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LDEF MATERIALS DATA BASES

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INTRODUCTION

The Long Duration Exposure Facility (LDEF) is a reusable, unmanned spacecraft designed to accommodate a wide variety of technology and science experiments which require long-term exposure to a known low Earth orbit (LEO) environment. The LDEF was designed to be transported into LEO via the Shuttle, free-fly for an extended time period, and be retrieved by the Shuttle for return to Earth. The LDEF was deployed on April 7, 1984 into a nearly circular 257 nautical mile orbit with a 28.4 degree inclination. On January 29, 1990, the LDEF was retrieved at a decreased altitude of 179 nautical miles after 69 months in space. During the mission life the LDEF was exposed to the range of solar conditions including solar minimum and maximum. As LDEF was gravity gradient stabilized, the leading edge of the spacecraft saw the greatest atomic oxygen (AO) exposure, \(1.47 \times 10^{23} \text{ atoms/in}^3\), with the trailing edge of the spacecraft having only minimal AO exposure. The environment that the LDEF was exposed to is described in reference 1.

The LDEF Materials Special Investigation Group (MSIG) was formed to investigate the effects of long-term LEO exposure on structure and experiment materials which were not original test specimens. A significant part of the MSIG's charter is to establish and develop an electronic data base which will eventually contain the wide variety and vast quantity of electrical, thermal, optical, and mechanical materials data being generated by the MSIG members and other LDEF investigators (ref. 1, 2). The MSIG chose to accomplish this task by a three-pronged approach. The first approach utilized a pre-existing global-access data base system, the Materials and Processes Technical Information System (MAPTIS), as the host for the LDEF Materials Data Base. The second approach was to build on the Optical Materials Data Base developed by the Boeing Defense & Space Group under the auspices of the Systems Special Investigation Group (SSIG) (ref. 3). The Optical Materials Data Base was expanded and four other PC/Macintosh (MAC) software-based data bases, commonly referred to as "mini-data bases", were developed. The third approach was to develop a version of the LDEF Materials Data Base for use with PDA Engineering's M/VISION® software. An overview of the capabilities and requirements of the three data bases will be discussed. Information on availability and how to access these data bases is given.

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1 Work done under NASA- Langley Research Center contract NAS1-19247.

2 The use of trademarks or names of manufacturers in this report is for accurate reporting and does not constitute an official endorsement, either expressed or implied, of such products or manufacturers by the National Aeronautics and Space Administration.

3 M/VISION is a registered trademark of PDA Engineering.
MAPTIS LDEF MATERIALS DATA BASE

NASA Marshall Flight Center Management has incorporated the LDEF Materials Data Base as a part of their automated storage, retrieval, and display data base system. The preliminary version of the LDEF Materials Data Base was released to MAPTIS users in June of 1992 and an updated version is currently available to all interested parties in the international space materials community. The goal of MAPTIS is to provide an efficient, reliable means of supplying the information needed for the selection and application of materials and processes to produce the hardware required for NASA's and industry's current and future space missions. MAPTIS uses ORACLE Corporation's relational data base management system and can be accessed via a modem and a 1-800 phone number or via Telnet. Users can access MAPTIS using hardware that emulates a Digital Equipment Corporation (DEC) VT100 terminal. There are several different data bases in MAPTIS, one of which is the LDEF Materials Data Base.

MAPTIS Main Screens

The main MAPTIS menu is a two-screen menu shown in figure 1. The LDEF Materials Data Base is contained in category 4B of the main menu. Category "4A. Overview" is not operational at this time.

Standard Menu Options

As noted in figure 1, standard menu options for the MAPTIS may be seen by typing "DO" which returns a list of frequently used commands. These commands, listed in figure 2, allow the user to switch between 132 and 80 character formats, determine standard and metric units of measure, and "move around" in the MAPTIS system.

LDEF Materials Data Base

Main Screen

After entering "4B" (or "4b") from the main MAPTIS menu, the user is shown the main LDEF Materials Data Base menu, shown in figure 3. The main LDEF Materials Data Base menu has been restructured to allow the user more flexibility in terms of output formats. The main menu is divided into six categories as shown in figure 3.

On-line help screens are available throughout the LDEF Materials Data Base. They may be accessed for a given option by typing an "H" followed by the option number for which the user is requesting help. The help screens show the input information that is required for a specific option and the information included in the output. A general help
screen is also available by typing "H" from the main LDEF Materials Data Base menu. This general screen, shown in figure 4, lists specific information that the new user may find useful.

LDEF Materials Listing

The first option on the main LDEF Materials Data Base menu is the Materials List. This option returns a list of all materials that were flown on LDEF that meet the user's search criteria. The output report tells the user which experiment the materials were flown on and whether the data base has any data on that material. The menu for this option is shown in figure 5. The materials list is searchable by the following criteria:

- **Materials Code**: a NASA designated five (5) digit code that represents a specific manufacturer's material, part, or assembly.
- **Use Type**: generic use of a given material (i.e., composite, thermal control blanket, etc...)
- **Designation**: the specific manufacturer's designation or generic trade name.
- **Composition**: the generic chemical composition of a given material (i.e., PTFE, FEP, aluminum alloy, etc.).
- **Designation/Composition**: both the designation and composition fields of the data base for the user supplied search string.
- **Specification**: any government or industry specification(s) that apply to the manufacture of a given material (i.e., MIL-W-22759, BMS 5-92, etc...).
- **Manufacturer/Supplier**: the manufacturer or supplier of a given sample.
- **Category (metals/nonmetals)**: metals, nonmetals, or both.
- **Experiment Number**: designated number of a given experiment.

For example, suppose a user is interested in seeing if any data are available on P1700 polysulphone resin. The user would select option "1. LDEF Materials List" from the main LDEF Materials Data Base menu. The LDEF Materials List Search Criteria menu shown in figure 5 would appear on the screen. Selecting option "3. Designation" would then prompt the user to enter the search criteria (in this case, %P1700%; the "%" is a wildcard character, using P1700% will return only the records where P1700 is the first item in the designation field and using %P1700% will return all records where P1700 is anywhere in the designation field.) When this query is executed it will retrieve all records which contain P1700 as part of the designation and will show the user which experiments contained P1700 and whether or not the data base has any data on the material. An example of the step-by-step screens to run this query are shown in figure 6. The output of this example is shown in figure 7 for the materials meeting the selected criteria. A future modification will add the contact information for the principal investigator(s).
Basic Data Search

As shown in figure 8, the help screen for the basic data search screen, which is seen by typing "h2" at the main LDEF Materials Data Base menu, lists the type of information that is returned using the basic data search. At the main LDEF Materials Data Base menu (fig. 2) select option 2 and the LDEF Materials Data Base Basic Data Search Criteria screen, shown in figure 9, is displayed. At this point the user may choose up to three search criteria.

For example, suppose the user was interested in looking at any available basic data on batteries such as the manufacturer, specification or other data as listed in figure 8. A basic data search using option "2. Use Type", and using "%batteries%" will return all basic data records on all batteries in the data base. The step-by-step screens with user required input are shown in figure 10. The report, shown in figure 11, shows that there are a number of batteries in the data base. Now the user may request more specific information on these batteries.

Property/Value Search

The Property/Value search option is a recent addition to the data base. It was specifically designed to allow the user to search for materials property data by property value regardless of other data. The search can be performed on up to five different properties at any one time, as listed on the LDEF Materials Data Base Property/Value menu shown in figure 12. As an example of a property/value search, suppose the user wanted data on all materials that had a post-flight hardness value greater than or equal to 50. A property/value search using option 12. "Hardness", and the operator >= (greater than or equal to) and value of 50 would return a list of all materials (by Use Type and designation) that had post-flight hardness values greater than 50 (with a qualifier denoting the scale of the reported property). The step-by-step screens with user required inputs are shown in figure 13. The output from this example is shown in figure 14. The information under the column heading of "DS #" is the data source number from which the data were taken. At the end of that section of data, detailed information on each specific data source is listed by data source number.

All Data Search

The All Data option returns all available information for the materials which meet a user specified criteria. After choosing option "4. All Data", the LDEF Materials Data Base Data Menu, as shown in figure 15, is displayed. The search criteria menu for the All Data option is shown in figure 16. Options 1 through 9 of the All Data Search Criteria menu have been previously discussed in the materials list search criteria. The following descriptions cover options 10 through 16:
Location- specific tray locations (i.e., row and/or ring number- A, E12, etc...).
E (eV) Value- specific range of energy of atomic oxygen.
Est. Sun Hours- estimated UV solar radiation exposure.
AO Flux Values- calculated atomic oxygen flux exposure.
Angle of Incidence Values- a given sample's angle off of the ram direction.
Post-Flight Value- specific post-flight value of specific properties.
Data Sources- data source of the information (discussed in the next section).

As an example, suppose the user wants to search for all available glass transition temperature data on any T300/934 graphite/epoxy composite materials that were flown on the leading edge (row 9) or the trailing edge (row 3). The user would then select option "4. All Data" from the main LDEF Materials Data Base menu as shown in figure 13. Next, the user would select option "4f" on the LDEF Materials Data Base Data Menu for glass transition temperature data as shown in figure 15. Then the user would select option "5, 10" from the LDEF Materials Data Base All Data Search Criteria menu. At the next screen to appear (the Designation screen) the user would be prompted to enter "%T300%934%". Finally the user would be prompted to enter the location (by row and/or ring number). In this example, the user would enter "%9%" and "%3%" for the leading and trailing edges, respectively. The data base then would execute the query and return the output shown in figure 17. The basic data is returned first, followed by any atomic oxygen concentration data that exists in the data base for the given material. The atomic concentration data are the results of X-ray photoelectron spectroscopic (XPS) analyses. The first column is the specimen location on the satellite. The second column describes whether the specimen was coated, uncoated, covered, or exposed. The remaining columns list the percentage of atomic concentration of a specific element in the first 5 nanometers of the surface (unless otherwise noted). The last column (under the heading "DS") lists the data source(s) from which the data were taken. In the example shown in figure 17, data from data source 1015 and 1032 are listed. Immediately following the data listing is a list of the data sources, which gives the title and author(s) of the published paper containing the original data or, if the data come from an unpublished source, the primary facility and principal investigator(s).

Data Source Searches

The last type of search is the data source search. From the main LDEF Materials Data Base menu, option "5. Data Sources" allows the user to search for a particular data source by data source number, primary facility at which the testing was performed, author(s) of the published paper or principal investigator(s), or by the document title of the published paper. This search returns only the complete listing of the data source (no materials property data are returned by this option). Option "16A" through "16D" on the LDEF Materials Data Base All Data Search Criteria menu screen (fig. 16) allows the user to search by the previously described options and returns all data taken from that data source. The output from this type of search is similar to the data source portion of the output in figure 17.
Miscellaneous Data

The final option from the main LDEF Materials Data Base Menu is Option "6. Miscellaneous Data". This option contains information that the user may find useful but that does not fall under any of the other five options. Currently option 6 contains a depiction of the LDEF satellite showing the row and ring number system used to designate locations (fig. 18).

Changes to the LDEF Materials Data Base

This data base is a growing entity. As more published and unpublished data becomes available, it will be incorporated into the data base. Feedback from the user community is appreciated so that this data base will grow into a valuable tool for both space materials researchers and spacecraft designers. The primary motivation for constructing this data base is to provide a central storage point for the vast amount of data so that LDEF materials' results will not be lost to future researchers, engineers, and designers in the aerospace industry. Researchers having data they would like to have incorporated into the LDEF Materials Data Base or users with comments and/or suggestions are asked to contact the first author, Joan Funk.

M/VISION

M/VISION is a materials software system, developed, and marketed by PDA Engineering, which allows for the organization and visualization of materials engineering data. M/VISION allows the user to analyze, manipulate, query and graph materials data. The M/VISION software includes graphics, spreadsheet, imaging, and modeling capabilities as well as data basing capabilities. Multiple data types, such as tabular data, graphs, and raster images (e.g., C-scans, photomicrographs, etc...) can be stored in a single M/VISION data base. M/VISION is a hybrid hierarchical/relational data base with both hierarchical and standard Structure Query Language (SQL) interfaces. An integrated engineering spreadsheet is included in the software that allows the user more efficient means to manipulate and visualize the information in the data base. Data bases can be manipulated via user-written FORTRAN and C codes.

M/VISION LDEF Materials Data Base

In the late spring of 1993, the LDEF Materials Data Base that runs on the M/VISION software will be available to users in the international space materials community to run on their own licensed M/VISION software. A preliminary version of the data base in the M/VISION format is shown in figures 19 and 20. Figure 19 is a depiction of the M/VISION data base window with a spreadsheet window overlaid on top of it. In the data base display the user has already made several choices such as the materials,
environment, descriptors, and experiment which are shown on the far right of the display. The main portion of the data base window displays the source and reference of the data. The actual data are displayed on a previous screen. The spreadsheet illustrates the direct connection between the spreadsheet and the data base. In this spreadsheet the user requested that all materials with "**934**" in the designation, where "*" is a wildcard character, which had mass loss data in terms of percent total loss and had an atomic oxygen flux value, be displayed. Also display by user-request are the property name, qualifier, post-flight value of the total mass loss and atomic oxygen flux of data meeting the given search criteria. The spreadsheet automatically calculates the log of the atomic oxygen and displays it in column F. The spreadsheet is then used as a template and data for both T300/P1700 and C6000/PMR15 that meet the mass loss and atom oxygen flux criteria are also imported into the spreadsheet. The data shown in the spreadsheet are plotted in figure 20 for all three materials. This is one example of data in the data base being manipulated by the spreadsheet and then plotted for the user’s easier visualization of the data and data trends. The spreadsheet can be stored and used as a template for future comparisons.

COMPARISON OF THE MAPTIS AND M/VISION VERSIONS OF THE LDEF MATERIALS DATA BASE

The users of the LDEF Materials Data Base are assumed to have a wide range of computer hardware, software, and expertise. The two versions of the LDEF Materials Data Base require different hardware, software, and computer expertise. By offering the user a choice of these two versions of the data base, users may tailor their investment in hardware, software, and time. The MAPTIS version of the LDEF Materials Data Base requires relatively inexpensive computer hardware and software and allows the user to search and retrieve tabular data. The M/VISION version of the LDEF Materials Data Base requires the user to have more sophisticated hardware and software allowing the user to manipulate and analyze the data. Once the M/VISION version of the data base is transferred to the user’s local machine, the data base requires only local access by the user and is available to any local networked X-device. The user can incorporate in-house data or data from other sources to augment the data base. Both versions of the LDEF Materials Data Base are available at no charge.

MINI-DATA BASES

Under contract to the SSIG and MSIG, Boeing Defense & Space Group has developed a series of data bases containing results from LDEF on specific topics. These data bases were developed to provide the user community with early access to LDEF data. The data bases were developed for use with PC and MAC versions of the Claris Corporation’s Filemaker® Pro software. Filemaker Pro is a flat file data base which

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Footnote: Filemaker Pro is a registered trademark of Claris Corporation.
means that the user can retrieve multiple data types such as tabular data, text, graphs, diagrams and/or picture files. The data bases' simple interface allows for easy use of the data base by the novice user. The individual data bases are password protected, allowing the user full access privileges to read, print, or download the data but not allowing the user to edit the data files. The software allows the user to search and retrieve specific information in a variety of layouts. Data can be exported to a variety of formats including ASCII. As with the other data bases, all data is traced back to its original data source. A more detailed report of the capabilities of these mini-data bases can be found in reference 3.

The mini-data bases cover the optical materials, silverized teflon thermal blankets, treated aluminum hardware, thermal control paints, and the LDEF environments areas of interest. The Optical Materials Data Base is a compilation of the results on the optical materials flown on LDEF and was originally developed by the SSIG. The Silverized Teflon Thermal Blankets Data Base covers the results from the silverized teflon thermal blankets utilized on LDEF. The Treated Aluminum Hardware Data Base is a compilation of data from the various types of aluminum hardware flown on LDEF including different alloys, surface conditions, etc. The Thermal Control Paints Data Base contains information on the wide variety of paints flown on LDEF. The LDEF Environments Data Base contains information on the environment that LDEF was exposed to, including thermal profiles, and solar UV, and AO exposure levels. Final versions of these data bases will be available by October 1993.

AVAILABILITY OF THE DATA BASES

For those parties interested in accessing the MAPTIS version of the LDEF Materials Data Base, a form, figure 21, is included in this paper. By filling out the form and returning it to the fax number listed on the bottom of the form, the requestor will be given a user identification name and password to MAPTIS. The M/VISION version of the LDEF Materials Data Base, once it is released to the public, will be available by contacting the first author, Joan Funk, or the third author, John Davis. Free copies of the LDEF mini-data bases will be available through December of 1994 by sending a written request including which format (PC or MAC) is being requested with a blank 3.5" floppy disk for each data base to: Gary Pippin, Technical Lead LDEF Materials Data Analysis, Boeing Defense & Space Group, P.O. Box 3999, M/S 82-32, Seattle, WA 98124-24999. After that time the data bases will be available from NASA.

ACKNOWLEDGEMENT

The authors thank Curt Loomis of PDA Engineering and Dr. Gary Pippin and Gail Bohnhoff-Hlavacek of Boeing Defense & Space Group for their help writing the M/VISION and mini-data bases portions of the text.
REFERENCES


1. MECHANICAL/PHYSICAL PROPERTY
   A. Metals
   B. Nonmetals
   C. Acoustics
   D. Atomic Oxygen
   E. Magnetic Materials
   F. High Temperature
   G. Bondline Information System
   H. Nozzles Materials

2. MATERIAL SELECTION
   A. Metals (MSFC-SPEC-522, etc)
   B. Nonmetals (NHB 8060.1, etc)
   C. Standard/Commercial Parts

3. VERIFICATION & CONTROL
   A. MUA - Mtrl Usage Agreements
   B. Foreign Alloy Cross Reference
   C. MIUL - Mtrl Id and Usage List
   D. Intercenter Agreement Cert.Leters

4. LONG DURATION EXPOSURE FACILITY DATA
   A. Overview
   B. Materials SIG Data

5. STRUCTURAL MATERIALS FAILURE ANALYSIS

6. (NOET) INFORMATION SYSTEM (NIS)
   A. Replacement Technology
   B. Propulsion Technology (TBD)

CHOICE: ENTER NUMBER & ALPHA (1C GETS THE ACOUSTICS DATABASE)
FOR HELP: ENTER H PRIOR TO CHOICE (H1C GETS HELP FOR ACOUSTICS DATABASE)
NOTE: ENTER DO FOR LIST OF STANDARD MENU OPTIONS

7. MANAGEMENT SYSTEMS FOR PROJECTS
   A. SSF - Space Station Freedom II
   B. NLS - National Launch System

8. SPECIFICATIONS AND STANDARDS

9. ADMINISTRATIVE
   A. MSFC Form 512.5
   B. MSFC Form 424

CHOICE: ENTER NUMBER & ALPHA (1C GETS THE ACOUSTICS DATABASE)
FOR HELP: ENTER H PRIOR TO CHOICE (H1C GETS HELP FOR ACOUSTICS DATABASE)
NOTE: ENTER DO FOR LIST OF STANDARD MENU OPTIONS

Figure 1. MAPTIS main screens.
**CHOICE: MAPTIS - STANDARD MENU OPTIONS**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 /PM</td>
<td>Previous Menu</td>
</tr>
<tr>
<td>97/MM</td>
<td>Main Menu</td>
</tr>
<tr>
<td>98/CM</td>
<td>Change menu display from full to brief or brief to full.</td>
</tr>
<tr>
<td>99/LO</td>
<td>Log off the MAPTIS VAX</td>
</tr>
<tr>
<td>AM</td>
<td>Activate the Action Menu</td>
</tr>
<tr>
<td>BB</td>
<td>Display Bulletin Board</td>
</tr>
<tr>
<td>BO</td>
<td>Toggle between running queries online (default) &amp; batch.</td>
</tr>
<tr>
<td>CF</td>
<td>Toggle report format between 132 (default) &amp; 80.</td>
</tr>
<tr>
<td>CU</td>
<td>Toggle report unit of measure between standard (def) &amp; metric.</td>
</tr>
<tr>
<td>CQ</td>
<td>Change action mode to Canned Query</td>
</tr>
<tr>
<td>DF</td>
<td>Display report format selection</td>
</tr>
<tr>
<td>TIME</td>
<td>Display the Date and Time</td>
</tr>
<tr>
<td>PHONE</td>
<td>Activate the VAX Phone Utility</td>
</tr>
<tr>
<td>MAIL</td>
<td>Activate the VAX Mail Utility</td>
</tr>
</tbody>
</table>

**CHOICE: MAPTIS - LDEF MATERIALS DATABASE REPORT FORMAT MENU**

<table>
<thead>
<tr>
<th>CHOICE:</th>
<th>MAPTIS - LDEF MATERIALS DATABASE REPORT FORMAT MENU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. LDEF materials listing</td>
<td>Returns general information and experiment numbers for all materials flown on the LDEF satellite.</td>
</tr>
<tr>
<td>2. Basic Data</td>
<td>Returns general information about the material and manufacturer.</td>
</tr>
<tr>
<td>3. Property/ Value</td>
<td>Returns the material(s), property and property value only.</td>
</tr>
<tr>
<td>4. All Data</td>
<td>Returns all available information for the material.</td>
</tr>
<tr>
<td>5. Data Sources</td>
<td>Returns information about the data sources only.</td>
</tr>
<tr>
<td>6. Miscellaneous Data</td>
<td>Returns information not applicable to above choices.</td>
</tr>
</tbody>
</table>

**CHOICE: ENTER REPORT FORMAT CHOICE (Example: 5)**

FOR HELP: ENTER H FOR GENERAL HELP OR H AND CHOICE FOR MORE SPECIFIC HELP

NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

**Figure 2. Standard menu options for MAPTIS.**

**Figure 3. The LDEF Materials Data Base main menu screen.**
VCM - this data found in the data base is defined as Volatile Condensible Materials according to the papers from which data has been taken.

When a query is run on the system, any data that is available that meets your search criteria will scroll across the screen as it is being retrieved and when the query is complete, you will receive a "Query Complete" message. If you receive a "Query Complete" message without seeing any data, this means there is no data currently in the system that meets your given search criteria.

The convention used for naming and describing all composites in this data base is fibers first, followed by matrix material (example: GY70 graphite fibers/934 epoxy, SP288 graphite fibers/V108 epoxy, etc...)

In this data base and throughout MAPTIS, Designation refers to the manufacturer's designation or name for a given material or the commonly referred to trade name (i.e., KAPTON, GY70 graphite fibers, etc...). Composition refers to the "generic" composition of a given material (i.e., polyimide, graphite, PTFE, FEP, etc...).

PRESS RETURN TO CONTINUE:

Figure 4. The LDEF Materials Data Base general help screen.

CHOICE: __________ LDEF MATERIALS DATABASE MATERIALS LIST SEARCH CRITERIA

1. Material Code
2. Use Type
3. Designation
4. Composition
5. Designation / Composition
6. Specification
7. Manufacturer / Supplier
8. Category (metals / non-metals)
9. Experiment Number

CHOICE: ENTER UP TO 3 SEARCH CRITERIA DELIMIT WITH A COMMA ( 2,5,6 )
FOR HELP: ENTER H PRIOR TO ANY CHOICE ( H1 GETS HELP ON MATERIAL CODE )
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Figure 5. The LDEF Materials Data Base materials list search criteria screen.
CHOICE: 1  
1. LDEF materials listing
   Returns general information and experiment numbers for all materials flown on the LDEF satellite.
2. Basic Data
   Returns general information about the material and manufacturer.
3. Property/ Value
   Returns the material(s), property and property value only.
4. All Data
   Returns all available information for the material.
5. Data Sources
   Returns information about the data sources only.
6. Miscellaneous Data
   Returns information not applicable to above choices.

CHOICE: ENTER REPORT FORMAT CHOICE (Example: 5)
FOR HELP: ENTER H FOR GENERAL HELP OR H AND CHOICE FOR MORE SPECIFIC HELP
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

CHOICE: ENTER UP TO 3 SEARCH CRITERIA (Example: 2,5,6)
FOR HELP: ENTER H PRIOR TO ANY CHOICE (H1 GETS HELP ON MATERIAL CODE)
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Enter up to three designations
You must supply all wildcards (%).

%P1700%
________________________________________
KEVLAR%
________________________________________
MYLAR%
________________________________________
%ALUMINUM%

Figure 6. Input screens for the example search on the materials list.
### MATERIAL CODE:
- **USE TYPE:** COMPOSITE
- **DESIGNATION:** C6000/P1700
- **COMPOSITION:** GRAPHITE FIBER WITH POLYSULPHONE

### REMARKS:

<table>
<thead>
<tr>
<th>EXPERIMENT NUMBER</th>
<th>TEST DATA INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0134</td>
<td>TEST DATA AVAILABLE</td>
</tr>
</tbody>
</table>

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### MATERIAL CODE:
- **USE TYPE:** COMPOSITE
- **DESIGNATION:** HMF 322/P1700/(+/-) 45 DEGREES
- **COMPOSITION:** GRAPHITE FIBERS/POLYSULPHONE

### REMARKS:

<table>
<thead>
<tr>
<th>EXPERIMENT NUMBER</th>
<th>TEST DATA INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0171</td>
<td>TEST DATA AVAILABLE</td>
</tr>
</tbody>
</table>

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### MATERIAL CODE:
- **USE TYPE:** STRIP
- **DESIGNATION:** 722 (GR/GL WEAVE)/P1700
- **COMPOSITION:** POLYSULPHONE

### REMARKS:

<table>
<thead>
<tr>
<th>EXPERIMENT NUMBER</th>
<th>TEST DATA INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>M0003</td>
<td>NO TEST DATA AVAILABLE</td>
</tr>
</tbody>
</table>

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Figure 7. Output from example search in figure 6.
MAPTIS - LDEF MATERIALS DATABASE HELP

BASIC DATA - is the general information about the material being returned. This data includes:

- MATERIAL CODE - NASA assigned material identifier
- DESIGNATION - Manufacturers' product identification
- COMPOSITION - Generic material makeup
- USE TEMPERATURE - Recommended temperature range for the product
- USE TYPE - Generic use of the material *Example: Adhesive, Coating
- REMARKS - Other information relating to the material
- SPECIFICATION - Specifications pertaining to the material
- MANUFACTURER/SUPPLIER - Company that makes and/or supplies the material
- ADDRESS - Address of manufacturer/supplier

ATOMIC CONCENTRATION data will be provided when available.

NOTE: BASIC DATA will be slightly different for metallic materials.

Figure 8. The LDEF Materials Data Base basic data help screen.

CHOICE: LDEF MATERIALS DATABASE BASIC DATA SEARCH CRITERIA

1. Material Code
2. Use Type
3. Designation
4. Composition
5. Designation / Composition
6. Specification
7. Manufacturer / Supplier
8. Category (metals / non-metals)

CHOICE: ENTER UP TO 3 SEARCH CRITERIAS DELIMIT WITH A COMMA (2,5,6)
FOR HELP: ENTER H PRIOR TO ANY CHOICE (H1 GETS HELP ON DESIGNATION)
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Figure 9. The LDEF Materials Data Base basic data search screen.
CHOICE: 2____

1. LDEF materials listing
   Returns general information and experiment numbers for all materials flown on the LDEF satellite.
2. Basic Data
   Returns general information about the material and manufacturer.
3. Property/Value
   Returns the material(s), property and property value only.
4. All Data
   Returns all available information for the material.
5. Data Sources
   Returns information about the data sources only.
6. Miscellaneous Data
   Returns information not applicable to above choices.

CHOICE: ENTER REPORT FORMAT CHOICE (Example: 5)
FOR HELP: ENTER H FOR GENERAL HELP OR H AND CHOICE FOR MORE SPECIFIC HELP
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

CHOICE: 2____

<table>
<thead>
<tr>
<th></th>
<th>LDEF MATERIALS DATABASE BASIC DATA SEARCH CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Material Code</td>
</tr>
<tr>
<td>2.</td>
<td>Use Type</td>
</tr>
<tr>
<td>3.</td>
<td>Designation</td>
</tr>
<tr>
<td>4.</td>
<td>Composition</td>
</tr>
<tr>
<td>5.</td>
<td>Designation / Composition</td>
</tr>
<tr>
<td>6.</td>
<td>Specification</td>
</tr>
<tr>
<td>7.</td>
<td>Manufacturer / Supplier</td>
</tr>
<tr>
<td>8.</td>
<td>Category (metals / non-metals)</td>
</tr>
</tbody>
</table>

CHOICE: ENTER UP TO 3 SEARCH CRITERIA DELIMIT WITH A COMMA ( 2,5,6 )
FOR HELP: ENTER H PRIOR TO ANY CHOICE (H1 GETS HELP ON MATERIAL CODE)
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Enter up to three use types
You must supply all wildcards (%) Enter <CR> to terminate entry.

%BATTERIES%

ADHESIVE

%COVER%

STRUCTURAL%

Figure 10. Input screens for example search of basic data.
Figure 11. Output from example search in figure 10.
<table>
<thead>
<tr>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Absorptivity</td>
</tr>
<tr>
<td>2. Absorptivity/ Emissivity</td>
</tr>
<tr>
<td>3. Change in Mass</td>
</tr>
<tr>
<td>4. Change in Thickness</td>
</tr>
<tr>
<td>5. Change in Surface Resistivity</td>
</tr>
<tr>
<td>6. Coeff. Thermal Expansion</td>
</tr>
<tr>
<td>7. Compression Strength</td>
</tr>
<tr>
<td>8. Elastic Modulus</td>
</tr>
<tr>
<td>9. Emissivity</td>
</tr>
<tr>
<td>10. Flexural</td>
</tr>
<tr>
<td>11. Glass Transition Temperature</td>
</tr>
<tr>
<td>12. Hardness</td>
</tr>
<tr>
<td>13. Load Deflection</td>
</tr>
<tr>
<td>14. Maximum Load</td>
</tr>
<tr>
<td>15. Optical Density</td>
</tr>
<tr>
<td>16. Percent Elongation</td>
</tr>
<tr>
<td>17. Reaction Efficiency</td>
</tr>
<tr>
<td>18. Reflectance</td>
</tr>
<tr>
<td>19. Shear</td>
</tr>
<tr>
<td>20. Short Circuit Current</td>
</tr>
<tr>
<td>21. State of Charge</td>
</tr>
<tr>
<td>22. Surface Roughness</td>
</tr>
<tr>
<td>23. Tensile Strength</td>
</tr>
<tr>
<td>24. Thermal Strain</td>
</tr>
<tr>
<td>25. Transmittance</td>
</tr>
<tr>
<td>26. VCM</td>
</tr>
</tbody>
</table>

**Figure 12.** The LDEF Materials Data Base Property/ Value search screen.
CHOICE: 3

1. LDEF materials listing
Returns general information and experiment numbers for all materials flown on the LDEF satellite.

2. Basic Data
Returns general information about the material and manufacturer.

3. Property/Value
Returns the material(s), property and property value only.

4. All Data
Returns all available information for the material.

5. Data Sources
Returns information about the data sources only.

6. Miscellaneous Data
Returns information not applicable to above choices.

CHOICE: ENTER REPORT FORMAT CHOICE (Example: 5)
FOR HELP: ENTER H FOR GENERAL HELP OR H AND CHOICE FOR MORE SPECIFIC HELP
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

CHOICE: 12

1. Absorptivity
2. Absorptivity/Emissivity
3. Change in Mass
4. Change in Thickness
5. Change in Surface Resistivity
6. Coeff. Thermal Expansion
7. Compression Strength
8. Elastic Modulus
9. Emissivity
10. Flexural
11. Glass Transition Temperature
12. Hardness
13. Load Deflection
14. Maximum Load
15. Optical Density
16. Percent Elongation
17. Reaction Efficiency
18. Reflectance
19. Shear
20. Short Circuit Current
21. State of Charge
22. Surface Roughness
23. Tensile Strength
24. Thermal Strain
25. Transmittance
26. VCM

CHOICE: ENTER UP TO 5 CHOICES DELIMIT WITH A COMMA (1,8,16)
FOR HELP: ENTER H AND CHOICE FOR HELP (H1)
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Do you want the value in HARDNESS to be ( =, NOT=, <, <=, >, >= )
Enter value (numeric)

> =

50.0

Figure 13. Input screens for example of property/value search.
<table>
<thead>
<tr>
<th>USE TYPE</th>
<th>DESIGNATION</th>
<th>PROPERTY NAME</th>
<th>QUALIFIER</th>
<th>PRE-FLT</th>
<th>POST-FLT UNITS</th>
<th>DS #</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURAL COVER</td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>60.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td>PLATE/CLAMPS</td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANODIZED</td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>60.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>61.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>61.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>62.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL B-SCALE</td>
<td>63.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>91.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>91.0</td>
<td></td>
<td>1021</td>
</tr>
<tr>
<td></td>
<td>CHROMIC ACID</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>91.5</td>
<td></td>
<td>1021</td>
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<td></td>
<td>CHROMIC ACID</td>
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<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>91.5</td>
<td></td>
<td>1021</td>
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<td>CHROMIC ACID</td>
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<td></td>
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<tr>
<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>92.0</td>
<td></td>
<td>1021</td>
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<td></td>
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<td></td>
<td>AL 2024-T6</td>
<td>HARDNESS</td>
<td>ROCKWELL F-SCALE</td>
<td>93.0</td>
<td></td>
<td>1021</td>
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<td>CHROMIC ACID</td>
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</tbody>
</table>

DATA SOURCE

DATA SOURCE: 1021
DATE: 30-JUN-91
FACILITY: PHILLIPS LABORATORY (WSMD) KIRTLAND AFB
DOCUMENT TYPE: TECHNICAL PAPER PRESENTED AT LDEF SYMPOSIUM, JUNE 1991
IDENTIFICATION: CP-3134, PART 2
TITLE: EFFECTS OF SPACE ENVIRONMENT ON STRUCTURAL MATERIALS
REMARK: C. MIDLIONICO, C. STEIN, R. ROYBAL, R. ROBERTSON; DEPARTMENT OF METALLURGICAL AND MATERIALS
FISHER, R. ARROWOOD

Figure 14. Output from example search in figure 13.
CHOICE: MAPTIS - LDEF MATERIALS DATABASE DATA MENU

1. All Available Properties
2. Electrical Properties
   A. All Electrical Properties
   B. State of Charge
   C. Short Circuit Current
3. Mechanical Properties
   A. All Mechanical Properties
   B. Elastic Modulus
   C. Tensile Strength
   D. Hardness
   E. Maximum Load
   F. Shear
   G. Flexural
   I. Compression Strength
   J. Load Deflection
   K. Percent Elongation
4. General Properties
   A. All General Properties
   B. Change in Mass
   C. Change in Thickness
   D. Optical Density
   E. Surface Roughness
   F. Glass Transition Temperature
   G. Change in Surface Resistivity
5. Optical/Thermal Properties
   A. All Opt./Thermal Properties
   B. Absorptivity
   C. Emissivity
   D. Absorptivity/Emissivity
   E. Reflectance
   F. Transmittance
   G. Coeff. Thermal Expansion

CHOICE: ENTER UP TO 3 CHOICES DELIMIT WITH A COMMA ( 3C,4A,5D )
FOR HELP: ENTER H FOR GENERAL HELP OF H AND CHOICE FOR MORE SPECIFIC HELP
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Figure 15. The LDEF Materials Data Base all data search menu.

CHOICE: LDEF MATERIALS DATABASE ALL DATA SEARCH CRITERIA

1. Material Code
2. Use Type
3. Designation
4. Composition
5. Designation / Composition
6. Specification
7. Manufacturer / Supplier
8. Category (metals / non-metals)
9. Experiment Number
10. Location
11. E (eV) value
12. Est. Sun Hours
13. AO Flux value
14. Angle of Incidence value
15. Post Flight Value
16. DATA SOURCES
   A. Data Source Number
   B. Primary Facility
   C. Author or Secondary Facility
   D. Document Title

CHOICE: ENTER UP TO 3 SEARCH CRITERIA DELIMIT WITH A COMMA ( 2,5,6 )
FOR HELP: ENTER H PRIOR TO ANY CHOICE ( H3 GETS HELP ON DESIGNATION )
NOTE: ENTER DO TO LIST STANDARD MENU OPTIONS

Figure 16. The LDEF Materials Data Base all data search criteria menu.
MATERIAL CODE: 05321
USE TYPE: LAMINATE/COMPOSITE
DESIGNATION: THORNEL T300/934
COMPOSITION: PAN BASE CARBON WITH EPOXY
USE TEMP MIN: (f)
USE TEMP MAX: (f)

REMARKS:

SPECIFICATION: MIL-C-83286
MANUFACTURER: IMPERIAL CHEMICAL INDUSTRIES
DIVISION: ICI AMERICAS INCORPORATED/FIBERITE
MANUFACTURER: AMOCO CORPORATION
DIVISION: (FORMERLY UNION CARBIDE)

ATOMIC CONCENTRATION DATA

LOCATION MATERIAL SIDE DS #

------------------------ ------------------------- -----
B9 COVERED SIDE, COATED 1032

Figure 17. Example output for an all data search.
<table>
<thead>
<tr>
<th>AG</th>
<th>AL</th>
<th>C</th>
<th>CL</th>
<th>CU</th>
<th>F</th>
<th>IN</th>
<th>K</th>
<th>N</th>
<th>NA</th>
<th>O</th>
<th>PB</th>
<th>S</th>
<th>SI</th>
<th>SN</th>
<th>ZN</th>
</tr>
</thead>
<tbody>
<tr>
<td>65.1</td>
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<td>2.4</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>1.7</td>
<td>24.8</td>
<td>3.4</td>
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<td>49.7</td>
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<td>34.0</td>
<td>13.0</td>
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<tr>
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<td>3.60</td>
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</tr>
<tr>
<td>52.7</td>
<td>1.70</td>
<td>32.1</td>
<td>11.8</td>
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<tr>
<td>64.5</td>
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<td>4.30</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GENERAL PROPERTY EFFECTS DATA**

**PROPERTY NAME:** GLASS TRANSITION TEMPERATURE

**QUALIFIER:**

**PRE-FLT:** 204

**POST-FLT:** 192

**UNITS:** DEGREES C

**MATERIAL SIDE:** EXPOSED SIDE

**LOCATION:** D9

**SUBSTRATE:**

**EXPERIMENT #:** M0003-8

**SAMPLE THICK:**

**EXPOSURE TIME:** 5.77 (yrs)

**EST. SUN HRS:** 11100

**E:** 5 (eV)

**FLUX:** $9.16 \times 10^{13}$ (atom/cm²*sec)

**A-O FLUX AOI:** 82 (deg)

**A-O FLUENCE:**

Figure 17 (continued). Example output for an all data search.
DATA SOURCE #: 1015

COMMENT: PRE-FLIGHT VALUE IS PUBLISHED VALUE, POST-FLIGHT VALUE IS ACTUAL MEASUREMENT

PROPERTY NAME: GLASS TRANSITION TEMPERATURE
QUALIFIER: 
PRE-FLT: 204
POST-FLT: 193
UNITS: DEGREES C
MATERIAL SIDE: EXPOSED SIDE
LOCATION: D3
SUBSTRATE: 
EXPERIMENT #: M0003-8

SAMPLE THICK: 
EXPOSURE TIME: 5.77 (yrs)
EST. SUN HRS: 11100
E: 5 (eV)
FLUX: 4.08E-05 (atom/cm2*s)

SAMPLE TEMP: 
A-O FLUX AOI: 82 (deg)

A-O FLUENCE: 

DATA SOURCE #: 1015

COMMENT: PRE-FLIGHT VALUE IS PUBLISHED VALUE, POST-FLIGHT VALUE IS ACTUAL MEASUREMENT

DATA SOURCE

DATA SOURCE: 1015
DATE: 30-JUN-91
FACILITY: BOEING DEFENSE AND SPACE GROUP
DOCUMENT TYPE: TECHNICAL PAPER PRESENTED AT LDEF SYMPOSIUM, JUNE 1991
IDENTIFICATION: CP-3134, PART 2
TITLE: RESULTS FROM ANALYSIS OF BOEING COMPOSITE SPECIMENS FLOWN ON LDEF EXPERIMENT M0003
REMARK: PETE E. GEORGE, SYLVESTER G. HILL

Figure 17 (continued). Example output for an all data search.
Figure 17 (concluded). Example output for an all data search.
Figure 19. An example of the data base and spreadsheet screens of the M/VISION version.
Figure 20. Example output using the spreadsheet screen in figure 19.
User Request Form for MAPTIS and the LDEF Materials Data Base

Employee Name: ______________________ 
Company/Mail Code: ______________________
Work Address: ______________________
City: _______________ State: __ Country: _______ 
Zip Code: ____________
Office Telephone Number: (___)___-______
FAX: (___)___-______

Signature: ______________________ Date: __/__/

Do Not Write Below This Line

System Information

Username: ______________________ Uic: (_______, _______)
Check only one:
Govt Contractor _____ Industry User _____ NASA (MSFC) _____
Bamsi/BCSS Programmer _____ EHO2 Personnel _____ NASA (OTHER) _______
NPSS/PSCN ID: ______________________ Initial Password: ______________________
Creation Date: __/__/____ By: ______________________
Deletion Date: __/__/____ By: ______________________

Complete and fax to Rene Hitson/ John Davis (205) 544-5786. If you have any problems, contact Rene Hitson at (205) 544-6972 or John Davis at (205) 544-2494.

Figure 21. User request form for access to MAPTIS and the LDEF Materials Data Base.
The Long Duration Exposure Facility (LDEF) and the accompanying experiments were composed of and contained a wide variety of materials representing the largest collection of materials flown in low Earth orbit (LEO) and retrieved for ground-based analysis to date. The results and implications of the mechanical, thermal, optical, and electrical data from these materials are the foundation on which future LEO space missions will be built. The LDEF Materials Special Investigation Group (MSIG) has been charged with establishing and developing data bases to document these materials and their performance to assure not only that the data are archived for future generations but also that the data are available to the spacecraft user community in an easily accessed, user-friendly form. This paper discusses the format and content of the three data bases developed or being developed to accomplish this task. The hardware and software requirements for each of these three data bases are discussed along with current availability of the data bases. This paper also serves as a user's guide to the MAPTIS LDEF Materials Data Base.