Composites Databases for the 1990's

By:
Darrell H. Reneker
John M. Crissman
Donald L. Hunston

Polymers Division
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

NISTIR# 88-4016

Composites Databases for the 1990's

By:
Darrell H. Reneker
John M. Crissman
Donald L. Hunston

Polymers Division
National Institute of Standards and Technology
Gaithersburg, Maryland 20899

NISTIR# 88-4016

U.S. Department of Commerce
Robert A. Mosbacher,
Secretary

Ernest Ambler,
Acting Under Secretary
for Technology

National Institute of Standards and Technology
Raymond G. Kammer,
Acting Director

Issued February 1989

FOREWORD

The work described in this report was supported by the U.S. Army Strategic Defense Command under Military Interdepartmental Purchase Request Number W31RPD-8-P4059, 23 March 1988. Lamoyne Cochran was the technical point of contact at USASDC.

Much information for the report came from the COMAT Subcommittee on Composites. Dr. D. H. Reneker, a co-author of the report, is chairman of that subcommittee. (COMAT is the Committee on Materials of the Federal Coordinating Council on Science, Engineering and Technology, which is in the White House Science Adviser's Office, the Office of Science and Technology Policy.)

The report was reviewed by Dr. J. R. Rumble and Dr. Herzl Chai of the National Institute of Standards and Technology, and by Dr. Huddie Haller of the Defense Technical Information Center of the Defense Logistics Agency. Dr. Clyde Northrup (then at the Strategice Defense Initiative Organization and now at Sandia Corporation) gave the project direction in its early stages. Dr. E. L. Stanton of PDA Engineering, Costa Mesa, California, and Dr. J. G. Kaufman of the National Materials Property Data Network, Columbus, Ohio, were helpful in many ways. Many others at NIST, in other Federal Agencies, in industry, in universities, and in trade, professional, and standards organizations contributed information that is incorporated into the report. The information and advice from all these people are sincerely appreciated.

TABLE OF CONTENTS

COMPOSITES DATABASES FOR THE 1990'S

By

Darrell H. Reneker
John M. Crissman
Donald L. Hunston

Polymers Division, National Institute of Standards and Technology, Gaithersburg, Maryland 20899.

ABSTRACT

This report contains a draft standard for databases on the identification of polymer matrix composite materials and for reporting of test results. The draft standard is based on a comprehensive description of the flow of data through the polymer matrix composites community. Two essentially different kinds of databases are required, one oriented toward a particular group of data users, and one designed to make the collection of all kinds of data straightforward. An interactive dictionary to serve as a tool in the development of the best names is described. Relationships of the draft standard to various groups concerned with composites are noted.

KEY WORDS

Composites, polymer matrix composites, data, database, design data, structure, standards, dictionary, gateway network, user oriented database, collection oriented data base, expectations, pervasive rules.

ABOUT THE DRAFT STANDARD

GENERAL REMARKS

This draft standard describes the way data and technical information are generated and flow throughout the community that is involved in the manufacture of products from composite materials. The viewpoint of the standard is that of the technical people who provide and use the information that the system contains. The draft does not address the internal workings of the database management system.

A distinction is made between a collection oriented data base and a user oriented database. The need for human intervention to select, transform, and reformat data to serve the needs of various parts of the community is recognized.

The collection oriented data base is a "special library" that provides a computer searchable repository for a comprehensive, eclectic, and heterogeneous collection of information and data. Criteria for including submitted information are minimal, and present no barriers more difficult than the familiar review process for manuscripts. Information is collected in the format in which it is published or otherwise made available. As much as possible is converted to a computer readable form. The users of this database are expected to deal with journal articles, images, diagrams, technical language and conventions, computer protocols, and the like.

Research results and other new information are incorporated into the collection oriented data base. The rapid transfer of new ideas, research results, and other new information to the engineering and manufacturing part of the community is essential for the maintenance of a competitive composites industry.

The user oriented databases contain more specialized information, neatly arranged, regularly updated, and conveniently accessible in the course of the users' work. Much attention is paid to the quality of the data, to ensure that it meets the users' expectations.

Few users of specialized information will want to develop the skills needed to extract the information they routinely use from the collection oriented data base. This creates a need for expert authors of user oriented databases and for data flow managers who keep such databases filled with current information. These expert authors and data managers are cognizant both of the needs of the specialized area and the procedures for sorting relevant information out of the collection oriented data base. The efficiency of this is obvious if the number of users served by the creation and maintenance of a particular collection of information is large.

The database system is constructed to serve the efficient development of a large and complex materials industry. It is desirable to maintain flexibility in the development of policies. Therefore policy controls should be implemented through rules and software, and not in the fundamental structure of the databases.

EXPECTATIONS

One approaches the use of a technical reference book with certain expectations. A book has a title, an author, a publisher, a table of contents, chapters, page numbers, and so forth. In this draft standard we concentrate on similar attributes that are coming to be expected for a computerized information base for composites. The shared expectations about data systems are augmented by useful new things that can be done with computers. Human thought and intervention are called for where appropriate.

Attaching a more specific name to a database, such as "user oriented database" creates another set of expectations. In this case the existence of a group of users with a recognized set of needs is implied, and the contents of the database would be expected to be restricted to the information that this set of users would need.

The expected attributes make it easier to use all parts of the interacting and overlapping databases that are essential to the development of the field of composite materials.

PERVASIVE RULES

Pervasive rules are the articulations of the expected attributes. These rules provide guidance and constraint for both those supplying information to the database and those extracting useful data. Many parts of the system are free to be chosen by users or contributors. The user oriented parts of the system can be specialized to a particular computing environment, or to the practices of a particular company.

For the collection oriented data base the expectation that there is a person responsible for each set of information is served by requiring that a name be attached to each set. The expectation that contextual information is useful in the utilization of particular elements of information leads to the combination of elements into sets, and to the requirement that information can be traced to its source. The expectation that the contents of the system be understood leads to the requirement that each element have a natural language (English) name. The expectation that usage guides the development of the system requires the creation of records of the use patterns in a form accessible to the managers of the databases and to organizations concerned with the establishment of standards, recommended practices, authoritative lists, and the like.

These are all the expectations that span the community of those concerned with polymer matrix composites and are important enough to articulate in the form of rules now.

INTERACTIVE DICTIONARY, UTILITY SOFTWARE, OTHER OUTPUTS

The interactive dictionary is the place names can be recorded and defined by users, and where definitions of names can be found. It is not regarded as an authority, but as a tool for the development of accepted terminology.

Utility software provides a thesaurus, expert systems to aid searching and collection of specialized sets of information, statistical analysis packages, source and usage traces, and many other kinds of help.

Other outputs derived from or associated with the databases,, including journals, handbooks, bibliographies, and newsletters provide a transition between traditional practice and the much greater reliance on computers which is developing now.

COMMENT ON CURRENT PRACTICE

Creators of specialized databases in a particular company may acquire data from measurements made in test laboratories of the company. This is the current approach of typical aerospace companies. This approach keeps proprietary information under closer control, shortens the time required to get the information into the hands of the user, and can handle large volumes of information. These, and other benefits, suggest that user oriented databases derived from information obtained outside such a company will, for the foreseeable future, need to be augmented with data from measurements made locally, or vice versa.

Disadvantages of current practice are that each company must pay the entire cost of generating a complete set of data for each new material. Each company becomes bound by the idiosyncrasies of its own testing laboratory. Progress toward standardization of databases is impeded by the investment each company is making in the status quo. Comparisons of materials properties reported by others are confused by questions about variations in measurement procedures. New measurements that are outside the capability of the particular test laboratory are difficult to obtain. Research results from other laboratories do not flow naturally into the system. Terminology tends to ramify. Local dialects tend to develop and complicate communication. There is no efficient and timely method for introducing new ideas and research results.

WHAT IS IMPROVED BY THE PROPOSED SYSTEM?

The collection oriented data base provides access to a comprehensive collection of all forms of information about advanced polymer matrix composites.

The roles of expert authors of user oriented databases and data flow managers are emphasized. Such functions may be supported either as publishing operations, or as part of the database operations of a particular company performed by special librarians and technical information specialists.

New kinds of advanced composites information are introduced systematically and disseminated rapidly. A wide range of context and structure in the information is preserved.

A tool for the development of widely accepted terminology is provided by the interactive dictionary.

The collection oriented data base provides a resource for researchers, textbook authors, and authors of computer aided instructional programs. It reduces the number of buplicative research efforts and conserves resources.

A body of information useful for the creation of standards, policies, and other kinds of authority is provided in the collection oriented data base.

The roles of existing organizations are preserved and enhanced.

> (A chart, "Composites Databases for the 1990's" accompanies this draft. Specific areas on the chart are referred to by row (letter) and column (number). Numbers on the chart refer to paragraph numbers in the draft standard. The information in parentheses after the name of each organization refers to the location on the chart where the general interest of the organization is likely to be greatest.)

Examples of the interactions of existing organizations are described below with reference to the location on the attached chart where the general interest of each organization is likely to be greatest.

ASTM -- Expert authors and data managers, (B,3 to 5).

Suppliers of Advanced Composite Materials Association (SACMA) -- Involved in interactions between materials suppliers and manufacturers using composites which are indicated by the double arrows in Row D of the chart.

The High Temperature Materials Information Analysis Center of the Department of Defense (HTMIAC) -- The collection part of the HTMIAC is an example of some aspects of the collection oriented data base described in this report, (A,4 & 5).

The Composite Materials Corporation -- This group plans to share design data collected by a contract testing laboratory among several aerospace manufacturing companies, (C,4).

Military Handbook 17 -- This is expected to evolve into a database for materials selection and design in the aerospace industry. It is shown on the chart as being accessed through the MPD Network Gateway System, (B,6).

Materials Properties Data Network -- This non-profit corporation, now working closely with Chemical Abstracts, is providing gateway services to access several databases containing information about materials properties, (A,5).

Commercial creators and vendors of polymer matrix composite databases -- Databases that serve the needs of identified user groups working in specialized environments, for example to provide input into particular finite element analysis programs or to serve purchasing agents, are commercially available, (B,3 to 5).

Independent and in-house testing laboratories -- In the absence of a comprehensive and efficient collection oriented data base, most organizations are either relying almost entirely on data collected in their own testing laboratories, or on independent testing laboratories making measurements under contract. This situation fosters the inefficiency of measurements on the same material being repeated in many different laboratories. This draft standard is a step toward making data on composites more generally accessible, (B, 3 to 5) and all of Rows C and D.

^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^|^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

DRAFT STANDARD FOR DATABASES ON THE IDENTIFICATION OF POLYMER MATRIX COMPOSITE MATERIALS AND FOR REPORTING OF TEST RESULTS

COMMENTS

1.0 SCOPE

1.1 Coverage

This is a comprehensive standard which covers the identification of a polymer matrix composite, the entry of a wide variety of data into a database, the extraction of interesting and useful subsets of data, and the use of the subsets.

A composite is identified by the totality of all the things that are known about it. This includes the names of its chemical constituents, trade names, generic names, and as more specificity is sought, the numerical values of the results of every kind of measurement.

The question, "Is this composite material the same as that?" has only one general answer, and that answer is "No." The more interesting question, that is usually intended, is "For my purposes, is this material the same as that?" Computer software, that makes it easy to identify elements that are different, and to record the opinion of a user about each, can help a user answer this question.

1.2 Collection and User Orientations

This draft standard is in two parts. The first concerns the collection of information in computerized form. The second concerns databases that serve specialized needs of identified groups of users.

This division results from the need both to efficiently collect significant data and to create user oriented databases. (A,4&5; C,1 to 8; D,4&5)

2.0 APPLICABLE DOCUMENTS

ASTM Standards[1]

Military Handbook 17[2]

Department of Defense Program Plan[3]

The National Materials Property Data Network[4]

Advanced Materials Database User's Guide[5]

SDS Spacecraft Materials Selection Guide[6]

The Potential of Thermoplastic Composites for European Space Projects[7]

Materials Data Systems for Engineering[8]

Less formal documents, such as Cecil Parsons' paper[9] in the book, "Computerized Aerospace Materials Data" give more insight into the general problem and the flow of information that is required.

An example of a database system to serve the needs of those who redesign and repair military aircraft is provided by the Advanced Materials Database System[10]

3.0 SIGNIFICANCE AND USE

This draft standard provides guidelines for the contents of a comprehensive computerized collection of information needed for: 1) the research and development to create composites, 2) to design structures, objects, and devices made of composites, 3) to process the materials into the objects, and 4) other related purposes.

A comprehensive, integrated set of databases which are arranged in a way that data can flow from one to the other is needed. This information flow will not necessarily be easy. Often human judgement is required to select the particular data that is to be transferred into a specialized database.

Significant problems are brought to the attention of the research community by maintaining records of information sought but not found in the collection oriented data base.

Information about new approaches, improved materials, better measurement methods and data on materials of current interest flows toward those who need it, for the purposes of design, processing, sales, recycling, or whatever.

. . . .

4.0 THE COLLECTION ORIENTED PART OF THE DATABASE

4.1 Sets of Elements

Data is collected in sets of elements. One element of each set contains the name of the author or creator of the set.

Sets may be created in many ways, e.g., by collecting all sets which have a common element, or all which have a common set of elements. A collection of sets is a new set. (A,4&5)7

Sets keep information collected about a particular material connected together in a useful way. That is to say, contextual information is retained in the <u>collection oriented data base</u>.

Each composite has an unbounded number of properties. A particular composite material is most usefully characterized when a large number of the properties are known.

An example of an interesting set is all the sets of measurements made on a material with a particular trade name.

The requirement that the author's name be a part of the set is based on the expectation that this will provide a natural way for identifying many collections of information. Publishing of technical papers is author oriented. The desirable aspects of attaching a person's name and responsibility to a piece of work are sought here.

4.1.1 Manager of Collection Oriented Database

The manager of the collection oriented data base monitors inputs; monitors use; records and disseminates examples of information sought but not found; manages other outputs such as newsletters, journals, bibliographies and handbooks; manages the interactive dictionary; establishes generally recognized categories of elements. (A-4&5)

Hard copy collections in the form of journals or handbooks provide a transition between traditional practice and the much greater reliance on computers that is expected.

Most of these duties are placed in an appropriate context elsewhere in the draft standard or the comments.

Advice of experts, users, and interested parties would be utilized to define the manager's duties in more detail.

4.2 Definition of Elements

The elements of the set are defined by the author of the set. The choice of the elements reflects the interests and judgement of the author. (A,4&5)

Appendix 1 contains a set of element names that are related to structural design. These are suitable for incorporation into the collection oriented data base. Note that there is no hierarchical arrangement in this list.

The author of the set is responsible for deciding how to present the information gathered. It is important that authors be able to innovate and try out new ideas, in order to keep the database responsive to changing needs.

The database manager is responsible for keeping the database on the subject of composites, and can reject irrelevant information, or information that does not meet minimal standards for quality. In this capacity the database manager acts much as the editor of a technical journal.

4.3 Inclusiveness of Sets

All kinds of information are included in the sets. (A,4&5)

One author might supply information about the chemical composition, another about the costs of the ingredients, another about the parameters in a constitutive equation appropriate for the material.

Sets containing information about matrix properties, interface properties, and fiber properties would serve those who think of composites not as materials, but as structures. This allows such designers to specify fibers, tape, fabric, and the like exactly where they are needed. This would take advantage of fiber placement robots and avoid the constraints inherent in pre-specified arrangements of tape, fabric, random mat, or some other less controlled way of positioning the fibers.

The sets arrive in the database at different times, in a variety of sizes and are each incorporated into the collection oriented data base independently.

4.4 Contents of Elements

Elements contain a natural language name, and something else. Examples are:

- Name + text
- Name + number
- Name + number and units
- Name + matrix of numbers
- Name + computer aided design files.
- Name + pictures and images
- Name + sound
- Name + symbol

Name + other useful kinds of information, or combinations of those specifically mentioned above.

Name + hierarchical structures or other special arrangements of information.

Name + other databases.
(A,4&5)

English is the preferred natural language.

The names of elements should completely avoid acronyms, code, conventions and the like. The element names are intended to be understood with minimal use of the interactive dictionary described elsewhere. Acronyms, codes, mnemonics, and conventions are dealt with by creating elements such as "Layup according to conventions established by XXX", "Mnemonics according to Wwwwww system" and putting appropriate definitions in the interactive dictionary.

The database accommodates the way that experts think about each aspect of composite materials. Computer files incorporate, and make available, all kinds of information that have been found useful, along with any new kinds of information that are identified in the future.

The database minimizes constraints on the ways that experts think about composite materials.

Ordered arrangements of information that already exist are incorporated without losing the benefits attached to the order.

Other databases are given natural language names. Instructions about how to use the particular database, or how to access it through a gateway network might be an element of a set that contains a database.

4.5 Generally recognized categories of elements

The elements of the sets may fall into generally recognized categories, but no rigid hierarchical structure is imposed. (A,4&5)

The generally recognized categories may serve as guidelines that characterize the kind of information that is of interest to some users of the database, although the general way a user finds interesting sets is through the search utility software.

Examples of generally recognized categories appropriate for an advanced composites database include:

- Commercial names
- Chemical names
- Material identifiers
- Fiber names
- Matrix names
- Mechanical properties
- Electrical properties
- Statements about the statistics
- ...and many more.

The names of such categories are appropriate as part of the names for some of the elements in the set. Sets named in this way provide ways for utility software to connect the set to categories of interest to a database user, and to create hierarchical structures that help particular groups of users.

. . . .

4.6 Interactive Dictionary

The name of each element is included in an interactive dictionary which provides a definition of the name, its etymology, distinctions from other similar names, examples of usage of the name, pronunciation, part of speech, and other lexicographic information.

Part of the definition may consist of a bibliography that refers to papers that clarify the meaning and use of the name.

The interactive dictionary is developed cooperatively to record the current practice, the thinking and the results of discussions of those who are using and contributing to the development of the database.

The interactive dictionary is not regarded as an authority, but as a tool. (B,4)

A user of the interactive dictionary has many options, including using a name already in the interactive dictionary, or creating a new name if no appropriate name existed.

The management of the dictionary utilizes computer mail, bulletin boards, and other ways that are now becoming familiar for using the computer to communicate, reach a consensus, and keep accessible records.

The dictionary philosophy is inclusive. Decisions are guided by the rules of the English language and by usage.

The interactive dictionary should serve the goal of creating an adequate and compact technical terminology for the field of composite materials.

Authority is established in a separate consensus process based, in part, on analysis of usage. Element names designated by authority constitute a non-interactive list.

4.7 Completeness of Sets of Elements

A set is complete when the author of the set and the database manager agree that it is complete. (A,4&5)

This means that a set can be small. Authors doing research may have a limited amount of information which is of significance. Information should not be kept out of the database on the grounds of incompleteness.

On the other hand, authors need guidelines that encourage them to collect the largest set of interesting information that their resources permit. This follows from the fact that larger sets of information tend to be of greater use than small sets.

4.8 Maintenance of Sets

A set, once created, is changed in limited ways, or not at all. (B,4)

Sets no longer of interest can be removed and placed in an archive. (A,5)

A new set can refer to an existing set to make comments, record usage patterns, to extend the information, or otherwise supplement it.

4.9 Thesaurus and Other Utility Software

A thesaurus is included. Expert systems provide assistance to users. Utility software to compare materials, for statistical analysis, for index generation, for rapid searching, to create hierarchical arrangements and for other purposes is provided.

The thesaurus is a familiar example showing one way that the knowledge of experienced workers can be made available to the less experienced.

Expert systems and utility software provide other ways of accumulating experience to make the database of growing usefulness.

5.0 THE USER ORIENTED PART OF THE DATABASE

If a group of users share an interest in a specialized set of information, there are economies if smaller, more specialized, user oriented databases are created to serve the shared needs. The creation of a user oriented database requires the technical judgement of an expert user combined with skill in creating interesting collections of data. For example, in a design database, the expert author selects the types of data that are needed by the designers to be served, and provides interfaces with the computer software and hardware of the users. Maintenance of a user oriented database requires an expert user who is skillful in extracting information from the collection oriented data base and updating the user oriented database. Such a data flow manager periodically selects new data for incorporation into the Design database, and provides reliable descriptions of the quality of the data. (B,3 to 5)

In a particular manufacturing company a materials selection database, a design database, a processing database, a purchasing database, a product testing database, and others are probably needed. A user of one of these specialized databases may have limited need to be familiar with the others. If the specialized database is well designed and maintained, its typical user has little need to search the collection oriented data base, since that has already been done, and continues to be done by someone who understands the user's needs and point of view. (C,1 to 8; D,4&5)

This standard erects no arbitrary barriers to the use of the collection oriented data base by the ultimate user of the data, or anyone else who is willing to deal with the more complicated search procedures.

The design of the user oriented database depends on the specific needs of the group of users, while design of the collection oriented data base accommodates all kinds of information to serve many experts with a wide variety of interests. The needs of the users must be identified before a user oriented data base can be designed.

....

5.1 Significance and Use

The user oriented database contains highly reliable information for uses that have a direct effect on the day to day business of the user.

Company owned, user oriented databases typically have a private and a public component.

Government owned data bases may have both classified and unclassified components.

The reliability is ensured largely by the data flow manager of the specialized database. Elaborate procedures to ensure the expected reliability can be used, if appropriate. (B,3 to 5)

Data that provides a competitive advantage is typically private. Data from published sources, on commodity products, on discontinued product lines, or on products from foreign suppliers, are often not regarded as private, and could be added to the collection oriented data base.

5.2 Special Features

user oriented databases are shaped by experienced experts to serve the business practices of the user and the organization of which he is a part.

The creation of user oriented databases requires a high level of skills and insights. Parts of user oriented databases may be "off the shelf", but the parts that serve special needs must be created for each organization. (B,4&5)

The user oriented database must have special features that make it work well in the computing environment of the user's organization. Local conventions and practices of the user organization must be respected and utilized.

Special features are also needed to integrate data from the user oriented database is integrated with the computer graphics capabilities of the user organization. Data are made available in forms that are easy to use in large calculations which must be done again and again, such as finite element analysis. (C,1 to 8; D,4&5)

5.3 Standardization of User Oriented Databases

This standard is organized to make more pervasive standardization of <u>user oriented databases</u> a straight forward procedure.

Standardization is mandated for only a few essential features.

Provision is made for the addition of specialized elements and data by the user or his organization.

Standardization is desirable, but not necessary, for the acquisition of new data and for the contribution of information in the database to uses that extend beyond the immediate business application.

The optimal degree of standardization is affected by conflicting points of view.

An author of a <u>user oriented database</u>, who is interested in selling the database and maintaining it for the user, would be expected to be a strong advocate for standardization.

Those who are concerned with maintaining business secrets, or who want the database integrated into some particular computer system they are already committed to, may be less concerned with adhering to widely accepted standards.

5.3.1 Traceability to Information Sources

All information in a <u>user oriented database</u> that is derived from the <u>collection oriented data base</u> should be directly relatable to the appropriate element of the <u>collection oriented data base</u>.

Compliance is achieved if, for example, the manager of the <u>user oriented database</u> causes the definition for an element name he wishes to use to be added to the interactive dictionary.

The dictionary helps to keep the meanings of words the same in all the related data bases.

5.3.2 Records of Information Usage

Appropriate records of the use of the elements of data in the collection oriented data base should be automatically maintained. (A,5)

The purpose of this requirement is to allow the managers of the databases to improve them in response to the actions of the users.

6.0 EXAMPLE OF A USER ORIENTED DATABASE.

Some aspects of the user database can be standardized, to the benefit of users who hold common expectations about the content of a design database, or a materials selection database, or the like.

Standard user oriented databases need descriptive names, such as "Design", or "Materials Selection. The things to be standardized depend upon the particular purpose of the user oriented database. For this example, we have chosen "Design" as the purpose. Implicit in this example is a strong influence from the aerospace industry. (C,4)

A typical "Materials Selection" database would contain other kinds of information. It reflects the expectations of those, such as materials suppliers, concerned with the choice of materials and with alternative product possibilities.

6.1 Contents of a Standard Design Database

6.1.1 Contents of Design Databases

A design database contains information for materials identification and specification. (C,4)

Sources of the material would usually be included here. A vendor's designation, a batch number, and something about the processing are the sorts of things that may be included. The list may be long, if the designer has more responsibility for choosing materials, or short if he does not. The business policies of the designer's firm dominate such choices.

. . . .

6.1.2 Data Names and Values

A design database includes a list of design data names and values. Names from the interactive dictionary are desirable, but other names that are understood by the intended user are also accommodated by adding them to the interactive dictionary. (C,4)

Appendix 2 contains a list of element names suitable for a typical <u>user oriented database</u> for structural design. The elements are grouped in a two level hierarchy to serve anticipated needs of a structural designer.

For design databases now in use, this list may contain a few hundred items. Different databases give different names to similar items. It may be worth proposing standard names for about 10% of these. Specialized names will always be required to serve the needs of particular businesses. Standard categories that encompass most of the names that vary can probably be found, and here such a hierarchical arrangement is of value.

For many purposes, this list must be extended; for example to deal comprehensively with stiffness matrices, or with the properties of an isolated ply that are needed to calculate the properties of various arrangements of plys in laminates.

6.1.3 Data Quality

A design database includes elements that contain information about the quality of the data. (C,4)

The objective is to ensure that the quality of the data meets the users' expectations.

Quality may be expressed in terms of results from a statistical analysis of the data, or it may be a comment describing the source, or other information. Limits on values to be used in designs may be specified.

6.1.4 Information for Powerful Work Stations

A design database may include other information that makes full use of the capabilities of the work station. (C,4)

Examples are graphics for computer aided design, images, graphs, or almost anything else that can go into and out of a computer.

7.0 OTHER USER ORIENTED DATA BASES

Other user oriented databases contain a few standard categories. Some data names and standards in these categories are the same as those in the interactive dictionary. Others are specialized to the purposes of the firm or organization using the database.

A database for materials selection has categories for cost, materials identification purchase specifications, environmental impact and disposal information, a short list of properties, and specialized information. A database for materials processing has categories for process parameters, materials identification, properties monitored, and specialized information.

Materials suppliers require a complementary and overlapping set of databases which include raw material characterization, process control, product characterization, alternative product possibilities, and technical data. (D,4&5)

Alternative hierarchical arrangements can be generated from lists of element names such as that given in Appendix 1. Appendix 3 gives two examples. In the first example all the elements from Appendix 1 which contain the word "Toughness" are listed together. The second example lists the elements that contain the word "Strain" together.

Other examples of specialized databases are oriented toward organizations, such as a database for reference data at the National Institute of Standards and Technology, or a database to serve the needs of the Strategic Defense Initiative Organization for high temperature resistant polymer matrix composites.

8.0 SOURCES OF DATA FOR USER ORIENTED DATABASES

Much of the data in a user oriented database would flow from the collection oriented data base. (A,4&5) Other sources of data include:

Measurements made in the laboratories of the firm using the database. (C,1 to 8)

Data from application specific tests on the products fabricated with the material.

Laboratories who measure properties of materials on contract to the data user.

Materials supply companies. (D,4&5)

Published reports.

It is expected that this mix of data sources will persist indefinitely.

Data on materials of continued availability, or on materials of historical interest, should flow from the user oriented databases to the collection oriented data base. The transfer of such data to the collection oriented data base makes it available as a resource for other creators of user oriented databases, designers, engineers, and scientists.

Results from tests on parts which can be converted to a material property, such as a modulus, are particularly valuable. The modulus value determined from measurements on the part can be compared with modulus values in the database, as a check on both processing and the design of the part.

Much information and data are exchanged in interactions between a particular materials supplier and a particular manufacturer. This includes information for process control, characterization, and new product possibilities, in addition to data. Non-proprietary parts of this should be in the collection oriented data base.

Gateway networks provide a way for data to be gathered from scattered databases by the creators of user oriented databases. (A,5)

APPENDIX 1 **Element names related to structural design for the <u>collection oriented data base</u>.**

laminate specification
laminate manufacturer
laminate manufacturer's code number
laminate date of manufacture
laminate commercial designation
laminate architectural form
laminate two or three dimensional drawing
laminate layup code
laminate stacking sequence
laminate thickness dimension
laminate width dimension
laminate length dimension
laminate fiber volume
laminate polymer content by weight
laminate polymer content by volume
laminate specific gravity
laminate wet batch glass transition temperature
laminate dry batch glass transition temperature
laminate nondestructive testing results
laminate cure history
laminate post cure treatment
laminate test specimen identification
laminate test specimen two or three dimensional drawing
laminate test specimen numbering system
laminate test specimen layout data
laminate test specimen drawing
laminate test specimen location
laminate test specimen orientation
laminate test specimen cross sectional area
laminate test specimen thickness
laminate test specimen width
laminate test specimen length
laminate test specimen dimensional tolerance acceptance criteria
laminate test specimen gage length
laminate test specimen tab material
laminate test specimen tab adhesive
laminate test specimen tab thickness
laminate test specimen tab length
laminate test specimen conditioning temperature
laminate test specimen conditioning time
laminate test specimen conditioning relative humidity
laminate test specimen weight before conditioning
laminate test specimen weight after conditioning
laminate test specimen moisture absorption data to equilibrium
laminate test specimen moisture content at the failure point
laminate test method ASTM or other designation
laminate test method date
laminate test method location
laminate test method machine identification

laminate test method machine operator identification
laminate test method temperature
laminate test method relative humidity
laminate test method atmosphere
laminate test method load sensing device
laminate test method strain sensing device
laminate test method test machine control mode
laminate test method grip type and identification
laminate test method grip torque up conditions
laminate test method crosshead speed
laminate test method deviations from the standard test procedure
laminate test data for tensile modulus average value
laminate test data for tensile modulus standard deviation
laminate test data for tensile modulus coefficient of variation
laminate test data for compressive modulus average value
laminate test data for compressive modulus standard deviation
laminate test data for compressive modulus coefficient of variation
laminate test data for shear modulus average value
laminate test data for shear modulus standard deviation
laminate test data for shear modulus coefficient of variation
laminate test data for tensile strength average value
laminate test data for tensile strength standard deviation
laminate test data for tensile strength coefficient of variation
laminate test data for compressive strength average value
laminate test data for compressive strength standard deviation
laminate test data for compressive strength coefficient of variation
laminate test data for shear strength average value
laminate test data for shear strength standard deviation
laminate test data for shear strength coefficient of variation
laminate test data for strain at failure average value
laminate test data for strain at failure standard deviation
laminate test data for strain at failure coefficient of variation
laminate test data for Poisson's ratio average value
laminate test data for Poisson's ratio standard deviation
laminate test data for Poisson's ratio coefficient of variation
laminate test data delamination mode I fracture toughness
laminate test data delamination mode II fracture toughness
prepreg specification
prepreg manufacturer
prepreg manufacturer's code number
prepreg commercial designation
prepreg manufacturer's lot number
prepreg date of manufacture
prepreg drawing showing fiber layout
prepreg fiber content
prepreg fiber weight per unit area
prepreg fiber orientation
prepreg polymer solids content
prepreg volatiles content

prepreg void content
prepreg moisture content
prepreg specific gravity
prepreg polymer flow
prepreg gel time
prepreg gel process temperature
matrix material type
matrix material specification
matrix material chemical family
matrix material chemical name
matrix material manufacturer
matrix material manufacturer's code number
matrix material commercial designation
matrix material manufacturer's lot number
matrix material date of manufacture
matrix material specific gravity
matrix filler material type
matrix filler material weight percent
matrix filler material specific gravity
matrix material glass transition temperature
matrix material dynamic mechanical analysis results
matrix material liquid chromatography results
matrix material infrared spectroscopy results
matrix material differential scanning calorimetry results
matrix material test data for fracture toughness fatigue precrack maximum cyclic load
matrix material test data for fracture toughness fatigue precrack maximum cyclic stress intensity factor
matrix material test data for fracture toughness fatigue precrack cyclic load ratio
matrix material test data for fracture toughness fatigue precrack cycles to complete precracking
matrix material test data for fracture toughness fatigue precrack fatigue crack length at edge 1
matrix material test data for fracture toughness fatigue precrack fatigue crack length at center
matrix material test data for fracture toughness fatigue precrack fatigue crack length at edge 2
matrix material test data for fracture toughness determination loading rate
matrix material test data for fracture toughness determination test chart slope
matrix material test data for fracture toughness determination candidate load
matrix material test data for fracture toughness determination candidate plane strain fracture toughness
matrix material test data for fracture toughness determination maximum load
matrix material test data for fracture toughness determination maximum stress intensity factor
matrix material test data fracture toughness value

matrix material test data fracture toughness post test specimen total crack length at edge 1
matrix material test data fracture toughness post test specimen total crack length at center
matrix material test data fracture toughness post test specimen total crack length at edge 2
matrix material test data fracture toughness post test specimen average crack length
matrix material test data fracture toughness post test specimen obliqueness of final crack
matrix material test data fracture toughness post test specimen crack plane angle
matrix material test data fracture toughness validity indices
matrix material test data fracture toughness validity criteria
fiber type
fiber specification
fiber chemical name
fiber manufacturer
fiber manufacturer's code number
fiber commercial designation
fiber manufacturer's lot number
fiber date of manufacture
fiber architecture classification
fiber crystal type
fiber structure degree of crystallinity
fiber cross sectional shape
fiber cross sectional area
fiber specific gravity
fiber surface treatment coating type
fiber surface treatment coating thickness
fiber surface treatment post application treatment
fiber bundle architecture
fiber bundle length
fiber bundle filament number per bundle
fiber bundle number of yarns per bundle
fiber bundle number of ends per bundle
fiber bundle number of plies
fiber bundle number of filaments per ply
fiber bundle ply twist
fiber bundle twist direction
fiber bundle singles twist
fiber bundle singles twist direction
fiber bundle roving twist
fiber bundle roving twist direction
fiber bundle impregnation procedures
fiber test method ASTM or other designation
fiber test method for determining the static tensile modulus
fiber test method for determining the dynamic tensile modulus
fiber test procedure for calculating the static tensile modulus
fiber test procedure for calculating the dynamic tensile modulus
fiber test frequency for determining the dynamic tensile modulus
fiber test results for average value of the tensile load of

bundle at fracture

fiber test results for standard deviation of the tensile load of bundle at fracture

fiber test results for individual fiber breaking load

fiber test results for average value of tensile stress of bundle at fracture

fiber test results for standard deviation of tensile stress of bundle at fracture

fiber test results for type of tensile stress at fracture reported

fiber test results for average value of tensile modulus of bundle

fiber test results for standard deviation of tensile modulus of bundle

fiber test results for average value of tensile modulus of individual fiber

fiber test results for average value of tensile strength of bundle

fiber test results for standard deviation of tensile strength of bundle

fiber test results for average value of tensile strength of individual fiber

fiber test results for average value of tensile elongation of bundle at fracture

fiber test results for standard deviation of tensile elongation of bundle at fracture

fiber test results for observations on the relationship between fiber properties and flaw type and distribution

APPENDIX 2 **Hierarchical list of element names suitable for a <u>user oriented database</u> for structural design. (The elements for a particular database are to be selected after evaluation of the expectations of the users for whom the database is intended.)**

1.0 Laminate identification
- 1.1 specification
- 1.2 manufacturer
- 1.3 manufacturer's code number
- 1.4 date of manufacture
- 1.5 commercial designation
- 1.6 architectural form
- 1.7 two or three dimensional drawing
- 1.8 layup code
- 1.9 stacking sequence
- 1.10 thickness dimension
- 1.11 width dimension
- 1.12 length dimension
- 1.13 fiber volume
- 1.14 polymer content by weight
- 1.15 polymer content by volume
- 1.16 specific gravity
- 1.17 wet batch glass transition temperature
- 1.18 dry batch glass transition temperature
- 1.19 Nondestructive testing conclusions
- 1.20 cure history
- 1.21 post cure treatment

2.0 Laminate test specimen
- 2.1 type
- 2.2 identification
- 2.3 numbering system
- 2.4 layout data
- 2.5 two or three dimensional drawing
- 2.6 location
- 2.7 orientation
- 2.8 cross sectional area
- 2.9 thickness
- 2.10 width
- 2.11 length
- 2.12 dimensional tolerance acceptance criteria
- 2.13 gage length
- 2.14 tab material
- 2.15 tab adhesive
- 2.16 tab thickness
- 2.17 tab length
- 2.18 conditioning temperature

2.19 conditioning time
2.20 conditioning relative humidity
2.21 weight before conditioning
2.22 weight after conditioning
2.23 moisture absorption data to equilibrium
2.24 moisture content at the failure point

3.0 Laminate test
3.1 date
3.2 method
3.3 ASTM or other designation
3.4 location
3.5 machine identification
3.6 machine operator identification
3.7 temperature
3.8 relative humidity
3.9 atmosphere
3.10 load sensing device
3.11 strain sensing device
3.12 machine control mode
3.13 grip type and identification
3.14 grip torque up conditions
3 15 crosshead speed
3.16 deviations from the standard test procedure

4.0 Laminate test data for
4.1 tensile modulus average value
4.2 tensile modulus standard deviation
4.3 tensile modulus coefficient of variation
4.4 compressive modulus average value
4.5 compressive modulus standard deviation
4.6 compressive modulus coefficient of variation
4.7 shear modulus average value
4.8 shear modulus standard deviation
4.9 shear modulus coefficient of variation
4.10 tensile strength average value
4.11 tensile strength standard deviation
4 12 tensile strength coefficient of variation
4.13 compressive strength average value
4.14 compressive strength standard deviation
4.15 compressive strength coefficient of variation
4.16 shear strength average value
4.17 shear strength standard deviation
4.18 shear strength coefficient of variation
4.19 strain at failure average value
4.20 strain at failure standard deviation
4.21 strain at failure coefficient of variation
4.22 Poisson's ratio average value
4.23 Poisson's ratio standard deviation
4.24 Poisson's ratio coefficient of variation

4.25 delamination fracture energy at crack initiation
4.26 delamination fracture energy at large crack extension
4.27 delamination type of crack starter
4.28 delamination test loading rate
4.29 delamination test specimen fiber volume
4.30 delamination test orthotropic elastic constants
4.27 constitutive equation parameters

5.0 Prepreg
5.1 specification
5.2 manufacturer
5.3 manufacturer's code number
5.4 commercial designation
5.5 lot number
5.6 date of manufacture
5.6 fiber content
5.7 fiber weight per unit area
5.9 fiber orientation
5.10 drawing
5.11 polymer solids content
5.12 volatiles content
5.13 void content
5.14 moisture content
5.15 specific gravity
5.16 polymer flow
5.17 gel time
5.18 gel process temperature
5.19 constitutive equation parameters

6.0 Matrix material
6.1 type
6.2 specification
6.3 chemical family
6.4 chemical name
6.5 manufacturer
6.6 manufacturer's code number
6.7 commercial designation
6.8 lot number
6.9 date of manufacture
6.10 type of filler if any
6.11 weight percent filler
6.12 specific gravity of matrix material
6.13 specific gravity of matrix filler material
6.14 tensile modulus
6.15 shear modulus
6.16 yield stress
6.17 method of determining yield stress
6.18 rate at which the yield stress was determined
6.19 glass transition temperature
6.20 dynamic mechanical analysis results
6.21 liquid chromatography results

6.22 infrared spectroscopy results
6.23 differential scanning calorimetry results
6.24 plane strain fracture toughness
6.24.1 fatigue precrack maximum cyclic load
6.24.2 fatigue precrack maximum cyclic stress intensity factor
6.24.3 fatigue precrack cyclic load ratio
6.24.4 fatigue precrack cycles to complete precracking
6.24.5 fatigue precrack length at edge 1
6.24.6 fatigue precrack length at center
6.24.7 fatigue precrack length at edge 2
6.24.8 specimen configuration code
6.24.9 loading code
6.24.10 crack plane orientation code
6.24.11 test temperature
6.24.12 test relative humidity
6.24.13 test loading rate change in stress intensity factor per unit time
6.24.14 test load displacement record
6.24.15 test chart slope
6.24.16 test candidate load
6.24.17 test candidate plain strain fracture toughness
6.24.18 test maximum load
6.24.19 test maximum stress intensity factor
6.24.20 post test specimen crack length at edge 1
6.24.21 post test specimen crack length at quarter 1
6.24.22 post test specimen crack length at center
6.24.23 post test specimen crack length at quarter 2
6.24.24 post test specimen crack length at edge 2
6.24.25 post test specimen average crack length
6.24.26 post test specimen percent obliqueness of final crack
6.24.27 post test specimen fatigue crack plane angle
6.24.28 validity criteria indices
6.24.29 plane strain fracture toughness validity criteria
6.25 constitutive equation parameters

7.0 Reinforcement material
7.1 type
7.2 specification
7.3 chemical name
7.4 manufacturer
7.5 manufacturer's code number
7.6 manufacturer's commercial designation
7.7 manufacturer's lot number
7.8 date of manufacture
7.9 classification as to continuous or discontinuous fiber
7.10 crystal structure and degree of crystallinity
7.11 cross sectional shape
7.12 cross sectional area
7.13 specific gravity
7.14 surface treatment

- 7.14.1 coating type
- 7.14.2 coating thickness
- 7.14.3 post application treatment

7.15 fiber bundle

- 7.15.1 architecture
- 7.15.2 length
- 7.15.3 filament number per bundle
- 7.15.4 number of yarns or ends per bundle
- 7.15.5 number of plies
- 7.15.6 number of filaments per ply
- 7.15.7 ply twist
- 7.15.8 twist direction
- 7.15.9 singles twist
- 7.15.10 singles twist direction
- 7.15.11 roving twist
- 7.15.12 roving twist direction
- 7.15.13 impregnation procedures

7.16 test method

- 7.16.1 ASTM or other designation
- 7.16.2 for determining the static tensile modulus
- 7.16.3 for determining the dynamic tensile modulus
- 7.16.4 of calculating the static tensile modulus
- 7.16.5 of calculating the dynamic tensile modulus
- 7.16.6 test frequency of dynamic measurement

7.17 test results for

- 7.17.1 average value for tensile load of bundle at fracture
- 7.17.2 standard deviation of tensile load of bundle at fracture
- 7.17.3 individual fiber breaking load
- 7.17.4 average value of tensile stress of bundle at fracture
- 7.17.5 standard deviation of tensile stress of bundle at fracture
- 7.17.6 type of tensile stress at fracture reported
- 7.17.7 tensile modulus of bundle average value
- 7.17.8 tensile modulus of bundle standard deviation
- 7.17.9 tensile modulus of individual fiber
- 7.17.10 tensile strength of bundle average value
- 7.17.11 tensile strength of bundle standard deviation
- 7.17.12 tensile strength of individual fiber
- 7.17.13 tensile elongation of bundle at fracture average value
- 7.17.14 tensile elongation of bundle at fracture standard deviation
- 7.17.15 observations on the relationship between fiber properties and flaw type and distribution

APPENDIX 3 Alternative hierarchical arrangements of elements listed in Appendix 1 and Appendix 2.

The first example groups all the elements which contain the word TOUGHNESS together.

lamina test data delamination mode I fracture TOUGHNESS

lamina test data delamination mode II fracture TOUGHNESS

matrix material test data for fracture TOUGHNESS fatigue precrack maximum cyclic load

matrix material test data for fracture TOUGHNESS fatigue precrack maximum cyclic stress intensity factor

matrix material test data for fracture TOUGHNESS fatigue precrack cyclic load ratio

matrix material test data for fracture TOUGHNESS fatigue precrack cycles to complete precracking

matrix material test data for fracture TOUGHNESS fatigue precrack fatigue crack length at edge 1

matrix material test data for fracture TOUGHNESS fatigue precrack fatigue crack length at edge 2

matrix material test data for fracture TOUGHNESS fatigue precrack loading rate

matrix material test data for fracture TOUGHNESS determination test chart slope

matrix material test data for fracture TOUGHNESS determination candidate load

matrix material test data fracture TOUGHNESS value

matrix material test data fracture TOUGHNESS post test specimen total crack length at center

matrix material test data fracture TOUGHNESS validity indices

matrix material test data fracture TOUGHNESS validity criteria

The second example groups all the elements which contain the word STRAIN together.

lamina test method STRAIN sensing device

lamina test data for STRAIN at failure average value

lamina test data for STRAIN at failure standard deviation

lamina test data for STRAIN at failure

coefficient of variation matrix material test data for fracture toughness determination candidate plane STRAIN fracture

REFERENCES

1. "ASTM Standards and Literature References for Composites", ASTM Committee D-30 on High Modulus Fibers and Their Composites, published by ASTM, 1916 Race Street, Philadelphia, Pennsylvania 191103.

2. "Military Handbook 17", coordinated by Materials Exploitation Division, Materials Technology Laboratory, Department of the Army, Watertown, Massachusetts, 02172-0001.

3. "Department of Defense Program Plan for Composites Technology Standardization Area", Frank C. Traceski, U.S. Army Materials Technology Laboratory, Watertown, Massachusetts, 02172.

4. "National Materials Property Data Network", J. Gilbert Kaufman, 2540 Olentangy River Road., P.O. Box 0224, Columbus, Ohio 43202.

5. "Advanced Materials Data Base User's Guide", Sacramento Air Logistics Center, Advanced Composites Program Office, McClellan Air Force Base, California 95652-5320; Prepared by PDA Engineering, 2975 Redhill Ave, Costa Mesa California 92626, Contract No.: F04606-86-D-0021-P00001.

6. "SDS Spacecraft Materials Selection Guide" Air Force Wright Aeronautical Laboratory, Materials Laboratory, Wright Patterson Air Force Base, Ohio; Prepared by Ametek, Composite Materials and Applications Division, 2900 Blue Star Street, Anaheim, California 92806-2591.

7. "The Potential of Thermoplastic Composites for European Space Projects", C.A.E. Arnold, Prepared by Westland Aerospace for Fulmer Research Ltd. under European Space Agency Contract No. 7090/87/NL/PH; J. Scragg, Program Manager, Westland Aerostructures Limited, East Cowes, Isle of Wight, PO32 6RH.

8. "Materials Data Systems for Engineering" - The Proceedings of a CODATA Workshop held at Schluchsee, The Black Forest, Federal Republic of Germany, September 22-27, 1985; edited by J.H. Westbrook, H. Behrens, G. Dathe, S. Iwata. Copies available from Fachinformationszentrum, Karlsruhe, 7514 Eggenstein-Leopoldshafen 2, West Germany.

9. "Computerized Materials Property Data for the Aerospace Industry - A Boeing Perspective" Cecil Parsons in "Computerized Aerospace Materials Data" , Edited by J.H. Westbrook, and L.R. McCreight, Published by the American

Institute of Aeronautics and Astronautics, Inc. 1633 Broadwaqy, New York, N.Y. 10019, (1987).

10. "Advanced Materials Database System" by E.L. Stanton, T.E. Kipp, Jr., K.J. Meyer, PDA Engineering, 2975 Redhill Avenue, Costa Mesa, CA 92626-5923. For the Sacramento Air Logistics Center, Advanced Composites Program Office, McClellan Air Force Base, CA 95652-5320.

Distribution List

Dr. Donald F. Adams, Director
Composite Materials Research Group
University of Wyoming
Box 3295
Laramie, WY 82071

Mr. Rick J. Anderson-Decina
Cummins Engine Company, Inc.
Mail Code 50183, Box 3005
Columbus, IN 47202-3005

Director, U. S. Army Research
& Technology Laboratories
Ames Research Center
Attn: DAVDL-D, Dr. R. Carlson
Moffet Field, CA 94035

Director, U. S. Army Research
& Technology Laboratories
Ames Research Center
Attn: DAVDL-AL-D,
Dr. I. C. Statler, MS215-1
Aeromechanics Laboratory
Moffet Field, CA 94035

Mr. D. Robert Askins, KL 162
University of Dayton Research Institute
300 College Park Avenue
Dayton, OH 45469

Dr. Larry Atha
U. S. Army Strategic Defense Command
Attention DASD-H-LK
P. O. Box 1500
Huntsville, AL 35807

Mr. Craig A. Ballinger
Research Structural Engineer
Structures Division - HNR-10
U. S. Department of Transportation
Federal Highway Administration
6300 Georgetown Pike
McLean, VA 22101-2296

Dr. Charlie Bersch
Institute for Defense Analysis
1801 Beauregard Street
Alexandria, VA 22311

Dr. Michael Bowman
E.I. Dupont de Nemours & Co., Inc.
Composite Development Laboratory
Chestnut Run Laboratory
Wilmington, DE 19898

Dr. Harris Burte
USAF, Wright Aeronautical Laboratory
Wright Patterson AFB
Dayton, OH 45433

Mr. Charles E. Byvik
W. J. Schaffer Associates
Suite 800
1901 North Ft. Meyer Drive
Arlington, VA 22209

Mr. James F. Chaney
Senior Documentalist Researcher
Purdue University
2595 Yeager Road
West Lafayette, IN 47906

Mr. Stanley Channon
2361 Daventry Road
Riverside, CA 92506

Ms. Mary Clor
MPD Network
2540 Olentangy River Road
P. O. Box 02224
Columbus, OH 43202-9990

Mr. Lamoyne Cochran
USASDC
Attn: CSSD-H-LK
P. O. Box 1500
Huntsville, AL 35807-3801

Mr. Tom Coyle
General Dynamics Corporation
P. O. Box 748
Mail Zone 2160
Fort Worth, TX 76101

Dr. Thomas J. Dearlove
General Motors Technical Center
Polymer Department
Warren, MI 48090-9055

Commander
Defense Technical Information Center
Attn: DTIC-FDAC
Cameron Station, Bldg. 5
5010 Duke Street
Alexandria, VA 22304-6145

Mr. Paul J. Doyle
U. S. Army Materials Technology Laboratory
Watertown, MA 02172-0001

Ms. Cita M. Furlani
National Institute of Standards & Technology
Center for Manufacturing Engineering
Factory Automation Systems Division
Gaithersburg, MD 20899

Mr. Tim Gall
ASM International
Metals Park, OH 44073

Mr. James P. Gallivan
U. S. Army Materials Technology Laboratory
Watertown, MA 02172-0001

Dr. Joseph F. Garibotti
General Manager
Ametek
Composite Materials & Applications Div.
2900 Blue Star Street
Anaheim, CA 92806-2591

Mr. Louis A. Gonzalez
Program Manager, MMCIAC
Kaman Tempo
816 State Street
P. O. Drawer QQ
Santa Barbara, CA 93102-1479

Ms. Huddy B. Haller
Program Analyst
Defense Logistics Agency
Defense Technical Information Center
Research Information System (MATRIS)
San Diego, CA 92152-6800

Dr. Gary Hagnauer
Polymer Research Branch, SLCMT-EMP
Army Materials Technology Laboratory
Watertown, MA 02172-0001

Mr. Clayton Harmsworth
USAF, Wright Aeronautical Laboratory
Wright Patterson AFB
Dayton, OH 45433

Mr. Richard H. Hartke
Director, Technology Programs
Aerospace Industries Association
1250 Eye Street, NW
Washington, DC 20005

Mr. Greg Henderson
Mail Zone 2899
P. O. Box 748
Ft. Worth, TX 76101

Dr. Cho-Yen Ho
Director, HTMIAC/CINDAS
Purdue University
2595 Yeager Road
West Lafayette, IN 47906

Mr. William Hong
Institute for Defense Analysis (IDA)
Science & Technology Division
1801 N. Beauregard Street
Alexandria, VA 22311

Mr. Brian Hunter
Deputy Commander
U. S. Army Strategic Defense Command
Attn: CSSD-H-LK
P. O. Box 1500
Huntsville, AL 35807-3801

Mr. Joseph C. Jackson
Executive Director, SACMA
1600 Wilson Blvd., Suite 1008
Arlington, VA 22209

Dr. Conor Johnson
CSA Engineering, Inc.
560 San Antonio Road
Suite 101
Palo Alto, CA 94306

Mr. Phil Johnson
SRS Technologies
990 Explorer Blvd., NW
Huntsville, AL 35806

Dr. J. G. Kaufman
National Materials Property Data Network, In
2540 Olentangy River Road
P. O. Box 02224
Columbus, OH 43202

Mr. James Kelly
Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, VA 22209

Mr. Frank Key
Materials Processes Technical
Information System
Space Science Laboratory
Marshall Space Flight Center
Huntsville, AL 35812

Dr. J. K. Lees
Composite Development Laboratory
Chesnut Run Laboratory
Wilmington, DE 19898

Ms. Karen Lewis
Boeing Computer Services
TMIS Project
1801 Alexander Bell Drive, 5th Floor
Reston, VA 22091

Dr. James W. McCauley
U. S. Army Materials Technology Laboratory
Materials Characterization Division
Watertown, MA 02172

Mr. Blair C. Maddock
Engineer-Finishes & Processes
Lockheed-Georgia Company
Marietta, GA 30063

Mr. Bernard Maggin
Aeronautics and Space Engineering Board
Commission on Engineering and Technical Systems
2101 Constitution Avenue
Washington, DC 20418

Mr. George A. Matzkanin, Director
Southwest Research Institute
P. O. Drawer 28510
San Antonio, TX 78284

Dr. Alan G. Miller
Manager, Chemical Technology
Boeing Commerical Airplane Company
P. O. Box 3707, MS 73-74
Seattle, WA 98124-2207

Mr. Harold Mindlin
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Dr. B. J. Moniz
E. I. Dupont de Nemours & Co., Inc.
Box 6090
Newark, DE 19714-6090

Dr. Daniel R. Mulville
Materials & Structures Division
NASA Headquarters
600 Independence Avenue
Washington, DC 20546

Mr. John Nardone, Chief
Plastics Technical Evaluation Center
SMCAR-AET-O
U. S. Army Armament R&D Center
Picatinny Arsenal
Dover, NJ 07801-5001

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Ms. Crystal Newton
Materials Sciences Corporation
Gwynedd Plaza II, Bethlehem Pike
Spring House, PA 19477

Mr. Chris Nuney
Cencad Services, Inc.
P. O. Box 5968
Garden Grove, CA 92645

Mr. Cecil Parsons
Boeing Commercial Airplane Company
P. O. Box 3707, MS 73-74
Seattle, WA 98124

Mr. Jerry Persh
Office of the Undersecretary of Defense
for Research and Engineering
Room 3D1039
The Pentagon
Washington, DC 20301

Prof. Byron Pipes
Dean of Engineering
University of Delaware
Newark, DE 19716

Mr. J. T. Quinlivan
Boeing Commercial Airplane Co.
P. O. Box 3707, MS 4456
Seattle, WA 98124-2207

Mr. Michael J. Ramos
Project Engineer
Advance Composites Program Office
McClelland Air Force Base, CA 95652-5320

Prof. Kenneth L. Reifsnider
Reynolds Metals Professor
Engineering Science and Mechanics
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

Dr. Theodore J. Reinhart
Chief, Materials Engineering Branch
Systems Support Division
Attn: MLSE
Air Force Aeronautical Laboratories
Wright Patterson AFB
Dayton, OH 45433-6533

Mr. Michael Rigden
Institute for Defense Analysis
1801 N. Beauregard Street
Alexandria, VA 22311

Mr. Walt Rosen
President
Materials Sciences Corporation
Gwynedd Plaza, II, Bethlehem Pike
Spring House, PA 19477

Dr. John Rumble, Jr.
National Institute of Standards and Technology
Materials Properties Data
Physics Bldg., Rm. A323
Gaithersburg, MD 20899

Mr. Abbe Scheiner
Plaspec
633 Third Avenue
New York, NY 10017

Dr. Don A. Scola
United Technologies Research Center
Hartford, CT 06101

Mr. Jim Scragg
Program Manager - Space Programs
Westland Aerostructures Limited
East Cowes, Isle of Wight
England PO32 6RH

Dr. J. C. Seferis
Polymeric Composites Laboratory
Department of Chemical Engineering
University of Washington
Seattle, WA 98195

Mr. Bradford Smith
Chairman, IGES/PDES
National Institute of Standards & Technology
Bldg. 233, Rm. A101
Gaithersburg, MD 20899

Mr. Joe Soderquist
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Mr. Ed Stanton
PDA Engineering
2975 Redhill Avenue
Costa Mesa, CA 92626-5923

Prof. Wayne Stinchcomb
Dept. of Engineering Science & Mechanics
Virginia Polytechnic Institute and
State University
Blacksburg, VA 24061-0219

Mr. Frank Traceski
U. S. Army Materials Technology Laboratory
Attn: SLCMT-MEE
Arsenal Street
Watertown, MA 02172-2719

Dr. Marilyn W. Wardle
E. I. Dupont de Nemours & Co., Inc.
Chestnut Run Plaza
P. O. Box 80701
Wilmington, DE 19898

Dr. J. H. Westbrook
Sci-Tech Knowledge Systems
133 Saratoga Road
Scotia, NY 12302

Mr. Victor Wigotsky
Senior Editor
Plastics Engineering
Society of Plastics Engineers, Inc.
14 Fairfield Drive
Brookfield, CT 06804-0403

Dr. Dick J. Wilkens Director
Center for Composite Materials
College of Engineering
University of Delaware
Newark, DE 19716

Dr. Dale W. Wilson
BASF Structural Materials, Inc.
11501 Steele Creek Road
P. O. Box 7687
Charlotte, NC 28217

Ms. Kathleen A. Wilson
Senior Administrator
Composites Group of SME
One SME Drive, P.O. Box 930
Dearborn, MI 48121

Mr. Ward Worthy
C&EN
P. O. Box 69
Willmette, IL 60091

Dr. Klaus Zwilsky
Executive Director
National Materials Advisory Board
2101 Constitution Avenue, NW
Washington, DC 20418

NBS-114A (REV. 2-8C)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NISTIR 88-4016	2. Performing Organ. Report No.	3. Publication Date FEBRUARY 1989

4. TITLE AND SUBTITLE

Composites Data for the 1990's

5. AUTHOR(S)

Darrell H. Reneker, John M. Crissman, Donald L. Hunston

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

NATIONAL BUREAU OF STANDARDS
U.S. DEPARTMENT OF COMMERCE
GAITHERSBURG, MD 20899

7. Contract/Grant No.

8. Type of Report & Period Covered

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

10. SUPPLEMENTARY NOTES

☐ 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 contains a draft standard for the identification of polymer matrix composite materials and for reporting of test results. The draft standard is based on a comprehensive description of the flow of data through the polymer matrix composites community. Two essentially different kinds of data-bases are required, one oriented toward a particular group of data users, and one designed to make the collection of all kinds of data straightforward. An interactive dictionary to serve as a tool in the development of the best names is described. Relationships of the draft standard to various groups concerned with composites are noted.

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

composites, polymer matrix composites, data, data base, design data, structure, standards, gateway network, user oriented data base, collection oriented data base

13. AVAILABILITY

☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

48

15. Price

$12.95

USCOMM-DC 6043-P80