry level for data. Some data may never be able to achieve a higher data quality level because the material involved is inherently variable in its characteristics.

Because of the particular data sources chosen for the MIST project, little current data qualifies for the "High Quality Data" designation. However, if users want a standard such as this for materials usable in critical applications, then in time appropriate data will no doubt become available to the system. Since it will be possible to include data quality designations grandfathered in by previous reference (i.e., "A Basis", "B Basis", "S Basis", etc. of MIL-HDBK-5), this is the appropriate time to propose and implement a system of good technical criteria for future data.

The origin of the data maintained by the system is also important to users so they apply only data appropriate to their problems. Thus, they have asked that bibliographic citations relating to data be available on request.

Whenever appropriate, preferred data sets will be indicated wherever possible if there is more than one data set.

The detailed definitions of these data quality indicators are still being developed. However, it appears that through the MIST project, a significant improvement can be made in quality assurance and appropriate audit trails established and maintained.

F. Data Integrity and Security Issues

Certain users of computer-based data compilations may need reassurance that the values included in the database remain unchanged unless by specific intervention and approval of those responsible for the integrity and security of the data. This question of data value integrity is closely tied to the security and integrity mechanisms provided by the underlying operating system(s), database management system(s), and telecommunication system(s). Methods are being studied to assure that data being sought and transmitted remain secure.

Related questions include:

who has access to the database?

who can add or change data values?

what audit trails exist to identify changes to values?

who have changed them and the reasons for such changes?

Other issues that the users expect will be part of the MIST design and operation include:

Traceability of the data whenever it is accessed.

Definitions of terms, units, and properties.

Checks on the continuing correctness of the data in the database.

The current version of MIST provides full audit trails for input and changes to each entity instance in the database, so that any subsequent analysis of data values could reference a complete history of changes.

Data security issues are recognized as very important and are being addressed separately.

G. Multisite Usage

Four DOE sites (LANL, LLNL, SNLA, SNLL) are participating in the initial development of the MIST prototype. The users strongly endorsed the concept of multisite access and usage of MIST because:

1. All users will have access to a single, common source of data containing the "best" information

2. The information can be updated regularly, assuring all of the DOE sites access to new data and minimizing duplication of data generation, evaluation, and maintenance efforts

3. Through MIST, the materials experts will become more aware of DOE needs and can focus their efforts on assuring that appropriately qualified information is obtainable from the system

4. Data will be formatted in ways to support increased use of CAD, CAE, CAM, and CIM

5. The system will provide a mechanism for increased communications between people working on similar problems at different DOE sites.

H. Database of DOE Materials Experts

The need for the data system to provide a capability both to identify experts and to provide fast communication with them has been included in the design of the MIST project. In further discussions, the material experts were enthusiastic about being identified as the local authorities on particular topics. They recognized that there is a growing trend to bypass expert analysis and instead for users to simply use digitized files existing on computers. Many of these experts are presently evaluating data, measuring properties, and consulting with project leaders. They are very receptive to having a framework to share the results of their work with a broader audience. This framework also includes: 1) serving on expert panels which periodically would review the data in their field of expertise, and 2) providing oversight to assure that the data being accepted into the system are appropriately qualified.

XI. DESIRED FUNCTIONAL CAPABILITIES OF THE MIST PROJECT

Below is given a description of the general functional capabilities that have been identified by the user community and that would comprise a comprehensive MIST system. However, the initial phases of the system development will, of course, not provide all these capabilities. The initial goals of Phases I and II have been outlined in sections III and IV above.

A. Modes of Access to the Database

The principal modes of access required by users are shown in Figure 4. The first mode is to obtain a description of some or all of the properties of a known material from the database. Another mode is to ascertain a confirming document, such as a specification for a particular material, material-form, or material-form-application combination. Such a requirement may serve a design engineer or a quality control engineer or a purchasing agent; whereas a person performing an engineering analysis is primarily interested in obtaining specific property values for previously identified materials. A powerful and attractive access mode, unique to the computer, is the ability to retrieve at one time, identifiers for all materials meeting a certain property profile, i.e., some specified combination of properties, either quantitative or qualitative. Other modes of access are also indicated in the Figure 4.

The following table, Table 3, summarizes the principal access paths to the database for different user functions or activities.

User Activity	Material Descrip.	Terms	Identification and Retrieval	W.Quant. Prop. Profiles	W.Qual. Property Profiles
Engn'g Design	X	X	X	X	X
Mat'ls Sel.	X	X	X	X	X
Engn'g Analysis		X	X	X	X
Data Analysis	X	X		X	
Quality Control	X	X	X	X	
Purchasing	X	X	X		
Mainten./Service	X	X	X	X	X

Table 3. Principal Choices of Access Paths to MIST Database

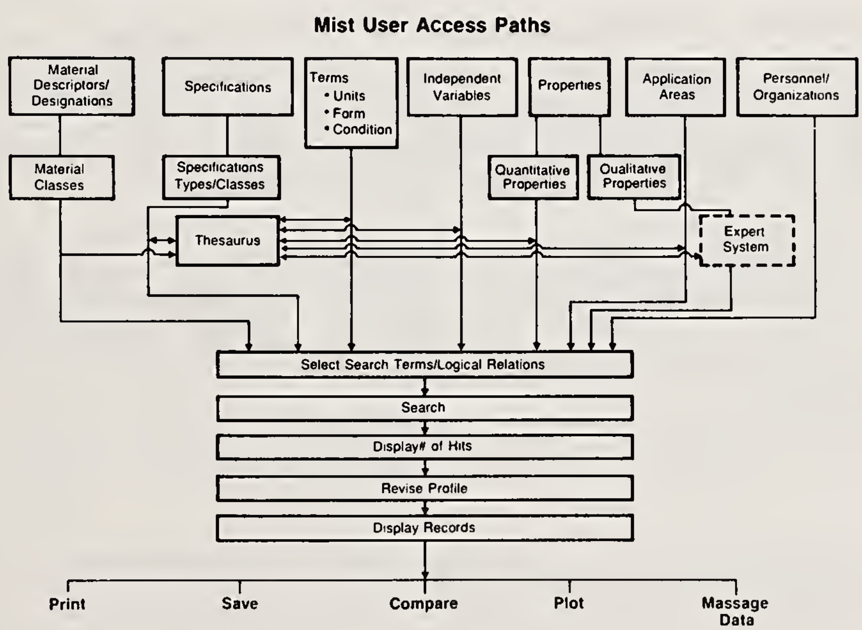

Figure 4.
Access Modes for Users of Materials Databases

The initial screens used to introduce different types of users to the system must therefore reflect the various types of access possible and needed.

The easiest method available is to provide the user with logical branching paths for the alternate search strategies, so that as a user reaches a decision stage in the search, the alternatives presented provide an unambiguous set of choices for search, display, or manipulation.

B. Support of Search and Retrieval (Query Scenarios)

a) Menus or Commands

While in principle it is possible to have users learn a number of search and display commands, in practice users are unwilling to spend much time mastering the idiosyncrasies of any computerized system, at least until they are convinced that the system is helpful and that they will use it frequently.

In designing the first two phases of MIST, it has been assumed that users will fall principally into two major divisions:

- Most users will prefer to take advantage of system-guided search, retrieval, and output functions. For these, a front-end access system based on menus will be developed. The contents of the menus will refresh the users' understanding of what the system can do for them, and optional HELP screens will guide their search, retrieval, and output preparation activities. Properly employed, these aids will expose the user to information which usefully supplies and complements the information that he/she is looking for.

- A smaller set of users consists of MIST developers or other frequent users, who will wish to exercise full logical access to the database. For these individuals, the underlying DBMS (database management system) query language (SPIRES), will provide the most powerful and efficient access to the data.

Therefore, initially, search and display-menus will be developed and presented, suitable for new users, with the opportunity for the more accomplished user to utilize "commands." Later, provision will be made for a combination of both menus and commands for users who use the system frequently.

The principal menus will cover:

i. Entry to the Database
   - Description
   - Options
   - Helps

ii. Options for Access Paths
   - Properties and Property Values
   - Materials
   - Applications
   - Specification Information
   - Terms
   - Helps
   - Manipulation of Data (later)
   - Enter Users Own Data (later)

iii. Options for Manipulation (later)
   - Point Plotting
   - Curve Fitting
   - Graphic Overlay
   - Statistical Analysis
   - Capability to Plot Output
   - Capability to Plot User Supplied Data (later)

iv. Options for Display
   - Material Description
   - Comparison Tables
   - Bibliographic References

For those individuals using menus, different levels of assistance will be needed.

o Some users will access MIST only very occasionally. Their approach to MIST will continually resemble the approach taken by any naive user who is starting out to use the system. Such users would probably rely on the front-end access system on each occasion of use, with only a minimal amount of retained knowledge of the techniques for accessing MIST. Such users will probably not expect to develop the skill required to fully exploit some of the more complex logical capabilities embodied in the system.

o Users who access MIST with greater frequency will be able, if they wish, to make more effective use of the front-end access system in two respects:

  - First, to obtain their information with a more streamlined use of the front-end, not being delayed by explanatory information which they no longer require.

- Second, to access logically sophisticated features of the front-end access system, that would be difficult for a naive or infrequent user, but that become convenient features as individuals acquire greater understanding and skill with respect to the MIST database.

b) Purposes for Searching, Manipulating, and Displaying Data

How data are to be used provides another way of looking at access paths for MIST.

Results or data from the database may be intended for:

- o incorporation into completely manual engineering design work
- o incorporation into a terminal/PC-aided work activity
- o downloading into a personal database either on a host or on a PC
- o direct incorporation into a computerized engineering design or application program on another computer.

Initial user input indicates that all these uses are contemplated, with downloading assuming the greatest immediate importance. The MIST system will be designed to eventually accommodate all of these output requirements, with as full as possible implementation in Phase II.

C. Search Capabilities

MIST will provide search and retrieval screens that make available to the user some of the power of the underlying DBMS, particularly as it relates to the needs for identifying candidate materials for an application for executing design engineering on a specified material, or for determining material-based requirements to perform repairs or replacement of a structure involving an unfamiliar material. Selection of candidate materials in terms of almost every category of data in the database will be directed by use of the menu screens.

It is assumed that most normal search and retrieval strategies will include such major data categories as:

- o Quantitative Properties
- o Qualitative Properties (including information such as machinability, processability, and application data)
- o Subject term descriptors which describe the generic category of the material involved (e.g., low alloy steel or aluminum casting alloy); the form in which it is supplied (e.g., sheet or wire); the process used (air melt or vacuum melt); etc.

Therefore, in Phase II, development will focus on the menu screens for the most effective use of these and other elements in formulating and searching for candidate materials.

This approach does not ignore the fact that other types of users, such as purchasing agents and manufacturing engineers, will access information about a material principally through use of a common name or designation number. Such an access strategy can also be efficiently supported by the search and retrieval menu screens.

a) Menu Search System

The menu search and retrieval screen system will support the user by providing:

- An orderly sequence to a search that reflects specific search and retrieval strategies (see next section)

- Easy access to a supporting thesaurus so users can obtain the information they need to select appropriate search parameters such as subject terms, property names, and quantitative property units.

- Supporting definitions and descriptions which enable the user to frame the search in familiar terms and in familiar logical sequences.

- Optional access to supporting definitions, pertinent test methods, etc., to clarify apparent inconsistences.

b) Specific Search and Retrieval Strategies

Three common uses of materials information will be supported by search and retrieval strategies.

- System Browsing

  Before specific property parameters are entered for a search, the user can browse through lists of quantitative and qualitative properties, and units (of measurement). In the MIST project, values for specific properties will be indexed uniformly in consistent units though entered in the units of the original source. The user may specify other units, in which case the system will convert, as necessary, during the performance of the search, and retrieved data will be presented in the units specified in the query.

- Materials with Specific Properties

  The menus will enable the user to retrieve any stored information which is linked to the materials related to the properties searched. Knowledge of the underlying DBMS query language will not be necessary in order to formulate a search strategy using sophisticated criteria.

- o Properties of Specific Materials

  The user either provides a material name or designation number(s) or selects other access paths, such as combinations of descriptor terms until the applicable UNS numbers of potential materials are determined. The existence of values for specific properties of these materials can then be ascertained by combining search parameters (e.g., property names, quantitative property values, subjects, titles, tradenames). Searches for a material's qualitative properties are possible by allowing the user to retrieve data by the presence of keywords or text strings in various property fields.

D. Manipulation Capabilities

Examples of some of the manipulation capabilities which will be available in MIST follow. However, not all (especially the latter two) will be available initially.

- o The existence of qualitative and quantitative properties data on materials for selected independent variables can be retrieved and compared in order to narrow a set of relevant property records. The user would first identify the properties of interest together with selected independent variables. The system then retrieves and displays the number of materials that satisfy those criteria. The user may then introduce other properties, property values or independent variables, or revise those previously supplied, to expand or contract the list and display a comparison table.

- o The user can perform quantitative property searches setting minimum, maximum, or nominal values for each of as many properties as needed. If desired, those properties can also be searched with respect to minimum, maximum, and desired values of independent variables which can be specified with or without specifying a value(s) for the property.

- o The user can view the presence or absence of quantitative properties for several materials at a time. The existence table that is displayed indicates whether or not quantitative properties data are available or derivable.

- o Materials having derivable properties can also be compared, and the property to be derived determined for several materials at a time. It is not necessary for the user to provide the formula involved in the derivation or to determine whether the properties used in the derivation process are already known for the materials. Ultimately, the user will be able to create his own derived property, such as a figure-of-merit, by defining the algebraic combination of standard properties desired.

Having retrieved a specified set of values from the database, the user may wish to:

- o obtain rank-ordered lists of property values for different materials

- o display combinations of data values in a comparison table

- o download the data to his/her own PC or workstation for further manipulation or incorporation in application programs. An appropriate file transfer format will need to be adopted for this purpose. Initially, the system should provide data output records which correspond to the format of the input records from data capture.

and in the future, have additional types of manipulation capability such as:

- o a statistical package to analyze and characterize retrieved and user-supplied data sets

- o a built-in graphics package to:

  - apply different coordinate types and scales
  - take tangents and intercepts at cursor-specified locations
  - interpolate or extrapolate from presented data according to stored algorithms

E. Display Capabilities

a) CRT Display Output

- o Display of qualitative and quantitative property data for one or more selected materials will be in a table of contents or existence table format.

- o Capability to select further from previously selected materials to appear in a display so that final outputs include only materials of interest.

- o Qualitative property data displays such that basic descriptive data for each individual material will be displayed separately. Quantitative property data will also be displayed for each separate material or, where appropriate, will also be given in tabular form showing material versus property value.

- o Screens for inspection of properties, comparison of properties and materials, and property derivations that prompt the user for entry of his choice of the appropriate fields and values. Performance of an inspection, comparison, or derivation may result in a multi-screen display that can be browsed; any or all screens may be saved for later printing. The user is also given the option of returning to previous screens for further refinement of the search/analysis or to branch to other activities.

- Graphical capabilities enabling the user to:

  - display values of any quantitative property as a function of one selected independent variable (2D plot) or two such variables (3D plot) with arbitrarily chosen coordinate types and scales.
  - overlay up to four such 2D plots over one another, providing all are members of the same family or involve a common independent variable.
  - display domain or cluster plots of any values of two different properties for a variety of materials.
  - exercise various manipulations of the point sets on which the graphical presentation is based.

b) Hard Copy Output

- The selection of materials and properties to be printed will be the same as that of CRT displays.

- Hard copy output can be printed locally, if compatible printers and/or plotters are available, or can be printed at a central site for subsequent delivery.

F. Application Programs

The user will wish to have, either on other mainframes or nearby on his own PC or workstation, various application programs to make engineering use of the data from MIST. The format, data units, and completeness of the database should be such as to permit direct operation of these programs with little or no restructuring or introduction of information external to the System. Such application programs include, for example:

finite element analysis
life prediction
failure rate projections
specific design calculations

As noted earlier, a File Transfer Format will need to be either established, or adapted from existing ones, such as IGES (Initial Graphic Exchange Specification), so that users will be able to download results and data to their own PCs or workstations.

G. Considerations for Entry of Private Data

The user is able to enter private data, following the System data structure, thereby using MIST as a type of electronic laboratory notebook. Once the data have been entered, the user should be able to install software "locks" to ensure the privacy of personal files.

H. On-Line Helps

a) System Helps

All of the software components of MIST will be supported by the provision of on-line help information. This has proven to be a very flexible way of providing readily accessible support for the user of a computer system. It is immediately there when the user requests it, but does not get in his way when it is not needed. An effective set of HELP messages can in many instances eliminate the need for a user to consult either written documentation or engage in oral communication with the MIST staff in order to discover how to take the next step.

Knowing that effective HELP messages are available and easy to access determine whether a computer system-shy user is willing to try the system or will decline to make continuing use of it.

b) Intellectual Helps

One important type of intellectual "help" is a "definition" command that can be invoked for each important term in the primary metadata list. Another is an "example" command that would present a concise instance of the usage of the term in question. For information systems of this complexity, thesauri must be available and continually expanded to provide equivalancy tables for both alternative material names and numbers, as well as indications of hierarchical relations between terms.

It might also be noted that the availability of HELP commands and the existence of a thesaurus also facilitate and provide validation during data entry, particularly when data are being extracted or compiled from diverse data sources.

I. Training

In order to be effective, MIST must be introduced to a large, diverse and scattered community of users. Many of the intended users will have had little experience or interest in using a computer-based information system. Efficient, effective, widespread use of MIST will, to a large measure, depend on how well it is introduced to the user community. A well-planned and well-executed training program can make a major contribution to the success of this introduction. Training will ensure:

- That the users understand the benefits which accrue from MIST, and that there are no economic or other penalties associated with making effective use of MIST;

- That the users have a detailed understanding of the available capabilities of MIST, where their access point(s) are located, and how to log-on the system and get started;

- That the users have sufficient technical information so that they can proceed to obtain from MIST those services which they realistically can expect to receive, and

- That these perspectives can be provided to new engineers and purchasing agents as they enter positions where MIST can provide important informational support.

a) Direct User Training

It is assumed that the basic introduction to MIST and how to use it will, to the maximum extent feasible, be provided in the form of direct user training. Computer systems which are delivered without adequate user training are often seriously underused for years following their introduction, and may even be discarded as a consequence of the lack of such support.

b) On-Line Tutorials

Although not a substitute for direct user training, there will be a role for on-line, computer-aided instruction which can be made available for system users. Such instructional programs can support users with:

- Introductions to modifications to MIST and expanded expositions of its informational capabilities.

- Opportunities for users to increase their technical skills in the uses of the System above those provided as part of the introductory training.

XII. DATA CAPTURE

Data capture is the process of selecting and entering materials property data into a Database. It involves a series of steps that consist of: identifying the data to be entered; editing the original source data and the associated information; keying the data into specific input formats; updating the database; and verifying that the data have been correctly entered.

The data capture steps described below pertain to material property data contained in various scientific and engineering handbooks. However, for the entering of existing computer files or user data into the MIST system, comparable procedures still need to be developed.

A. STEP 1. Data Selection and Identification

The criteria for the selection of the material and properties for the prototype system have been given earlier. This process can be generalized as follows:

a) Identifying and setting priorities for the materials to be included, as well as the properties desired, based on the pertinent application areas.

b) Identifying the property data available and their occurrence in the various data sources.

c) Selecting the property data to be processed. This step involves identifying from which source the data are to be obtained and in what form they are presented, (i.e., table, paragraph, figure, or graph).

d) Identifying the bibliograhic and secondary references from which the data were originally obtained.

B. STEP 2. Source Editing and Data Transcription

Data editing is the process of preparing the data sources for input into the MIST Database. The procedures involved are dependent on the type of source being processed:

a) Paragraphs/References - paragraphs and reference data require no editing, other than providing a copy of the data which has been marked to identify the selected information.

b) Tables - tables usually require no additional editing other than providing a copy of the table. However, complex tables may require special attention by an editor.

c) Figures/Graphs - figures and graphs require several types of editing activities so that:

- the dependent and independent variables be correctly identified for entry into the database

- the data from the plot be captured in digitized form (using a sufficient number of points to define the graph), either manually or semiautomatically, by the use of an electronic tablet.

- all associated metadata needed for interpretation of a graph or figure be identified. Some of these data may lie outside the graph proper - in the caption, text, or elsewhere.

C. STEP 3. Data Entry

Data entry involves the keying of data into a predesigned input format, dependent on the record type required for that type of data. A complete discussion of the different record types and the data within them will be included in the Data Entry Manual. The general procedures for handling the different types of data are given below:

a) Paragraphs/References - the data for paragraphs and references are extracted directly from the source provided.

b) Tables - tabular data require an understanding of the structure of the individual tables and identifying the various independent and dependent variables. The data must be inputted in a controlled structure, so that the unique column and row structure is preserved and a subsequent loading program can identify the individual data tuples to be extracted and stored in the database.

c) Figures/Graphs - the treatment of figures and graphs is analogous to that of tabular data except that the axis-based structure of the figure or graph is captured rather than the column and row structure of the table. The inputting of the digitized data from the electronic tablet is straightforward once the structure of the graph is established.

In the MIST database, the data structure, formats, and order in which the data are to be entered are very important, and special controls must be exercised during this stage of data capture in order to ensure correct order, exact data element names, and correct formats in the data files.

D. STEP 4. Data Validation

Data validation is performed on all data entered into the MIST database, either during data entry, by testing the input against validation tables, or after data entry, by obtaining a presentation printout of the inputted data in a format appropriate for the type of data being validated, (i.e., table, graph, paragraph, etc.), and then comparing it with the original data source. Checking for correctness of terms, etc., can be performed during data entry using built-in file definition and thesaurus validation procedures within the system.

E. User-Entered Data

In the future, users will be provided the option of entering their own data, either to be directed into a private file for their own use or else following some review and acceptance procedure into a central file for general access. If the data are to be used privately, then the individual user will be responsible for entering and maintaining the data. If the data are to be directed for general use, then a central location will need to be established to accept, process, and validate such data. In either case, the steps outlined above must be further evaluated and procedures developed to ensure the consistency and integrity of user-selected and -entered data.

Materials Data Retrieval System User Requirement Survey

NAME:____

TITLE:____

MAILING ADDRESS:________________________________

____

____

____

TELEPHONE NUMBER(S):____________________________

MATERIALS DATA RETRIEVAL SYSTEM USER REQUIREMENTS SURVEY

A WORD ABOUT THIS PROJECT: As you know, we are trying to develop an on-line system which would give engineers and other scientific personnel easy access to the kinds of scientific information they often need. Instead of leaving the lab or office to visit a library, the engineer could sit down at his own computer terminal and quickly get the answers to whichever questions arise most often. We need your help in determining (a) which data should be made available, (b) in which forms users require information, and (c) what computer tools they need to facilitate retrieval and use of such data.

Please answer each of the following questions, giving us your candid answers. We may not be able to provide everything everyone wants, but your answers will help us to set priorities. Conversely, if what we have in mind is overly complex or elaborate, you can help to conserve valuable resources by letting us know that.

1A. **Below is a list of different kinds of activities which your work may involve. For each one, please circle one answer showing how much of your time is spent on that type of activity.**

		Takes a lot time	Takes some time	Takes very little time	Takes no time
1	Material Selection	1	2	3	4
2	Part/Sub-component Design	1	2	3	4
3	Component Design	1	2	3	4
4	System/Multicomponent Design	1	2	3	4
5	Quality Control	1	2	3	4
6	Develop Material Specifications	1	2	3	4
7	Stress Analysis	1	2	3	4
8	Thermal Analysis	1	2	3	4
9	Fatigue Analysis	1	2	3	4
10	Solid Modelling	1	2	3	4
11	Other major aspects of my job PLEASE DESCRIBE:	1	2	3	4

____

____

1B. **Are there any types of activities which take very little of your time (coded "3" in part A) but which are crucial aspects of your work?**

[ ]Yes (WHICH ONES?)

[ ]No

2 **We also need to know the extent to which CAD/CAM (i.e., computer- assisted design and computer-assisted manufacturing) systems are important in each of the major aspects of your work. Please answer the following only for those activities you indicated are your major activities (those for which you circled a "1" in Question 1A). Circle one answer showing the extent to which you use CAD/CAM is important to each of your major activities.**

		Usually use CAD/CAM	Sometimes use CAD/CAM	Rarely use CAD/CAM	Never use CAD/CAM	Not a major activity
1	Material Selection	1	2	3	4	5
2	Part/Sub-component Design	1	2	3	4	5
3	Component Design	1	2	3	4	5
4	System/Multicomponent Design	1	2	3	4	5
5	Quality Control	1	2	3	4	5
6	Develop Material Specifications	1	2	3	4	5
7	Stress Analysis	1	2	3	4	5
8	Thermal Analysis	1	2	3	4	5
9	Fatigue Analysis	1	2	3	4	5
10	Solid Modelling	1	2	3	4	5
11	Other major aspects of my job PLEASE DESCRIBE:					

____

____

3. **Below is a list of application areas.**

A. First, please indicate how often you (or someone in your department or section) need information for purposes of such application.

B. Next, please indicate in the right hand columns, for which of the activities from Question 1 you would be likely to need information for the different kinds of applications listed below.

	A. We need information about this...				B. The Activities for which we are likely to need information in this area (Please enter identifying number(s) from Question 1.)
	Often	Sometimes	Rarely	Never	
1. Structural-Static Applications (e.g, coat hangers, shelf brackets, relay racks and other simply and lightly loaded applications)	1	2	3	4	____________
2. Structural-Dynamic Applications (e.g., impact, fatigue and other-time-dependent loading)	1	2	3	4	____________
3. Structural-T Dependent (including both cryogenic and high temperature regimes)	1	2	3	4	____________
4. Heat Transfer Applications (e.g., conductive, convective, and radiative properties of heat transfer media and of materials to contain them)	1	2	3	4	____________
5. Magnetic Applications (including soft magnetic-ferrites, electrical lamination steels, etc.; hard or permanent magnetic alnicos, RE cobalt, Nd-Fe-B, etc.)	1	2	3	4	____________
6. Electrical Applications (such as conductors, insulators, resistors, superconductors, etc.)	1	2	3	4	____________
7. Friction and Wear (including brakes, clutches, bearings, guides, ways)	1	2	3	4	____________
8. Optical Applications	1	2	3	4	____________
9. Nuclear Applications	1	2	3	4	____________
10. Explosive Applications	1	2	3	4	____________
11. Thermochemical Applications	1	2	3	4	____________

Question 3 (continued)

C. **Are there any other kinds of application areas for which you sometimes (or often) want information?**

[ ]Yes [ ]No

If Yes: Please use a line below to describe each and indicate the activities for which you are most likely to need information (again using identifying numbers from Question 1).

Kind of Applications:______________________________ For Activities:______________________

Kind of Applications:______________________________ For Activities:______________________

Kind of Applications:______________________________ For Activities:______________________

D. Are there any application areas on which you *rarely* need data (code "3" circle in Question 3A on previous page) but which are crucial aspects of your work?

[ ]Yes (Which Ones? ____________________________________)
numbers from A on previous page

[ ]No, no others

4. Below is a list of different kinds of information you may have needed in your recent work -- that is, your work in the last 12 months. For each of the application areas for which you circled a "1" or a "2" in question 3, please indicate how important it is to you to have each kind of information about the properties of a given material. For the areas which do not take much of your time (not circled "1" in Q3), please check the box and move on to the next group.

Structural Static Properties:
Such as coat hangers, shelf brackets, relay racks and other simply and lightly loaded applications.

[ ]Did not circle "1" in Q3, move to Structural Dynamic

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
24	Density	1	2	3	4	5
70	Tensile Yield Strength	1	2	3	4	5
68	Tensile Ultimate Strength	1	2	3	4	5
64	Tensile Modulus	1	2	3	4	5
62	Tensile Elongation	1	2	3	4	5
66	Tensile Reduction in Area	1	2	3	4	5
78	Torsion Yield Strength	1	2	3	4	5
77	Torsion Ultimate Strength	1	2	3	4	5
76	Torsion Modulus	1	2	3	4	5
13	Compressive Yield Strength	1	2	3	4	5
12	Compressive Modulus	1	2	3	4	5
50	Poisson's Ratio	1	2	3	4	5
38	Hardness	1	2	3	4	5
41	Machinability	1	2	3	4	5
37	Hardenability	1	2	3	4	5
32	Formability	1	2	3	4	5
51	Primary Constraining Property	1	2	3	4	5

Other Structural Static properties (please specify below)
a.
b.

Structural Dynamic Properties:
For structural-dynamic applications such as impact, fatigue and other-time-dependent loading

[ ]Did not circle "1" in Q3, move to Structural Temperature Dependent

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
46	Service Temperature Minimum	1	2	3	4	5
24	Density	1	2	3	4	5
70	Tensile Yield Strength	1	2	3	4	5
68	Tensile Ultimate Strength	1	2	3	4	5
64	Tensile Modulus	1	2	3	4	5
62	Tensile Elongation	1	2	3	4	5
66	Tensile Reduction in Area	1	2	3	4	5
23	Damping Capacity	1	2	3	4	5
9	Impact Strength - Charpy	1	2	3	4	5
34	Fracture Toughness - K_Ic	1	2	3	4	5
33	Fracture Toughness - Notch Tensile Ratio σ_n/σ_{un}	1	2	3	4	5
35	Fracture Toughness - da/dt	1	2	3	4	5
29	Fatigue Strength Coefficient - σ_f'	1	2	3	4	5
26	Fatigue Ductility Coefficient - ϵ_f'	1	2	3	4	5
30	Fatigue Strength Exponent - b	1	2	3	4	5
21	Cyclic Strength Coefficient - K'	1	2	3	4	5
20	Cyclic Strain Hardening Exponent - n'	1	2	3	4	5
58	Tensile Yield Strength (Strain Rate Dependence)	1	2	3	4	5
60	Impact Strength (Temp. Dep.)	1	2	3	4	5
27	Fatigue Ductility Exponent - c	1	2	3	4	5
51	Primary Constraining Constraining Property	1	2	3	4	5
22	Cyclic Yield Strength S_y'	1	2	3	4	5
81	Impact Strength - Izod	1	2	3	4	5
102	Fatigue Strength (S-N curve)	1	2	3	4	5

Other Structural Dynamic Properties (please specify below)
a.
b.

Structural Temperature Dependent Properties:
For applications including both cryogenic and high temperature regimes.

[ ]Did not circle "1" in Q3, move to Temperature Dependent Properties

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
41	Machinability	1	2	3	4	5
45	Melting Point	1	2	3	4	5
38	Hardness	1	2	3	4	5
24	Density	1	2	3	4	5
70	Tensile Yield Strength	1	2	3	4	5
68	Tensile Ultimate Strength	1	2	3	4	5
64	Tensile Modulus	1	2	3	4	5
62	Tensile Elongation	1	2	3	4	5
66	Tensile Reduction in Area	1	2	3	4	5
100	Stress Rupture Strength - 100 HR.	1	2	3	4	5
5	Stress Rupture Strength - 1000 HR.	1	2	3	4	5
1	Stress Rupture Strength - 10,000 HR.	1	2	3	4	5
3	Stress Rupture Strength - 100,000 HR.	1	2	3	4	5
17	Creep Strength 10E-5 % / HR.	1	2	3	4	5
15	Creep Strength 10E-3 % / HR.	1	2	3	4	5
72	Thermal Coefficient of Expansion	1	2	3	4	5
74	Thermal Conductivity	1	2	3	4	5
44	Service Temperature Maximum	1	2	3	4	5
47	Oxidation Resistance	1	2	3	4	5

Temperature Dependent Properties
(i.e., given for different temperatures)

[ ]Did not circle "1" in Q3, move to Heat Transfer Properties

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
71	Tensile Yield Strength (Temp. Dep.)	1	2	3	4	5
69	Tensile Ultimate Strength (Temp. Dep.)	1	2	3	4	5
65	Tensile Modulus (Temp. Dep.)	1	2	3	4	5
63	Tensile Elongation (Temp. Dep.)	1	2	3	4	5
67	Tensile Reduction in Area (Temp. Dep.)	1	2	3	4	5
101	Stress Rupture Strength - 100 HR. (Temp. Dep.)	1	2	3	4	5
6	Stress Rupture Strength - 1000 HR. (Temp. Dep.)	1	2	3	4	5
2	Stress Rupture Strength - 10,000 HR. (Temp. Dep.)	1	2	3	4	5
4	Stress Rupture Strength - 100,000 HR.(Temp. Dep.)	1	2	3	4	5
18	Creep Strength 10E-5 % / HR. (Temp. Dep.)	1	2	3	4	5
16	Creep Strength 10E-3 % / HR. (Temp. Dep.)	1	2	3	4	5
75	Thermal Conductivity (Temp. Dep.)	1	2	3	4	5
51	Primary Constraining Property	1	2	3	4	5
73	Thermal Coefficient of Expansion (Temp.Dep.)	1	2	3	4	5
102	Fatigue Strength (S-N surve)	1	2	3	4	5

Other Temperature Dependent Properties (please specify below)

a.

b.

Heat Transfer Properties:
For Heat Transfer applications such as conductive, convective, and radiative properties of heat transfer media and of materials to contain them.

[ ]Did not circle "1" in Q3, move to Magnetic Properties

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
24	Density	1	2	3	4	5
70	Tensile Yield Strength	1	2	3	4	5
68	Tensile Ultimate Strength	1	2	3	4	5
64	Tensile Modulus	1	2	3	4	5
62	Tensile Elongation	1	2	3	4	5
54	Electrical Resistivity	1	2	3	4	5
57	Specific Heat	1	2	3	4	5
74	Thermal Conductivity	1	2	3	4	5
25	Emissivity	1	2	3	4	5
14	Continuous Service Temperature	1	2	3	4	5
72	Thermal Coefficient of Expansion	1	2	3	4	5
47	Oxidation Resistance	1	2	3	4	5
32	Formability	1	2	3	4	5
51	Primary Constraining Property	1	2	3	4	5

Other Heat Transfer Properties (please specify below)

a.

b.

Magnetic Properties:
For Magnetic applications including soft magnetic-ferrites, electrical lamination seels, etc,; hard or permanent magnetic alnicos, RE cobalt, Nd-Fe-B, etc.

[ ]Did not circle "1" in Q3, move to Electrical Properties

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
24	Density	1	2	3	4	5
68	Tensile Ultimate Strength	1	2	3	4	5
79	Transverse Rupture Modulus	1	2	3	4	5
38	Hardness	1	2	3	4	5
54	Electrical Resistivity	1	2	3	4	5
72	Thermal Coefficient of Expansion	1	2	3	4	5
41	Machinability	1	2	3	4	5
11	Coercive Force -- H_c	1	2	3	4	5
39	Coercive Force Intrinsic -- H_{ci}	1	2	3	4	5
53	Residual Magnetic Inductance -- B_r	1	2	3	4	5
48	Magnetic Peak Inductance -- B_{is}	1	2	3	4	5
42	Magnetic Energy Product -- $(BH)_{max}$	1	2	3	4	5
8	Magnetic Induction at $(BH)_{max}$	1	2	3	4	5
36	Magnetic Field Strength at $(BH)_{max}$	1	2	3	4	5
52	Magnetizing Field Required	1	2	3	4	5
49	Magnetic Permeability	1	2	3	4	5
7	Permeability Average Recoil	1	2	3	4	5
40	Magnetic Hysteresis Loss	1	2	3	4	5
19	Curie Temperature	1	2	3	4	5
51	Primary Constraining Property	1	2	3	4	5

Other Magnetic Properties (please specify below)

a.

b.

Electrical Properties:
For electrical applications such as conductors, insulators, resistors, superconductors, etc.

[ ]Did not circle "1" in Q3, move to Friction and Wear Properties

	Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
24 Density	1	2	3	4	5
70 Tensile Yield Strength	1	2	3	4	5
68 Tensile Ultimate Strength	1	2	3	4	5
64 Tensile Modulus	1	2	3	4	5
62 Tensile Elongation	1	2	3	4	5
57 Specific Heat	1	2	3	4	5
74 Thermal Conductivity	1	2	3	4	5
72 Thermal Coefficient of Expansion	1	2	3	4	5
54 Electrical Resistivity	1	2	3	4	5
59 Temperature Coefficient of Resistivity	1	2	3	4	5
41 Machinability	1	2	3	4	5
51 Primary Constraining Property	1	2	3	4	5

Other Electrical Properties (please specify below)

a.

b.

Friction and Wear Properties:
For friction and wear applications including brakes, clutches, bearings, guides, ways.

[ ]Did not circle "1" in Q3, move to next question.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this term
13	Compressive Yield Strength	1	2	3	4	5
24	Density	1	2	3	4	5
12	Compressive Modulus	1	2	3	4	5
31	Flexural Strength	1	2	3	4	5
38	Hardness	1	2	3	4	5
64	Tensile Modulus	1	2	3	4	5
43	Service Load (Stress) Maximum	1	2	3	4	5
28	Fatigue Strength	1	2	3	4	5
80	Wear Ratio	1	2	3	4	5
74	Thermal Conductivity	1	2	3	4	5
72	Thermal Coefficient of Expansion	1	2	3	4	5
10	Friction Coefficient	1	2	3	4	5
57	Specific Heat	1	2	3	4	5
61	Maximum Service Temperature	1	2	3	4	5
41	Machinability	1	2	3	4	5
51	Primary Constraining Property	1	2	3	4	5

Other Friction & Wear Properties (please specify below)

a.
b.

5A. **All materials can be divided into the following categories. For each one, please circle one answer to indicate how important it has been for you to have information about materials in that category for your work in the last 12 months.**

		Very Important	Somewhat Important	Not too Important	Don't need this at all
1	Cast Irons	1	2	3	4
2	Cast Steels	1	2	3	4
3	Carbon Steels	1	2	3	4
4	High Strength, Low Alloy Steels (HSLA)	1	2	3	4
5	Alloy Steels	1	2	3	4
6	Stainless Steels	1	2	3	4
7	Aluminum-Base Alloys	1	2	3	4
8	Magnesium-Base Alloys	1	2	3	4
9	Heat Resistant Alloys	1	2	3	4
10	Copper-Based Alloys	1	2	3	4
11	Titanium-Based Alloys	1	2	3	4
12	Miscellaneous Alloys (not classifiable above)	1	2	3	4
13	Plastics	1	2	3	4
14	Other Organic Chemicals	1	2	3	4
15	Inorganic Chemicals	1	2	3	4
16	Adhesives	1	2	3	4
17	Glass and Ceramics	1	2	3	4
18	Composites	1	2	3	4
19	Electronic materials	1	2	3	4

5B **Are there any other categories of materials which are at least somewhat important in you work?**

[ ]Yes, the following are also important in my work

PLEASE DESCRIBE:

[ ]No, no others of importance

5C. **Below is a list of specific materials which have been tentatively included in each of the categories listed in Q5A above. For each category of importance to you (either code 1 or code 2 circled in 5A above), please circle one answer to indicate how important information about that material has been for your work in the last twelve months. For each type material not important to you (neither code "1" nor "2" circled in Q5A), please check the box at the top of that group and move to the next group.**

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
Cast Irons						
[ ]Neither "1" nor "2" circled in Q5A.						
1	gray ASTM 48-30	1	2	3	4	5
2	gray ASTM 48-60	1	2	3	4	5
3	ductile ASTM 536 (80-55-6)	1	2	3	4	5
4	ductile ASTM 395 (60-45-15)	1	2	3	4	5
5	heat resist Grade HH	1	2	3	4	5
6	Other Cast Irons? (Please specify below)					
	a.					
	b.					
Cast Steels						
[ ]Neither "1" nor "2" circled in Q5A.						
1	Med. C. ASTM 27 (65-35)	1	2	3	4	5
2	Low Alloy 4335	1	2	3	4	5
3	Cr-Mo-V	1	2	3	4	5
4	Stainless CF-8	1	2	3	4	5
5	Stainless CA-15	1	2	3	4	5
6	Other Cast Steels? (Please specify below)					
	a.					
	b.					

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
Carbon Steels						
[ ]Neither "1" nor "2" circled in Q5A.						
1	1045	1	2	3	4	5
2	1095	1	2	3	4	5
3	1010	1	2	3	4	5
4	1020	1	2	3	4	5
5	Other Carbon Steels? (Please specify below)					
	a.					
	b.					
HSLA Steels						
[ ]Neither "1" nor "2" circled in Q5A.						
1	A242	1	2	3	4	5
2	VAN-80 (A715)	1	2	3	4	5
3	Gainex (Armco).	1	2	3	4	5
4	RQC-100	1	2	3	4	5
5	A441	1	2	3	4	5
6	A572	1	2	3	4	5
7	A514	1	2	3	4	5
8	A517	1	2	3	4	5
9	A515	1	2	3	4	5
10	Other HSLA Steels? (Please specify below)					
	a.					
	b.					

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Alloy Steels

[ ]Neither "1" nor "2" circled in Q5A.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
1	4130	1	2	3	4	5
2	4140	1	2	3	4	5
3	4320	1	2	3	4	5
4	4330	1	2	3	4	5
5	4335	1	2	3	4	5
6	4340	1	2	3	4	5
7	4620	1	2	3	4	5
8	5160	1	2	3	4	5
9	52100	1	2	3	4	5
10	6150	1	2	3	4	5
11	8620	1	2	3	4	5
12	8630	1	2	3	4	5
13	8735	1	2	3	4	5
14	9262	1	2	3	4	5
15	E9310	1	2	3	4	5
16	18 Ni Maraging 250	1	2	3	4	5
17	18 Ni Maraging 300	1	2	3	4	5
18	9 Ni, 4 Co, 0.2 C	1	2	3	4	5
19	H11 Modified	1	2	3	4	5
20	D6AC	1	2	3	4	5
21	Hytuf	1	2	3	4	5
22	300 M	1	2	3	4	5
23	Nitralloy 135	1	2	3	4	5
24	AMS 6418	1	2	3	4	5
25	5 Cr-Mo-V	1	2	3	4	5
26	HY80	1	2	3	4	5
27	HY130	1	2	3	4	5
28	Other Alloy Steels? (Please specify below)					
	a.					
	b.					

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Stainless Steels

[ ]Neither "1" nor "2" circled in Q5A.

1	302	1	2	3	4	5
2	304	1	2	3	4	5
3	304L	1	2	3	4	5
4	310	1	2	3	4	5
5	316	1	2	3	4	5
6	321	1	2	3	4	5
7	301	1	2	3	4	5
8	347	1	2	3	4	5
9	410	1	2	3	4	5
10	431	1	2	3	4	5
13	Nitronic 40	1	2	3	4	5
14	Nitronic 60	1	2	3	4	5
15	303	1	2	3	4	5
16	316L	1	2	3	4	5
17	416	1	2	3	4	5

18 Other Stainless Steel? (Please specify below)

a.

b.

PH Stainless Steels

[ ]Neither "1" nor "2" circled in Q5A.

1	17-4 PH	1	2	3	4	5
2	17-7 PH	1	2	3	4	5
3	PH 15-7 Mo	1	2	3	4	5
4	PH 13-8 Mo	1	2	3	4	5
5	15-5 PH	1	2	3	4	5
6	AM-350	1	2	3	4	5
7	Custom 450	1	2	3	4	5
8	Custom 455	1	2	3	4	5
9	AM-355	1	2	3	4	5

10 Other PH Steel? (Please specify below)

a.

b.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Aluminum-Base, Wrought

[ ]Neither "1" nor "2" circled in Q5A.

1	1100	1	2	3	4	5
2	1350	1	2	3	4	5
3	2014	1	2	3	4	5
4	2024	1	2	3	4	5
5	2219	1	2	3	4	5
6	3003	1	2	3	4	5
7	5052	1	2	3	4	5
8	5083	1	2	3	4	5
9	5154	1	2	3	4	5
10	5456	1	2	3	4	5
11	6061	1	2	3	4	5
12	6063	1	2	3	4	5
13	6101	1	2	3	4	5
14	7050	1	2	3	4	5
15	7075	1	2	3	4	5

16 Other Aluminum-Base, Wrought? (Please specify below)

a.

b.

Aluminum Base - Cast

[ ]Neither "1" nor "2" circled in Q5A.

1	242	1	2	3	4	5
2	A332	1	2	3	4	5
3	355	1	2	3	4	5
4	A356	1	2	3	4	5
5	A360	1	2	3	4	5
6	319	1	2	3	4	5
7	380	1	2	3	4	5
8	413	1	2	3	4	5
9	520	1	2	3	4	5
10	514	1	2	3	4	5
11	C355	1	2	3	4	5
12	356	1	2	3	4	5

13 Other Aluminum Base - Cast? (Please specify below)

a.

b.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Mg-Base Alloys

[ ]Neither "1" nor "2" circled in Q5A.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
1	HK31A-wgt	1	2	3	4	5
2	HM21A-wgt	1	2	3	4	5
3	ZK60A-wgt	1	2	3	4	5
4	AZ91C-cast	1	2	3	4	5
5	ZK61A-cast	1	2	3	4	5
6	AZ31B-wgt	1	2	3	4	5

7 Other Mg-Base Alloys? (Please specify below)
a.
b.

Heat-Resistant Alloys

[ ]Neither "1" nor "2" circled in Q5A.

1 Inconel 718 12345
2 Inconel 600 12345
3 Inconel 625 12345
4 Inconel X-750 12345
5 René 41 12345

6 Haynes 188 12345
7 Udimet 500 12345
8 A286 12345
9 Hastelloy C276 12345
10 Hastelloy B-2 12345

11 Haynes Stellite 25 12345
12 Hastelloy C-4 12345
13 B-1900 12345
14 Mar-M 200 12345
15 Incoloy 800 12345
16 Other Heat-Resistant Alloys? (Please specify below)
a.
b.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Copper Base - wgt

[ ]Neither "1" nor "2" circled in Q5A.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
1	CDA 101 OFHC	1	2	3	45	
2	CDA 102 OF	1	2	3	45	
3	CDA 103 OF,XLoP	1	2	3	45	
4	CDA 110 ETP	1	2	3	45	
5	CDA 120 DLP	1	2	3	45	
6	CDA 175 Be-Cu	1	2	3	45	
7	CDA 220 Comm Bz	1	2	3	45	
8	CDA 230 Red Br	1	2	3	45	
9	CDA 240 LoBr	1	2	3	45	
10	CDA 260 Cart Br	1	2	3	45	
11	CDA 510 P-Bz	1	2	3	45	
12	CDA 706 10 Ni	1	2	3	45	
13	CDA 715 30 Ni	1	2	3	45	
14	717 Ni-Silver (55-18)	1	2	3	45	
15	280 Muntz Metal	1	2	3	45	
16	360 FM Brass	1	2	3	45	
17	Other Copper Base - wgt? (Please specify below)					
	a.					
	b.					

Ti-Base

[ ]Neither "1" nor "2" circled in Q5A.

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material
1	Ti-6 Al-4V	1	2	3	4	5
2	unalloyed ASTM Gd2	1	2	3	4	5
3	unalloyed AST M Gd4	1	2	3	4	5
4	Ti-0.2Pd	1	2	3	4	5
5	Ti-5 Al-2.5 Sn	1	2	3	4	5
6	Other Ti-Base? (Please specify below)					
	a.					
	b.					

		Very Important	Somewhat Important	Not too Important	Don't need this at all	Don't know this material

Misc. Alloys

[ ]Neither "1" nor "2" circled in Q5A.

1	Nichrome	1	2	3	4	5
2	Invar	1	2	3	4	5
3	Kovar	1	2	3	4	5
4	Babbitt	1	2	3	4	5
5	Pb-Sn solder	1	2	3	4	5
6	3 1/4 Si-Fe, orient.	1	2	3	4	5
7	Cr-Si-Fe, non-or.	1	2	3	4	5
8	3.5 Cr mag. steel	1	2	3	4	5
9	Zn die cast AG40A	1	2	3	4	5
10	Zn die cast AC41A	1	2	3	4	5
11	Cb FS85	1	2	3	4	5
12	Mo TZM	1	2	3	4	5
13	Zirc 2	1	2	3	4	5
14	Berylli um	1	2	3	4	5

15 Other Misc. Alloys? (Please specify below)

a.

b.

Other Specific Materials - Not otherwise classified (Please specify below)

a.

b.

6. **Please indicate how you recommend handling each of the following issues involving alternative ways of gaining access to the desired data.**

A. **There are many synonymous (or almost synonymous) names or identification numbers for any given material. For each of the following designations, please indicate how desirable you feel it is to have it as one way of accessing information about the desired material stored in computer.**

		Must have as access alternative	Desirable as access alternative	Not necessary for access	Don't know this designation
1	Common Names or Trade Names	1	2	3	4
2	ASTM Designations	1	2	3	4
3	AISI Designations	1	2	3	4
4	UNS Designations	1	2	3	4
5	AMS Designations	1	2	3	4
6	SAE Designations	1	2	3	4
7	NEMA Designations	1	2	3	4
8	AGMA Designations	1	2	3	4
9	AA Designations	1	2	3	4
10	AWS Designations	1	2	3	4
11	ACI Designations	1	2	3	4
12	CDA Designations	1	2	3	4
13	A Registry Number	1	2	3	4
14	Military Spec Number	1	2	3	4
15	Federal Spec Number	1	2	3	4

16 Are there any other designations that should be used access any given materials(s)?

[ ]Yes, which ones?

[ ]No, no others needed

B. **Should "form" of material (e.g., bar, sheet, wire, etc.) be searchable?**

[ ]Yes, definitely
[ ]Possibly, but not sure
[ ]No, definitely not

C. **Should "Property Name" be a searchable parameter?**

[ ]Yes, Definitely
[ ]Possibly, but not sure
[ ]No, definitely not

D. **Which of the following comes closest to your point of view regarding the composition of an alloy?**

[ ]The system must be able to search for materials having a certain percentage of a particular element or group of elements

[ ]If the system simply provided a textual description of the full composition of a particular alloy (which could be displayed but not searched), that would be adequate

E. **Should a thesaurus of all the subject terms used in the data base be available as an index entry tool?**

[ ]Yes, Definitely
[ ]Possibly, but not sure
[ ]No, definitely not

F. **Please use this space to tell us any other things you would like to see used as ways of indexing and accessing information on materials properties.**

7. **Which of the following ways would you prefer to have the source of a data value presented?**

[ ]Would like to have the actual data source (i.e., the detailed reference) appear on the screen at the same time that the data value appears

[ ]Would like to see the generic source (e.g., NBS-OSRD or Marks'Handbook), but want nothing more to appear on the screen unless I specifically request it

[ ]Not necessary

[ ]Other (Please specify below)

____

____

APPENDIX B

EXISTENCE TABLE FOR INITIAL SET OF 5 ALLOYS
IN DESIGNATED SOURCES.

MATERIAL	UNS NO.	ASMH	SAH	MIL-5	SAE/J1099	DTDH
304	S30400	X	X			X
316	S31600	X	X			X
4340	G43400	X	X	X	X	X
17-4PH	S17400	X	X	X		X
A356	A13360	X	X	X		

ASMH - Aerospace Structural Metals Handbook, 5 vols. (Metals and Ceramics Information Center, Battelle Columbus Laboratories, Columbus, OH, 1983).

SAH - Structural Alloys Handbook, 2 vols. (Metals and Ceramics Information Center, Battelle Columbus Laboratories, Columbus, OH, 1983).

MIL-5 - Military Standardization Handbook, Metallic Materials and Elements for Aerospace Vehicle Structures, MIL-HDBK-5D, 2 vols. (available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphia, PA 19120).

SAE/J1099 - Technical Report on Fatigue Properties SAE Handbook J1099 (Society of Automotive Engineers, Warrendale, PA)

DTDH - Damage Tolerant Design Handbook (Metals and Ceramics Information Center, Battelle Columbus Laboratories, Columbus, OH, 1982)

APPENDIX C

REQUIRED PROPERTIES FOR EACH OF THE APPLICATION AREAS

PROPERTY	APPLICATION AREA			
	Structural	Structural	Structural	Heat
Mechanical Properties	Static	Dynamic	Temp-Dep.	Transfer
a.Tensile Properties				
Tensile Yield Strength	X	X	X	X
Tensile Ultimate Strength	X	X	X	X
Tensile Reduction in Area	X	X	X	
Tensile Elongation	X	X	X	X
Tensile Modulus	X	X	X	X
Strain Rate Exponent		X	X	
Tensile Stress-Strain Curve	X	X	X	
Poisson's Ratio	X	X	X	
b. Torsion Properties				
Yield Strength in Shear (Torsion)	X	X		
Ultimate Strength (Torsion)	X	X		
Torsion Modulus	X	X		
c. Compression Properties				
Compressive Yield Strength	X	X		
Compressive Modulus	X	X		
Compression Stress-Strain Curve	X	X		
Bulk Modulus	X	X		
d. Fatigue Properties				
Fatigue Strength		X		
Fatigue Strength Coefficient		X		
Fatigue Ductility Coefficient		X		
Fatigue Strength Exponent		X		
Cyclic Strength Coefficient		X		
Cyclic Strain Hardening Exponent		X		
Fatigue Ductility Exponent		X		
Cyclic Yield Strength		X		
Goodman Diagram		X		
e. Impact Properties				
Impact Strength - Charpy		X		
f. Fracture Related Properties				
Fracture Toughness,		X		
Notch Tensile Strength		X		
Fatigue Crack Propagation Rate		X		
Service Temperature Minimum		X	X	

g. Creep and Stress-Rupture Properties				
Stress-Rupture Strength			X	
Creep Strength			X	
Minimum Creep Rate			X	
h. Other Mechanical Properties				
Hardness	X	X	X	
Damping Capacity		X		
Thermal Properties				
Thermal Coefficient of Expansion			X	X
Thermal Conductivity			X	X
Service Temperature Maximum			X	
Melting Range			X	X
Emissivity				X
Continuous Service Temperature				X
Specific Heat				X
Other Physical Properties				
Density	X	X	X	X
Electrical Properties				
Electrical Resistivity				X
Environmental Properties				
Oxidation Resistance				
Potential Constraining Property	X	X	X	X

APPENDIX D

DESIGNATION CROSS REFERENCE DATA

MATERIAL DESIGNATIONS

COMMON	UNS	OTHER NAMES
304	S30400	AISI 304 CF-8
316	S31600	AISI 316 ASME CF8M 18-8 Mo SAE J405 (30316)
4340	G43400	AISI 4340 SAE 4340 SAE J404 (4340) SAE J412 (4340) SAE J770 (4340)
17-4PH	S17400	ASTM 630 Cb-7Cu-1 CB-7Cu
A356	A13560	ASTM SG70B AA356.0 SAE J452 (336) SAE J453 (336)
ADDIT. ORIGINALS		
304L	S30403	CF-3
2024	A92024	24S (obsolete) SAE J454 (2024) AA 2024
CLAD 2024	--	Clad 24S (obsolete) Alclad 2024
Ti-5Al-2.5Sn	R54520	A110AT HA-5137 MST-5Al-2.5 Sn RS110C, 5Al-2.5Sn ELI RMI 5Al-2.5Sn

APPENDIX E

MIST DATABASE APPLICATION AREAS

* Structural - Static

* Structural - Dynamic

* Structural - Temperature Dependent

* Heat Transfer

\+ Electrical

\+ Magnetic

\+ Friction and Wear

? Nuclear

? Explosive

? Thermochemical

? Optical

? Material Processing

* Initial areas of interest for Demonstration Stage I

\+ Areas contemplated for Demonstration Stage II

? Areas suggested by one or more users for eventual coverage

APPENDIX F

REQUIRED PROPERTIES FOR STRUCTURAL STATIC, DYNAMIC, TEMP. DEP.; HEAT TRANSFER APPLICATION AREAS

PROPERTY	SHORT NAME	5-CHAR. ABBREV.
Mechanical Properties		
a.Tensile Properties		
Tensile Yield Strength	TENS. YIELD STR	YS
Tensile Ultimate Strength	TENS. ULT. STR	UTS
Tensile Reduction in Area	RED. IN AREA	RA
Tensile Elongation	ELONG.	EL
Tensile Modulus	TENS. MOD	E
Strain Rate Exponent	STRAIN RATE EXP	SRX-m
Tensile Stress-Strain Curve	TENS. STR-STR CURVE	
Poisson's Ratio	POISS. RATIO	PR-nu
b. Torsion Properties		
Yield Strength in Shear (Torsion)	TORS. YIELD STR	YSST
Ultimate Strength (Torsion)	TORS. ULT. STR	USST
Torsion Modulus	TORS. MOD	G
c. Compression Properties		
Compressive Yield Strength	COMPR. YIELD STR	YSC
Compressive Modulus	COMPR. MOD	EC
Compression Stress-Strain Curve	COMPR. STR-STR CURVE	
Bulk Modulus	BULK MOD	BLKMD
d. Fatigue Properties		
Fatigue Strength	FAT. STR	FATST
Fatigue Strength Coefficient	FAT. STR. COEFF	FATSC
Fatigue Ductility Coefficient	FAT. DUCT. COEFF	FATDC
Fatigue Strength Exponent	FAT. STR. EXP	FATSX
Cyclic Strength Coefficient	CYCLIC STR. COEFF	CSTRC
Cyclic Strain Hardening Exponent	CYCLIC STR. HARD. EXP	CSHX
Fatigue Ductility Exponent	FAT. DUCT. EXP	FATDX
Cyclic Yield Strength	CYCLIC YIELD STR	CYYS
Goodman Diagram	GOODMAN DIA	
e. Impact Properties		
Impact Strength - Charpy	I E CHARPY V	ISCVN
f. Fracture Related Properties		
Fracture Toughness,	KIc	KIc
Notch Tensile Strength	NOTCH TENS. STR	NTS
Fatigue Crack Propagation Rate	da/dn	da/dn
Service Temperature Minimum	SVC. TEMP. MIN	SVTMN

g. Creep and Stress-Rupture Properties		
Stress-Rupture Strength	STR.-RUPT. STR	RPSTR
Creep Strength	CREEP STR	CRSTR
Minimum Creep Rate	MIN. CREEP RATE	MNCRR
h. Other Mechanical Properties		
Hardness	HARDNESS	HARD
Damping Capacity	DAMP. CAP	DMPCP
Thermal Properties		
Thermal Coefficient of Expansion	THERM. COEFF. EXP	THEXP
Thermal Conductivity	THERM. COND	THCON
Service Temperature Maximum	SVC. TEMP. MAX	SVTMX
Melting Range	MELT. RANGE	MLTRG
Emissivity	EMISSIVITY	EMISS
Continuous Service Temperature	CONT. SVC. TEMP	SVTCN
Specific Heat	SPEC. HEAT	SHTCP
Other Physical Properties		
Density	DENSITY	DENS
Electrical Properties		
Electrical Resistivity	ELECT. RES	ELRES
Environmental Properties		
Oxidation Resistance	OXID. RES	OXRES
Potential Constraining Property	POT. CONSTR. PROP	PCONP

APPENDIX G

EXISTENCE TABLE FOR MATERIAL-PROPERTIES MATRIX IN DATA SOURCES

6.3: MATERIAL - 4340

PROPERTY	DATA SOURCES				
	ASMH	SAH	MIL-5	SAE/ J1099	DAM-T
Mechanical Properties					
a.Tensile Properties					
Tensile Yield Strength	X	X	X	X	X
Tensile Ultimate Strength	X	X	X	X	X
Tensile Reduction in Area	X	X		X	
Tensile Elongation	X	X	X	X	
Tensile Modulus	X	X	X	X	
Strain Rate Exponent		X			
Tensile Stress-Strain Curve	X	X	X		
Poisson's Ratio	X	X	X		
b. Torsion Properties					
Yield Strength in Shear (Torsion)		X			
Ultimate Strength (Torsion)	X	X	X		
Torsion Modulus	X	X	X		
c. Compression Properties					
Compressive Yield Strength	X	X	X		
Compressive Modulus	X	X	X		
Compression Stress-Strain Curve	X	X	X		
Bulk Modulus					
d. Fatigue Properties					
Fatigue Strength	X	X	X	X	
Fatigue Strength Coefficient		X		X	
Fatigue Ductility Coefficient		X		X	
Fatigue Strength Exponent		X		X	
Cyclic Strength Coefficient					
Cyclic Strain Hardening Exponent		X		X	
Fatigue Ductility Exponent		X		X	
Cyclic Yield Strength		X		X	
Goodman Diagram	X	X			
e. Impact Properties					
Impact Strength - Charpy	X	X			
f. Fracture Related Properties					
Fracture Toughness,	X	X	X		X
Notch Tensile Strength	X	X			
Fatigue Crack Propagation Rate	X	X			X
Service Temperature Minimum					

g. Creep and Stress-Rupture Properties				
Stress-Rupture Strength	X	X		
Creep Strength		X		
Minimum Creep Rate				
h. Other Mechanical Properties				
Hardness	X	X		X
Damping Capacity				
Thermal Properties				
Thermal Coefficient of Expansion	X	X	X	
Thermal Conductivity	X	X	X	
Service Temperature Maximum				
Melting Range	X	X		
Emissivity			NOT REQUIRED	
Continuous Service Temperature			NOT REQUIRED	
Specific Heat			NOT REQUIRED	
Other Physical Properties				
Density	X	X		
Electrical Properties				
Electrical Resistivity			NOT REQUIRED	
Environmental Properties				
Oxidation Resistance	X			
Potential Constraining Property				

EXISTENCE TABLE FOR MATERIAL-PROPERTIES MATRIX IN DATA SOURCES

6.4: MATERIAL - 17-4PH

PROPERTY	DATA SOURCES ASMH	SAH	MIL-5	SAE/ J1099	DAM-T
Mechanical Properties					
a. Tensile Properties					
Tensile Yield Strength	X	X	X		X
Tensile Ultimate Strength	X	X	X		X
Tensile Reduction in Area	X	X	X		
Tensile Elongation	X	X	X		
Tensile Modulus	X	X	X		
Strain Rate Exponent					
Tensile Stress-Strain Curve	X	X	X		
Poisson's Ratio	X	X	X		
b. Torsion Properties					
Yield Strength in Shear (Torsion)	X	X			
Ultimate Strength (Torsion)	X	X			
Torsion Modulus	X	X	X		
c. Compression Properties					
Compressive Yield Strength	X		X		
Compressive Modulus	X		X		
Compression Stress-Strain Curve	X	X	X		
Bulk Modulus					
d. Fatigue Properties					
Fatigue Strength	X	X	X		
Fatigue Strength Coefficient					
Fatigue Ductility Coefficient					
Fatigue Strength Exponent					
Cyclic Strength Coefficient					
Cyclic Strain Hardening Exponent					
Fatigue Ductility Exponent					
Cyclic Yield Strength					
Goodman Diagram		X			
e. Impact Properties					
Impact Strength - Charpy	X	X			
f. Fracture Related Properties					
Fracture Toughness,	X	X			X
Notch Tensile Strength	X	X			
Fatigue Crack Propagation Rate	X	X			X
Service Temperature Minimum					

g. Creep and Stress-Rupture Properties			
Stress-Rupture Strength	X	X	
Creep Strength			
Minimum Creep Rate			
h. Other Mechanical Properties			
Hardness	X	X	X
Damping Capacity			
Thermal Properties			
Thermal Coefficient of Expansion	X	X	X
Thermal Conductivity	X	X	X
Service Temperature Maximum			
Melting Range	X		
Emissivity		NOT REQUIRED	
Continuous Service Temperature		NOT REQUIRED	
Specific Heat		NOT REQUIRED	
Other Physical Properties			
Density	X	X	X
Electrical Properties			
Electrical Resistivity		NOT REQUIRED	
Environmental Properties			
Oxidation Resistance			
Potential Constraining Property			

APPENDIX H

INDEPENDENT VARIABLES IN MIST DEMO DATABASE

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
Application Requirement		
	Application Requirement	
		hydraulic
		mechanical
		pressure
		pressure vessel
		structural
		welding
Composition		
	composition	
		per cent
		element name/element symbol
		content
		atomic fraction
		additions
Condition	COND or condition	ann
		all/{subclass name}
		any value below
/State of Cold Work		
	cold work	cw/cold worked
		/cold worked and stress relieved
		cd/cold drawn
		cr/cold rolled
		annealed and cold drawn/Ann. and CD
		CD to high tensile
/Temper	temper	tempered
		soft temper
		hard temper
		spring temper
		pre-stressed
		cold-finished
		hot-finished
/Heat Treatment	Ht Treatment	
		annealed/ann/A
		solution treated/ST
		water quenched/WQ
		air cooled/AC
		quenched and tempered/Q&T
		stress relieved
		solution and precipitation heat treated
		normalized and tempered

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
Condition contd.		
/Specific heat treatments		Code Nos. (e.g.,T-6, H1150M)
/Specific heat treatments →		may or maynot specify variable parameters
oil quenched, tempered and air cooled		OQ, T + AC
oil quenched and tempered		OQ + T
austenitized, oil quenched and tempered		A, OQ + T
/Sensitization	sensitization	sensitized
/Other Conditions	other COND	welded
		irradiated
		% cross-sectional area carburized
		as cast
Cycles		
	cycles/cycles to failure	N/cycles
Environment	environment	
/Gaseous		air
		H2
		relative humidity
		gas pressure
		argon/dry argon atm /100% humid argon
/Aqueous		seawater
		boiling MgCl2
		depth of ocean
		brackish water
Form	form	all forms
/Cast	cast	cast
		all cast forms/type of mold not restricted
		casting(s)
		centrifugal/centrifugally cast(ing)(s)
		chill (cast)
		continuous (cast)(ing)(s)
		die(cast)(ing)(s)
		investment (cast)(ing)
		permanent mold (cast)
		plaster (cast)(ing)

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
Form contd.		
/Cast	cast contd.	
		precision/precision investment (cast)
		premium grade(s)(cast)(ing)
		sand(cast)(ing)/sand mold/(with chills)
		special mold
		cast test bar
		bar cut from casting
		(cast)pipe
		(cast)plate(cast)
/General		
/Miscellaneous		
/Powder Metallurgy		
	powder metallurgy	
		HIP(ped)
		hot pressed
		sintered
/Welded	Welded	
		welded joint
		weld specimen
		weld metal
		weldment
	Welding Electrodes	
		bare
		coated
		covered stick
		rods
		(weld)wire
/Wrought	Wrought	all wrought products
		all wrought forms
		wrought products
//Drawn	drawn	
		(drawn) rod
		(drawn) tubing/tube
		(drawn) hydraulic(tubing)(tube)
		(drawn) mechanical(tubing)(tube)
		(drawn) seamless(tubing)(tube)
		(drawn) structural(tubing)(tube)
		(drawn)wire
		(drawn)bolting(wire)
		(drawn)cold heading(wire)
		(drawn)wire)
		(drawn)ire)
		(drawn)(cold finished)(wire)
		(drawn)spring(wire)
		(drawn)weld(wire)

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
//Extruded	extruded	
		(extruded)bar(extruded)
		extrusion(s)
		(extruded)pipe(extruded)
		(extruded)sections
		(extruded)shapes
		(extruded)strip
		(extruded)tubing/tube
		(extruded)hydraulic (tubing)(tube)
		(extruded)mechanical (tubing)(tube)
		(extruded)seamless(tubing)(tube)
		(extruded)structural
//Forged	forged	forging(s)
		(forged) bar(s)
		(forged) billet(s)
		(forged) log(s)
		(forged) plate(s)
		(forged) ring(s)
		(forged) shape(s)
//Rolled	rolled	all rolled products
		(rolled)bar(s)
		(rolled)billet(s)
		(rolled)bloom(s)
		(rolled)pipe(s)
		(rolled)pierced pipe
		(rolled)welded pipe
		(rolled)plate(s)
		(rolled)ring(s)
		(rolled)rod(s)
		(rolled)section(s)
		(rolled)shape(s)
		(rolled)sheet
		(rolled)clad (sheet)
		(rolled)coiled sheet/coil
		(rolled)flat sheet
		(rolled)foil (sheet)
		(rolled)skelp
		(rolled)slab(s)
		(rolled)strip(s)
		(rolled)tubing/tube
		(rolled)tubing(hydraulic)(pressure)
		(rolled)tubing(mechanical)
		(rolled)tubing(seamless)
		(rolled)tubing(structural)
		(rolled)tubing(welded)
		(rolled)wire
Microstructure	microstructure	
		grain size
		weld/weld metal
		base/base metal, parent metal

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
Processing		
/melting	melting(process)	
		air melt/air melted
		induction vacuum melt/vacuum induction melt
		consumable electrode melt/VAC-CE
		electroslag refined/ESR
		vacuum
		vacuum arc remelted/VAR
		argon-oxygen
		heat no.
/Casting	casting(process)	
		precision investment cast
		centrifugally cast
		permanent mold cast
		premium strength casting
		sand casting
/Working	working(process)	
		hot rolled/HR
		cold rolled/CR
		roto-rolled
		cross-rolled
/joining	joining	
		welded/as welded
Radiation	radiation dose(exposure)	
		integrated neutron flux
		neutron fluence
Size	size	in/cm/mm/ft/m
	thickness	
	outside diameter/OD	
	wall thickness	
	diameter	
	section size	
	depth	
	specimen size	
Strain	strain/% strain(in specified length)	
	cold reduction	%/percent
	tensile strain	
	strain	
	reduction by rolling	
	true strain	
	creep deformation	
	cyclic plastic strain range	
	plastic strain	

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
Strength	strength	
	tensile strength	
	yield strength	
	hardness	
Stress		
	applied stress	
	stress	
	stress ratio	
	stress concentration	
	stress intensity range	
	maximum stress	
	pre-stress	
Temperature		
	temperature/T	F/C/K
	test temperature	
	exposure temperature	
	aging temperature	
	stress relief temperature	
	annealing temperature	
	heat treat temperature	
	tempering temperature	
	austenitizing temperature	
Test Parameters		
/Rate effects		
	strain rate/ /epsilon dot	strain rate/ /{s epsilon_dot}
		cross-head rate
		true strain rate
/Sample orientation	direction/orientation	
		longitudinal/L
		transverse/T
		short transverse/ST
		axial
/Test bar	test bar	
		smooth
		notch(ed)
	notch root radius	
	notch depth	
/Test loading	(test)loading(type)	
		axial loading
		bending
		tensile loading
		compression loading

Independent Variable Class/Subclass	Independent Variable Name	Possible Values/Synonyms
/Test method	(test)method(of test)	
		static
		dynamic
		bend
		rotating cantilever
		cyclic creep
		constant load
		reversed bending
		Charpy V-notch
		Charpy keyhole
		Izod
Time	time	N sec/min/hour
	exposure time	
	time at temperature	
	test time	
	rupture time/time to rupture	

APPENDIX I

EXISTENCE TABLE FOR DATA FOR 172 SELECTED ALLOYS IN DESIGNATED SOURCES

DATA SOURCES INCLUDED :

Aerospace Structural Metals Handbook (ASMH)
Structural Alloys Handbook (SAH)
MIL-V Handbook (MILHBK 5)
Damage Tolerant Design Handbook (DTDH)
SAE - Pub. J1099

See Appendix B for Complete References

UNS NUMBER	COMMON MATERIAL DESIGNATION	PRINTED DATA SOURCE SAH	MIL-V HNDBK	ASMH	DTDH	SAE J-1099
Stainless Steels						
S20200	202	X		X		
S30100	301	X	X	X		
S30200	302	X		X		
S30300	303	X		X		
S30400	304	X		X	X	X
S30403	304L	X		X		
S31000	310	X		X		X
S31600	316	X		X	X	
S31603	316L	X				
S32100	321	X		X		
S34700	347	X		X	X	
S41000	410	X		X		
S41600	416	X		X		
S42000	420	X		X		
S43100	431	X		X		
S44004	440C	X		X		
S41800	Greek Ascoloy	X		X		
S21900	Nitronic 40 (21-6-9)	X		X		
S21800	Nitronic 60	X				
PH Stainless Steels						
S13800	PH 13-8Mo	X	X	X	X	
S15500	15-5PH	X	X	X	X	
S15700	PH 15-7Mo	X	X	X	X	
S17400	17-4PH	X	X	X	X	
S17700	17-7PH	X	X	X	X	
S35000	AM-350	X	X	X		X
S35500	AM-355	X	X	X	X	
S45000	Custom 450	X	X	X		
S45500	Custom 455	X	X		X	
Heat Resistant Alloys						
R30021	Haynes Stellite 21			X		
N07041	Rene' 41		X	X		
R30155	N-155		X			
R30188	Haynes 188		X	X		
?	Mar-M 246			X		
N07252	M-252		X	X		
S66286	A286		X	X	X	
N07500	Udimet 500		X	X		
N06600	Inconel 600		X	X	X	
R30605	L-605		X	X		
N06625	Inconel 625		X	X	X	
N09707	Inconel 706		X	X		
N07718	Inconel 718		X	X		
N07750	Inconel X-750		X	X		
N08800	Incoloy 800			X		
N08810	Incoloy 800-H			X		
?	B-1900			X		
N06002	Hastelloy X		X	X		

UNS NUMBER	COMMON MATERIAL DESIGNATION	PRINTED DATA SOURCE SAH	MIL-V HNDBK	ASMH	DTDH	SAE J-1099
Aluminum-Base, Wgt						
A91100	1100	X				X
A92014	2014	X	X	X	X	X
A92024	2024	X	X	X	X	X
A92124	2124		X	X	X	
A92219	2219	X	X	X	X	
A93003	3003	X				
A93004	3004	X				
A95052	5052	X	X	X		
A95083	5083	X	X			
A95086	5086	X				
A95456	5456	X	X	X		X
A96061	6061	X	X	X	X	
A96151	6151		X			
A97049	7049			X		
A97050	7050		X	X	X	
A97075	7075	X	X	X	X	X
A97175	7175			X		
A97178	7178	X				
A97475	7475			X		
Aluminum-Base, Cast						
A12010	A201		X			
A03540	354	X	X			
A03550	355	X	X	X		
A33550	C355	X		X		
A03560	356	X		X		
A13560	A356	X	X	X		
A13570	A357	X	X			
A03590	359	X	X			
A05200	520		X			
A07120	712		X			
?	K01	X		X		
Mg-Base Alloys						
M13210	HM21A-wgt	X	X	X		
M11311	AZ31B-wgt	X	X	X		
M13310	HK31A-wgt	X	X	X		
M16600	ZK60A-wgt	X	X	X		
M16610	ZK61A-cast	X		X		
M11914	AZ91C-cast	X	X	X		
Ti-Base Alloys						
R50400	Unalloyed, ASTM Gd 2	X	X	X		
R50700	Unalloyed, ASTM Gd 4	X	X	X		
R54520	Ti-5Al-2.5Sn	X	X	X	X	
R56400	Ti-6Al-4V	X	X	X	X	
R56620	Ti-6-6-2	X	X	X	X	

UNS NUMBER	COMMON MATERIAL DESIGNATION	SAH	PRINTED DATA SOURCE MIL-V HNDBK	ASMH	DTDH	SAE J-1099
Alloy Steels						
K24728	D6AC	X	X		X	
K91283	HP9-4-30	X	X	X	X	
?	H-11 Mod. (5Cr-Mo-V)	X	X	X	X	X
K14675	17-22A			X		
K31820	HY80	X				
K32045	HY100	X				
K51255	HY130 (5Ni-Cr-Mo-V)			X		
K24065	Nitralloy 135	X		X		
K92890	18 Ni Marag. 250	X		X	X	
K93120	18 Ni Marag. 300	X		X	X	
K44220	300 M	X	X	X	X	
G41300	4130	X	X	X		X
G41400	4140	X	X	X	X	X
G43200	4320	X				
K23080	4330V		X	X	X	
?	4335V		X	X		
G43400	4340	X	X	X	X	X
G46200	4620	X				
G61500	6150	X				
K32550	Hytuf(AMS 6418)	X	X		X	
G86200	8620	X				
G86300	8630	X	X	X		
G87350	8735		X			
G52986	52100	X		X		X
HSLA Steels						
K11510	A242 (1)	X				
K12211	A441	X				
K11646	A514 (H)	X				
K03101	A515/A515M(70)	X				
K11630	A517 (B)	X				
K12437	A537/A537M	X				
?	A572(Gd-50)	X				
Carbon Steels						
G10100	1010	X				
G10200	1020	X				
G10450	1045	X				
G10950	1095	X				

UNS NUMBER	COMMON MATERIAL DESIGNATION	PRINTED DATA SOURCE SAH	MIL-V HNDBK	ASMH	DTDH	SAE J-1099
Copper Base - Wgt						
C10100	CDA 101 OFHC	X				
C10200	CDA 102 OF	X				
C10300	CDA 103 OFXLoP	X				
C11000	CDA 110 ETP	X				
C12000	CDA 120 DLP	X				
C17500	CDA 175 Be-Cu	X	X			
C22000	CDA 220 Comm Bz	X				
C23000	CDA 230 Red Br	X				
C24000	CDA 240 LoBr	X				
C26000	CDA 260 Cart Br	X				
C28000	CDA 280 Muntz Metal	X				
C36000	CDA 360 FM Brass	X				
C51000	CDA 510 P-Bz	X				
C70600	CDA 706 10 Ni	X				
C71500	CDA 715 30 Ni	X				
C77000	CDA 717 Ni-Silver (55-18)	X				
Copper Base-Cast						
C86200	CDA 862---	X	X			
C86300	CDA 863 ¦- Mn Brz	X	X			
C86500	CDA 865---	X	X			
C90300	CDA 903---	X	X			
C90500	CDA 905 ¦	X	X			
C910000	CDA 910 ¦- Sn Brz	X	X			
C92200	CDA 922 ¦	X	X			
C92300	CDA 923---	X	X			
C95200	CDA 952---	X	X			
C95300	CDA 953 ¦- Al Brz	X	X			
C95400	CDA 954 ¦	X	X			
C95500	CDA 955---	X	X			
Misc. Alloys						
L13910	Babbitt					
R19920	Beryllium CR Sheet		X	X		
?	Beryllium-HP		X	X		
?	Cb FS 85			X		
K93600	Invar					
K94610	Kovar					
?	Lockalloy			X		
N06004	Nichrome					
R03640	Mo TZM			X		
L13630	Pb-Sn solder					
R60802	Zirc 2			X		

UNS NUMBER	COMMON MATERIAL DESIGNATION	SAH	PRINTED DATA SOURCE MIL-V HNDBK	ASMH	DTDH	SAE J-1099
Cast Steels						
J92600	Stainless CF-8	X				
J91150	Stainless CA-15	X				
J03001	Med. C, ASTM 27 (65-35)	X				
J42015	HY80-cast	X				
J13432	Low Alloy 4335M	X				
J93503	Grade HH, Heat Resistant	X				
Cast Irons						
F12101	Gray, ASTM 48-3	X				
F14101	Gray, ASTM 48-6	X				
F32800	Ductile, ASTM 395 (60-40-18)	X				
F33800	Ductile, ASTM 536 (80-55-6)	X				
F43000	Corr. & Heat Resist. (Ni-Resist, ASTM A439-D2)	X				

APPENDIX J

PERTINENT APPLICATION AREAS FOR 172 SELECTED ALLOYS

APPLICATION AREAS COVERED :

SS - Structural Static
SD - Structural Dynamic
STD - Structural Temperature Dependent
HTXF - Heat Transfer
EL - Electrical
MAG - Magnetic
F&W - Friction & Wear

UNS NUMBER	COMMON MATERIAL DESIGNATION	SS	SD	STD	HTXF	EL	MAG	F&W
		RELATED APPLICATION AREAS						
Stainless Steels								
S20200	202	X	X	X				
S30100	301	X	X	X	X			
S30200	302	X	X	X	X			
S30300	303	X	X	X	X			
S30400	304	X	X	X	X			
S30403	304L	X	X	X	X			
S31000	310	X	X	X	X			
S31600	316	X	X	X	X			
S31603	316L	X	X	X	X			
S32100	321	X	X	X	X			
S34700	347	X	X	X	X			
S41000	410	X	X	X	X			
S41600	416	X	X	X	X			
S42000	420	X	X		X			
S43100	431	X	X	X	X			
S44004	440C	X	X	X	X			
S41800	Greek Ascoloy	X	X	X				
S21900	Nitronic 40 (21-6-9)	X	X	X				X
S21800	Nitronic 60	X	X	X	X			X
PH Stainless Steels								
S13800	PH 13-8Mo	X	X	X	X			
S15500	15-5PH	X	X	X	X			
S15700	PH 15-7Mo	X	X	X	X			
S17400	17-4PH	X	X	X	X			
S17700	17-7PH	X	X	X	X			
S35000	AM-350	X	X	X	X			
S35500	AM-355	X	X	X				
S45000	Custom 450	X	X	X				X
S45500	Custom 455	X	X	X	X			
Heat Resistant Alloys								
R30021	Haynes Stellite 21	X	X	X	X			
N07041	Rene' 41	X	X	X	X			
R30155	N-155	X	X	X	X			
R30188	Haynes 188	X	X	X	X			
?	Mar-M 246	X	X	X	X			
N07252	M-252	X	X	X	X			
S66286	A286	X	X	X	X			
N07500	Udimet 500	X	X	X	X			
N06600	Inconel 600	X	X	X	X			
R30605	L-605	X	X	X	X			
N06625	Inconel 625	X	X	X	X			
N09707	Inconel 706	X	X	X	X			
N07718	Inconel 718	X	X	X	X			
N07750	Inconel X-750	X	X	X	X			
N08800	Incoloy 800	X	X	X	X			
N08810	Incoloy 800-H	X	X	X	X			
?	B-1900	X	X	X	X			
N06002	Hastelloy X	X	X	X	X			

UNS NUMBER	COMMON MATERIAL DESIGNATION	SS	SD	STD	HTXF	EL	MAG	F&W
Aluminum-Base, Wgt								
A91100	1100	X	X					
A92014	2014	X	X	X	X			
A92024	2024	X	X	X	X			
A92124	2124	X	X	X	X			
A92219	2219	X	X	X	X			
A93003	3003	X	X	X	X			
A93004	3004	X	X	X	X			
A95052	5052	X	X	X	X			
A95083	5083	X	X					
A95086	5086	X	X					
A95456	5456	X	X		X			
A96061	6061	X	X	X	X			
A96151	6151	X	X					
A97049	7049	X	X	X				
A97050	7050	X	X	X				
A97075	7075	X	X	X	X			
A97175	7175	X	X	X	X			
A97178	7178	X	X					
A97475	7475	X	X	X	X			
Aluminum-Base, Cast								
A12010	A201	X	X		X			
A03540	354	X	X					
A03550	355	X	X	X	X			
A33550	C355	X	X	X	X			
A03560	356	X	X	X	X	X		
A13560	A356	X	X	X	X			
A13570	A357	X	X		X			
A03590	359	X	X		X			
A05200	520	X	X		X			
A07120	712	X	X		X			
?	K01	X	X			X		
Mg-Base Alloys								
M13210	HM21A-wgt	X	X	X	X			
M11311	AZ31B-wgt	X	X	X	X			
M13310	HK31A-wgt	X	X	X	X			
M16600	ZK60A-wgt	X	X	X	X			
M16610	ZK61A-cast	X	X	X	X			
M11914	AZ91C-cast	X	X	X	X			
Ti-Base Alloys								
R50400	Unalloyed, ASTM Gd 2	X	X		X			
R50700	Unalloyed, ASTM Gd 4	X	X		X			
R54520	Ti-5Al-2.5Sn	X	X	X	X			
R56400	Ti-6Al-4V	X	X	X	X			
R56620	Ti-6-6-2	X	X					

UNS NUMBER	COMMON MATERIAL DESIGNATION	RELATED APPLICATION AREAS SS	SD	STD	HTXF	EL	MAG	F&W
Alloy Steels								
K24728	D6AC	X	X	X				
K91283	HP9-4-30	X	X	X				
?	H-11 Mod. (5Cr-Mo-V)	X	X	X	X			
K14675	17-22A	X	X	X	X			
K31820	HY80	X	X	X				
K32045	HY100	X	X	X	X			
K51255	HY130 (5Ni-Cr-Mo-V)	X	X	X	X			
K24065	Nitralloy 135	X	X		X			X
K92890	18 Ni Marag. 250	X	X	X	X			
K93120	18 Ni Marag. 300	X	X	X	X			
K44220	300 M	X	X	X				
G41300	4130	X	X	X	X			
G41400	4140	X	X	X	X			
G43200	4320	X						
K23080	4330V	X	X	X				
?	4335V	X	X	X	X			
G43400	4340	X	X	X	X			
G46200	4620	X	X					X
G61500	6150	X	X					
K32550	Hytuf(AMS 6418)	X	X	X				
G86200	8620	X	X	X				X
G86300	8630	X	X	X	X			X
G87350	8735	X	X					
G52986	52100	X	X					X
HSLA Steels								
K11510	A242 (1)	X	X	X	X			
K12211	A441	X	X	X				
K11646	A514 (H)	X	X	X				
K03101	A515/A515M(70)	X	X	X				
K11630	A517 (B)	X	X	X				
K12437	A537/A537M	X	X	X	X			
?	A572(Gd-50)	X	X	X	X			
Carbon Steels								
G10100	1010	X	X					
G10200	1020	X	X					
G10450	1045	X	X					
G10950	1095	X	X					

UNS NUMBER	COMMON MATERIAL DESIGNATION	RELATED APPLICATION AREAS						
		SS	SD	STD	HTXF	EL	MAG	F&W
Copper Base - Wgt								
C10100	CDA 101 OFHC	X	X		X	X		
C10200	CDA 102 OF	X	X		X	X		
C10300	CDA 103 OFXLoP	X	X		X	X		
C11000	CDA 110 ETP	X	X		X	X		
C12000	CDA 120 DLP	X	X		X	X		
C17500	CDA 175 Be-Cu	X	X	X	X	X		
C22000	CDA 220 Comm Bz	X	X		X			
C23000	CDA 230 Red Br	X	X		X			
C24000	CDA 240 LoBr	X	X		X	X		
C26000	CDA 260 Cart Br	X	X		X	X		
C28000	CDA 280 Muntz Metal	X			X	X		
C36000	CDA 360 FM Brass	X		X				
C51000	CDA 510 P-Bz	X			X	X		X
C70600	CDA 706 10 Ni	X			X	X		
C71500	CDA 715 30 Ni	X			X	X		
C77000	CDA 717 Ni-Silver (55-18)	X			X			
Copper Base-Cast								
C86200	CDA 862---	X			X			
C86300	CDA 863 ¦- Mn Brz	X	X		X			X
C86500	CDA 865---	X	X		X			X
C90300	CDA 903---	X			X			X
C90500	CDA 905 ¦	X	X		X			X
C910000	CDA 910 ¦- Sn Brz	X			X			X
C92200	CDA 922 ¦	X	X		X			X
C92300	CDA 923---	X			X			X
C95200	CDA 952---	X	X		X			
C95300	CDA 953 ¦- Al Brz	X	X		X			
C95400	CDA 954 ¦	X	X		X			
C95500	CDA 955---	X	X		X			
Misc. Alloys								
L13910	Babbitt	X			X			X
R19920	Beryllium CR Sheet	X		X	X			
?	Beryllium-HP	X	X	X	X			
?	Cb FS 85	X		X	X			
K93600	Invar	X						
K94610	Kovar	X						
?	Lockalloy	X	X	X	X			
N06004	Nichrome	X	X	X	X	X		
R03640	Mo TZM	X		X	X			
L13630	Pb-Sn solder	X			X			
R60802	Zirc 2	X	X	X	X			

UNS NUMBER	COMMON MATERIAL DESIGNATION	RELATED APPLICATION AREAS SS	SD	STD	HTXF	EL	MAG	F&W
Cast Steels								
J92600	Stainless CF-8	X	X	X	X			
J91150	Stainless CA-15	X	X	X	X			
J03001	Med. C, ASTM 27 (65-35)	X	X					
J42015	HY80-cast	X	X					
J13432	Low Alloy 4335M	X	X					
J93503	Grade HH, Heat Resistant	X	X	X	X			
Cast Irons								
F12101	Gray, ASTM 48-3	X	X	X	X			X
F14101	Gray, ASTM 48-6	X	X	X	X			X
F32800	Ductile, ASTM 395 (60-40-18)	X	X	X	X			X
F33800	Ductile, ASTM 536 (80-55-6)	X	X	X	X			X
F43000	Corr. & Heat Resist. (Ni-Resist, ASTM A439-D2)	X	X	X	X			X

APPENDIX K

DERIVED PROPERTIES

PROPERTY NAME	FORMULA
SPECIFIC_YIELD_STRENGTH	YIELD_STRENGTH / DENSITY
SPECIFIC_TENSILE_MODULUS	TENSILE_MODULUS / DENSITY
THERMAL_DIFFUSIVITY	THERMAL_CONDUCTIVITY / (DENS x SP.HEAT)
SPEED_OF_SOUND	(gE/p)EXP1/2
ACOUSTIC_IMPEDANCE	(gEp)EXP1/2
HOMOLOGOUS_TEMPERATURE	T(K) / (K),(Measuring Temp.)/(Melt. Pt.)
IMPACT_TRANSITION_TEMPERATURE*	Inflection Point of IS.f(T) curve
ELECTRICAL_RESISTIVITY	1 / ELECTRICAL_CONDUCTIVITY
ELECTRICAL_CONDUCTIVITY	1 / ELECTRICAL_RESISTIVITY
SPECIFIC_GRAVITY	DENSITY / DENSITY_OF_WATER (If DENSITY UNITS are lbs/ftEXP3, Divisor is 62.45; If DENSITY UNITS are grms/cc or kg/mEXP3 Divisor is 1.00)
SPECIFIC_VOLUME	1 / DENSITY
FLUIDITY	1 / DYNAMIC_VISCOSITY
WAVE_NUMBER	1 / WAVE_LENGTH
CRITICAL_CRACK_LENGTH	(1 / (pi))(FRACTURE_TOUGHNESS / Y.S)EXP2

Where g = gravitational constant, 9.806 650 m/sec^2
p = rho
* Do not use until curve strategy specified

APPENDIX L

DATA ELEMENTS IN MIST DATABASE

The following pages list the data elements present in six of the entity types, namely:

Name	Entity Name	Designation	No. of Pages
Exhibits	Sources	Rec 02	6
Terms	Terms	Rec 04	2
People	People	Rec 05	1
Citation	Bibliographic Citations	Rec 06	1
Databases	Databases	Rec 07	1
Data	Data	Rec 08	1

As with any dynamic database, additional data elements and entities will be added as time goes on.

```
  Element Characteristics as of 01/30/86 at 10:26:48
**** Record Type REC02 ******  SOURCES ************************

  0   SEC  OCC   LEN  TYPE    ST/EL        ELEMENT, ALIAS NAME(S)
  0   ---  ----  ---  ------  -----
  1   Req  Sing       Struc   00/00  key   SOURCE_STR
  2   Req  Sing       String  01/00  key   . database, source
  3   Req  Sing       String  01/01        . volume, chapter, section
  4   Req  Sing       String  01/02        . source_format, representation,
  4                                            source_type
  5   Req  Sing       String  01/03        . source_part, component, exhibit,
  5                                            figure, page, paragraph, table
  6   Req  Sing    4  Hex     01/04        . revision_date
  7   Req  Mult       Struc   00/01        AUDIT_TRAIL
  8   Fix  Sing    4  Hex     02/00  key   . mod_date
  9   Fix  Sing    2  Hex     02/01        . mod_time
 10   Fix  Sing    8  String  02/02        . mod_account
 11   Req  Sing       String  02/03        . mod_person
 12   Req  Sing       String  02/04        . mod_desc
 13   Req  Sing       String  00/02        modifier
 14   Req  Sing       String  00/03        mod_description
 15   Opt  Mult       String  00/04        review_status
 16   Opt  Mult       String  00/05        classification
 17   Opt  Mult       String  00/06        sigma_level
 18   Opt  Sing       String  00/07        page_number, page
 19   Opt  Sing       String  00/08        title
 20   Opt  Mult       Struc   00/09        VARIABLE_INFO
 21   Req  Sing       Struc   03/00  key   . VAR_NAME_EXT
 22   Req  Sing       String  04/00  key   . . variable_name, variable
 23   Opt  Sing       String  04/01        . . variable_exten, var_ext
 24   Opt  Mult       String  03/01        . variable_type
 25   Opt  Sing       String  03/02        . units
 26   Opt  Sing       String  03/03        . value_type
 27   Opt  Sing       String  03/04        . measure_method
 28   Opt  Sing       String  03/05        . fitting_method
 29   Opt  Sing       String  03/06        . measure_level
 30   Opt  Mult       String  03/07        . capture_method, data_capture
 31   Opt  Sing       String  03/08        . reliability_code
 32   Opt  Sing       String  03/09        . evaluation_meth
 33   Opt  Sing       String  03/0A        . evaluation_org
 34   Opt  Sing       String  03/0B        . evaluation_pers
 35   Opt  Sing       String  03/0C        . uncertainty
 36   Opt  Sing       String  03/0D        . signif_figures
 37   Opt  Sing       String  03/0E        . print_format
 38   Opt  Sing       String  03/0F        . missing_codes
 39   Opt  Mult       Struc   03/10        . REFERENCE_STR
 40   Req  Sing       String  05/00  key   . . reference_key, ref, ref_id,
 40                                              reference
 41   Opt  Sing       String  05/01        . . ref_page, page
 42   Vir  Sing       Struc   05/02        . . LINK_TO_REF
 43   Opt  Mult       String  03/11        . vtest_method, test_method
 44   Opt  Mult       String  03/12        . expert, contact, person_respon
 45   Opt  Mult       String  03/13        . organization
 46   Opt  Mult       Struc   03/14        . NOTE_STR
 47   Req  Sing       String  07/00  key   . . note, note_id, note_key,
 47                                              note_name
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 48   Opt  Sing      String  07/01        . . note_text, text
 49   Opt  Mult      String  03/15        . remarks
 50   Vir  Mult      Struc   03/16        . LINK_TO_PEOPLE
 51   Vir  Mult      Struc   03/17        . LINK_TO_ORG
 52   Vir  Mult      Struc   03/18        . LINK_TO_TEST
 53 ! Opt  Sing      String  00/0A        number_graphs
 54 ! Opt  Mult      Struc   00/0B        GRAPH_INFO
 55   Req  Sing      String  0B/00   key  . graph_id, graph
 56   Req  Mult      Struc   0B/01        . XY_INFO
 57   Req  Sing      String  0C/00   key  . . axis
 58   Req  Sing      String  0C/01        . . scale_type
 59   Req  Sing      Struc   0C/02        . . VAR_NAME_EXT
 60   Req  Sing      String  0D/00   key  . . . variable_name, variable
 61   Opt  Sing      String  0D/01        . . . variable_exten, var_ext
 62   Opt  Mult      Struc   0C/03        . . INSET_TEXT
 63   Req  Sing      String  0E/00   key  . . . type
 64   Opt  Mult      String  0E/01        . . . text
 65   Opt  Mult      String  0E/02        . . . xy_top_left
 66   Opt  Mult      String  0E/03        . . . xy_bot_left
 67   Opt  Mult      String  0E/04        . . . xy_top_right
 68   Opt  Mult      String  0E/05        . . . xy_bot_right
 69   Opt  Sing      String  0E/06        . . . justification
 70   Opt  Sing      String  0E/07        . . . case
 71   Opt  Sing      String  0C/04        . . scale_location
 72   Opt  Sing      String  0C/05        . . maximum_value
 73   Opt  Sing      String  0C/06        . . minimum_value
 74   Opt  Sing      String  0C/07        . . origin_value
 75   Opt  Mult      String  0C/08        . . axis_length
 76   Opt  Mult      String  0C/09        . . axis_length_unit
 77   Opt  Mult      String  0B/02        . number_quadrants
 78   Opt  Mult      String  0B/03        . graph_material, material,
 78                                         material_name
 79   Opt  Mult      Struc   0B/04        . INSET_TEXT
 80   Req  Sing      String  0F/00   key  . . type
 81   Opt  Mult      String  0F/01        . . text
 82   Opt  Mult      String  0F/02        . . xy_top_left
 83   Opt  Mult      String  0F/03        . . xy_bot_left
 84   Opt  Mult      String  0F/04        . . xy_top_right
 85   Opt  Mult      String  0F/05        . . xy_bot_right
 86   Opt  Sing      String  0F/06        . . justification
 87   Opt  Sing      String  0F/07        . . case
 88   Opt  Mult      Struc   0B/05        . GIND_VAR_INFO, GIND_INFO
 89   Req  Sing      Struc   10/00   key  . . VAR_NAME_EXT
 90   Req  Sing      String  11/00   key  . . . variable_name, variable
 91   Opt  Sing      String  11/01        . . . variable_exten, var_ext
 92 ! Opt  Sing      String  10/01        . . value
 93   Opt  Mult      Struc   0B/06        . REFERENCE_STR
 94   Req  Sing      String  12/00   key  . . reference_key, ref, ref_id,
 94                                           reference
 95   Opt  Sing      String  12/01        . . ref_page, page
 96   Vir  Sing      Struc   12/02        . . LINK_TO_REF
 97   Opt  Mult      String  0B/07        . note, qualifier_ptr
 98   Opt  Sing      String  0B/08        . n_point_sets
 99   Opt  Sing      String  0B/09        . n_curves
100   Opt  Mult      Struc   0B/0A        . POINT_INFO_STR, CURVE_INFO_STR
101   Req  Sing      String  14/00   key  . . point_set_id, curve, curve_id,
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 101                                                  curve_set, point_set
 102    Opt  Mult     String  14/01         . . curve_material, material,
 102                                              material_name, ps_material
 103    Opt  Mult     Struc   14/02         . . PIND_VAR_INFO
 104    Req  Sing     Struc   15/00   key   . . . VAR_NAME_EXT
 105    Req  Sing     String  16/00   key   . . . . variable_name, variable
 106    Opt  Sing     String  16/01         . . . . variable_exten, var_ext
 107  ! Opt  Sing     String  15/01         . . . value
 108    Opt  Mult     Struc   14/03         . . REFERENCE_STR
 109    Req  Sing     String  17/00   key   . . . reference_key, ref, ref_id,
 109                                                reference
 110    Opt  Sing     String  17/01         . . . ref_page, page
 111    Vir  Sing     Struc   17/02         . . . LINK_TO_REF
 112    Opt  Mult     String  14/04         . . note, qualifier_ptr
 113    Opt  Mult     Struc   14/05         . . INSET_TEXT
 114    Req  Sing     String  19/00   key   . . . type
 115    Opt  Mult     String  19/01         . . . text
 116    Opt  Mult     String  19/02         . . . xy_top_left
 117    Opt  Mult     String  19/03         . . . xy_bot_left
 118    Opt  Mult     String  19/04         . . . xy_top_right
 119    Opt  Mult     String  19/05         . . . xy_bot_right
 120    Opt  Sing     String  19/06         . . . justification
 121    Opt  Sing     String  19/07         . . . case
 122    Opt  Sing     String  14/06         . . point_set_type, curve_type,
 122                                              type
 123    Opt  Mult     String  14/07         . . line_type
 124    Opt  Sing     String  14/08         . . point_shape, symbol
 125    Opt  Sing     String  14/09         . . symbol_direction
 126    Opt  Sing     String  14/0A         . . point_fill, symbol_fill
 127    Opt  Mult     String  14/0B         . . ls_coefficients
 128    Opt  Mult     String  14/0C         . . spline_coeffs
 129    Opt  Sing     String  14/0D         . . ntuples, number_tuples, points
 130    Opt  Mult     Struc   14/0E         . . XY_PAIR, XY
 131  ! Opt  Sing     String  1A/00         . . . x_value, x
 132  ! Opt  Sing     String  1A/01         . . . y_value, y


 133  ! Vir  Mult     String  14/0F         . . curve_uns_code


 134  ! Vir  Mult     String  0B/0B         . graph_uns_code
 135    Opt  Mult     Struc   00/0C         TABLE_INFO
 136    Req  Sing     String  1B/00   key   . table_id, table
 137    Req  Sing     String  1B/01         . nrows
 138    Req  Sing     String  1B/02         . ncols
 139  ! Req  Sing     String  1B/03         . grouping, group, rec_grouping
 140  ! Opt  Mult     Struc   1B/04         . WHOLE_TABLE_INFO
 141  ! Opt  Mult     String  1C/00         . . table_material, material
 142    Opt  Mult     Struc   1C/01         . . TIND_VAR_INFO
 143    Req  Sing     Struc   1D/00   key   . . . VAR_NAME_EXT
 144    Req  Sing     String  1E/00   key   . . . . variable_name, variable
 145    Opt  Sing     String  1E/01         . . . . variable_exten, var_ext
 146  ! Opt  Sing     String  1D/01         . . . value
 147    Opt  Mult     Struc   1C/02         . . REFERENCE_STR
 148    Req  Sing     String  1F/00   key   . . . reference_key, ref, ref_id,
  48                                                reference
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 149    Opt  Sing       String  1F/01             . . . ref_page, page
 150    Vir  Sing       Struc   1F/02             . . . LINK_TO_REF
 151    Opt  Mult       String  1C/03             . . note, qualifier_ptr


 152 !  Vir  Mult       String  1C/04             . . table_uns_code, uns_code
 153    Opt  Mult       Struc   1B/05             . ROW_INFO
 154    Req  Sing       String  21/00  key        . . row
 155    Opt  Sing       String  21/01             . . format
 156    Opt  Mult       String  21/02             . . entry, entries
 157    Opt  Mult       String  21/03             . . rule, line
 158    Opt  Mult       String  21/04             . . row_material, material,
 158                                                  material_name
 159    Opt  Sing       Struc   21/05             . . CELL_VARIABLE, CELL, CELL_VAR,
 159                                                  property, property_name,
 159                                                  property_var
 160    Opt  Sing       Struc   22/00             . . . VAR_NAME_EXT
 161    Req  Sing       String  23/00  key        . . . . variable_name, variable
 162    Opt  Sing       String  23/01             . . . . variable_exten, var_ext
 163    Opt  Mult       Struc   21/06             . . RIND_VAR_INFO
 164    Req  Sing       Struc   24/00  key        . . . VAR_NAME_EXT
 165    Req  Sing       String  25/00  key        . . . . variable_name, variable
 166    Opt  Sing       String  25/01             . . . . variable_exten, var_ext
 167 !  Opt  Sing       String  24/01             . . . value
 168    Opt  Mult       Struc   21/07             . . REFERENCE_STR
 169    Req  Sing       String  26/00  key        . . . reference_key, ref, ref_id,
 169                                                    reference
 170    Opt  Sing       String  26/01             . . . ref_page, page
 171    Vir  Sing       Struc   26/02             . . . LINK_TO_REF
 172    Opt  Mult       String  21/08             . . note, qualifier_ptr


 173 !  Vir  Mult       String  21/09             . . row_uns_code, uns_code
 174    Opt  Mult       Struc   1B/06             . COLUMN_INFO
 175    Req  Sing       String  28/00  key        . . column, col
 176    Opt  Mult       String  28/01             . . col_material, material,
 176                                                  material_name
 177    Opt  Sing       Struc   28/02             . . CELL_VARIABLE, CELL, CELL_VAR,
 177                                                  property, property_name,
 177                                                  property_var
 178    Opt  Sing       Struc   29/00             . . . VAR_NAME_EXT
 179    Req  Sing       String  2A/00  key        . . . . variable_name, variable
 180    Opt  Sing       String  2A/01             . . . . variable_exten, var_ext
 181    Opt  Mult       Struc   28/03             . . CIND_VAR_INFO
 182    Req  Sing       Struc   2B/00  key        . . . VAR_NAME_EXT
 183    Req  Sing       String  2C/00  key        . . . . variable_name, variable
 184    Opt  Sing       String  2C/01             . . . . variable_exten, var_ext
 185 !  Opt  Sing       String  2B/01             . . . value
 186    Opt  Mult       Struc   28/04             . . REFERENCE_STR
 187    Req  Sing       String  2D/00  key        . . . reference_key, ref, ref_id,
 187                                                    reference
 188    Opt  Sing       String  2D/01             . . . ref_page, page
 189    Vir  Sing       Struc   2D/02             . . . LINK_TO_REF
 190    Opt  Mult       String  28/05             . . note, qualifier_ptr
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191 ! Vir  Mult   String  28/06        . . col_uns_code, uns_code
192   Opt  Mult   Struc   00/0D        PARAGRAPH_INFO
193   Req  Sing   String  2F/00   key  . paragraph, para, paragraph_id
194   Opt  Sing   String  2F/01        . parag_title, header, heading,
194                                        title
195   Opt  Mult   String  2F/02        . text
196 ! Opt  Mult   Struc   2F/03        . WHOLE_PARAG_INFO
197 ! Opt  Mult   String  30/00        . . pg_material, material
198 ! Opt  Mult   Struc   30/01        . . PGIND_VAR_INFO
199 ! Req  Sing   Struc   31/00   key  . . . VAR_NAME_EXT
200 ! Req  Sing   String  32/00   key  . . . . variable_name, variable
201 ! Opt  Sing   String  32/01        . . . . variable_exten, var_ext
202 ! Opt  Sing   String  31/01        . . . value
203 ! Opt  Mult   Struc   30/02        . . REFERENCE_STR
204 ! Req  Sing   String  33/00   key  . . . reference_key, ref, ref_id,
204 !                                          reference
205 ! Opt  Sing   String  33/01        . . . ref_page, page
206 ! Vir  Sing   Struc   33/02        . . . LINK_TO_REF
207 ! Opt  Mult   String  30/03        . . note, qualifier_ptr


208 ! Vir  Mult   String  30/04        . . pg_uns_code, uns_code
209 ! Opt  Mult   Struc   2F/04        . PROPERTY_INFO
210 ! Req  Sing   Struc   35/00        . . CELL_VARIABLE, CELL, CELL_VAR,
210 !                                       property, property_name,
210 !                                       property_var
211 ! Opt  Sing   Struc   36/00        . . . VAR_NAME_EXT
212 ! Req  Sing   String  37/00   key  . . . . variable_name, variable
213 ! Opt  Sing   String  37/01        . . . . variable_exten, var_ext
214 ! Req  Sing   String  35/01        . . property_value, value
215 ! Opt  Mult   Struc   35/02        . . PRIND_VAR_INFO
216 ! Req  Sing   Struc   38/00   key  . . . VAR_NAME_EXT
217 ! Req  Sing   String  39/00   key  . . . . variable_name, variable
218 ! Opt  Sing   String  39/01        . . . . variable_exten, var_ext
219 ! Opt  Sing   String  38/01        . . . value
220 ! Opt  Mult   String  35/03        . . prop_material, material,
220 !                                       material_name
221 ! Opt  Mult   Struc   35/04        . . REFERENCE_STR
222 ! Req  Sing   String  3A/00   key  . . . reference_key, ref, ref_id,
222 !                                          reference
223 ! Opt  Sing   String  3A/01        . . . ref_page, page
224 ! Vir  Sing   Struc   3A/02        . . . LINK_TO_REF
225 ! Opt  Mult   String  35/05        . . note, qualifier_ptr


226 ! Vir  Mult   String  35/06        . . prop_uns_code, uns_code
227 ! Opt  Mult   Struc   00/0E        LOCAL_QUALIFIERS, DATA_QUALIFIERS
228 ! Req  Sing   String  3C/00   key  . qualifiers_id, dq, footnote, lq,
228 !                                     qid, qualifiers
229 ! Opt  Mult   String  3C/01        . qual_text, text
230 ! Opt  Sing   String  3C/02        . units
231 ! Opt  Sing   String  3C/03        . value_type
232 ! Opt  Sing   String  3C/04        . measure_method
233 ! Opt  Sing   String  3C/05        . fitting_method
234 ! Opt  Sing   String  3C/06        . measure_level
235 ! Opt  Mult   String  3C/07        . capture_method, data_capture
```

```
 236 ! Opt  Sing       String  3C/08       . reliability_code
 237 ! Opt  Sing       String  3C/09       . evaluation_meth
 238 ! Opt  Sing       String  3C/0A       . evaluation_org
 239 ! Opt  Sing       String  3C/0B       . evaluation_pers
 240 ! Opt  Sing       String  3C/0C       . uncertainty
 241 ! Opt  Sing       String  3C/0D       . signif_figures
 242 ! Opt  Sing       String  3C/0E       . print_format
 243 ! Opt  Sing       String  3C/0F       . missing_codes
 244 ! Opt  Mult       Struc   3C/10       . REFERENCE_STR
 245 ! Req  Sing       String  3D/00  key  . . reference_key, ref, ref_id,
 245 !                                          reference
 246 ! Opt  Sing       String  3D/01       . . ref_page, page
 247 ! Vir  Sing       Struc   3D/02       . . LINK_TO_REF
 248 ! Opt  Mult       String  3C/11       . test_method
 249 ! Opt  Mult       String  3C/12       . expert, contact, person_respon
 250 ! Opt  Mult       String  3C/13       . organization
 251 ! Opt  Mult       Struc   3C/14       . NOTE_STR
 252 ! Req  Sing       String  3F/00  key  . . note, note_id, note_key,
 252 !                                          note_name
 253 ! Opt  Sing       String  3F/01       . . note_text, text
 254 ! Opt  Mult       String  3C/15       . remarks
 254
```

```
 ! Element Characteristics as of 01/30/86 at 10:26:48
 **** Record Type REC04 ******  TERMS    ************************

   0   SEC  OCC   LEN  TYPE    ST/EL          ELEMENT, ALIAS NAME(S)
   0   ---  ----  ---  ------  -----
   1   Req  Sing       String  00/00   key   term, key_term
   2   Req  Mult       Struc   00/01         AUDIT_TRAIL
   3   Fix  Sing    4  Hex     01/00   key   . mod_date
   4   Fix  Sing    2  Hex     01/01         . mod_time
   5   Fix  Sing    8  String  01/02         . mod_account
   6   Req  Sing       String  01/03         . mod_person
   7   Req  Sing       String  01/04         . mod_desc
   8   Req  Sing       String  00/02         modifier
   9   Req  Sing       String  00/03         mod_description
  10   Req  Sing       String  00/04         type
  11   Opt  Mult       String  00/05         review_status
  12   Opt  Mult       String  00/06         classification
  13   Opt  Mult       String  00/07         sigma_level

**************** GENERAL ELEMENTS SHARED BY ALL TYPES OF TERMS
  14   Opt  Sing       String  00/08         miser_index_code
  15   Opt  Mult       Struc   00/09         DEFINITIONS, DB_DEFINITIONS
  16   Req  Sing       String  02/00   key   . database
  17   Opt  Sing       String  02/01         . defined_by, authority
  18   Opt  Sing       String  02/02         . short_desc, synopsis, title
  19   Opt  Mult       String  02/03         . description, definition
  20   Opt  Mult       String  02/04         . label
  21   Opt  Mult       String  02/05         . abbreviation
  22   Opt  Sing       String  02/06         . standard_symbol, symbol
  23   Vir  Sing       Struc   02/07         . LINK_TO_ORGANIZN
  24   Opt  Mult       String  00/0A         broader_term, broader, bt
  25   Opt  Mult       String  00/0B         narrower_term, narrower, nt
  26   Opt  Mult       String  00/0C         related_term, related, rt
  27   Opt  Mult       String  00/0D         standard_term, main_term, use
  28   Opt  Mult       String  00/0E         alias, synonym
  29   Opt  Mult       String  00/0F         used_for
  30   Opt  Mult       String  00/10         application_area
  31   Opt  Mult       String  00/11         related_material
  32   Opt  Mult       String  00/12         citation_key, related_document
  33   Opt  Mult       String  00/13         expert, contact, contact_person
  34   Opt  Sing       String  00/14         date_defined, revised,
  34                                           revision_date
  35   Opt  Mult       Struc   00/15         NOTE_STR
  36   Req  Sing       String  04/00   key   . note, note_id, note_key,
  36                                             note_name
  37   Opt  Sing       String  04/01         . note_text, text

**************** TYPE = VARIABLE ELEMENTS
  38   Opt  Mult       String  00/16         valid_units, units,
  38                                           units_of_measure
  39   Opt  Sing       String  00/17         standard_units, siunits
  40   Opt  Sing       String  00/18         usual_units
  41   Opt  Mult       String  00/19         rqd_var, rqd_ind_var
  42   Opt  Mult       String  00/1A         max_on_line
  43   Opt  Mult       String  00/1B         min_on_line
  44   Opt  Mult       Struc   00/1C         FORMULA
```

```
  45   Req  Sing       String  05/00  key  . name
  46   Opt  Mult       String  05/01       . equation
  47   Opt  Mult       String  05/02       . text
  48   Opt  Mult       String  05/03       . parameter
  49   Opt  Sing       String  00/1D       assumed_range
  50   Opt  Sing       String  00/1E       rec_rounding
  51   Opt  Sing       String  00/1F       missing_specs
  52   Opt  Sing       String  00/20       dimensionality

**************** TYPE = MEASUREMENT UNIT ELEMENTS
  53   Opt  Sing       String  00/21       standard_unit
  54   Opt  Sing     4 Real    00/22       standard_convert, siconvert
  55   Opt  Sing       String  00/23       system
  56   Opt  Sing       String  00/24       domain

**************** TYPE = MATERIAL ELEMENTS
  57   Opt  Sing       String  00/25       uns_code
  58   Opt  Mult       Struc   00/26       CONSTRAINT_STR
  59   Req  Sing       String  06/00  key  . variable, conditional_var
  60   Req  Mult       Struc   06/01       . CONSTRAINT_INFO
  61   Req  Sing       String  07/00  key  . . constraint_var
  62   Req  Mult       String  07/01       . . constraint_short, constraint,
  62                                             warning_short
  63   Req  Mult       String  07/02       . . constraint_long, warning_long
  64   Opt  Mult       Struc   00/27       COMPOSITION
  65   Req  Sing       String  08/00  key  . type
  66   Req  Sing       String  08/01       . percentage_basis, basis
  67   Req  Mult       Struc   08/02       . ELEMENT_PCT
  68   Req  Sing       String  09/00  key  . . component
  69   Opt  Mult       String  09/01       . . aggregate_elems
  70   Opt  Sing       String  09/02       . . min
  71   Opt  Sing       String  09/03       . . max
  72   Opt  Sing       String  09/04       . . ratio
  73   Opt  Sing       String  09/05       . . ratio_ref_elem
  74   Opt  Mult       String  00/28       special_consid, considerations

**************** TYPE = ORGANIZATION ELEMENTS
  75   Opt  Mult       String  00/29       mail_stop
  76   Opt  Mult       String  00/2A       street_address
  77   Opt  Sing       String  00/2B       city
  78   Opt  Sing       String  00/2C       state, country
  79   Opt  Sing       String  00/2D       zip_code
  80   Opt  Mult       String  00/2E       telephone
  81   Opt  Mult       String  00/2F       special_interest
  82   Vir  Mult       Struc   00/30       LINK_TO_PEOPLE
  83   Vir  Mult       Struc   00/31       LINK_TO_CITATION
  84   Vir  Sing       String  00/32       pointer
  84
```

```
! Element Characteristics as of 01/30/86 at 10:26:48
**** Record Type REC05 ******  PEOPLE  *************************

  0   SEC  OCC   LEN  TYPE    ST/EL        ELEMENT, ALIAS NAME(S)
  0   ---  ----  ---  ------  -----
  1   Req  Sing       String  00/00  key   name
  2   Req  Mult       Struc   00/01        AUDIT_TRAIL
  3   Fix  Sing    4  Hex     01/00  key   . mod_date
  4   Fix  Sing    2  Hex     01/01        . mod_time
  5   Fix  Sing    8  String  01/02        . mod_account
  6   Req  Sing       String  01/03        . mod_person
  7   Req  Sing       String  01/04        . mod_desc
  8   Req  Sing       String  00/02        modifier
  9   Req  Sing       String  00/03        mod_description
 10   Opt  Mult       String  00/04        review_status
 11   Opt  Mult       String  00/05        classification
 12   Opt  Mult       String  00/06        sigma_level
 13   Opt  Mult       String  00/07        title
 14   Opt  Mult       String  00/08        department
 15   Opt  Sing       String  00/09        organization
 16   Opt  Mult       String  00/0A        mail_stop
 17   Opt  Mult       String  00/0B        street_address
 18   Opt  Sing       String  00/0C        city
 19   Opt  Sing       String  00/0D        state, country
 20   Opt  Sing       String  00/0E        zip_code
 21   Opt  Mult       String  00/0F        office_phone
 22   Opt  Mult       String  00/10        fts_phone
 23 ! Opt  Mult       String  00/11        email, elec_mail_addr
 24 ! Opt  Mult       String  00/12        expertise, subject_area
 25 ! Opt  Mult       String  00/13        remarks, comments
 26 ! Opt  Mult       String  00/14        publication, citation
 27 ! Vir  Sing       Struc   00/15        LINK_TO_ORGANIZN
 28 ! Vir  Mult       Struc   00/16        LINK_TO_CITATION
 28
```

! Element Characteristics as of 01/30/86 at 10:26:48
**** Record Type REC06 ****** BIBLIOGRAPHIC CITATIONS *******

0	SEC	OCC	LEN	TYPE	ST/EL		ELEMENT, ALIAS NAME(S)
0	---	----	---	------	-----		
1	Req	Sing		String	00/00	key	identifier, id
2	Req	Mult		Struc	00/01		AUDIT_TRAIL
3	Fix	Sing	4	Hex	01/00	key	. mod_date
4	Fix	Sing	2	Hex	01/01		. mod_time
5	Fix	Sing	8	String	01/02		. mod_account
6	Req	Sing		String	01/03		. mod_person
7	Req	Sing		String	01/04		. mod_desc
8	Req	Sing		String	00/02		modifier
9	Req	Sing		String	00/03		mod_description
10	Opt	Mult		String	00/04		review_status
11	Opt	Mult		String	00/05		classification
12	Opt	Mult		String	00/06		sigma_level
13	Opt	Sing		String	00/07		unstructured, literal, one_liner,
13							raw_text, string
14	Opt	Sing		String	00/08		title
15	Opt	Sing		String	00/09		publication_date, revision_date
16	Opt	Sing		String	00/0A		class
17	Opt	Mult		String	00/0B		author
18	Opt	Sing		String	00/0C		inside
19	Opt	Mult		String	00/0D		editor
20	Opt	Sing		String	00/0E		publisher
21	Opt	Mult		String	00/0F		address
22	Opt	Sing		String	00/10		volume
23	Opt	Sing		String	00/11		number
24	Opt	Sing		String	00/12		chapter, section
25	Opt	Sing		String	00/13		pages
26	Opt	Sing		String	00/14		abstract
27	Opt	Mult		String	00/15		remarks, comments
28	Opt	Sing		String	00/16		isbn
29	Opt	Sing		String	00/17		issn
30	Opt	Sing		String	00/18		version, change_date, edition
31	Opt	Mult		String	00/19		subject_term
32	Opt	Mult		String	00/1A		organization
33	Opt	Mult		String	00/1B		contract, contract_number
34	Opt	Mult		String	00/1C		cited_in
35	Vir	Sing		Struc	00/1D		LINK_TO_ORGANIZN
36	Vir	Mult		Struc	00/1E		LINK_TO_PEOPLE
37	Vir	Sing		Lctr	00/1F		pointer
37							

! Element Characteristics as of 01/30/86 at 10:26:48
***** Record Type REC07 ****** DATABASES ********************

0	SEC	OCC	LEN	TYPE	ST/EL		ELEMENT, ALIAS NAME(S)
0	---	----	---	------	-----		
1	Req	Sing		String	00/00	key	database_name, database, dbid
2	Req	Mult		String	00/01		database_type
3	Req	Mult		Struc	00/02		AUDIT_TRAIL
4	Fix	Sing	4	Hex	01/00	key	. mod_date
5	Fix	Sing	2	Hex	01/01		. mod_time
6	Fix	Sing	8	String	01/02		. mod_account
7	Req	Sing		String	01/03		. mod_person
8	Req	Sing		String	01/04		. mod_desc
9	Req	Sing		String	00/03		modifier
10	Req	Sing		String	00/04		mod_description
11	Opt	Mult		String	00/05		review_status
12	Opt	Mult		String	00/06		classification
13	Opt	Mult		String	00/07		sigma_level

```
 ! Element Characteristics as of 01/30/86 at 10:26:48
 **** Record Type REC08 ******  DATA    ************************

   0   SEC  OCC   LEN  TYPE    ST/EL        ELEMENT, ALIAS NAME(S)
   0   ---  ----  ---  ------  -----
   1   Req  Sing       Struc   00/00  key  REC08_KEY, REC08
   2   Req  Sing       String  01/00  key  . database, source
   3   Req  Sing       String  01/01       . volume, chapter, section
   4   Req  Sing       String  01/02       . source_format, representation,
   4                                           source_type
   5   Req  Sing       String  01/03       . source_part, component, exhibit,
   5                                           figure, page, paragraph, table
   6   Req  Sing       String  01/04       . source_subpart, col, curve,
   6                                           piece, row, subcomponent,
   6                                           subpart
   7   Req  Sing    4  Hex     01/05       . revision_date
   8   Req  Mult       Struc   00/01       AUDIT_TRAIL
   9   Fix  Sing    4  Hex     02/00  key  . mod_date
  10   Fix  Sing    2  Hex     02/01       . mod_time
  11   Fix  Sing    8  String  02/02       . mod_account
  12   Req  Sing       String  02/03       . mod_person
  13   Req  Sing       String  02/04       . mod_desc
  14   Req  Sing       String  00/02       modifier
  15   Req  Sing       String  00/03       mod_description
  16   Req  Mult       String  00/04       material
  17 ! Req  Mult       String  00/05       property, prop
  18 ! Req  Mult       String  00/06       entry, column, point, row
  19 ! Req  Mult       Struc   00/07       TUPLE
  20 ! Req  Sing       String  03/00  key  . variable_name, var, xvar
  21 ! Req  Mult       String  03/01       . value, datum
  22 ! Opt  Sing       String  03/02       . unique_values
  23 ! Opt  Mult       String  00/08       review_status
  24 ! Opt  Mult       String  00/09       classification
  25 ! Opt  Sing       String  00/0A       maxvals

**************** TYPE = MATERIAL ELEMENTS
  26 ! Vir  Mult       String  00/0B       uns_code
```

NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBS/SP-726	2. Performing Organ. Report No.	3. Publication Date November 1986

4. TITLE AND SUBTITLE

MATERIALS INFORMATION FOR SCIENCE AND TECHNOLOGY - PROJECT OVERVIEW

5. AUTHOR(S) Walter Grattidge, Jack Westbrook, John McCarthy, Clyde Northrup, John Rumble, Jr.

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
Gaithersburg, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered
Final

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

Same as item 6.

10. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number 86-600590

[ ] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report documents the initial phases of the MIST database, which is a demonstration project jointly supported by the Department of Energy and the National Bureau of Standards. The purpose of the Materials Information for Science and Technology (MIST) is to demonstrate the power and utility of computer access to materials property data. The initial goals include: to exercise the concept of a computer network of materials databases and to build a demonstration of such a system in a way as to be suitable for use as the core of operational systems in the future. Phases I and II are described in detail. In addition, a discussion is given of the expected usage of the databases.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

data capture; distributed data systems; engineering materials; materials databases; materials property data; numeric databases

13. AVAILABILITY

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14. NO. OF PRINTED PAGES
119

15. Price

USCOMM-DC 6043-P80

*U.S. Government Printing Office:1986-0-181-076 (40193)

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