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CONTRACTOR REPORT ARAED-CR-87011

CREATION OF A DATA BASE ON ENERGETIC MATERIALS

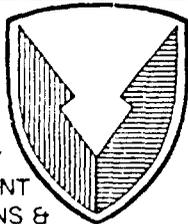
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A computerized, comprehensive energetic materials properties data base currently does not exist. The objective of this study was to determine the feasibility of establishing such a data base. Over 80% of the respondents to a survey questionnaire that was sent to more than 1,900 energetic materials specialists indicated they would use such a data base if it was available. Based on the survey results, the data base management system software requirements, special processing functions, input procedures, and output options were established.		

SUMMARY

While a computerized, comprehensive energetic materials properties data base currently does not exist, the results of this feasibility study show that such a data base is needed and could be implemented as a successful commercial information system. Over 80% of all survey respondents said that they would use such a service if it was available.

→ A survey of over 1,900 energetic materials specialists in both government and industry was conducted to determine the feasibility of establishing an energetic materials data base. The survey was also used to define the optimum characteristics of such a data base - its contents, access methods, and required special features. → The results indicated that most users want a user-friendly system that incorporates on-line help and software menus, as well as a sophisticated query language to handle complex searches. → The expected usage rate is over 1,690 hours per month - enough to require a dedicated computer system with at least nine telecommunication ports. → A substantial list of material properties and characteristics was obtained from the survey as well.)

The results of the survey were used to establish a baseline set of requirements for the proposed data base. Requirements were outlined for the data base management software, the computer system (including peripherals), special data processing functions, data input procedures, and data output options.

Based on these requirements, an extensive software selection study was conducted to find the best candidate Data Base Management System (DBMS) for the Energetic Materials Data Base (EMDB). Only relational type DBMS's were considered because of the need for a highly flexible data base structure. Forty packages were evaluated based on fixed criteria which resulted in several demonstrations and the identification of three major candidate systems.



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## FOREWORD

This report was prepared by SRS Technologies under Contract No. DAAA21-86-C-0288 entitled "Creation of a Data Base on Energetic Materials," for the U.S. Army Armament, Munitions and Chemical Command of the U.S. Army. The work was administered under the direction of Mr. Charles Ribaldo who served as the Technical Monitor.

This report describes the work done by the Aerospace and Commercial Systems Department at SRS Technologies, Systems Technology Division, during the October, 1986 - March, 1987 period.

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## INTRODUCTION

This report contains the results of a six month effort to determine the feasibility of developing a comprehensive automated energetic materials properties data base. Such a data base that focuses on energetic material properties separate from their application (munitions, missiles, etc.) does not currently exist.

A survey was conducted consisting of over 1,900 specialists from a wide range of government agencies and private industry. The results of the survey included the projected usage of the data base, a substantial list of user-defined properties and characteristics, optimum user interface designs, and many reliable sources of energetic materials data.

From the survey results, a set of computer hardware and software requirements for the data base was established. A software selection study was done to determine which DBMS (Data Base Management System) systems best met the user's requirements. Additionally, special data processing functions were identified that would make the system even more useful to the community. A preliminary relational architecture for the data base was completed and tested on several DBMS packages.

### TASK 1 - USER REQUIREMENTS DEFINITION

A survey of the potential users in the munitions, explosives, pyrotechnics, and propellants community was conducted to define their energetic materials data requirements. The survey helped define the data base contents; the types of potential users, and what hardware and software system should be developed to meet their needs. A mailing list of over 2,000 names was obtained from the Franklin Research Center, publishers of the newsletter 'Explosives and Pyrotechnics'. Other names were obtained from the literature survey and conversations with Charles Ribaldo. Over 232 responses have been received as of this writing. The survey design and the survey results are described in the following sections. A copy of the cover letter and survey are presented in Appendix A.

#### User Survey Design

The first step in constructing the user survey was to establish a candidate list of energetic material properties and characteristics that would be included in the data base. This list could then be modified and/or commented upon by the survey respondents. A literature survey was done to identify the most often-cited properties. A good overview was obtained from References 3-7, the Encyclopedia of Explosives and Related Items. The candidate list of properties obtained is shown in Figure 1. As discussed later in the Results section, this list was improved considerably by the survey respondents.

The survey questions were designed to determine first the feasibility of establishing an energetic materials data base, and then, if feasible, what type of

data base would receive the most use. The key characteristics of the data base that the survey was expected to determine include (1) frequency of usage, (2) type of user interface, (3) DBMS (data base management system) software/hardware system, and (4) data base contents. The survey questions are listed in Figure 2 along with their major purpose.

Question 1 determines the amount of time that the user expects to access the data base. These projections help determine the performance required from the DBMS. If many respondents expect to be on-line several hours a day, then the ability of the computer system to handle multiple simultaneous users quickly is important, whereas if most users project a lesser demand, then perhaps a smaller computer system would be adequate and still commercially viable.

Questions 2 and 3 attempt to define the turnaround time that the system must perform. If most respondents do not want instant response, then on-line processing would be of less importance in the system. Requests could be entered into a queue and later batch processed by an information specialist. Many computer information services provide periodic custom information summaries, where areas of specific interest to the user are tracked on a regular basis. For example, if a user's main interest was in military primers, then a special search application could be written to find and report on all the materials that have application as a primer substance. This report could be then be mailed to the user at regular intervals, or whenever the data base is updated. Question 3 tried to find out how often the user would need updates when subscribing to such a service.

The interface between the user and the data base can influence whether a system is used or not, even if the needed data is there. When a system is hard to use, then no matter how powerful the query language, the first time user may get frustrated and not get past their first attempt. Likewise, if the experienced user is forced to wade through many menus to perform a relatively simple task, then he too will stop using the system. Typically an easy-to-use menu driven system backed up by a powerful query language is the optimum solution. Questions 4 and 5 address this issue. Should on-line help, custom report generation, extensive menu support, or graphical output of data be available? A positive response from the survey on this question would justify the extensive programming that might be required to implement these features.

Question 6 asks if the user's organization subscribes to a network service, such as DIALOG, or TELENET. SRS has worked actively with the MPDN (Materials Property Data Network) system which hopes to connect many data bases through a proprietary network. If many users showed a positive response on this question, the data base could be set up as a member on this network. Users could then dial local numbers, access their network, and then connect to the SRS system without calling long distance.

Question 7 asks how often the respondent uses non-automated materials sources. This question helped us locate those who could benefit the most from the energetic materials data base. The users who spend much of their time tracking down materials data could profit the most by having access to a centralized source of property data. Finally, Questions 8 and 9 are designed to identify often used sources for energetic materials property data for inclusion in the data base.

## User Survey Results

As of this writing, over 232 completed surveys have been returned out of approximately 1,900 valid mailings. More are coming in daily. As shown in Figure 3, the respondents represent a wide cross section of the government and private concerns. Many of those surveyed added extensive comments to their responses. The survey results are analyzed in the following sections.

### Projected Usage

From the answers to the first three questions on the survey, an estimate of the data base system usage rates can be determined. As shown in Figure 4, an overwhelming 89% of the respondents answered "yes"; they would use a computerized energetic materials data base if it were available. These respondents also estimated the amount of time they would spend on-line accessing the data base. The frequency of response was scattered, as shown in Figure 5. Forty-four percent of those surveyed expected to be on-line up to six hours per month, while 59% projected up to eight hours per month. In contrast, only 14% projected more than 20 hours on-line per month. Seventeen percent did not specify a frequency on this question.

The response to the second question is shown in Figure 6 and indicates how quickly users would expect their information requests to be satisfied. Not shown on the graph is that 42% wanted at least same day turnaround, while 16% wanted the data by the next day. This would rule out regular mail in most cases. While only 5% actually specified an instantaneous response, this is misleading because the lowest option given in the question was one hour. It is expected that many of the people who picked one hour would prefer as fast a response as possible. However, there is a significant group (39%) who can wait over two days for data. These users would not require an interactive, on-line system and could mail or phone in their requests, probably at a reduced rate. For the majority of cases, requests could be entered into a processing queue and searches performed later by an information specialist.

The third question asks if, and how often, updates would be needed to custom information summaries. The response is shown in Figure 7; only one person did not want such a service. The response was well defined - the majority (54%) wanted a monthly update while 39% preferred annual updates. Either monthly or annual updates would satisfy 91% of the customers. From this response, it appears the custom information summary would be a popular feature of the EMDB.

An estimate of the amount of time the respondents expect to save by using the automated data base can be found by comparing their time spent using non-automated methods (Question 7) with their projected EMDB usage (Question 1). Figure 8 shows the time people spend using non-automated methods. The current total is 2,188 hours per month spent using non-automated methods to obtain energetic material data. The projected EMDB usage total is 1,690 hours per month. This shows a 23%

average time savings that the respondents expect to see. While the actual time savings should be much higher, it is significant that the respondents do expect to save time by using the automated system.

#### Hardware/Software System Requirements

Questions 1, 4, 5, and 6 help define the requirements of the host computer system and its DBMS software. From the projected usage rates, the number of telecommunication ports required on the computer system can be estimated. The other issues include the type of user interface for the on-line system, graphics processing, and the potential for access to the EMDB through a computer network system.

The number of required telecommunication ports can be estimated as follows. Take the total number of on-line hours that the respondents projected they would need and convert to total system demand per day. Then allow for a 12-hour work day to accommodate west and east coast users. There is currently a total projected usage (the sum of all the respondent's projections) of 1,690 hours per month. With 21 working days per month, and 12 hours per port available per day, then a minimum of seven ports are required, just to meet the expected demand of those responding to the survey.

$$\frac{1690 \text{ hours/month}}{21 \text{ working days/month} \times 12 \text{ hours/port/day}} = 7 \text{ ports}$$

These ports would be occupied full-time to accommodate the demand. However, because there will be peak times when most users will call in and slack times (such as during lunch) when few will call, the actual number of ports will have to be greater than seven. Adding 25% to the figure gives a minimum requirement of nine telecommunication ports on the EMDB system.

There are several unknown factors that this estimate does not consider. The estimate might be considered low because it only includes those who responded to the survey. It is expected that there are many others who would use the system but were not on the mailing list. No estimates of the actual user base were attempted during this study. Conversely, it is likely that each user's estimate of his usage is too high. After the initial learning process for each user, they should be able to search the data base very quickly, depending on the complexity of their search. Below is a table that shows how the number of required ports changes if the respondents did over-estimate their projections.

<u>Overestimate On-line Hrs.</u>	<u># of Ports Required</u>
10%	7
25%	6
33%	5
50%	4

Question 4 attempts to define the optimum user interface for the system. The response is shown in Figure 9, where the most important features chosen were menu support (36%) and on-line help (33%). Therefore, the DBMS selected for the EMDB should contain an applications programming language for development of custom menus and built-in help features as well as a strong query language. A versatile report generator is important as well.

The response to Question 5, shown in Figure 10, indicates that a large majority (90%) of the potential users have access to graphics terminals and/or plotters. It would be wise to take advantage of that equipment to display graphical data. Many characteristics of a set of data become more meaningful when the data is plotted (effects vs. time, distribution plots, trend plots, etc.) rather than tabulated. The system design will require consideration of graphics protocols and storage methods. Graphical display is discussed in the sections entitled Hardware Specifications and Data Output Option.

One option for increasing the accessibility of the EMDB system would be to have it available on one of the nationwide computer networks, such as DIALOG, or TELENET. The response to Question 6, shown in Figure 11, indicates that such an option should be considered. Over half (56%) of the respondents who expressed interest in the data base did subscribe to some computer network service.

SRS is not yet committed to a specific network option. In fact, the survey results suggest this matter requires more extensive research to determine if a networking option is feasible for SRS's data resources management system, and if so, which one. Several options are available, or are in the development stage. First, SRS has the present capability to provide remote access to the EMDB, which would be resident on its VAX 11/780 computer in Huntsville, Alabama. Second, access to the EMDB could be provided to users through their subscription to a third party commercial network service (DIALOG, TYMNET, etc.). Another option may provide users with access to the EMDB by subscribing to a specialized network service such as the Materials Properties Data Network (MPDN) currently being developed to support a variety of materials data base projects. The demand for, and cost effectiveness of on-line interactive connections to the EMDB must be evaluated before a networking option can be chosen.

#### Data Base Contents

A major purpose of the survey was to identify the material properties and characteristics that users need the most. A candidate property list was included with each survey for the respondents to modify to reflect his specific material interests. The comments and additional properties that we received helped us compile a new, more comprehensive list. Because of its length, the list was broken

down into several categories. Redundant items were removed by identifying the many different names for similar properties. After several iterations, the following eight data categories were defined:

1. Characteristic Data (unique to energetic materials)
2. Physical - Chemical Properties
3. Induced Property Variations
4. Mechanical Properties
5. Sensitivity (Explosion)
6. General Information (Manufacturer/Formulator)
7. Safety
8. Additional Data/Information on Related Topics

The complete list of the properties in each category are listed in Appendix B. While this list includes all requested properties, it has not yet been ranked. Some of the data will only be needed by a few users with unique interests while other data will have more widespread application. Before the data is gathered for the data base, this list will have to be ranked in order of applicability.

#### Major Sources of Energetic Materials Data

The survey also identified many sources of energetic materials data that could be included in the EMDB. This list is summarized in Figure 12, along with the number of respondents who cited each reference. Government<sup>+</sup> supplied data was listed the most. The most cited specific reference was the handbook published by the Lawrence Livermore National Laboratory (LLNL). The Encyclopedia of Explosives (from Picatinny Arsenal) was the second most cited, followed by the manuals published by the Chemical Propulsion Information Agency and the Army Materiel Command. This list provides a valuable bibliography of material data sources that would be good candidates for inclusion in the EMDB.

Figure 13 shows the percentage of respondents whose organization maintains an in-house energetic materials data base. Over half do not. And even among those who do have in-house data, most expressed interest in the EMDB system. This may be because their data base is not automated and they want the speed and flexibility the automated system would provide. Or, if their data base was computerized, they may be interested in subscribing to a data service whereby they could incorporate subsets of the EMDB into their data base. Automated or not, their data may be very specialized (and proprietary) and they could use a more generalized data service.

#### TASK 2 - DATA BASE REQUIREMENTS DEFINITION

This section defines the software and hardware specifications that are required for a successful energetic materials data base system. This includes the Data Base Management System (DBMS) software, methods for entering data, and system processing functions.

## Software Specifications

A review of the commercially available DBMS software packages was performed to determine the most applicable software system. Three types of data base management systems - hierarchical, network, and relational - were considered for the energetic materials data base. A relational system was determined to be the most suitable because of its inherent flexibility and the availability of good relational data base systems that do not suffer significant losses in performance compared to network or hierarchical types. A relational DBMS structure can be modified easily to include new relations, categories, material properties, etc. The other two types are most appropriate for performance-oriented applications with static structures and require significant effort to modify. Structural flexibility is deemed a more important requirement for this similar data base than high speed performance. SRS has used relational systems in-house for data base prototyping and development with good success. Therefore relational DBMS's were emphasized in this initial software selection study.

During this study, several commercial data base management systems were identified which satisfy the major software requirements for the EMDB. Significant recent technological advances have been made in relational data base management software which may enhance the implementation of planned features of the EMDB. Eight factors are generally used as criteria for judging a comprehensive DBMS. These factors were combined into an analysis matrix (Figure 14) as baseline acceptance criteria for the EMDB. Extensive technical conversations have been held with several DBMS vendor representatives, and demonstrations of the ORACLE, SYSTEM 1032, and INGRES packages were conducted at the SRS facility. Approximately 40 technical literature packages were received from major DBMS vendors, and have been subjected to technical evaluations based on the following factors:

1. Data Dictionary/Data Definition Language
2. Telecommunications Monitor
3. Query Language
4. Report Generator
5. Security Procedures
6. Applications Development Language
7. Recovery Procedures
8. Transaction Integrity

These factors and their importance as criteria for evaluating the DBMS systems are discussed below. Cost, while certainly a factor, was not an initial evaluation criterion.

To eliminate inconsistencies in stored data, an integrated, active data dictionary is an essential component of the DBMS, and is a key tool in managing the data resource. An active data dictionary is one in which the DD/D (Data Definition/Dictionary) is the sole source of metadata (the information about the data's structure) in the data management system, mandating that all users and software components of the DBMS obtain metadata from a single source. This insures a high degree of control over data definitions and standards. Data items, records, primary and secondary keys, and relationships are specified by the data definition language.

In a networked environment, it is essential that all remote terminal accesses be managed. In the EMDB, this will be accomplished by an integrated telecommunications monitor. Analyses of teleprocessing features desired for the EMDB focus on protection against unauthorized access, and multilevel access security capabilities generally associated with a comprehensive integrated teleprocessing monitor/access security DBMS software component.

The degree to which the query language provides user friendly data base search capabilities was a critical factor in the DBMS software analysis. The query language should provide a powerful, interactive retrieval capability based on high-level English language commands. Ideally, such a query language permits users with no training in procedural languages, such as COBOL and BASIC, to retrieve information that is stored in the data base. The American National Standards Institute (ANSI) has proposed IBM's SQL (Structured Query Language) as the basis for a standard language for relational data base management systems. Data base management systems which utilize SQL generally apply it as a multi-function command language for all major functions of the DBMS.

The report generation function of the DBMS is the integrated facility with which the user can design a new report without writing applications code. This is a desired feature for commercial data bases which offer periodic selective dissemination of information services in response to specific user-defined search profiles.

Security features which are mandatory for the EMDB include mechanisms which protect against accidental or intentional misuse or destruction of stored data. Among those receiving specific attention in the DBMS analysis are content security procedures which define what explicit actions (read-only, update, etc.) may be taken by each user and what access level is permitted. Unauthorized access protection is more closely allied with the teleprocessing monitor described previously.

An application development facility is a set of program modules and commands for on-line program development, including text editing and word processing. The EMDB software analysis revealed proprietary applications generators which utilize interactive question and answer dialog techniques to assist the user in building unique data entry, update, and query applications. This facility would typically be used by SRS personnel to develop custom retrieval applications for users.

Recovery mechanisms provide for restoration of the DBMS to a known state if a hardware or software failure occurs. The most common techniques revealed during this study involve rollback to a known state, and autosave procedures which occur after a specified number of changes to the data base.

Transaction integrity pertains to simultaneous retrieval and/or update actions which may be incorrectly processed because they are occurring at the same time. Integrity is normally provided by specifying a sequence of steps which constitute an activity (such as changing a data value), and which are executed if, and only if, the transaction is processed successfully in its entirety. Any transaction which is not executed successfully is aborted, preventing future transaction processing based on erroneous results.

The software specification study identified 13 data base management systems which partially, or fully satisfied the DBMS evaluation criteria, and are listed below:

<u>DBMS NAME</u>	<u>DBMS VENDOR</u>
INFO-DB <sup>+</sup>	Henco Software, Inc.
INGRES	Relational Technology, Inc.
ORACLE	Oracle, Inc.
SYSTEM 1032	Software House, Inc.
ADABAS	Software AG
RIM	Boeing Computer Service
RT FILE	Comtel, Inc.
REXCOM	Rexcom Systems, Inc.
DATAMAT	Transtime Technology, Inc.
XAMPLE	Landmark Software Systems, Inc.
SMARTSTAR	Signal Technology, Inc.
IIS/DESTINY	Intelligent Information Systems, Inc.
SATURN-BASE	Saturn Systems, Inc.

Saturn Systems notified SRS that, based on their analysis of the EMDB data types, SATURN-BASE would probably not be an efficient DBMS on which to implement the EMDB. Therefore, SATURN-BASE will not be considered as a candidate DBMS for the EMDB. All other DBMS's listed satisfy the gross requirements of the evaluation criteria, but major differences in the proprietary manner in which significant DBMS features are implemented in each system impact the overall selection decision process.

Presently, no decision has been made as to how SRS will make the EMDB and its other data bases available to the end-user. Therefore, the various networking options must be evaluated based on the results of the questionnaire survey, as well as pertinent data from other sources. Additionally, such features as graphics and 4GL (4th Generation Languages) which allow SRS to enhance the user-friendliness and custom applications options (menus, data input screens, report formats, etc.) must be given strong consideration.

SRS's internal requirements analysis has revealed several factors which must be consistent with the company's data resource management plan, as well as with the requirements for current parallel data base development efforts. Cost effectiveness and data management capabilities of the DBMS are major factors which must be considered in the selection decision. In addition, the DBMS must have the capability to interface with microcomputer (primarily IBM-PC) software, such as spreadsheets, word processing systems, and project management programs, and still be compatible with presently developed in-house microcomputer applications software packages.

Of the DBMS's previously shown, INGRES, ORACLE, and System 1032 are the top candidates for the SRS DBMS because of their cost effectiveness, industry reputation, and capacity to handle SRS's major data resource management requirements in an extremely efficient manner. In addition, they easily permit integration with existing SRS projects and current proprietary software packages.

## Hardware Specifications

The computer hardware requirements for the EMDB include four basic components - the disk storage, available output devices, telecommunication equipment, and sufficient computing power to provide a reasonable response time to the users.

Because the price of disk storage has dropped so much in recent years, many computer systems (including microcomputers) can be configured with enough to handle the EMDB. The size of the EMDB was estimated by assuming that all the material properties and characteristics identified during Task 1 were available for each chemical compound listed in the handbook entitled Explosives, by Rudolf Meyer. There are approximately 1,980 materials in the handbook and 283 characteristics identified during this study. This gives 560,340 data items in the data base. Many of the items are real numbers, requiring 8 bytes of storage each. However, many are text fields (aging characteristics, test methods, source descriptions, etc.) and require much more space (~2,000 bytes). Assuming that one percent of the data is lengthy text, the EMDB was estimated to require 15 megabytes of disk storage. This is a conservative estimate because it is unlikely that all of the data is available for a fraction of all energetic materials, so the actual size will be much smaller. However, this size is well within the capability of most computer systems, while allowing plenty of space for the data base to expand in the future.

The minimum peripheral output devices necessary for the EMDB are a line printer and a magnetic tape drive. A line printer is essential for off-line printouts of data searches and customized reports. Users who requested information by mail or phone would receive printed reports. While a laser printer would be ideal because of its clarity and 8½ x 11 page format, a standard mechanical line printer would suffice. A 9-track magnetic tape drive will also be required both for data input and data transfers. Magnetic tape is the most universal medium for data exchange among mini and mainframe computer systems. Magnetic tape is also essential for periodic file backup procedures to provide physical data security.

Some graphics output devices, such as a terminal and/or a pen plotter would also be a desired feature on the EMDB system. Plots could be reconstructed from the data and mailed to the users, or if the user had the proper terminal, the plots could be displayed on his screen in real time. The graphics library that the EMDB system used would probably be compatible with Tektronix terminals and Hewlett Packard plotters. The exact specifications for the graphics software will depend on the computer system chosen, the DBMS software, and the type of graphics output that will be needed. For example, if microfiche output is specified, then the graphics software must interface with a microfiche camera system.

A digitizing table for digitizing a variety of graphical data would also be a useful device. The accuracy of the digitized data will depend on the resolution of the digitizer and the quality of the plot itself, but it could speed up data entry of graphical data considerably.

The "power" of a computer system is an ill-defined term that combines many characteristics including the number of processors, their size and clock speed,

internal memory size, input/output processing speeds, and the number of simultaneous users supported. For commercial systems such as the EMDB, it is important that the on-line user experiences an acceptable response time to system commands. Delays of more than a few seconds will frustrate users and possibly increase his cost, depending on the equation used for computation of the user access fee. To the user, it is the response time that distinguishes the performance of multi-user micro computers from the mini-mainframe class when both have a similar number of users.

Three candidate systems were defined for the EMDB, each representative of a different size class of computers. The major features of these systems are shown in Figure 15. The expected demand for the EMDB falls within the range of the DEC VAX system. The VAX system has the added advantage of high compatibility with the major DBMS systems and can be expanded easily to meet increased demand. The workstation solution (micro VAX or Apollo) would work well for a start-up system or if the demand level estimates are found to be too high. They support a few users very well, require less dedicated facility space, and cost much less than a complete VAX system. However, they have limited expansion potential and slow response when all remote access ports are busy. No full mainframe system could be justified for the EMDB alone. However, the EMDB could be implemented on an existing mainframe system if the additional ports for telecommunications were available. While the EMDB would fit on a microcomputer (IBM PC AT or equivalent), multiple users are not supported well and performance would likely be unacceptable.

### Processing Functions

Processing functions in a data base management system are those operations other than the standard search and retrieval procedures. A modern system will include many of these to improve the usefulness of the data base. The major processing functions available on commercial DBMS systems have been identified and are listed below.

- Editing and program library facility
- Screen forms generator
- Interfaces to various programming languages
- Color/Monochrome graphics
- Integrated spreadsheet application
- Integrated text processing
- Custom report generator
- Data validation processing (field length, range checking, etc.)

The main processing function requirement for the EMDB is a well-implemented interface between the DBMS and various programming languages (especially FORTRAN). Potential requirements exist for many different custom routines, such as statistical processing of data, unit conversions, and data curve-fit programs. It is also conceivable that separate application programs, such as thermodynamic property codes or Chapman-Jorjet detonation programs (Reference 9) could be put on the EMDB system. These programs often require empirical data, such as the JANNAF thermodynamic tables, which could be stored in the data base.

## Data Input Procedures

Data for the EMDB may come in several formats that the hardware/software combination will need to support. Data obtained from other computerized data bases may have to be converted to the EMDB system's format. In reviewing the commercial data base management systems, it was found that most provide a facility for importation of data from external files if the format of that file is known. This is a key requirement for the EMDB. The ability to import data from other systems without retyping saves time and money. Though not a hard requirement, the ability to digitize graphical data would also save on data input costs.

Because most data will have to be keyed in manually, verification becomes a key factor in the system. Some DBMS's will verify that the input data falls within a certain range, is of a predefined type (text, integer, real number, etc.), or is of a specified field length. Typing in the data twice and comparing the results is also an option for verification.

It is essential for the success of the system that all the data be validated - a few errors will raise doubts about the entire data base. Most of the DBMS systems reviewed during this study included some method for developing custom input screens that prompt the data entry operator for input records and can perform some degree of error-checking.

## Data Output Options

Providing flexibility in the display or reporting of the data retrieved from the data base is an important requirement of the EMDB. According to the user survey, most users will remotely access the EMDB via a terminal and a modem. Searches can be done on-line and the results displayed on the user's terminal screen. However, some customized reports may need to be printed off-line and mailed to the user. It may be more cost-effective for the user to have large reports printed off-line rather than on-line. Subsets of the data base could be disseminated on floppy disk to users with personal computers. Likewise, custom information summaries, which periodically track a particular area of interest for the subscriber, may be distributed either as printed reports or on floppy disk. While no one floppy format is universal, using the IBM PC 5.25" format, the Apple 3.5" disk format, and a 8" CP/M format should be adequate for a large percentage of the customer base. Special cases can be handled by commercial format exchange services.

Graphics output is one of the most desired features in a data base system but also one of the hardest to implement. Graphics reproduction is inherently dependent on the display hardware (different graphics terminals and plotters). Some graphics protocols are more common, e.g., Tektronix, Hewlett Packard, Calcomp, etc., but none are true standards. One solution is to only produce requested graphical output off-line on an output device (plotter, electrostatic printer, microfiche, etc.) at the central site and then mail the plots to the user. Then only one protocol is used. However, if users want to display graphics on-line,

hardware and software compatibility will be an issue, as only a limited number of protocols could be supported.

Although a standardized method of providing graphics to data base users has not yet been established, the National Bureau of Standards and the American Society of Testing Materials are supporting such a development effort. The ASTM E-49 Committee on Standardization of Computerized data bases is working to define a uniform materials data interchange format (MDIF) that will have an integrated graphics component. This concept will permit data base users to develop their own computer programs to access the MDIF, while reducing the proprietary software development efforts required to interface with a wide range of materials data bases providing graphics data. SRS is making a contribution to the MDIF effort by having an EMDB representative on the E-49 Committee.

### TASK 3 - DATA BASE ARCHITECTURE AND DESIGN

A preliminary definition of the EMDB relational structure was completed. Based on a literature survey and on the user survey results, the following classification scheme was used to define the relationships. The main categories are Primary (initiating) Explosives, Secondary or High Explosives, Pyrotechnics, and Propellants. The Primary Explosives are the initiating explosives in an explosive train. They are characterized by extreme sensitivity but low power. They can be easily detonated by heat, flame, spark, impact, friction, exploding wires, and electrical current. They are used in primers, igniters, blasting caps, and detonators. Secondary, or High Explosives, are less sensitive but possess much greater power. They require more energy to initiate their detonation. These are also further subdivided into commercial and military applications. Commercial high explosives include dynamites and blasting gelatin and are used for mining and civil engineering. The military high explosives can be subdivided into 'booster' and 'burster' explosives. The booster type are more sensitive but less powerful than the burster type high explosives. The burster (or bursting) explosives constitute the main charges of projectiles, mines, torpedoes, bombs, etc. Examples of booster explosives are Tetryl, RDX, and HMX. Examples of bursting explosives are Amatols, TNT, Compositions A, B, & C, and Picatrol.

Within these categories, explicit data fields, or 'entities', can be derived and organized according to how they relate to one another. For the EMDB, each material will have properties of different types - physical, mechanical, electrical, thermal, and chemical. There may be several properties of each type but each one will have a data value with defined units. To provide a logical structural model of the data base permitting the capability to 'join' data fields, it is necessary to perform an analysis of these entities called data normalization. This process removes repeating groups of data and improves the efficiency of retrieving and updating the data base. Figure 16 shows the data base structure that results from the normalization of the candidate data fields identified for EMDB. This graphical illustration shows the optimum entity-attribute relationships determined by normalization analyses. Normalization analysis is based on an investigation of the specific properties of energetic materials and the descriptive relationship of each entity-attribute pair. The exercise of normalizing data relationships

enhances the efficiency of the EMDB's logical data base design by eliminating the necessity to store repetitive data, and permits implementation of the EMDB on any DBMS, regardless of the physical design of the DBMS. The analysis is conducted in such a manner that a unique identifier, or primary key, is assigned for each explosive property category, data value, data unit, manufacturer, or other attribute which may become relevant at a later time. In addition, should the structural nature of the EMDB change, the normalization data relationships allow an audit trail for configuration control of the EMDB.

Several entities were not included in this preliminary normalization. The manufacturer of the substance should also be included with the data, as well as the material's typical application in industry. Where applicable, experimental procedures used to determine the properties will be included as a text field associated with the data value. Also, some reference to the source of the data will also be included.

#### TASK 4 - ACCESS FEE STRUCTURE

Fee structures for direct, interactive data base access, and automated accounting procedures for the SRS VAX 11/780 computer system were evaluated to determine their application in monitoring utilization of the EMDB. Typical commercial data bases compute user fees based on a combination of factors including CPU time, requirements for use of peripheral devices, and output options chosen (hardcopy, remote interactive, batch, graphics processing, etc.).

A survey of 100 existing commercial data bases similar to the EMDB was conducted using The Computer Data and Database Source Book. The thrust of this effort was to determine options for different fee structures, as well as actual user charges. The most prevalent fee structure in the sample was computed based on on-line connect time to the host computer. The average hourly charge for on-line access was \$67.78/hour. Most data base services have a minimum per query charge, which covers an average minimum processing time for a single data base query. Data bases providing bibliographic citations and abstracts as the major output, generally have an additional charge for each bibliographic reference retrieved above a computed threshold. The majority of commercial data bases are available by subscription to networking services such as DIALOG, Tymnet, Telenet, Dow Jones, I.P. Share Associates, and SDC Information Services, for which an additional fee may be charged.

#### SUMMARY OF RECOMMENDATIONS

The results of this feasibility study show that a computerized energetic materials properties data base is needed and could be implemented as a successful commercial information service. Over 80% of all survey respondents said that they would use such a service if it is available. This study recommends that the system be implemented.

Because of the high projected usage rates from the survey, a larger computer system such as a DEC VAX 11/780 should be used rather than a mini-computer system. The computer system should include at least nine telecommunication ports, 100 megabytes of hard disk storage, a 9-track tape drive, a printer, and a plotter. The system should be implemented with a relational data base system and the top choices are ORACLE, INGRES, and SYSTEM 1032. The user interface should consist of software menus, on-line help, and an SQL-type query language. Custom information searches should be available on a subscription basis. It should be possible to generate search results (including plots) off-line and have them mailed to the user.

## REFERENCES

1. Fair, H. D. and R. F. Walker, Energetic Materials, New York: Plenum Press, 1977.
2. Definitions of Metallurgical Terms, American Society for Metals, 1977.
3. B. T. Fedoroff, Encyclopedia of Explosives and Related Items Volume 1 - PATR 2700, Picatinny Arsenal, Dover, New Jersey, 1960.
4. B. T. Fedoroff and G. D. Clift, Encyclopedia of Explosives and Related Items Volume 2 - PATR 2700, Picatinny Arsenal, Dover, New Jersey, 1962.
5. B. T. Fedoroff and O. E. Sheffield, Encyclopedia of Explosives and Related Items Volume 3 - PATR 2700, Picatinny Arsenal, Dover, New Jersey, 1966.
6. B. T. Fedoroff and O. E. Sheffield, Encyclopedia of Explosives and Related Items Volume 4 - PATR 2700, Picatinny Arsenal, Dover, New Jersey, 1969.
7. B. T. Fedoroff and O. E. Sheffield, Encyclopedia of Explosives and Related Items Volume 5 - PATR 2700, Picatinny Arsenal, Dover, New Jersey, 1972.
8. R. A. Finn and P. K. Trojan, Engineering Materials and Their Applications, Houghton Mifflin Co., 1975.
9. Glassman, I. and R. F. Sawyer, The Performance of Chemical Propellants, Slough, England: Technivision Services, 1970.
10. Gordon, Sanford, and Bonnie J. McBride, Computer Program for Calculation of Complex Chemical Equilibrium Compositions, Rocket Performance, Incident and Reflected Shocks, and Chapman-Jouquet Detonations, NASA SP-273, Washington, DC: NASA, 1971.
11. Gregory, C. E., Explosives for Engineers, St. Lucia, Queensland: University of Queensland Press, 1966.
12. Kit, Boris and Douglas Evered, Rocket Propellant Handbook, New York: Macmillan Company, 1960.

13. Lenz, Robert R., Explosives and Bomb Disposal Guide, Springfield, Illinois: Charles C. Thomas Publisher, 1970.
14. Myer, R., Explosives, Verlag Chemie, Weinheim, New York, 1977.
15. Rhein, Robert A., Handbook of Energetic Polymers and Plasticizers, NWC TP 6720, China Lake, CA: Naval Weapons Center, 1986.
16. Sarner, Standley F., Propellant Chemistry, New York: Reinhold Publishing Corp., 1966.
17. Siegel, Bernard, and Leroy Schieler, Energetics of Propellant Chemistry, New York: John Wiley and Sons, 1964.
18. Urbanski, Tadeusz, Chemistry and Technology of Explosives, Elmsford, New York: Pergamon Press, 1983.

Abrasion Resistance	Heat of Formation
Activation Energy	Heat of Fusion
Aging Characteristics	Heat of Reaction
Air Gap	Heat of Vaporization
Atomization Energy	Ignition Temperature
Average Ignition Delay	Impact Strength
Bond Strength	Impetus
Brisance	Load Carrying Capacity
Bulk Modulus	Loading Density
Bulk Strength	Machinability
Cartridge Strength	Modulus of Elasticity
Coefficient of Friction	Molecular Weight
Composition	Operating Temperature Range
Compressive Strength	Oxygen Compatability
Creep Properties	Permeability
Critical Density	pH
Critical Diameter	Propagation Velocity
Critical Length	Rate of Reaction
Critical Mass	Resistivity
Cure Schedule	Seaming/Joining Techniques
Density	Shear Strength
Detonation Pressure	Shrinkage
Detonation Velocity	Specific Heat
Elastic Limit	Specific Impulse
Emissivity	Storage Life
Explosion Sensitivity	Temperature of Reaction
Explosive Strength	Tensile Strength
Flammability	Thermal Conductivity
Flexural Strength	Thermal Expansion Coefficient
Jap Test	Thermal Shock Resistance
Glass Transition Temperature	Toxicity
Grain Size	Viscosity
Hardness	Volatility
Heat Capacity	Water Resistance
Heat of Combustion	Weight Strength
Heat of Deflagration	Work Stability
Heat of Explosion	

Figure 1. Candidate property list for the EMDB

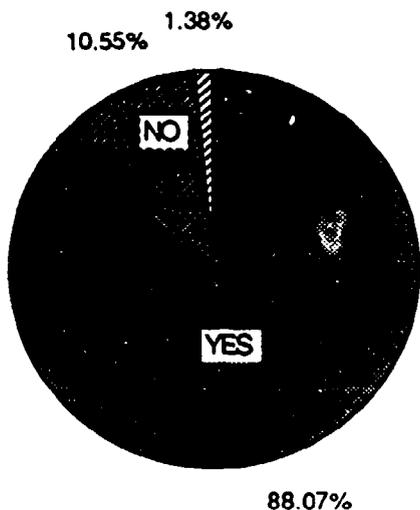
QUESTION	INTENT OF QUESTION
<p>1. Would you use a computerized Energetic Materials Data Base if it was available?  <b>YES</b>      <b>NO</b>  _____ Hours per      Day  _____ Week      Month</p>	Frequency of Usage
<p>2. What would be your expected turn-around-time requirement for an information request?  _____ Hour(s)      _____ Day(s)  _____ Week(s)</p>	Frequency of Usage, DBMS system, user interface
<p>3. If you were to subscribe to an energetic materials custom information summary service, how often would you need updates?  None    Monthly  Weekly      Annually</p>	Frequency of Usage, DBMS system, user interface
<p>4. The proposed EMDB will support a variety of on-line user interfaces to support the different types of users (e.g., experienced vs novice). Please rank these based on your anticipated needs.  On-line help  Menu support  Custom report generation  Query language  Data manipulation language</p>	User Interface, DBMS system
<p>5. Do you have in-house hardware capable of processing and displaying graphical data?  <b>YES</b>      <b>NO</b></p>	User Interface, DBMS system
<p>6. Does your organization subscribe to a network service (DIALOG, etc.)?  _____ Network Name</p>	DBMS system, user interface
<p>7. How much time do you spend using non-automated methods to obtain property data on energetic materials?  _____ Hours per      Day  _____ Week      Month</p>	Frequency of Usage
<p>8. Does your organization maintain an in-house energetic materials data base?  <b>YES</b>      <b>NO</b>  Approximate Size: _____ Records</p>	Data Base Contents
<p>9. What are your major sources of energetic materials data?</p>	Data Base Contents

Figure 2. EMDB survey questions

Princeton Combustion Research Labs, Incorporated  
National Technical Systems  
Naval EOD Technology Centers  
Fresno Co. Sheriff's Department - Forensic Laboratory  
U.S. Department of Labor - Mine Safety and Health Administration  
FBI  
AMCCOM-ARDC-LCWS  
Riverside Police Dept.  
Air Force Wright Aeronautical  
Arnolt Corporation  
KMS Fusion  
CPIA (Chemical Propulsion Information Agency)  
Hercules Incorporated  
Naval Ordnance Station  
John Brown Associates, Incorporated  
Los Angeles Sheriffs Department - Crime Lab  
Flash Fireworks  
Naval Weapons Support Center  
Israel Military Industries  
AFWL/NTED, Kirtland AFB  
Aeroject Ordnance Co.  
Goex Incorporated

Figure 3. Examples of companies and organizations responding to the user survey

**SURVEY RESPONSE: QUESTION 1  
PERCENTAGE OF RESPONDENTS WHO WOULD  
USE AN ENERGETIC MATERIALS DATA BASE**

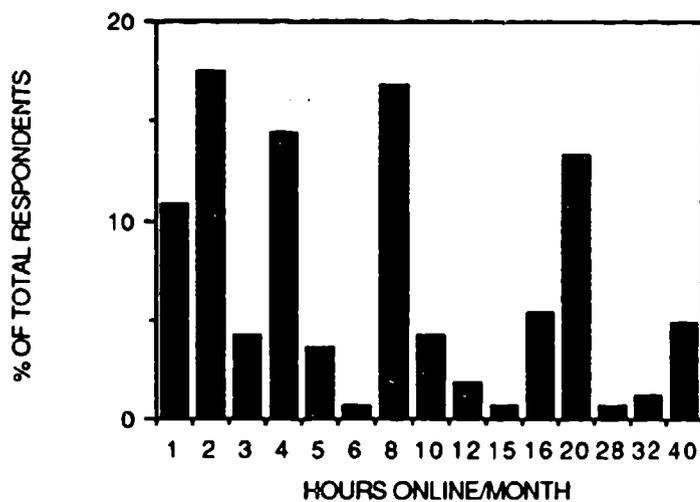


QUESTION: WOULD YOU USE A COMPUTERIZED ENERGETIC MATERIALS DATA BASE IF IT WERE AVAILABLE?

- YES
- ▨ NO
- ▩ MAYBE

Figure 4.

**SURVEY RESPONSE: QUESTION 1  
ANTICIPATED TIME SPENT USING EMDB**



QUESTION: WOULD YOU USE A COMPUTERIZED ENERGETIC MATERIALS DATA BASE IF IT WAS AVAILABLE?

- HOURS PER DAY
- WEEK
- MONTH

Figure 5.

**SURVEY RESPONSE: QUESTION 2  
ANTICIPATED TURN AROUND TIME**

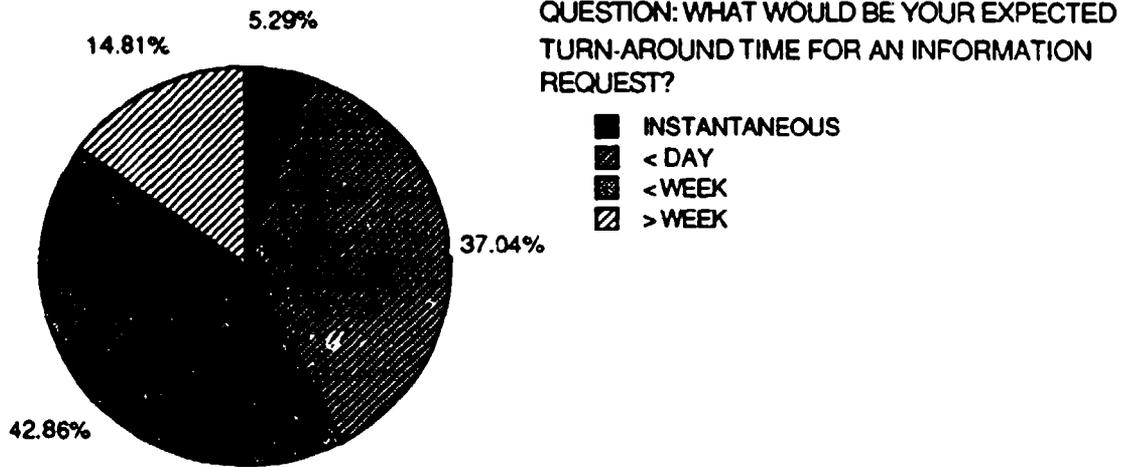


Figure 6.

**SURVEY RESPONSE: QUESTION 3  
ANTICIPATED INFORMATION SUMMARY UPDATES**

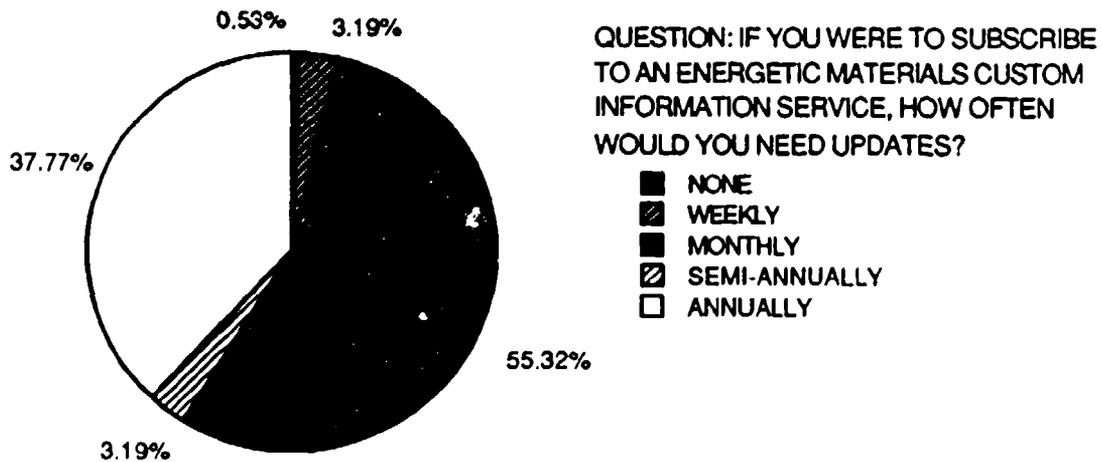


Figure 7.

**SURVEY RESPONSE: QUESTION 7  
TIME SPENT USING NONAUTOMATED METHODS**

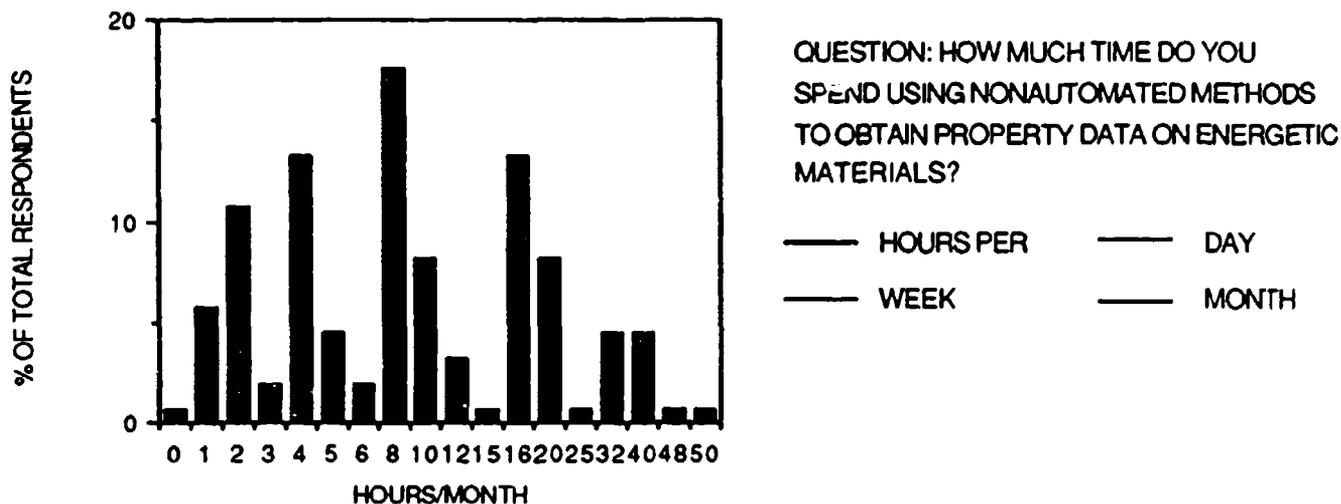


Figure 8.

**SURVEY RESPONSE: QUESTION 4  
TOP CHOICE FOR ON-LINE USER INTERFACE**

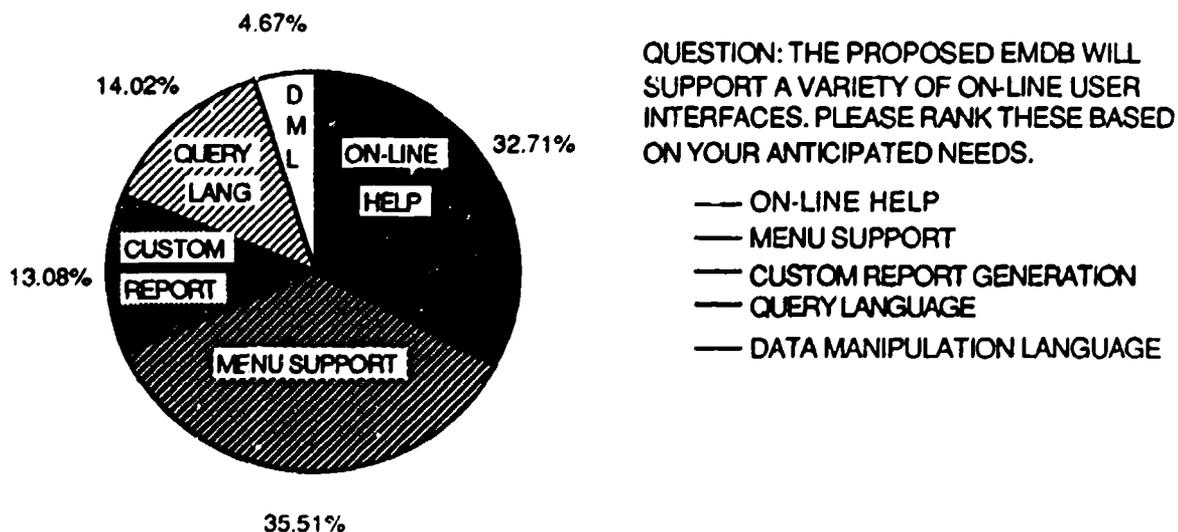


Figure 9.

**SURVEY RESPONSE: QUESTION 5  
RESPONDENTS WHO CAN PROCESS GRAPHICS**

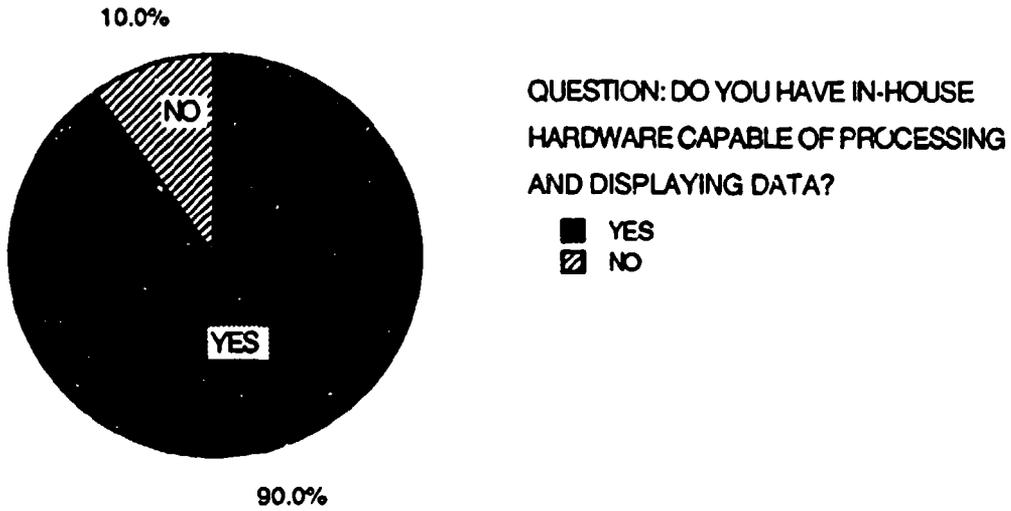


Figure 10.

**SURVEY RESPONSE: QUESTION 6  
RESPONDENTS WHO HAVE A NETWORK SERVICE**

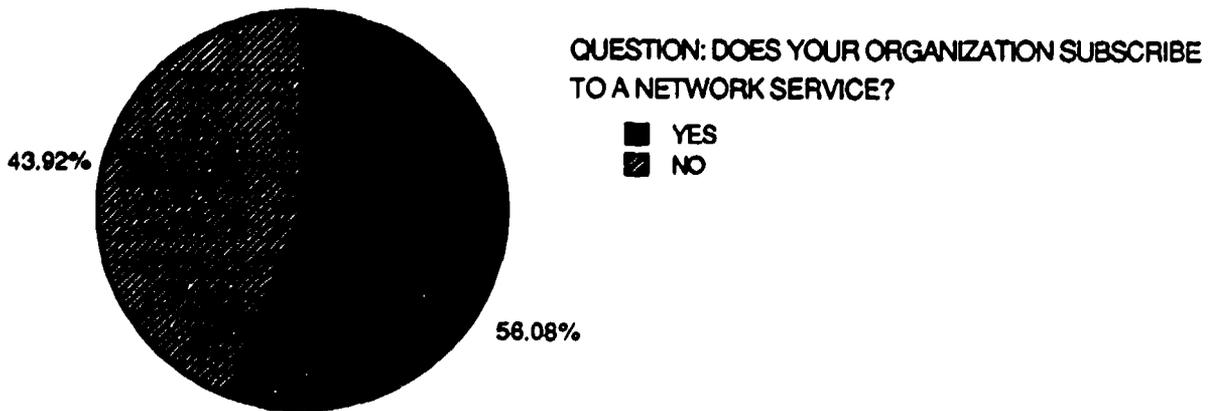


Figure 11.

NUMBER  
OF  
RESPONSES MAJOR SOURCES OF ENERGETIC MATERIALS DATA

64	Government supplied data and handbooks (incl. military, NASA, Bureau of Mines, FBI, Fire dept., NBS, Sandia, Picatinny, NWC, NSWC, AMCCOM)
44	Testing or in-house data or contractor reports
41	Vendor supplied data or civilian supplied (incl. safety data sheets)
41	Lawrence Livermore National Laboratory (LLNL) Explosives Handbook
26	Encyclopedia of Explosives and Related Items
20	CPIA manuals (Chemical Propulsion Info. Agency)
19	AMCP reports and manuals (Army Materials Command pamphlets) (incl. AMCP-706-177) Tomlinson, T.R.
11	Los Alamos Scientific Laboratory (LASL) explosive property data
9	Chemistry and Technology of Explosives: Urbanski, T.
9	NTIS data base and reports (National Technical Information Service)
8	Chemical Abstracts
8	Defense Technical Information Center (DTIC)
7	Explosives - Meyer, R.
7	Dialog
7	Computer programs or data bases (incl. thermochemical codes)
6	Explosives and Pyrotechnics; Electric Initiation handbook; symposia - Franklin Institute
6	JANNAF thermochemical tables, NSRDS - NBS 37; abstracts. Dow Chemical
5	Military Specifications
5	Detonation Symposium
5	TM manuals (Army, Navy, and Air Force) (incl. prop. of expl.)
4	Nav BED Vol 1-3, (Navy Bank Explosives Data)

Figure 12. Major sources of energetic materials data

NUMBER  
OF  
RESPONSES MAJOR SOURCES OF ENERGETIC MATERIALS DATA

4	Military Explosives - TM 9-1300-214
4	NOLTR's (76-176, 111) (Naval Ordnance Lab)
4	Foreign reports and publications (TTCP) (inc. intelligence)
3	Propellant, explosives, pyrotechnics (Official Journal of International Pyrotechnic Society)
3	Engineering Design Handbook - Explosives ..., AD-764340
3	Seminars
3	DoD's DROLS system
3	ARDEC-PLASTEAC (Ammunition research and development center)
3	ADPA symposia and reports (American Defense Preparedness Assoc.)
2	Journal of Physical Chemistry (incl. Vol. 1 #2, 221-277, 1972)
2	Handbook of Chemistry and Physics, Weast, (CRC)
2	COMPAT data bank
2	Society of Explosion Engineers
2	Book by Conkling
2	IPS reports and members
1	Data from Dyno Industrier, Norway
1	Energy data base
1	Patents
1	IME
1	TIGER, BKW (computer code)
1	NERAC
1	ATF
1	Jefferson Proving Grounds
1	Propellant Ingredient Research-Simmons, AFATL-TR-84-51
1	Handbook of energetic polymers and plasticizers - Rhein, NWC TP6720 (Naval Weapons Center)

Figure 12. Major sources of energetic materials data  
(continued)

NUMBER  
OF  
RESPONSES MAJOR SOURCES OF ENERGETIC MATERIALS DATA

1	Journal of Chemical Physics
1	International Journal of Chemical Kinetics
1	Handbook of reactive chemical hazards
1	"Sensitivity of TATB..." - Dobratz UCID 17808
1	National Bomb Data Center Publications
1	Forensic Science Journals
1	ORDP-20-177 (ordnance pamphlet)
1	Naval ordnance report OP 2212
1	OSRD 2014 and 3014 (office of Scientific Research & Development)
1	Aerospace Ordnance Handbook, Pollard, F.B., and Arnold, J.H., 1966.
1	DDESB compilations
1	NBEP reports
1	List of explosive materials NAS 7-100 (1964)
1	IABTI
1	Book by Beilstein
1	NWC Igniter Materials Handbook
1	Journal of Hazardous Materials
1	AIAA Publications
1	ACS Publications
1	Dangerous properties of industrial materials - Sax
1	AD-400-496
1	Lidners lecture notes on theory and performance of propellant and explosive systems
1	Selected values of Chemical Thermodynamics properties, NBS
1	Indian head technical report 386, 1972
1	The heat of formation of propellant ingredients AFRPL-TR-67-311 (Air Force Rocket Propulsion Laboratory)

Figure 12. Major sources of energetic materials data (continued)

NUMBER  
OF  
RESPONSES MAJOR SOURCES OF ENERGETIC MATERIALS DATA

1	Bureau of explosives test data
1	Handbook of Navy explosives
1	Book by McClain
1	Book by McIntyre
1	IHTR 522 (Naval publication)
1	Handbook of Chemistry - Lange
1	International critical tables
1	Book by T. Davis
1	CRDEC
1	Material properties manual-Hercules Inc.
1	Engineering index (Compendex)
1	NASA/RECON and aerospace data base
1	DRI's DMS data base
1	Go. C. mfg. plants

Figure 12. Major sources of energetic materials data  
(continued)

**SURVEY RESPONSE: QUESTION 8  
RESPONDENTS IN-HOUSE DATA**

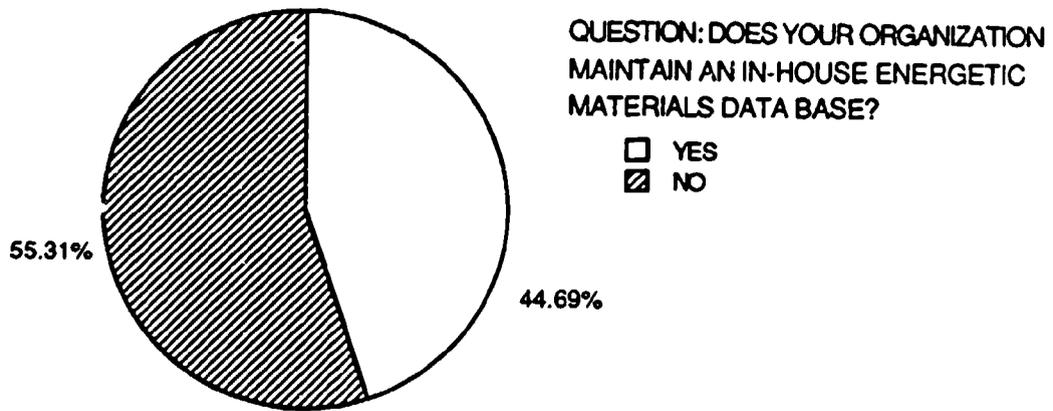


Figure 13.



COMPUTER SYSTEM	APPROXIMATE COST	NO. OF USERS SUPPORTED	DISK STORAGE AVAILABLE
<u>MAINFRAME</u> DEC VAX 11/780	\$300,000	50	300 MEGABYTES
<u>MINI</u> APOLLO WORKSTATION, DEC MICROVAX	\$30,000	3-4	80 MEGABYTES
<u>MICRO COMPUTER</u> IBM PCAT, KAYPRO, etc.	\$10,000	1	40 MEGABYTES

Figure 15. Computer system comparison as host for EMDB



APPENDIX A  
COVER LETTER AND SURVEY

December XX, 1986

Name  
Position  
Organization  
City, State, Zip Code

Subject: Energetic Materials Data Base

SRS Technologies is evaluating the feasibility of establishing a computerized Energetic Materials Data Base that contains properties and characteristics of munitions, explosives, and propellants. This effort is sponsored by the U.S. Army Armament, Munitions, and Chemical Command in Dover, New Jersey ( Technical Monitor-Mr. Charles Ribaud ).

The purpose of this data base is to provide a central repository of energetic materials data that will serve the needs of military and civilian rocket motor and weapon system designers and manufacturers. The data base will be easy to use, and will have powerful search and retrieval functions such as custom report generation. Various data base content and architecture options are being assessed to identify the most useful data and query options.

To identify the energetic material data needs of the defense and aerospace community, we are distributing this questionnaire to potential users such as yourself (if you are not a potential user but others in your organization are - please route this questionnaire to them). This questionnaire was designed to answer the following questions : (1) What contents would you like to see in an energetic materials data base? (2) What methods of access would be most convenient for you ?

Please take a few minutes to fill out the attached one page questionnaire, and review the material properties list for omissions which may pertain to your areas of interest. Your help will enhance the quality, relevancy, and responsiveness of an on-line, interactive Energetic Materials Data Base service.

Feel free to duplicate this questionnaire for dissemination to your colleagues. If you would like to discuss any aspect of this effort, please call me or Bruce Tiller at (205) 895-7000.

Sincerely,

Rodney Bradford  
Vice President  
Aerospace and Commercial Systems

Enclosures: As Stated

## ENERGETIC MATERIALS DATA BASE (EMDB) USER SURVEY

Name : \_\_\_\_\_

Organization \_\_\_\_\_  
 \_\_\_\_\_

Phone Number : (\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_

**Energetic Materials  
Areas of Interest**

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_

1. Would you use a computerized Energetic Materials Data Base if it was available?

YES      NO  
 \_\_\_\_\_ Hours per \_\_\_\_\_ Day  
           \_\_\_\_\_ Week    \_\_\_\_\_ Month

2. What would be your expected turn-around-time requirement for an information request?

\_\_\_\_\_ Hour(s)      \_\_\_\_\_ Day(s)  
 \_\_\_\_\_ Week(s)

3. If you were to subscribe to an energetic materials custom information summary service, how often would you need updates?

\_\_\_\_\_ None      \_\_\_\_\_ Monthly  
 \_\_\_\_\_ Weekly    \_\_\_\_\_ Annually

4. The proposed EMDB will support a variety of on-line user interfaces to support the different types of users (e.g., experienced vs novice). Please rank these based on your anticipated needs.

- \_\_\_\_\_ On-line help
- \_\_\_\_\_ Menu support
- \_\_\_\_\_ Custom report generation
- \_\_\_\_\_ Query language
- \_\_\_\_\_ Data manipulation language

5. Do you have in-house hardware capable of processing and displaying graphical data?

\_\_\_\_\_ YES      \_\_\_\_\_ NO

6. Does your organization subscribe to a network service (DIALOG, etc.)?

\_\_\_\_\_ Network Name

7. How much time do you spend using non-automated methods to obtain property data on energetic materials?

\_\_\_\_\_ Hours per \_\_\_\_\_ Day  
                   \_\_\_\_\_ Week    \_\_\_\_\_ Month

8. Does your organization maintain an in-house energetic materials data base?

\_\_\_\_\_ YES      \_\_\_\_\_ NO  
 Approximate Size: \_\_\_\_\_ Records

9. What are your major sources of energetic materials data?

\_\_\_\_\_

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NOTE : MATERIALS PROPERTIES ARE LISTED ON THE REVERSE SIDE

The Energetic Materials Data Base (EMDB) will contain information about materials in several major categories, including : PRIMARY (INITIATING) EXPLOSIVES, SECONDARY OR HIGH EXPLOSIVES, AND PROPELLANTS. High Explosives will be subdivided into Commercial and Military Applications. Listed below are specific material properties/characteristics which apply to those categories. Please review this alphabetical list and add any specific properties you would like to see included in the EMDB.

Abrasion Resistance  
 Activation Energy  
 Aging Characteristics  
 Air Gap  
 Atomization Energy  
 Average Ignition Delay  
 Bond Strength  
 Brisance  
 Bulk Modulus  
 Bulk Strength  
 Cartridge Strength  
 Coefficient of Friction  
 Composition  
 Compressive Strength  
 Creep Properties  
 Critical Density  
 Critical Diameter  
 Critical Length  
 Critical Mass  
 Cure Schedule  
 Density  
 Detonation Pressure  
 Detonation Velocity  
 Elastic Limit  
 Emissivity  
 Explosion Sensitivity  
 Explosive Strength  
 Flammability  
 Flexural Strength  
 Gap Test  
 Glass Transition Temperature  
 Grain Size  
 Hardness  
 Heat Capacity  
 Heat of Combustion  
 Heat of Deflagration  
 Heat of Explosion

Heat of Formation  
 Heat of Fusion  
 Heat of Reaction  
 Heat of Vaporization  
 Ignition Temperature  
 Impact Strength  
 Impetus  
 Load Carrying Capacity  
 Loading Density  
 Machinability  
 Modulus of Elasticity  
 Molecular Weight  
 Operating Temperature Range  
 Oxygen Compatability  
 Permeability  
 pH  
 Propagation Velocity  
 Rate of Reaction  
 Resistivity  
 Seaming/Joining Techniques  
 Shear Strength  
 Shrinkage  
 Specific Heat  
 Specific Impulse  
 Storage Life  
 Temperature of Reaction  
 Tensile Strength  
 Thermal Conductivity  
 Thermal Expansion Coefficient  
 Thermal Shock Resistance  
 Toxicity  
 Viscosity  
 Volatility  
 Water Resistance  
 Weight Strength  
 Work Stability

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APPENDIX B  
MATERIALS PROPERTIES AND CHARACTERISTICS

PHYSICAL - CHEMICAL PROPERTIES

Activation Energy & Pre-Exponential Factor	Stagnation Pressure
Atomization Energy	Stagnation Temperature
Coefficient of Friction	Bond Strength
Composition	Phase Changes and Temperature of Color
Light Emission Color ( $\lambda$ )	Density, Bulk, Crystal and Max. Theor.
Vapor Pressure	Emissivity
Heat Capacity	Grain Size/Shape and Distribution
Heat of Fusion	Heat of Formation
Heat of Vaporization	Heat of Reaction
Permeability	Molecular Weight of Reactants and Products
Resistivity	pH
Specific Heat of Reactants and Products	Thermal Conductivity
Viscosity	Thermal Expansion Coefficient
Covolume	Volatility
Equation of State (Reactants and Products)	Hygroscopicity (Humidity Test)
Molecular Structure	Luminosity (Candle Power, Light Flux)
Physical Form	Reaction Kinetics (Rate of Reaction)
Chemical Formula	Crystal Structure
Bond Length and Angle	Appearance (Microscopy)
Melting Point	Ratio of Specific Heats (Polytrop Exponent) of Reactants and Products
Solubility	Boiling Point
Entropy	Sound Velocity (Sonic Velocity, Acoustic Velocity)
Polymorphism	Porosity Distribution
Thermoanalytical Curves - DTA, DSC, TGA	Resonance Frequencies - NMR, NQR, IR, VIS, UV
Off-gassing Rate	Dielectric Loss Constant and Loss Tangent vs. Microwave Frequencies

## APPENDIX B

## Contents of the Data Base

CHARACTERISTIC DATA (UNIQUE TO ENERGETIC MATERIALS)

Air Gap (see sympathetic detonation) (gap test)	Average Ignition Delay
Bulk Strength (or Cartridge Strength)	Brisance (Trauzl Lead Block Test, TNT Equivalency)
Critical Density	Critical Diameter
Critical Length	Critical Mass
Detonation Pressure	Detonation Velocity (or Propagation Velocity)
Explosive Strength	Heat of Deflagration
Heat of Combustion	Ignition Temperature (Dust layer or cloud ignition temp.) (Deton. temp., Deflag. temp., 5 sec. expl. temp.)
Heat of Explosion	Impetus
Impact Strength (see impact sensitivity tests) (critical initiation energy)	Specific Impulse
Loading Density (Packing Density)	Weight Strength
Temperature of Detonation (or temp. of reaction) ( temp. of expl.)	Gas Volume
Burn Rate	Specific Energy
Closed Bomb Test Data	NATO Tests
C-J Data	Shock Initiation Pressure (see shock sensitivity test)
Blast Overpressure, Peak and Impulse	Solid Hugoniot Fit
Shock Hugonoids (unreacted)	Relative Quickness
1-D Time to Explosion (see also time to explosion)	Thermal Dynamic Energy
Running Distance	Blast/Impulse Coefficients
Performance Ratios, i.e. similitude eqt. underwater shock	Self Heating
Combustion Temperature (flame temperature) (exotherm temp.)	Pressure Exponent
Wedge Test	$\pi_K$ Characteristic Velocity
	Cylinder Energy (Brisance)

CHARACTERISTIC DATA (UNIQUE TO ENERGETIC MATERIALS) (Continued)

No Fire/All Fire Energy (see impact sensitivity test)	Adiabatic Flame Temperature
Decomposition Temperature	Auto-Ignition Temperature
C-H-N-O Analysis	Sympathetic Detonation
Detonation Products (Explosion Products)	Heat of Detonation (Detonation Energy)
Combustion Products	Decomposition Formula
Adiabatic Calorimetry Data	Decomposition Products
Stoichiometric Fuel/O <sub>2</sub>	Ratio of the Burning Rate to the Velocity of Sound in the Unburned Gas
Gruneisen Constant	Underwater Bubble Energy
Fragmentation Data	Detonation/Deflagration Char.
Dead Pressing	Minimum Priming Charge
Gurney Characteristic Velocity	Temperature Sensitivity of Burn Rate
Gurney Energy	Gurney Constant
P <sup>2</sup> T Criteria	Burning Zone Length
Embedded Gauge	Pop Plot
N (Thermodynamic Property)	Adiabatic Index
Minimum Ignition Energy	Critical Temperature
Frequency Factor	Coley's Ratio
Failure Diameter	Crystalline Habit Structure
	Failure Thickness

INDUCED PROPERTY VARIATIONS

Aging Characteristics

Shrinkage

Dynamic Properties (loss/storage moduli)

Thermal Stability (Temperature Resistance) and Thermal Shock Resistance

Effect of High G Shock on Inputs and Outputs of Detonators

Thermal Cycling Stability

Deterioration/Degradation Properties

Detonation Velocity as a Function of Temperature and Density

Effects of Radiation on Reactive Materials

Acoustic Signal Generation Water, Air, Earth Seismic Vibration

Recrystallization Effects

HE Loading Properties - Cast vs. Pressed

Quantity-Distance Table

Compatibility/Incompatibility with Chemicals, Adhesives, Metals, Plastics, Etc.

Burning Rate at 1000 psi

Shaped Charge Effectiveness

Work Stability

Consolidation Properties

Explosion Sensitivity as a Function of Temperature

Explosion Temperature vs. time

Detonation Velocity at Various Densities

Oxygen Compatibility

Water Resistance

Humidity Test (hygroscopicity)

Vacuum Stability Test (Vacuum Thermal Stability, Vacuum Test, Chemical Reactivity Test)

Blast Effects in Air

Density as a Function of Consolidation Pressure

Performance/Degradation vs. Hi-Temp. Storage

Performance vs. Variations in Composition

Nuclear Survivability of

- Electrically Exploded Devices
- Propellants
- Secondary or HE
- Semiconductors (control initiation)
- Combustible Cartridge Cases

Non-ideal Explosives and Their Properties

Corrosion with Metals and Alloys

Charge Size Effects

Density vs. Loading Pressure

Confined Small Scale Cookoff Times and Temperatures

Compaction Characteristics

Bulk Density vs. Particle Size

DDT Length vs. Density vs. Length vs.

Confinement vs. Temperature vs.

Stimulus

MECHANICAL PROPERTIES

Abrasion Resistance	Bulk Modulus
Compressive Strength	Creep Properties
Elastic Limit	Flexural Strength
Glass Transition Temperature	Hardness
Load Carrying Capacity	Machinability
Modulus of Elasticity	Shear Strength
Tensile Strength	Poisson's Ratio
Pressure-Volumetric Strain Curves	Uniaxial Stress-Strain
Elongation	Strain Rate Sensitivity
Modulus of Toughness	

Sensitivity

or

Explosion Sensitivity to

- Impact (Drop Weight Test, Brucceton)
- Static Electricity
- Friction
- Stab Detonators
- Heat
- RF (Dielectric RF Heating)
- Gap (small and Large Scale)
- Laser Initiation
- Bullet Impact
- Shock and Shock Threshold
- Initiation by Various Firing Pins, and Boosters
- EMI
- Susan Test
- Explosion
- Threshold, of Propellants, Secondary or HE, Semi-Conductors, Combustible Cartridge Cases, and Electrically Exploded Devices in Pin to Pin Mode or Pin to Case Mode to:
  - DC Signal
  - RF Signal
  - Electrostatic Discharge
  - Capacitor Discharge
  - Lightning
  - EMP
  - High Power Microwave (HPM)

GENERAL INFORMATION (MANUFACTURER/FORMULATOR)

Cure Schedule	Operating Temperature Range
Seaming/Joining Techniques	Storage Life
Storage Temperature Range	Synthesis (Preparation)
Quality Control Methods	Applications
Military Specifications	Cost
Availability	Manufacturers/Formulators of...
Manufacturing/Processing Data or Parameters	Status of Approval/Disapproval for New Designs
Alternate Names	Interim and Final Qualification Results

SAFETY

In Process Safety Data for Inter- mediate Expl. Products	Hazards Analysis Info. on Specific Common EM Process Equipment
Hazard Classification	Fire Fighting Recommendations
Safety Protection/Precautions	Storage Compatibility Group
UNO Hazard Class. & Div.	Environmental Hazards
Accident History	Explosive Fumes Generated by
Methods to Decompose Other Than Explode or Burn	(1) Ideal Mixture
Decontamination Procedures	(2) Non-Ideal Mixture
DOD and DOT Classifications and Tests (transportation req.)	Handling and Packaging Instructions
Methods for Out-of-Line Safety	Disposal/Destruction Methods
Testing of Explosive Trains	Bulk Mixing in Field
Deterioration Hazards	(1) Calibration of Equipment
Flammability	(2) Allowable Variation of Components and Mix
Flashpoint	Toxicity of Reactants and Products

ADDITIONAL DATA/INFORMATION (RELATED TOPICS)

Additives for Stability or  
Processing  
Binder Properties  
Thin Film Properties  
CN/INDO Calation  
Taggants

Data on Percussion Primer  
Deterioration/Degradation Mechanisms  
Primer Specifications  
Dynamic Desensitization  
Metabolities

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