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INTRODUCTION

The Long Duration Exposure Facility (LDEF) carried 57 experiments and 10,000 specimens for some 200 LDEF experiment investigators. The external surface of LDEF had a large variety of materials exposed to the space environment which were tested preflight, during flight, and postflight. Thermal blankets, optical materials, thermal control paints, aluminum, and composites are among the materials flown. The investigations have produced an abundance of analysis results. One of the responsibilities of the Boeing Support Contract, Materials and Systems Special Investigation Group, is to collate and compile that information into an organized fashion. This paper describes the databases developed at Boeing to accomplish this task.

DATABASE OBJECTIVES

The main objective of this task was to compile and organize the LDEF results into a database as part of the LDEF contract data analysis. After a trade study of various database software and an examination of the available investigators papers, a prototype database was developed. Important field names were chosen to serve as a framework upon which to build information and make it easy for a user to follow and understand the data in the database. Once the framework was established, initial data was inputted, in order to evaluate the database performance. When the framework was found to be acceptable, the bulk of the data was inputted. The Optical Materials Database was the first database developed. Because of the good response received from the LDEF community with the Optical Materials Database, additional databases were developed for Treated Aluminum Hardware, Silverized Teflon, Thermal Control Paints, and the LDEF Environments. These database subjects were chosen because of the large amount of data available for compilation, and because there was a need to disseminate the information quickly, especially to support materials research for future spacecraft applications.

DATABASE CHARACTERISTICS

The LDEF database design has several important and distinguishing characteristics. Because of the intuitive user interface, it requires no computer experience to operate, and is very easy to use. The data provided in the database is entirely traceable back to the original source of the information. The principal investigators in charge of the LDEF experiment, and other experimenters who authored papers are always acknowledged. Database users are encouraged to consult the original papers, or contact the experimenters for their first-hand accounts. A database password protection mechanism is employed which enables the user to have full access to the LDEF information in order to read all available data, print

copies, or download into other medium, but it does not give the user an opportunity to edit the results. Even though upgrading the information in the database is quite easy, all corrections and additions are done at Boeing. Exporting data can be done to a variety of formats, including ASCII, the WKS worksheet format used in the Lotus 1-2-3 software™, SYLK a spreadsheet format for Microsoft Excel™, and the dBase format used in the Ashton Tate dBase software™. This way information can be downloaded into the user's own spreadsheets, reports, or databases like M/VISION™ of PDA Engineering or the Materials and Processes Technical Information System (MAPTIS) which is the NASA-wide storage, retrieval, and display system for materials and processes information managed by the NASA Marshall Space Flight Center. The user is not limited to a single layout design, but can create whatever layout they prefer. The application software results in a flat file database, which can contain text, tables, graphs, diagrams and even picture files. (A flat file database was chosen over other types of databases because most of the information being produced by LDEF investigators came in the form of text, graphs, pictures, and small tables; rarely was the information contained in long narrow columns of tabulated data which is most appropriate for relational databases.) Further, the principal investigator's interpretation of the results is considered vital to the databasing process, and every attempt was made to capture it intact within the database. In essence the LDEF databases prepared at Boeing are a compilation of results summaries, conclusions, lessons learned, descriptions of flight hardware, and the full spectrum of environmental exposure parameters the samples were exposed to. The database was not intended for, nor was it designed to archive every data point or perform relational studies. Further, the database is only as complete as the information that is available from the investigators for input.

STATUS OF DATABASES

To date five databases have been created and respective LDEF data inputted. The first, in 1991, was funded by the Systems Special Investigative Group (SSIG) effort to compile information on the optical materials that flew on LDEF. As a follow-on to this task, we will update the Optical Materials Database in fiscal year 1993. The other four databases were started in 1992 and funded by the Materials SIG effort including: Silverized Teflon Thermal Blankets; Treated Aluminum Hardware (chromic acid anodize, alodyne, sulfuric acid, polished and untreated aluminum); Thermal Control Paints (e.g. A276, S13-GLO) and the LDEF Environment. The LDEF Environment Database compiles extensive overall data charts, graphs, diagrams, images of the LDEF environment including such parameters as the thermal environment, solar ultraviolet (UV), meteoroid and debris (M/D) impacts, atomic oxygen (AO) exposure, and LDEF historical information. In addition, it will contain information on the LDEF microenvironments.

All of these databases are run on the Filemaker Pro software developed by the Claris Corporation.¹ Presently the software is available for Macintosh computers only. However, as mentioned earlier, information contained in the databases is exportable to DOS computers, by saving to a variety of formats that are readable on the receiving computer. By the third quarter of 1992, the Claris Corporation has advised us that there will be a DOS / Windows version that will allow one to use the full capability of the Filemaker Pro database structure on IBM-compatible personal computers. In addition, an upgraded Mac version will be available to the Macintosh users by that time as well. This is important for network users, since the user's network resident fileserver will have access to both types of computer, and the data will be transparent between the Mac and PC.

DATABASE DEMONSTRATION

The database design is built upon a structure of "field names". Some field name entries provide necessary background information such as: experiment name, experiment number, principal investigators (PIs), and experiment objectives as shown in Figure 1. Other field names detail the environmental parameters specific to that experiment or location (AO, UV, M/D impacts, etc.). Figure 2 shows the ensuing field name titles that indicate the hardware that flew on the experiment, and what measurements were performed on those parts. Following these field names are others that provide a results summary and the principal investigator's conclusions (Figure 3). Along with the PI's system analysis and recommendations for future designs, the database also contains a list of other published papers by this author, the references used to make up this database record, the experiment status, the hardware archive locations, and a date describing the latest database upgrade, as shown in Figure 4. The amount of information contained under each field name is not limited to a certain number of characters.

In addition to text, the database can utilize tables, graphs and picture files. These inputs add greatly to the user's understanding of the text or tables already in the database. For example, Figure 5 is an example of a picture file within the LDEF Environmental Database. It documents the atomic oxygen fluence around the LDEF structure.² This information could just as easily have been put into a numerical table, but the diagram gives the reader an excellent perspective of LDEF, and a better understanding of the directionality associated with the AO fluence. The second example illustrated in Figure 6 is a graph of the bidirectional reflectance distribution function (BRDF) results from a piece of silverized teflon (AgFEP).³ This plot provides the viewer a better opportunity to evaluate the variation of diffuse reflectance scatter on samples exposed to AO at various locations on LDEF. Further it shows the slight asymmetry in the measurement due to the orientation of the sample with respect to the measuring laser beam, and the directionality of the roughened surface of these specimens. Figure 7 shows a micrometeoroid debris impact in metal, which has a different appearance than that of an M/D impact in glass or in an organic coating, all of which can be seen in the database.⁴ The last example (Figure 8) shows a scanning tunneling microscope 3-D analysis plot illustrating the surface projections that are on the order of a wavelength of light on a diffuse area of the AgFEP. This picture supports the author's interpretation that the opaqueness seen on the AgFEP is likely due to the interaction of visible light with the roughened surface through classical reflection-refraction processes.⁵ In summary, these four examples illustrate how important it is to be able to include graphics in the various LDEF databases.

The following is a demonstration of how easy it is to utilize the database to search and query information. In this example, we will use the database to find any information concerning Experiment S0050. We place S0050 in the Experiment Number slot, and press "find" as shown in Figure 9. The database searches and finds Experiment S0050, "Effects of Long Duration Exposure on Active Optical System Components" as shown in Figure 10. Using the computer we can read through the entire entry, gathering a great deal of information on the various optical materials (Figure 11) that were exposed on this experiment.

GETTING PRELIMINARY COPIES OF THE DATABASE

To receive a free preliminary copy of the LDEF databases for review, please send a written request with an empty 3.5" floppy disk for each database you request to: Dr. Gary Pippin, Technical Lead LDEF Materials Data Analysis, Boeing Defense and Space Group, P.O. Box 3999, M/S 82-32, Seattle, WA 98124-2499. For your convenience, the table below summarizes which databases are available, and the date of their most recent upgrade at the time of this conference.

Table 1. Available LDEF Databases

<u>LDEF Database</u>	<u>Latest Upgrade Date</u>
Optical Materials	12/91
Silverized Teflon	05/92
Treated Aluminum	05/92
Thermal Control Paints	05/92
LDEF Environment	05/92

CONCLUSIONS

In conclusion, the database fulfills our main objective, namely to compile the LDEF materials exposure results into an organized database. Even more than that, the Boeing LDEF databases serve as a unique research tool. The databases are application specific, and each database is an independent self-contained unit of information. This database design allows for efficient and easy transfer of LDEF findings to the space community.

ACKNOWLEDGEMENT

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¹Claris Corporation, 5201 Patrick Henry Drive, Box 58168, Santa Clara, CA. 95052-8168, Telephone 408/727-8227.

²Bourrassa, R. and Gillis, J.R.: "Atomic Oxygen Exposure of LDEF Experiment Trays", *LDEF Supporting Data*, NASA Contract NAS1-19247 Report, pg. 12, March 1992.

³Rousslang, Ken, Crutcher, E.R. and Pippin, H.G.: "Results of Examination of Silvered Teflon from the Long Duration Exposure Facility", *LDEF 69 Months in Space: First LDEF Post-Retrieval Conference Proceedings*, NASA CP-3134, February 1992.

⁴See, T.H., Allbrooks, M.K., Atkinson, D.R., Simon, C.G., and Zolensky, M.E.: *Meteoroid and Debris Impact Features Documented on the Long Duration Exposure Facility*, NASA Publication #84, JSC #24608, pg. 9, 1990.

⁵Young, P.R. and Slemple, W.: "An Analysis of LDEF-Exposed Silvered FEP Teflon Thermal Blanket Material", NASA Technical Memorandum 104096, December 1991.

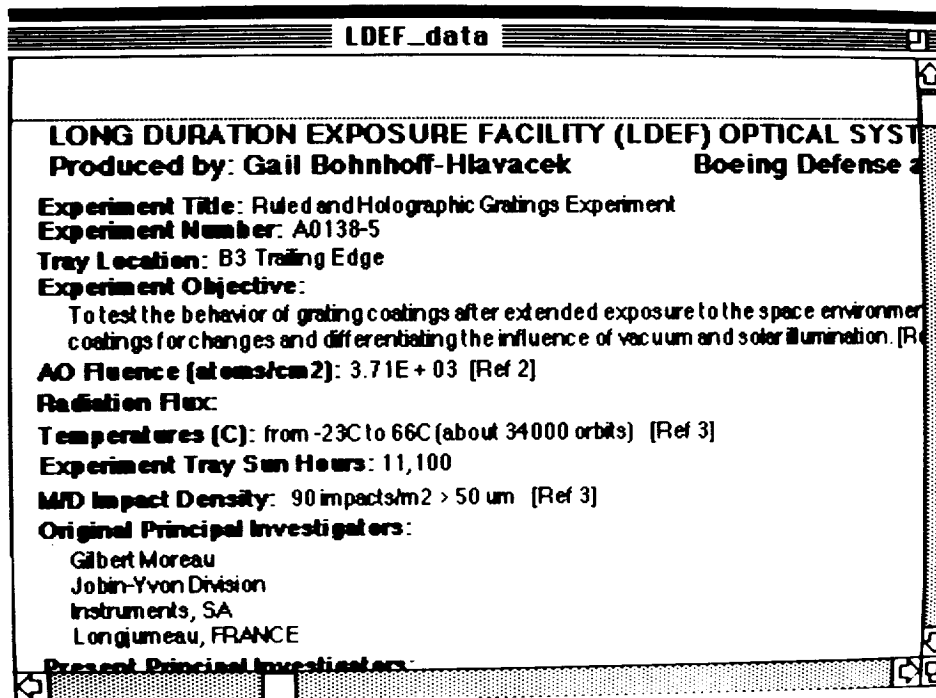


Figure 1. Database record with field names and referenced data entries.

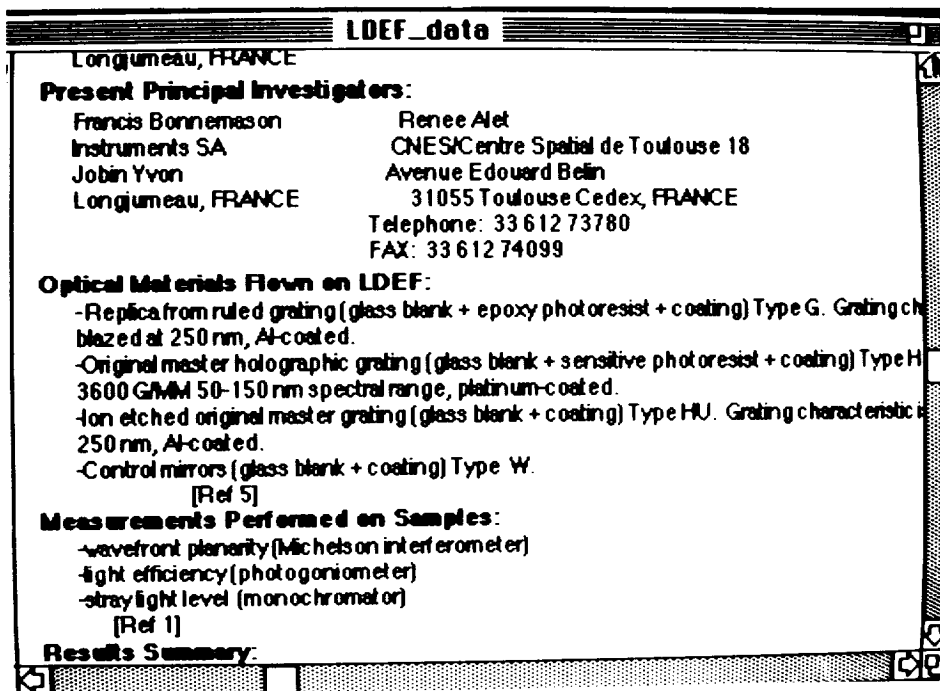


Figure 2. Continuation of database record from Figure 1.

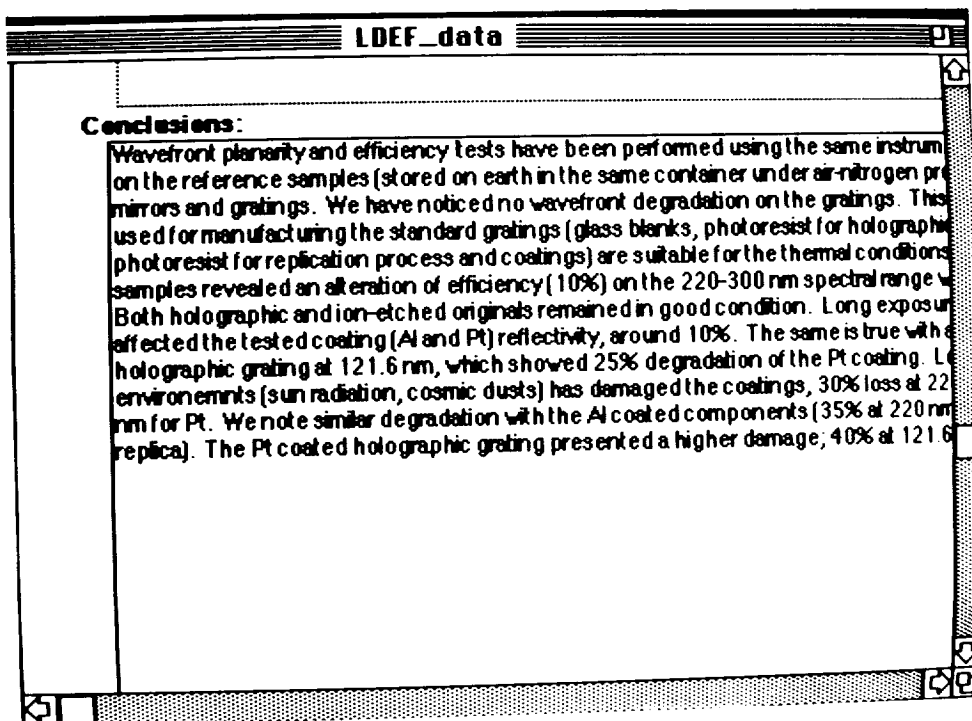


Figure 3. Continuation of database record from Figure 2.

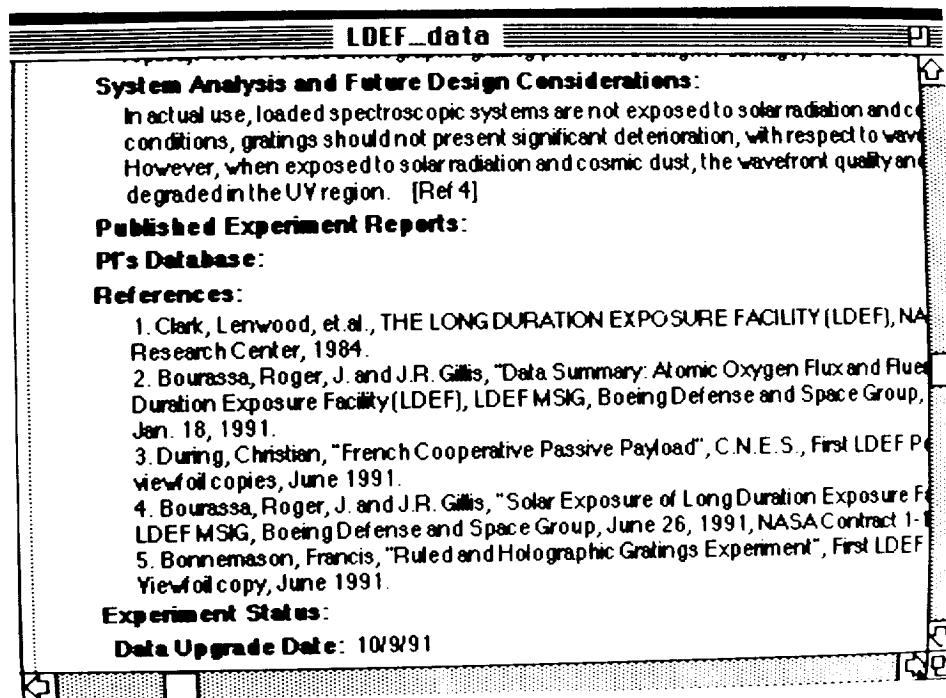


Figure 4. Continuation of database record from Figure 3.

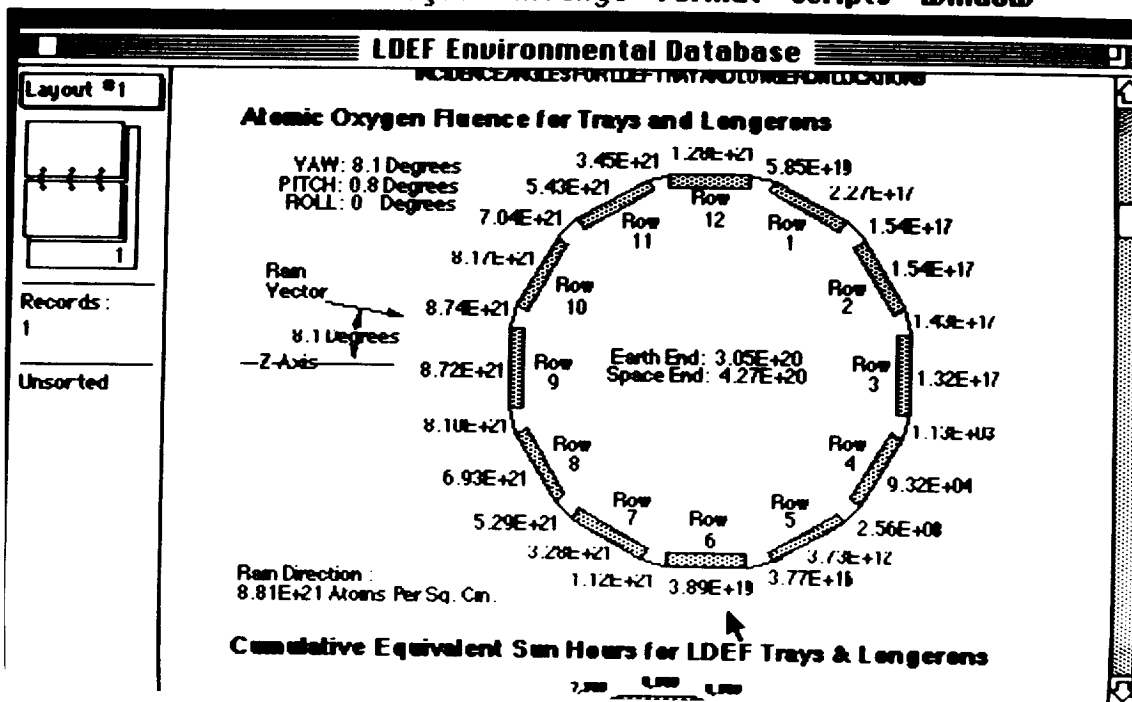


Figure 5. Example of a drawing in database.

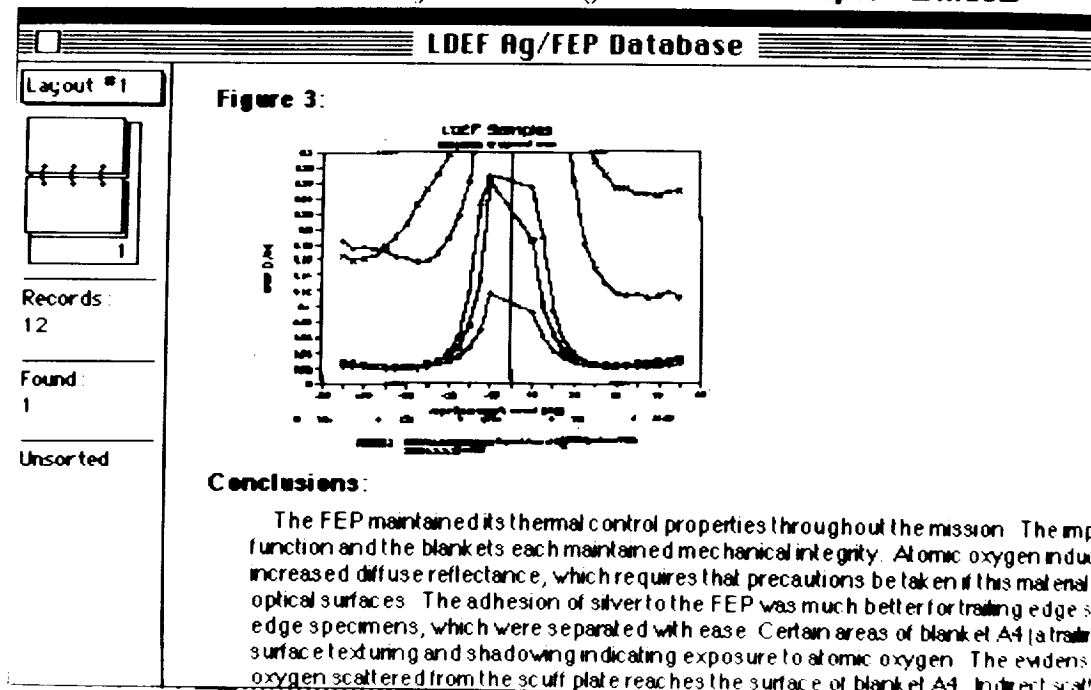


Figure 6. Example of graphical plot in database.

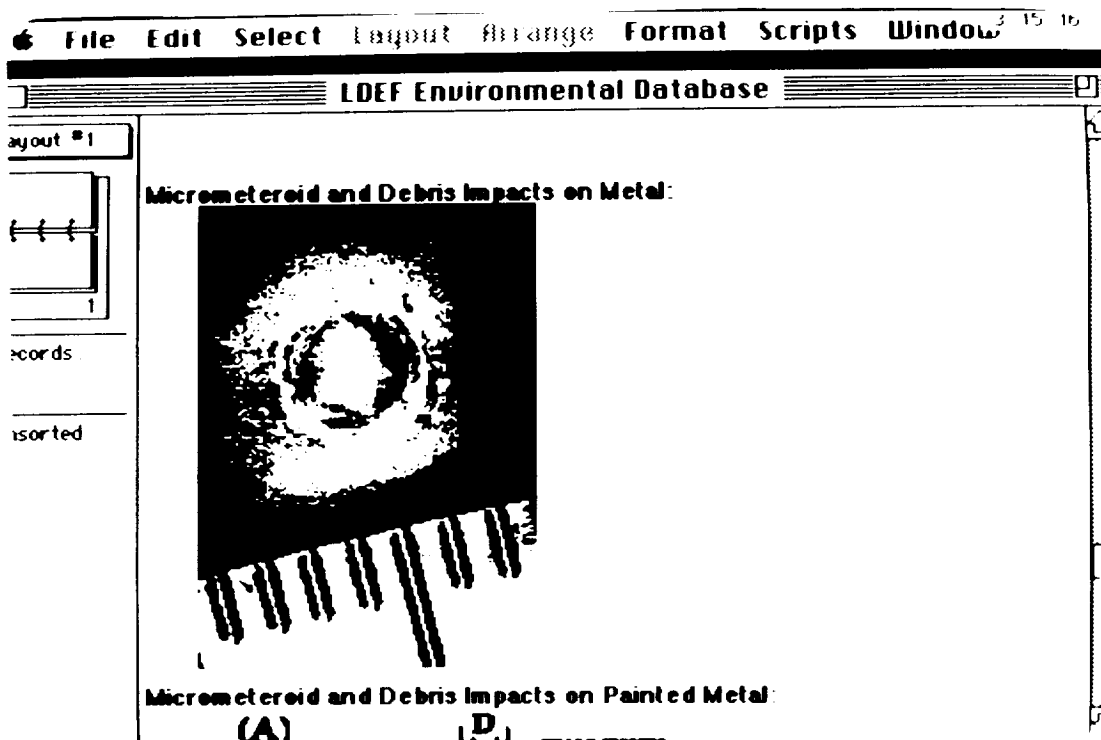


Figure 7. Example of picture file in database.

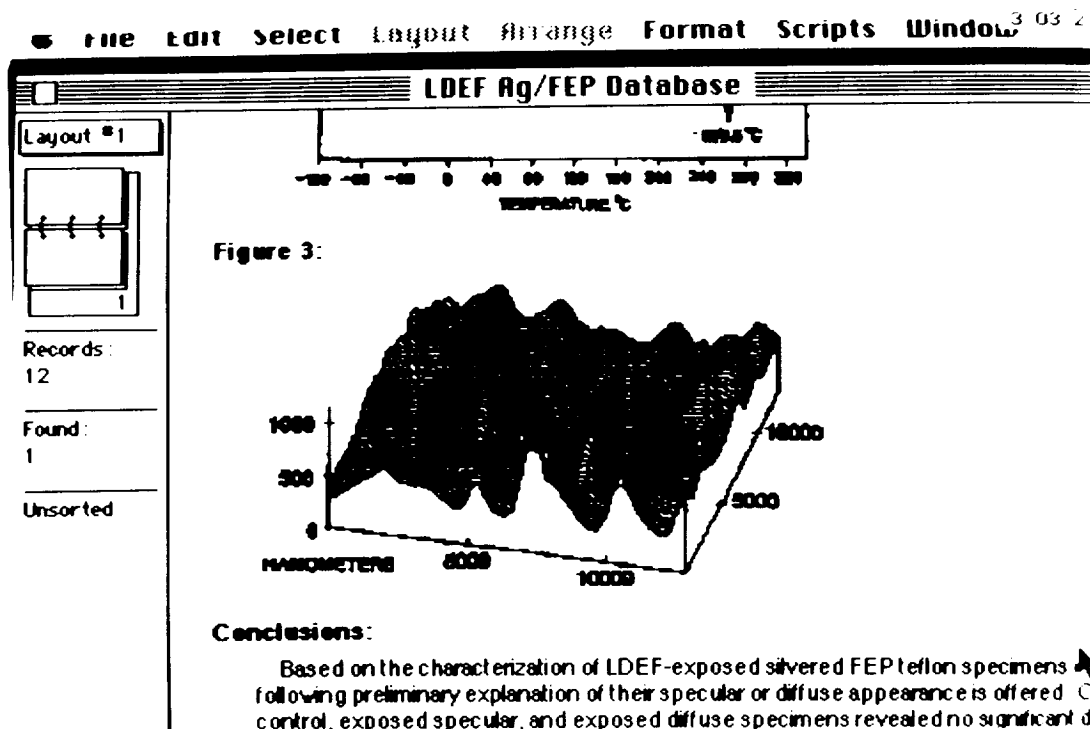


Figure 8. Example of 3-D plot in database.

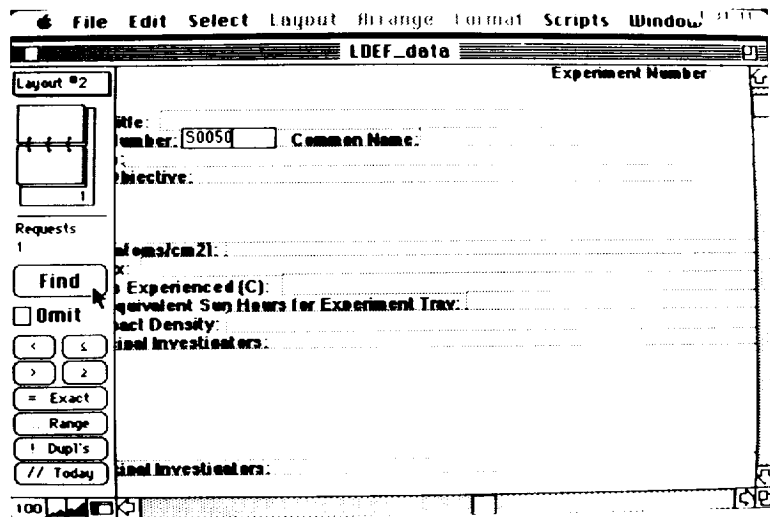


Figure 9. Search function on database.

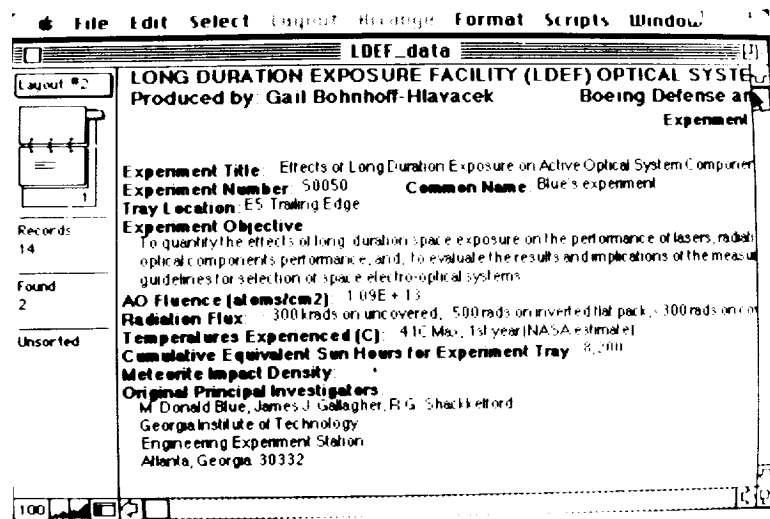


Figure 10. Database retrieves Experiment S0050.

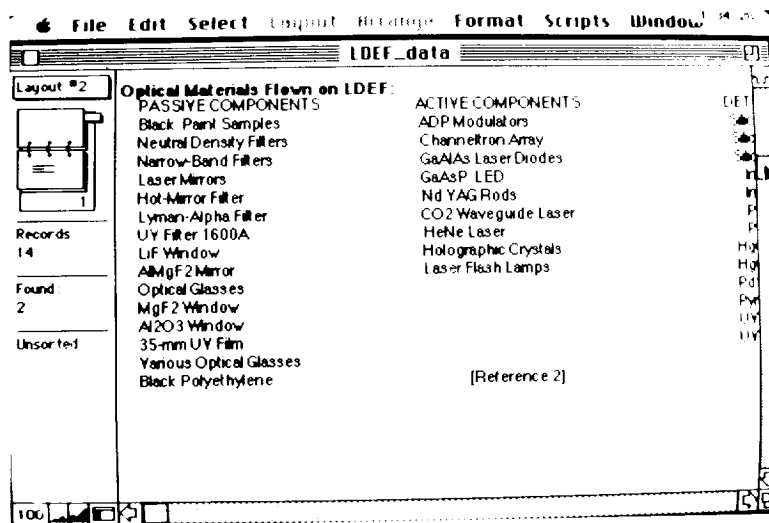


Figure 11. Scanning the "Optical Materials Flown on LDEF" field name in this database record.

ORIGINAL DATA IS
OF HIGHER QUALITY

