# INDC   INTERNATIONAL NUCLEAR DATA COMMITTEE

# IAEA INTERNATIONAL DATABASE ON IRRADIATED NUCLEAR GRAPHITE PROPERTIES

## Prepared by:

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**February 2000**

## Abstract

This report describes an IAEA database containing data on the properties of irradiated nuclear graphites. Development and implementation of the graphite database followed initial discussions at an IAEA Specialists' Meeting held in September 1995. The design of the database is based upon developments at the University of Bath (United Kingdom), work which the UK Health and Safety Executive initially supported. The database content and data management policies were determined during two IAEA Consultants' Meetings of nuclear reactor graphite specialists held in 1998 and 1999. The graphite data are relevant to the construction and safety case developments required for new and existing HTR nuclear power plants, and to the development of safety cases for continued operation of existing plants. The database design provides a flexible structure for data archiving and retrieval and employs Microsoft Access 97. An instruction manual is provided within this document for new users, including installation instructions for the database on personal computers running Windows 95/NT 4.0 or higher versions. The data management policies and associated responsibilities are contained in the database Working Arrangement which is included as an Appendix to this report.

# Table of Contents

# 1.    Introduction

During discussions at an IAEA Specialists Meeting on "Graphite Moderator Lifecycle Behaviour" held in Bath, United Kingdom in September 1995 (Ref. 1), concern was expressed at the potential risk to the existing knowledge database on the irradiation behaviour of nuclear graphites arising from the loss of acknowledged specialists from around the world, and from the potential withdrawal of certain countries from graphite-moderated reactor technology. Against this background, there has been a renewed interest in developments in high-temperature-reactor technology, and a need for the development of more sophisticated safety cases for the continued operation and life extension of existing graphite-moderated plant, particularly in the United Kingdom (Magnox reactors and Advanced Gas-Cooled Reactors) and Russia, Ukraine and Lithuania (RBMK reactors). Decommissioning activity has also generated a new interest in certain types of graphite data.

Historically, such irradiation data as have been archived were generally confined to the interests of the compiler and to the graphite grades used by the nation concerned. A large volume of data has also been subject to security classification and to restrictions on publication. It was felt in the discussions in Bath that the situation had now greatly changed.

The matter was therefore brought to the attention of the IAEA International Working Group on Gas-Cooled Reactors, which also covers the interests of RBMK design and its forerunners, in a paper presented at its 13th Meeting held in March 1996 (Ref. 2). In the preparation of Ref. 2, nine Member States were consulted about their possible interests in such an activity, which at that time was envisaged as involving both the compilation of irradiation data directly in a central computer archive, and the separate collection and publication of "anecdotal" information from those involved in the development of graphites for earlier generations of reactors, and from those involved in monitoring their performance.

The 13th IWGGCR expressed a preference for effort to be concentrated on the direct compilation of data. Funding of the activity was perceived as a major obstacle as it was indicated by the IAEA that it should be self-financing. After due reflection, the United Kingdom government elected to support the initial development of the Database Project in three principal ways:

(a) by placing a contract with the University of Bath, United Kingdom, to develop a suitable modern database building upon commercial software, and to commence the input to the database of those data which were readily available

(b) by offering direct funding to the IAEA to establish its own personnel for subsequent operation of the Database, and for the provision of computer hardware; and

(c) by appointing its own representative to work with the IAEA and potential data providers towards the establishment of the Database.

Further informal specialists meetings were held, in Forschungszentrum Jülich, Germany in September 1997 and at ECN Petten, The Netherlands (now NRG) in November 1997. The continuing interest of numerous Member States influenced the IAEA to establish a formal Consultants' Meeting in February 1998 to draw up a Working Arrangement for the establishment of the Database Project. Six Member States were represented, out of eight original expressions of interest, together with a potential sponsor for the project, and a

thorough discussion of all aspects of the project including issues of access rights, different classifications of data, and database security took place.

The main outcome of the meeting was the production of a Draft Arrangement which contained the formal basis for the constitution of the project.

IAEA then invited Member States with interests in graphite-moderated reactors, to review the Draft Arrangement and to make formal application for Membership, together with the appointment of liaison officers to be the formal link with the IAEA, and technical specialists to serve on the Steering Committee.

A second Consultants' Meeting took place in February 1999, attended by five Member States and an additional potential financial sponsor, at which a final version of the Working Arrangement was approved. This document is attached as Appendix 1, and contains a full explanation of the Membership requirements, classifications of data available, and procedures for ensuring security of data during transfer to and from Members.

The adoption of this Arrangement allowed additional Member States to make formal Membership applications. The IAEA was then invited to formally establish the Project under its auspices. An initial technical discussion also took place at the second Consultants' Meeting and an Agenda for the first formal Technical Steering Committee meeting, scheduled for September 1999, was drawn up.

The first meeting of the Technical Steering Committee was held 23-24 September 1999 at the IAEA, in which the database was confirmed as being formally established and the first release of the Database was distributed to Database Members and Sponsors. A variety of technical topics were discussed, including those concerning the input of new graphite data, uses of the database in graphite research, and the next database release.

This report contains a description of the database and its structure, including an outline of the data contained, plus details of the personnel involved from the participating Member States and the IAEA. Details of the categories of Membership and the application procedure (should further qualifying Members States express an interest in participation) are included in the Working Arrangement [Appendix 1]).


## 2.    Members and Personnel

At the time of writing, the following Member States are represented as Full Members of the Database Project:

> Japan
> United Kingdom
> United States of America
>
> together with Forschungszentrum Jülich, nominated as the formal Member by Germany

Represented as Associate Member: Lithuania

The Liaison Officers are:

| | |
|---|---|
| Japan: | Dr. M. Eto, JAERI (Tokai) |
| United Kingdom: | Dr. A.J. Wickham, consultant to HSE NSD |
| United States of America: | Dr. T.D. Burchell, ORNL |
| FZJ (Germany): | Dr. G. Haag |

The Steering Committee Members are:

| | |
|---|---|
| Japan: | Dr. M. Eto, JAERI (Tokai) |
| United Kingdom: | Dr. A.J. Wickham, consultant to HSE NSD *(Committee Chairman until February 2002)* |
| United States of America: | Dr. T.D. Burchell, ORNL |
| FZJ, Germany: | Dr. G. Haag |
| Lithuania (Associate Member) | Mr. A. Smaizys |

The responsible IAEA staff are:

Drs. J.A. Stephens and R.E.H. Clark, Department of Nuclear Science and Applications, Division of Physical and Chemical Sciences, IAEA, in succession to Dr. R.K. Janev, whose work in support of the foundation of the Database is gratefully acknowledged.

Dr. J. Kupitz, Department of Nuclear Energy, Division of Nuclear Power, IAEA

Technical Officers for the Database:

Dr. J.A. Stephens, IAEA.

Mr. P. Hacker, Department of Materials Science and Engineering, The University of Bath, Bath, United Kingdom.

Database Sponsors at the time of writing, for which the Steering Committee has agreed to make available similar access rights as for full Members of the Database during the period of their sponsorship, are:

> The Toyo Tanso Company, Japan
>
> The Pebble-Bed Modular High-Temperature Reactor Consortium (ESKOM AEA Technology plc United Kingdom, and FZJ Germany)

Further applications for Database Membership, or for access, or offers of further sponsorship, should be made to the IAEA (for the attention of one of the officers named above) who will refer such requests or offers for discussion by the Steering Committee. The Membership/Sponsorship conditions are included in Appendix 1.

# 3. Description of the Database

## 3.1 Technical Objectives

This database aims to increase the usefulness and availability of irradiated graphite data. As such, this database is complementary to existing IAEA archives. From the outset, a basic set of technical objectives was agreed between the potential participants as described below.

- User friendly interaction with the Database, based upon "point and click" activity and menus, requiring no specialist IT knowledge;
- Clear presentation of data;
- Flexible methods of data retrieval;
- Flexible database structure to allow for different data types;
- Compatibility with the IAEA's ALADDIN databases *(this last point was seen as a requirement only at the very basic level for e-mail transfer of data between databases, the present system having numerous advantages and updates compared with ALADDIN)*.
- Secure methods of data distribution.

Presently, the database concentrates upon numerical data, although the Steering Committee may elect to extend the capabilities within the system for the inclusion of anecdotal references and graphical material in due course.

## 3.2 Database Platform

Microsoft Access 97 has been used as the main tool for storing data and for development of the database. Access 97 is a recent release of Microsoft's relational database development software. As such, is allows rapid development of customisable interfaces to data and also allows data formatting changes to be rapidly applied. Access 97, and software developed using it, can operate on any Personal Computer (PC) running Microsoft Windows 95 (or higher) or Microsoft Windows NT V4 (or higher). A CD-ROM drive is also required for installation of the database.

## 3.3 Classification of Data

At an early stage in the technical discussions, it was realised that a number of Member States regarded irradiated nuclear graphite data as sensitive information which should not be available without restriction (for example, *via* the Internet). This led to specific definitions within the Working Arrangement as follows:

Unrestricted Data are data published in the open literature and those offered by Database Members on behalf of the data supplier for free dissemination. All other data are regarded as Restricted Data but are, nonetheless, available for dissemination to other Database Members for non-commercial purposes (and to current sponsors at the direction of the Steering Committee and the representatives of the Member States proffering such data).

In addition, the commercial reactor-operating utilities of the United Kingdom have offered additional <u>Restricted Data</u> from the operating plant subject to potential users agreeing a confidentiality agreement direct covering their use with the data providers. For classification purposes, this data is marked within the database as <u>L2 Restricted Data</u>. Details of these additional data are made available with all listings of mainstream <u>Restricted Data</u>.

Restricted Data are transmitted between Members only by CD-ROM, and the files are not held on computers which are accessible through the Internet.

It has been agreed that Unrestricted Data will be available to all through the IAEA Web Page, although for cost reasons, data may in preference be distributed to interested parties in CD-ROM format. Sponsor identities will be appropriately displayed, subject to the regulations of the IAEA.

## 3.4    Technical Parameters Currently Covered by the Database

Where possible, or where necessary, data are input in order of priorities determined by the Steering Committee. These reflect the particular interests of the Members, and currently cover, principally, the physical and mechanical changes upon irradiation relevant to the construction of operational safety cases for existing plants and for the overall safety cases for new HTR designs.

The Members of the Steering Committee have given considerable thought to the problems raised by the application of various standards or definitions, for example for absorbed neutron dose, in different Member States. This is an important topic, which is kept under constant review by the Steering Committee, and, for the present, all data have been entered in the original units provided by the supplier without conversion or rationalisation. The units are, however, easily retrieved from the database.

The current list of properties is described below.

**Sample Characterisation**

Irradiation Temperature
Fuel Burn Up
Fluence
Sample Number
Direction[1]
Graphite Grade
Experiment

**Sample Properties**

Initial Weight
Final Weight
Weight Loss (%)
Initial Density

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[1] Of measurement with respect to extrusion direction, unless stated otherwise. The precise nature of the sample direction is not always given in a report.

Final Density
Density Change (%)

## Crystal Properties

a Initial
a Final
c Initial
c Final
La Initial
La Final
Lc Initial
Lc Final

## Elastic Moduli

Initial Young's Modulus
Final Young's Modulus
Initial Shear Modulus
Final Shear Modulus

## Electrical Resistivity

Initial Resistivity
Final Resistivity

## Coefficient of Thermal Expansion

Initial CTE
Final CTE
CTE Temperature Range

## Thermal Conductivity

Initial Thermal Conductivity
Final Thermal Conductivity
Thermal Conductivity measurement temperature

## Strength[2]

Initial St
Final St
Initial Sc
Final Sc
Initial Sb
Final Sb

---

[2] St, Sc and Sb refer to tensile, compressive and bending strength respectively. If bending strength values are archived a note will appear in the supplemental information section for that volume to differentiate between 3 and 4 point bending tests.

**Poissons Ratio**

Initial Poissons ratio
Final Poissons ratio

**Dimensional Changes**

Length Change (%)
Diameter Change (%)
Volume Change (%)

**Acoustic Properties**

Initial Sonic Velocity
Final Sonic Velocity
Initial Attenuation
Final Attenuation

**Irradiation Creep**

Applied Stress
Creep Strain
Creep Coefficient

**Stored Energy**

Total S
dS/dT
Release Start Temperature[3]

**Pore Volume[4]**

Initial OPV
Final OPV
Initial CPV
Final CPV

## 3.5    Database Construction and Functionality

The data received from each source whether electronically or as a paper report is defined as a 'Volume' within the database. The Volumes correspond to uniquely identifiable reports, which are referenced with a title, author and source to ensure traceablity of the data. Volumes should be preferably submitted using a predefined template (see Section 3.7) which minimises additional formatting requirements. Each of these Volumes is then stored in the database as a separate Table of data.

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[3] The Release Start Temperature is a notional temperature used for the purpose of comparison of data. It should be recognised that low rates of release may be possible below this temperature.

[4] OPV and CPV stand for Open Pore Volume and Closed Pore Volume respectively.

The key elements that form the database are shown in Figure 1. The Tables form the basic data repository and are similar to standard spreadsheet tables with each property being identified by a column heading; the Tables are stored within a single Access 97 file together with the other database components. Relationships between the different properties are created from program code at run time, so ensuring a flexible method of data retrieval.
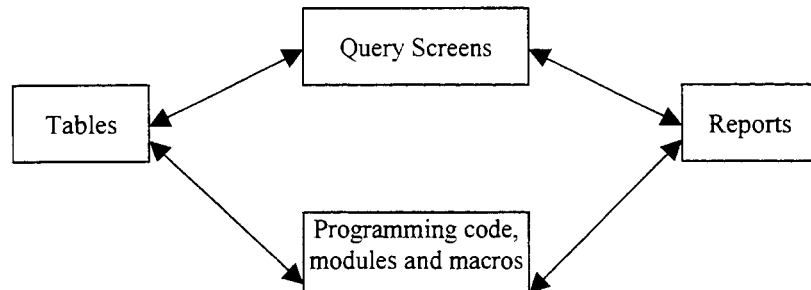


**Figure 1** The Key Database Elements

Query Screens ask the user for particular pieces of information relating to the final dataset they wish to retrieve. For example, users may specify countries of origin for particular Volumes of data to be retrieved. A succession of Query Screens enables the user to specify a data set that is retrieved by the database.

Reports display the retrieved data set, generated by program code, as prescribed by the users' responses to the Query Screens. The custom report allows the user to specify individual properties for display.

Program code is used to control the operation of the user interface and to generate the retrieved data set. Microsoft Visual Basic for Applications (VBA) is one of the Microsoft Visual Basic families of products and, as such, uses common language syntax to produce code.

The database also contains small amounts of supplemental text based information, which gives additional notes relating to the data. For example, important experimental details may be included without which the user could not make full use of the data.

## 3.6    Current Content

The database currently contains data submissions from the USA, Germany, Japan and the UK. The majority of the data has been submitted in the form of paper reports although some electronic submissions have also been made. Approximately 160 reports have been submitted to the database and around 15,000 records are archived.

## 3.7    Information for Data Suppliers

Information relating to the organisation and maintenance of the database can be found on the World Wide Web (WWW). The IAEA web site is at http://www-amdis.iaea.org/graphite.html. An informational web site is also maintained at the University of Bath which can be found at

http://www.bath.ac.uk/~mssph. The web sites contains important information for data suppliers and should be visited for up to date information on the following:

- Archived properties
- Preferred units of measurement
- Database participants and structure
- The data input template (see the following section)

The Web site may also contain links to unrestricted data that are to be placed on the Internet in the future.

### 3.7.1   The Data Input Template

The data input template is the preferred method of supplying data to the database.
The data input template can be downloaded form the project web site by following the appropriate hyperlink. It is a comma separated data file that can be opened in any spreadsheet. Reference information, including the units of measurement for the Volume being submitted is entered next to the appropriate heading. The numerical data is entered underneath each property heading.

## 3.8   Future Developments Expected

In addition to further submission and archiving of data, it is seen to be desirable to also include anecdotal text or graphical information which can be used in combination with the numerical data. This is in addition to the supplemental information described above which contains only a small amount of information that is very specific to the data. The anecdotal information could contain broad elements from reports and papers and could include diagrams and graphs. Due to the nature of this information it would be appropriate to present it in the same format as that used by the World Wide Web, i.e. as a series of linked hypertext pages.

The scope of the data archive may also be expanded. One need expressed by several Members is the requirement for isotopic content data that is of particular use during decommissioning. Although this reactor specific data may be of limited use in a general context, the Steering Committee intend to explore the usefulness of such data within this archive.

## 4    User Instructions

This section contains step by step instructions for users of the database and also contains information for data providers. These instructions assume the user is familiar with the Windows 95/NT V4 environment.

## 4.1 Database Installation

### 4.1.1 System Requirements

The database has been developed using Microsoft Access 97 and as such requires a Personal Computer (PC) with the following **minimum** system specifications.

- Microsoft Windows 95 or Microsoft Windows NT V4.0 operating system.
- Ability to have a desktop resolution of 1024 by 768 pixels (see next section).
- 20MB of hard disk space for the database plus an additional 40MB if the run time version of Access 97 is required, i.e. Access 97 is not already on the PC[5].
- A Web browser, such as Microsoft Internet Explorer is required for viewing the database overview and the anecdotal information sections of the database. A connection to the Internet is NOT required.
- A CD-ROM drive.

### 4.1.2 Screen Resolution

Although the database will operate with any desktop resolution, to display each screen conveniently, the desktop resolution must be set at 1024 by 768 pixels. Detailed information on changing the resolution settings can be found in the Windows documentation, so only a brief guide is given here. The desktop resolution can be checked or changed according to the following procedure.

1. Using the *right mouse button* click on a portion of the computer screen that contains only the background wallpaper.
2. Select 'Properties'.
3. From the Display Properties Box select the 'Settings' tab.
4. By clicking and holding, ensure the 'Desktop Area' slider is at 1024 by 768 pixels.
5. Select OK.
6. It may be necessary to adjust the monitor to ensure that the desktop is displayed correctly on the screen. Refer to the documentation that came with your monitor on how to do this.

### 4.1.3 Installation

After ensuring that your PC meets the minimum specification, the database is installed by placing the CD into your CD-ROM drive. After a few seconds the set-up screen should appear. If it does not, perform the following procedure.

1. Open 'My Computer'
2. Open the CD-ROM drive with the database installation CD in it.
3. Run the 'Setup.exe' file. (NOTE: Do not execute the file acmesetup.exe or any file other than setup.exe).

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[5] Access 97 is a component of Microsoft Office 97 Professional edition and may have been installed on the PC unknowingly as part of this product.

You will then be guided through the installation process. Selection of the typical installation route, when prompted, will be sufficient for most users. If an advanced user wishes to specific elements, i.e. the run time database, the custom set up option can be selected.

After installation is complete, follow the instructions and restart your computer.

### 4.1.4  Starting the Database

The installation programme will have placed a shortcut to the database in the 'Programmes' section off of your 'Start button' menu, entitled 'Irradiated Graphite Database'. Execution of the application within this section starts the database. After initialisation you will be prompted for the database password. After entry of the correct password the database starts automatically. Password are distributed to database members via the IAEA.

## 4.2    Using the Main Database

This section details how data is retrieved from the main section of the database which contains irradiated graphite data before and after a specified period of irradiation. The use of the graphical archive, the retrieval of anecdotal information and the methods for displaying manufacturing information on different graphite grades are discussed in following sections.

Data is retrieved from the database by the user submitting responses to a series of Query Screens. Each screen asks the user to make a selection, each of which, forms part of the definition of the final data set retrieved. Each query screen contains a selection of buttons, which perform specified functions, or information display areas that contain a list of items that can be selected. Collectively, these are known as Controls. The selections made on the query screens can be edited and reviewed by using the '< Back' and 'Next >' buttons found on each Query Screen. These link to the previous and subsequent Query Screens respectively.

### 4.2.1   Getting Help

Anyone familiar with the Windows environment should find each query screen to be self-explanatory. Additional help can be found by placing the mouse pointer over a particular control, e.g. a Button or a text box. A small yellow box will then appear with an additional explanation of the control, Figure 2. NOTE: Do not click the control to receive the help, the information will be shown automatically.
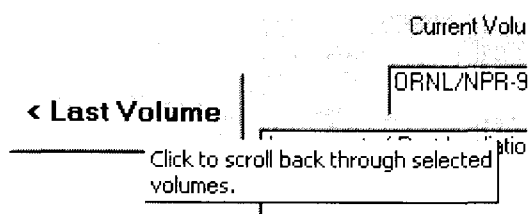


Figure 2. Example of Control Help.

### 4.2.2 The Start Screen

The start screen, Figure 3, is the entry point to the database and appears automatically after entering the database password. The 'Exit' button closes the database. The 'Start' button displays the first Query Screen. The centre button displays an overview of the database using the same format as World Wide Web pages. As such a Web browser, for example, Microsoft Internet Explorer, is required to view this information. Upon clicking the 'Start Button' the 'Country Selection' Query Screen appears.
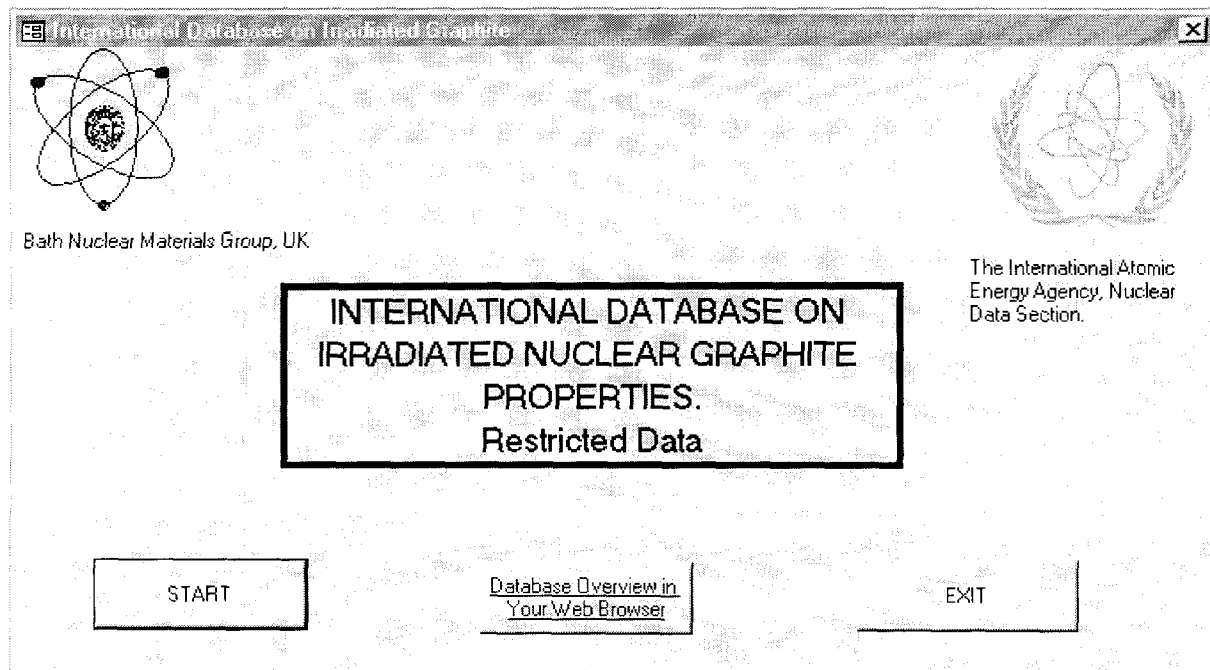


**Figure 3.** The Start Screen

### 4.2.3 The Country Selection Screen

This screen, Figure 4, allows users to specify the countries of origin for the data they wish to retrieve. Clicking the required country with the mouse makes the selection. A second click removes the country from the selection. Selected countries appear in black boxes. The selection of multiple countries can be made by holding down the CTRL key while making selections. After the selection has been made clicking the 'Next' button moves onto the next Query Screen. The 'Back' button redisplays the Start Screen. As an alternative to the selection of individual countries the 'Select All countries' button moves onto the next query screen without filtering the data by country of origin.
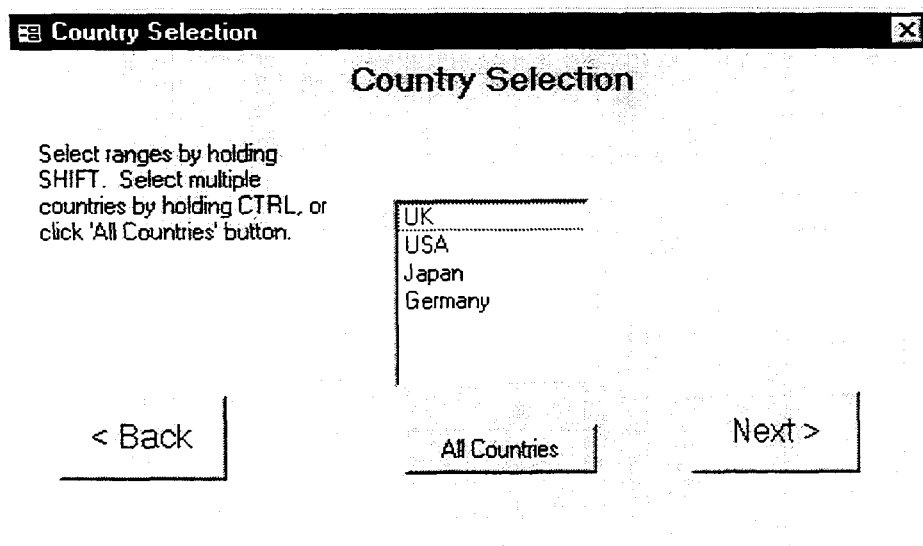
**Figure 4.** The Country Selection screen.

## 4.2.4 The Volume Selection Screen

The retrieved data Volumes, based upon the users previous response, are displayed in the large central text box of the Volume Selection Screen, Figure 5. In a similar manner to the previous Query Screen, individual Volumes are selected using the mouse. Again all of the available Volumes can be selected by clicking the appropriate button. The Graphs Archive can also be accessed at this point by clicking the appropriate button and is discussed in section 4. Clicking the 'Next' button queries the database based upon the Volumes selected and then displays the 'Experiment Selection Screen'
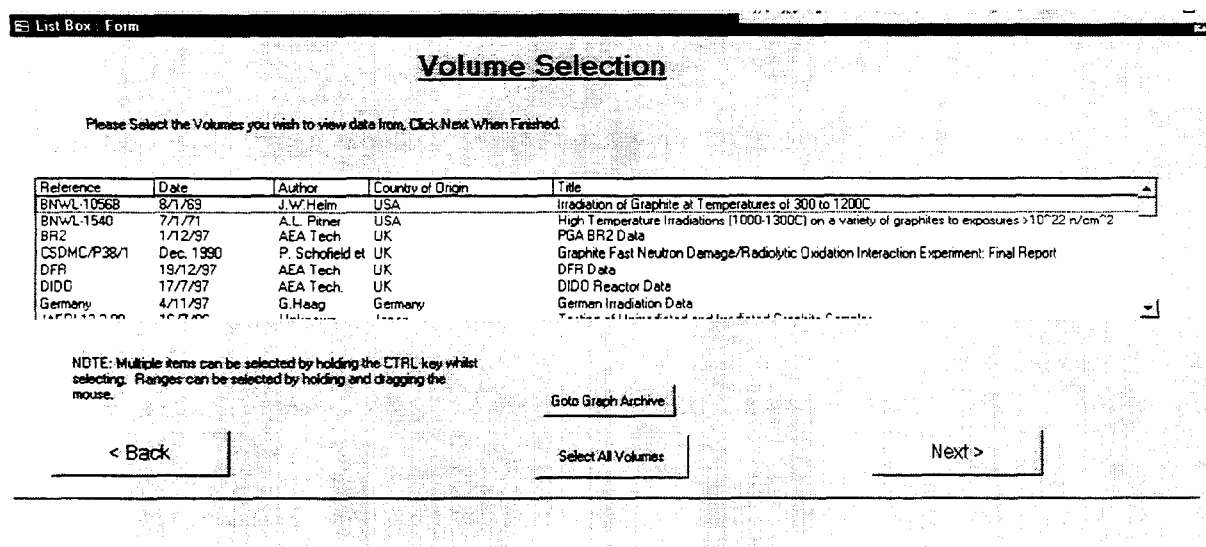


**Figure 5.** Volume Selection Screen

## 4.2.5 The Experiment Selection Screen

The Experiment Selection screen, Figure 6, allows individual tables of data to be selected from each Volume chosen. This feature is only likely to be useful if the user is familiar with the Volumes required. Again, individual Experiments can be selected or the 'Select All Experiments' button can be used.
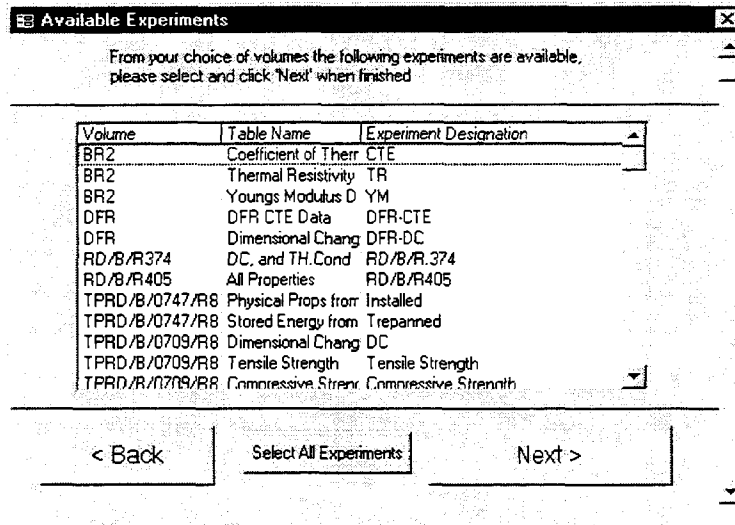


**Figure 6.** Experiment Selection Screen.

## 4.2.6 The Report Selector Screen

The initial Query Screens enable a broad data-set to be defined based upon the source of data Volumes. The Report Selector Screen allows manipulation of the chosen Volumes and prepares the data for display.

On this screen the user can perform the following functions.

- Navigate through the selected Volumes using the 'Next Volume' and 'Previous Volume' buttons.
- Obtain reference information for each Volume, including supplemental information.
- Go to the graphical archive, see section 4.3.
- Go to the 'As Received' information section of the database. This is discussed in section 4.5.
- Produce a 'Custom Report', see next section.
- Have all of the selected Volumes made available on a single continuous output. NOTE: This function may take some time to complete, especially on a low specification machine. The 'Select All Volumes button' is a toggle button, this means it will remain depressed until clicked for a second time. After being clicked for a second time the display reverts to the selection of individual Volumes of data.

The current report reference and title is shown in the bottom half of the screen. Upon clicking the reference information button, the 'Supplemental Information' screen is shown. This contains reference information for the report. Also included is additional text which directly supports an understanding of the numerical data. Examples of the implementation of

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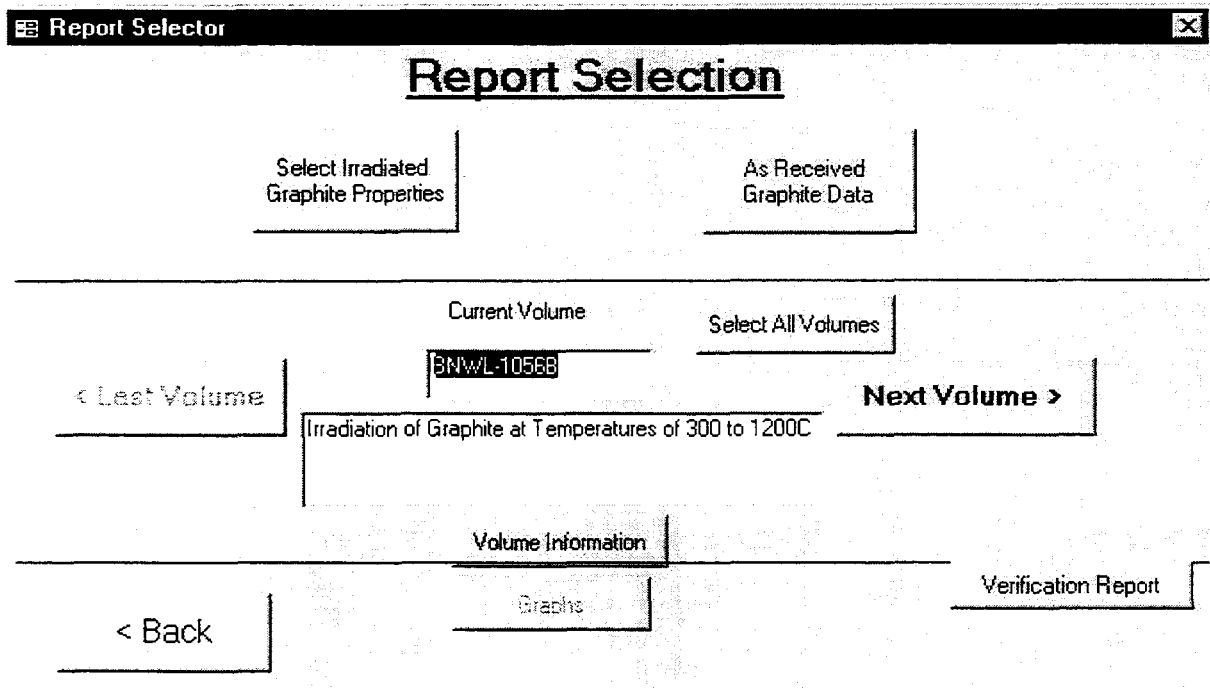Hypertext links to anecdotal information are also shown on this screen and are discussed in section 4.4.



**Figure 7.** The Report Selector Screen.

### 4.2.7 The Property Selection Screen

This screen displays a list of all the properties in the database. A maximum of 14 different fields can be selected for subsequent display using the mouse to individually select or deselect properties. After the selection of the properties of interest the Report form is displayed by clicking the 'Next' button.

For Volume [CSDMC/P38/1]   Select From Properties Below (Max 14).

Sample Characterisation

Irradiation Temp
Fluence
Burn Up
Graphite Grade
Direction
Sample Number
Experiment

Crystallite Parameters

C Initial
C Final
Lc Initial
Lc Final
a Initial
a Final
La Initial
La Final

Elastic Moduli

Initial E
Final E
Initial G
Final G

Electrical Resistivity

Initial Resistivity
Final Resistivity

Coeff. of Thermal Expansion

Initial CTE
Final CTE
CTE Temp Range

Sample Properties

Initial Density
Final Density
Density Change (%)
Weight Initial
Weight Final
Weight Loss (%)
Initial OPV
Final OPV

Thermal Conductivity

Initial TH-COND
Final TH-COND
TH-COND Temp

Strength

Initial Sc
Final Sc
Initial St
Final St
Initial Sb
Final Sb

Poissons Ratio

Initial u
Final u

Dimensional Changes

Length Change (%)
Diameter Change (%)
Volume Change (%)

Irradiation Creep Properties

Apld Stress
Creep Strain
Creep Coeff

Accustic Properties

Initial Sonic Velocity
Initial Attenuation
Final Sonic Velocity
Final Attenuation

Stored Energy

Total S
dS/dT
Release Start Temp

< BACK          NEXT >

**Figure 8.** The Property Selection Screen.

## 4.2.8 The Custom Report

This displays the data for the properties selected in tabular format. The selected Volumes can still be scrolled through (unless the output has been generated from all Volumes) by using the appropriate buttons at the top of the form. Additional information on the selected Volume can be obtained by clicking the Volume reference located between the 'previous' and 'next' buttons. The currently selected record is indicated by the black triangle in Figure 9. The records can be scrolled though by using the mouse with the right hand side scroll bar, by using the record bar at the bottom left of the form or by using the Graphite Toolbar (see next section).

The general dataset has now been defined, however there may be many black records in the retrieved data set where properties are not available and certain further restrictions may be required to be placed upon the data in order to achieve the required data set. Some quick additional filtering can be applied using the 'Record Display' buttons at the bottom of the Report. Simply clicking a radio button, Figure 10, performs the quick filtering function.
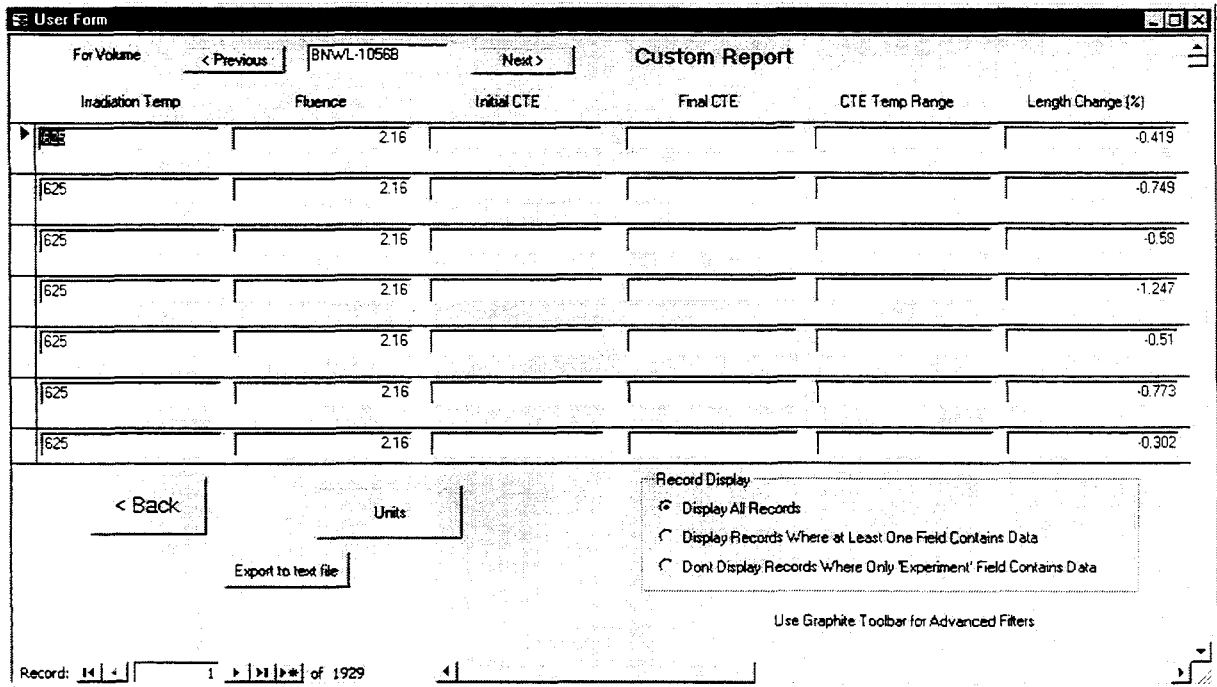
For Volume [ < Previous ] [ BNWL-1056B ] [ Next > ] **Custom Report**

| Irradiation Temp | Fluence | Initial CTE | Final CTE | CTE Temp Range | Length Change (%) |
|---|---|---|---|---|---|
| 625 | 2.16 | | | | -0.419 |
| 625 | 2.16 | | | | -0.749 |
| 625 | 2.16 | | | | -0.58 |
| 625 | 2.16 | | | | -1.247 |
| 625 | 2.16 | | | | -0.51 |
| 625 | 2.16 | | | | -0.773 |
| 625 | 2.16 | | | | -0.302 |

[ < Back ]   [ Units ]   [ Export to text file ]

Record Display
- ● Display All Records
- ○ Display Records Where at Least One Field Contains Data
- ○ Dont Display Records Where Only 'Experiment' Field Contains Data

Use Graphite Toolbar for Advanced Filters

Record: |◄| |◄| [ 1 ] |►| |►I| |►*| of 1929

**Figure 9.** The Custom Report.

Record Display
- ● Display All Records
- ○ Display Records Where at Least One Field Contains Data
- ○ Dont Display Records Where Only 'Experiment' Field Contains Data

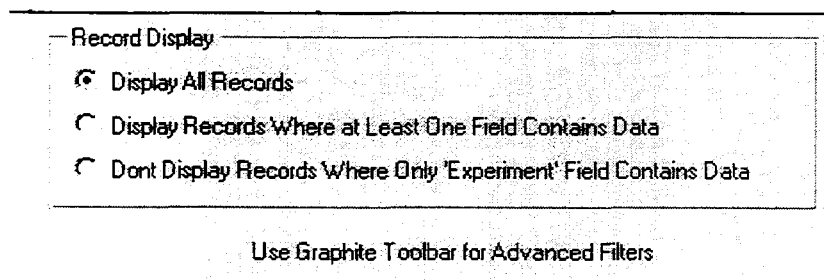Use Graphite Toolbar for Advanced Filters

**Figure 10.** Record Display 'Quick Filtering'

More advanced filtering techniques (and other formatting functions) are available using the Graphite Toolbar, Figure 11. The toolbar contains Icons (small pictures) that the user can click to perform the required function. Moving the mouse pointer over each icon provides a brief description of its function. From left to right, these are as follows.

- Sort Ascending. Rearranges the records in ascending order, numerically or alphabetically depending on the selected field. Clicking on the data of the required property changes the selected field.
- Sort Descending. As above but in descending order.
- Filter By Selection. In combination with the 'Filter Excluding Selection' option this is one of the most useful data filtering tools. Simply by selecting a particular data value using the mouse and then clicking this icon, results in only records with that value being displayed.
- Filter Excluding Selection. This works in a similar manner to the 'Filter by Selection' tool, except that all records that exclude the selected value are now displayed. This is especially useful for removing null values from the data output.
- Advanced Filter/Sort. Clicking this icon displays the advanced filtering menu as shown in Figure  and described below.

- Apply Filter. Once an advanced Filter has been defined clicking this button applies it to the data set.
- Apply Filter/Sort. If a data Sort has been defined in addition to a data Filter then clicking this button applies it to the data set.
- Remove Filter/Sort. Removes a previously applied Filter/Sort.
- First Record. Moves the record pointer to the first record in the data set.
- Previous Record. Moves the record pointer back one.
- Next Record. Moves the record pointer forward one.
- Last Record. Moves the record pointer to the last record in the data set.
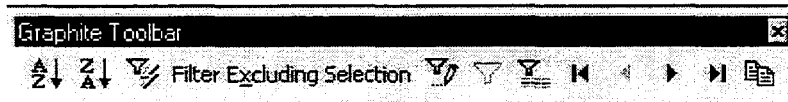- Copy. Copies Selected Records.



**Figure 11.** The Graphite Toolbar.

## 4.2.9 Advanced Filter/Sort

The advanced Filter/Sort Screen (FSS) allows specific criteria to be used to filter the data set and is intended for advanced users familiar with Access 97. Each of the sections in the lower half of the FSS enable a property (marked as Field) from the data set to be selected. Underneath this field a sort methods, i.e. ascending can be given for the property. Finally a combination of criteria can be specified in the criteria box. Criteria can specify numerical ranges, such as "<400 and >100", which means "Values less than 400 but greater than 100". Or wildcards can be supplied, for example, "Like Iso*" returns all records where part of the record contains 'Iso'. This could return, for example, a record containing the word "Isotropic". This procedure can now be repeated for other properties in adjacent boxes, the results from each box will be coupled with the logical 'OR' condition while criteria in the same box will be coupled with the logical 'AND' condition.

When all sort and filter criteria have been applied, the 'Apply Filter/Sort' button on the graphite toolbar should be clicked which immediately applies the defined filer/sort to the data. The defined filter or sort can be removed and reapplied by repeated clicking of the 'Apply Filter/Sort' button, which toggles the feature on and off.
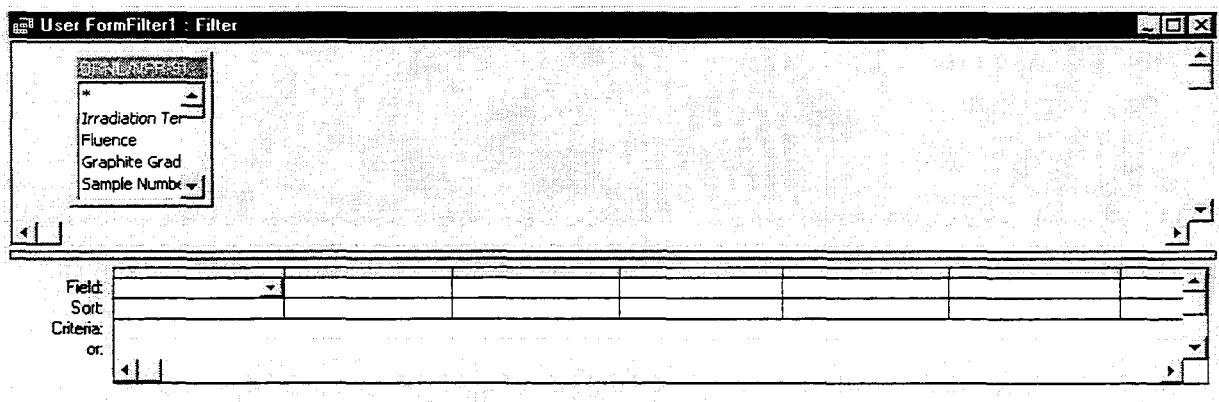


**Figure 12.** The Advanced Filter/Sort Screen.

TIP: A quick way of performing many of the common filtering tasks is to use the right mouse button to click the property of interest. A selection of options is then available, including the filter by selection and filter excluding selection options discussed above, Figure 13.
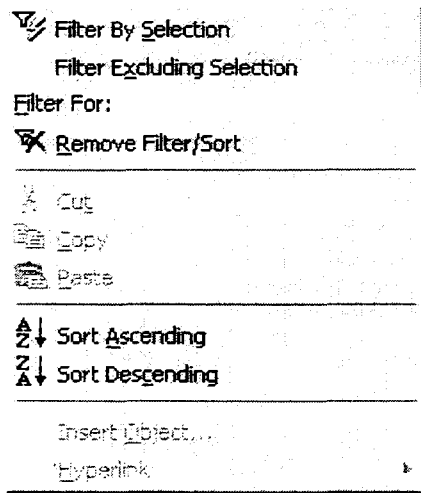


**Figure 13.** The List of Options Available on Clicking the Right Mouse Button in the Report.

## 4.2.10 Units

The units of measurement for each Volume can be displayed by clicking the Units button. The 'Unit Display' screen is then shown which contains a list of all properties defined in the database with units that vary between reports. The units of measurement for each property contained within the report are shown. N/A indicates that no data is contained within this particular Volume for that property.
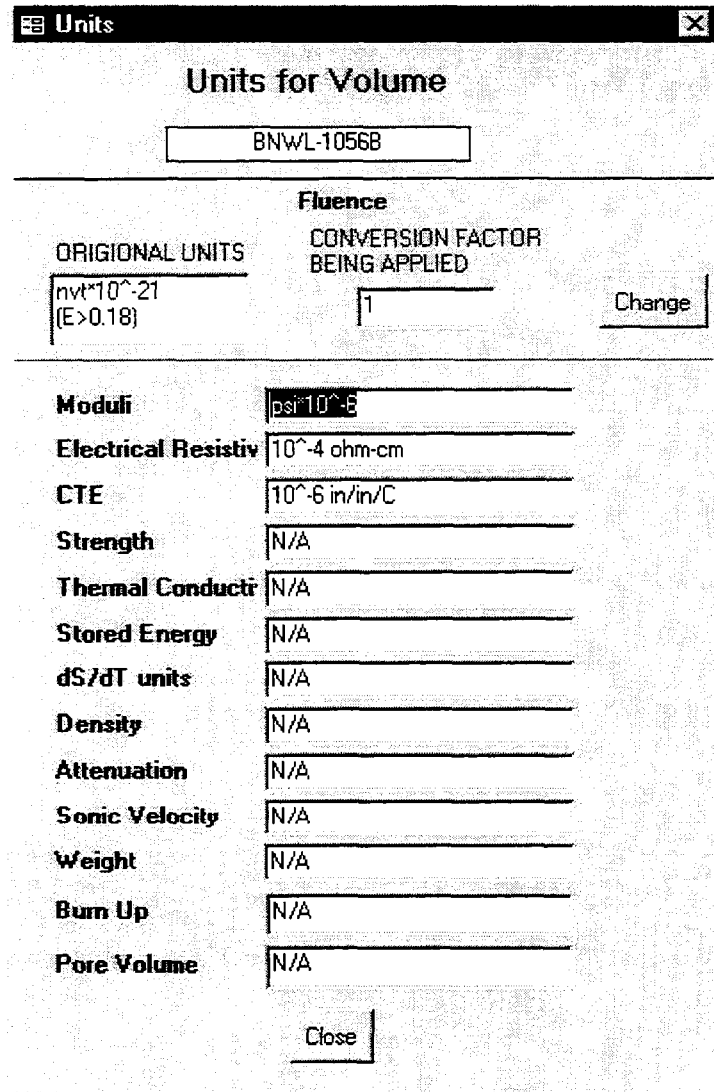
**Figure 14.** The Units Display Screen

For an individual Volume, the units of neutron flux (or fluence) can be changed via the 'Unit Display' screen. The button marked 'change' can be applied to display the 'Current Conversion Factors' screen. User defined numerical conversion factors can be entered in the fluence conversion factor text box. Alternatively, pre-defined conversion factors to other fluence units can be applied by clicking the Pre-defined Units button. Fluence units can then be selected from the pull down list box and applied to the data.

## 4.2.11 Copying Data to other Applications

The simplest way to copy data to another Windows application (such as Microsoft Excel) is to select the report data that is required by dragging the mouse over records of interest or by holding down the CTRL key and pressing 'A' which selects all the data on the report. After selection has been made, click the 'Copy' icon on the Graphite Toolbar. The data is now placed on the Windows clipboard. Then simply paste your data into the other Windows application.

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Data can also be exported as a text file by clicking the 'Export to text file' button on the Report screen. After specifying the location and name of the text file, a comma delimited file is produced which contains each data point separated by a comma. This can be imported into spreadsheet applications for example.

## 4.3   The Graphical Archive

The purpose of the database is to archive numerical data, the graphical archive is only included as a demonstration of further developments that could be included if required by the Steering Committee.

The graphical archive can be reached by clicking the appropriate button on the Volume Selection screen or, if a graph is available for the current Volume, from the Report Selector screen. The first graph then appears together with supporting information. Each field of the supporting information can be searched by first selecting the data in the field with the mouse and then clicking the 'Search for a Graph' button.
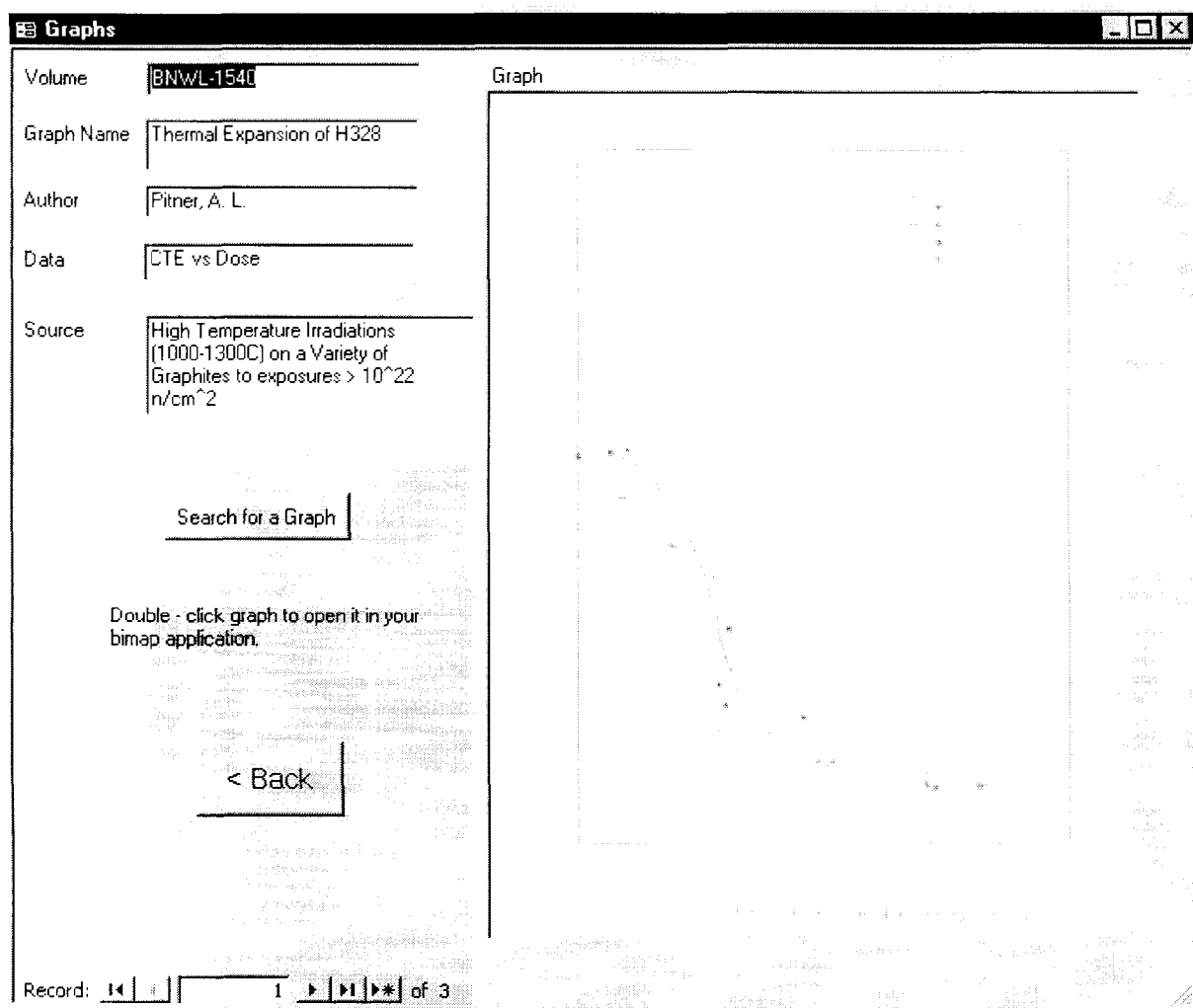


| Graphs | | |
|---|---|---|
| Volume | BNWL-1540 | Graph |
| Graph Name | Thermal Expansion of H328 | |
| Author | Pitner, A. L. | |
| Data | CTE vs Dose | |
| Source | High Temperature Irradiations (1000-1300C) on a Variety of Graphites to exposures > 10^22 n/cm^2 | |

Search for a Graph

Double - click graph to open it in your bimap application.

< Back

Record:  1  of 3

**Figure 15.**  The Example Graphical Section of the Database.

## 4.4 Anecdotal Information

In addition to the text information that directly supports the numerical data, the facility also exists for the storage of further relevant textural and pictorial information. Again, this facility is only a demonstration of the further developments that could be incorporated if required by the Steering Committee.

The anecdotal information is stored in the same format as World Wide Web files with links between information. The anecdotal information is available from the 'Supplemental Information screen via the hyperlink in the top right text box. The information is displayed in a Web browser.
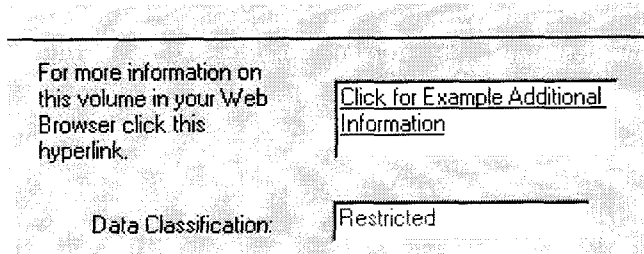


**Figure 16.** Link to Anecdotal Information from the Supplemental Information screen.

## 4.5 The 'As Received' Archive

The 'As Received' archive contains manufacturing and physical property information on a range of graphites before irradiation. For example, coke type and forming method are included. This section of the database is accessed from the report selector screen by clicking the 'As received graphite data' button. The manufacturing data is then presented, Figure 17.



**Figure 17.** Manufacturing Information.

Clicking the reference box displays further information on the supplying Volume of data in the Supplemental Information screen. Clicking the Physical properties button displays each graphite grade along with any archived physical property information. Again, reference information for the supplying Volume can be obtained by clicking the Volume reference button.

# 5    Conclusions

An IAEA database containing data on irradiated nuclear graphite has been implemented following initial discussions at an IAEA Specialist Meeting in September 1995. The database is based upon development at the University of Bath (United Kingdom) from funding provided by the UK Health and Safety Executive, and is also the product of many discussions amongst graphite specialists and debates at IAEA Consultants' Meetings.

Microsoft Access 97 was chosen as the development platform for the database because of its flexibility and ease of use. The properties currently archived reflect the particular interests of the members by containing, principally, data relevant to the construction and safety case developments required for new and existing HTR plants, and data relevant to the development of safety cases for continued operation of existing plant.

The current list of Database Members and Liaison Officers for the project are contained within this report. The definition of these positions and the associated responsibilities are contained in the Working Arrangement (Appendix 1).

The Database design provides a flexible structure for data archiving and retrieval and has been designed to be simple to use. An instruction manual has been provided within this document for new users. The database also contains an on-line overview and various help features. Data search and retrieval methods are easily incorporated and data can be transferred to other applications. Installation of the database is conducted on a users Personal Computer running Windows 95/NT V4 or higher.

Data security is maintained by controlled distribution of CD-ROM's. These are to be distributed to database Members by the IAEA according to the security classifications defined in this report.

# References

1.    International Atomic Energy Agency, "Graphite Moderator Lifecycle Behaviour" - Proceedings of a Specialists Meeting held in Bath, United Kingdom, 24-27 September 1995, IAEA-TECDOC-901, August 1996.

2.    A.J. Wickham, "A Proposal for the Central Archiving of Data on Irradiated Nuclear Graphite", paper presented at the 13th IWGGCR Meeting, IAEA Vienna, March 27, 1996 (issued as part of the archived Working Material).

## INTERNATIONAL DATABASE ON IRRADIATED NUCLEAR GRAPHITE PROPERTIES - WORKING ARRANGEMENT

*1.*     *Establishment of International Graphite Database*

1.1.     Pursuant to Article III, paragraph A.3 of its Statute, the International Atomic Energy Agency (hereinafter referred to as the "Agency") shall establish the International Database on Irradiated Nuclear Graphite Properties (hereinafter referred to as "Graphite Database") in collaboration with interested Agency Member States and organizations in Member States recognized by those States.

1.2.     The Graphite Database shall consist of data on the physical, chemical, mechanical and other relevant properties of irradiated nuclear graphites contributed by Member States and organizations in Member States recognized by those States.

1.3.     The operation of the Graphite Database shall be financed by voluntary contributions from the Graphite Database Members, Associate Members and Database Sponsors.

*2.*     *Purpose and Objectives of Graphite Database*

2.1.     The purpose of the Graphite Database is to preserve and further expand the existing scientific information on the physical, chemical, mechanical and other properties of irradiated graphites (including zero dose) relevant for nuclear power, nuclear safety and other nuclear science and technology applications, and to create a comprehensive international source for such information including reference data.

2.2.     The Graphite Database shall: (a) facilitate the development of national and international programmes on graphite moderated reactors and fusion technologies, (b) assist the safety authorities in the assessment of safety aspects of graphite moderated reactors, including the safety aspects of reactor decommissioning, and (c) serve as a comprehensive source of scientific information for a broad range of material science applications, including the non-nuclear technology areas.

*3.*     *Membership*

3.1.     Membership in the Graphite Database shall be restricted to Member States of the Agency which are willing and able to provide data relevant to the Graphite Database owned by them or non-governmental organizations within their territories for inclusion in the Database.

3.2.     To participate in the Graphite Database an official request to this effect (Application for Membership) is to be made by the Member State to the Director General of the Agency. Such request shall include the information prescribed in Section 3.3 below and a commitment to fulfil the obligations laid down in Section 4.1 below. Those States which are accepted are hereinafter referred to as Graphite Database Members.

3.3.    A prospective member of the Graphite Database shall provide to the Agency, together with the application for membership, the following information:

- amount of relevant data offered for immediate inclusion in the Graphite Database,
- brief description of data offered for inclusion in the Graphite Database (including any access restriction),
- estimate of the future data contributions to the Graphite Database,
- statement of acceptance of the obligations stipulated in Section 4.

3.4.    Every Member State which is a member of the Graphite Database shall appoint a Liaison Officer to act as a co-ordinator and focal point.  A Deputy Liaison Officer may also be appointed.

3.5.    Each Graphite Database Member fulfilling its responsibilities as laid down in Section 4.1 below shall have the same rights and privileges with respect to the Graphite Database.

3.6.    Member States which are not in possession of data relevant to the Graphite Database, but have a strong interest in the use of such data and in the development of the Graphite Database, may be accepted as Associate Members of the Graphite Database.

3.7.    A prospective Associate Member of the Graphite Database shall make an official request (Application for Associate Graphite Database Membership) to the Director General of the Agency.  Such request shall include the following information:

- description of the current and future data needs of the Member State which motivate the application for Associate Graphite Database Membership,
- description of the expected non-data contribution of the applicant to the Graphite Database development and maintenance,
- statement of acceptance of the obligations stipulated in Section 4.

3.8.    A Member State which has been accepted as an Associate Graphite Database Member shall appoint a Liaison Officer to act as a Co-ordinator and focal point.  A Deputy Liaison Officer may also be appointed.

3.9.    Each Associate Graphite Database Member fulfilling the responsibilities of Section 4.2 below shall have equal rights and privileges with respect to the Database.

3.10.   Associate Graphite Database Members shall have access to the Database as described in Section 6 below.

3.11.   Each Member shall be represented in the Graphite Database by a Liaison Officer officially appointed by that Member. The principal responsibility of the Liaison Officer shall be to co-ordinate the input to the Database from the corresponding Database Member and to see whether it satisfies the accepted standards and format.

4.      *Responsibilities of Graphite Database Members*

4.1.    A Member of the Graphite Database shall be responsible at its own expense for:

4.1.1. the collection, validation, categorization, specification and appropriate formatting of nuclear graphite properties data relevant to the Graphite Database;

4.1.2. providing periodically, but not less than once a year, to the Agency properly validated, categorized, documented and formatted data owned either by the Member State or non-governmental organization within its territory for inclusion in the Graphite Database;

4.1.3. providing advice and recommendations to the Agency on matters relating to the maintenance, improvement and development of the Graphite Database;

4.1.4. providing information services to and monitoring contact with, to the extent practicable, users of the Graphite Database within its territory and representing users' views at Graphite Database related meetings;

4.1.5. obtaining clearance from each Graphite Database member before providing information derived from the Graphite Database to non-members of the Database.

4.2. Each Database Member shall identify which data amongst those provided as input into the Graphite Database shall be treated as restricted. If no explicit indication in that respect is made, the Agency shall treat all such data as restricted, until clarification has been obtained.

4.3. An Associate Member of the Graphite Database shall be responsible at its own expense for:

4.3.1. providing information at the meetings of the Steering Committee regarding its needs for irradiated nuclear graphite data;

4.3.2. providing information on the Graphite Database and its use to the users within its territory;

4.3.3. providing advice and recommendations to the Graphite Database Members on matters relating to the use of the Graphite Database.


5. *Management of Graphite Database*

5.1. The Agency shall provide secretariat functions for the Graphite Database.

5.2. The principal functions of the Agency Secretariat, subject to availability of funds, are:
5.2.1. the management of the Graphite Database to ensure that its rules and procedures are correctly implemented and the efficient operation and continued improvement of the Graphite Database. The Secretariat shall take into account the interests of all Graphite Database members, including those with associate status, in managing the operation of the Graphite Database;

5.2.2. the integration of input from Graphite Database members into the Graphite Database files, including checks for scope and format consistency;

5.2.3.  the continuous maintenance and development of the Graphite Database files, in collaboration with Graphite Database Members, including security aspects of the Graphite Database;

5.2.4.  arranging meetings of the Steering Committee of the Graphite Database and, if necessary, other meetings related to the Graphite Database;

5.2.5.  preparation and custody of registers of Graphite Database Members, Associate Graphite Database Members and Graphite Database sponsors;

5.2.6.  administration of the extra budgetary contributions from the Graphite Database Members, Associate Graphite Database Members, and Graphite Database Sponsors in accordance with the Agency Financial Regulations and Rules;

5.2.7.  training, upon request, of Member's personnel in the preparation and processing of the data input and with data retrieval procedures;

5.2.8.  security of the Graphite Database in accordance with Section 9 of this Agreement.


6.      *Access to the Graphite Database*

6.1.    Members and Associate Members of the Graphite Database who have fulfilled all requirements specified in Section 4 shall have full access to all data in the Database.

6.2.    Non-members of the Graphite Database may access un-restricted data in the Graphite Database.

6.3.    Access to restricted data by non-members shall be through the Agency, and will require the express approval of the Member who supplied the data. Any request by a non-member made to the Agency for the release of restricted data from the Graphite Database shall contain detailed specification of the requested data and a description of the purpose and planned use of the data. The approval of the data supplier and all records of the request shall be entered and kept in a registry by Agency for the life of the Graphite Database.

6.4.    Any request for access to the Graphite Database by a non-member shall be at its own expense.

6.5.    Any final product or publication of any user resulting from the use of, or containing information obtained from, the Graphite Database shall refer to and acknowledge the Graphite Database and the data supplier (original data source). Acceptance of such obligation by the data user shall be a condition for release of the data.

6.6.    The Agency shall have the same rights of access to the Graphite Database as a Member. The Agency may use restricted data in the Graphite Database for analyses, evaluations or for preparing guidelines and recommendations for developing countries without releasing the data.

6.7.    If a Member of the Graphite Database elects to withdraw from membership, data provided by that Member will remain in the Graphite Database. Restricted data provided by a former Member may be released only with the approval of that Party.

7.      *Steering Committee*

7.1.    There shall be a Steering Committee of the Graphite Database made up of: (a) one representative from each Member State of the Graphite Database appointed by the appropriate national authority, and (b) one representative each of Associate Members. The International Working Group on Gas Cooled Reactors (IWGGCR) shall be invited as observer. A representative of the Agency shall attend meetings of the Steering Committee as an observer.

7.2.    Members of the Steering Committee shall elect from among themselves a Chairman who shall hold the office for three years. This appointment shall be approved by the Director General of the Agency.

7.3.    The Steering Committee shall meet once a year. The agenda for each meeting will be prepared by the Agency Secretariat in consultation with the Chairman of the Committee, and issued to the Committee Members at least one month before the meeting.

7.4.    The programme of the Steering Committee meetings will include:

-       all technical matters relating to data and Graphite Database operation;
-       consideration of annual progress report prepared by the Agency, in cooperation with the Liaison Officers of Graphite Database Members;

-       evaluation of the Graphite Database status and operations, and the progress made in its development;
-       recommendations on the procedures regulating the operation of the Graphite Database;
-       consideration of financial aspects of the Graphite Database and recommending relevant measures and actions;
-       discussion of proposals from the Members and Associate Members of the Graphite Database relating to the operation and development of the Graphite Database.

7.5.    Urgent decisions or recommendations of the Steering Committee which may be required by the Agency in the process of management and operation of the Graphite Database shall be taken or formulated by the Committee Chairman after obtaining the consent from all available members of the Steering Committee.

7.6.    The Chairman of the Steering Committee may invite representatives of Graphite Database Sponsors to attend the Steering Committee meetings as observers for obtaining information or advice on specific items of the agenda or following a specific request for attendance from the Sponsors. The invitation will be extended through the Agency.

7.7.    Participation in meetings of the Steering Committee shall be at the expense of the respective Member, Associate Member or Database Sponsor.

8. *Database Sponsors*

8.1. Non-governmental organizations which have made voluntary contributions to the operation and maintenance of the Graphite Database shall be referred to as Database Sponsors.

8.2. An appropriate acknowledgment shall be given to the Database Sponsor in all general documents related to the Graphite Database (e.g. WWW home page, etc), with indication of the period of its sponsorship.

8.3. A Database Sponsor may access restricted data with the approval of the Member who provided the data.

8.4. A Database Sponsor shall be informed about the Agenda of each forthcoming Steering Committee Meeting and may request to be invited to attend the meeting.

8.5. A Database Sponsor, may on request, be invited to all technical meetings that may be organized by the Agency in relation with the Graphite Database.

9. *Security Matters*

9.1. Responsibility for the security of the Graphite Database shall rest with the Agency. There shall be no release of restricted data other than by the means described below.

9.2. Unrestricted data will be made available by the Internet via the database home page.

9.3. Restricted data will be held in the Graphite Database by the Agency on a secure system without Internet access and on a separate operating platform from the unrestricted data files. Transmission of these restricted data by the Agency shall be entirely in the form of CD-ROM with appropriate precautions to secure the material in transit.

9.4. Security for transmission of restricted data to the Agency for further inclusion in the Graphite Database shall be the responsibility of the Database Member supplying the data.

9.5. The structure and operating system are specified in the Annex.

10. *Change of Status*

If the Steering Committee, decides that a Database Member or Associate Member is not adequately fulfilling its responsibilities laid out in Section 4 above, discussions will be initiated and a concerted effort made to bring the Database Member or Associate Member into compliance. A Database Member or Associated Member that has not fulfilled its responsibilities as laid down in Section 4 above for two consecutive years, shall forfeit the right to access the Graphite Database as stipulated in Section 6 above, except in cases where the Steering Committee, is satisfied that the failure is due to conditions beyond the control of the Database Member or Associate Member.

_Definitions_

"Member State" means a member state of the Agency

"Unrestricted Data" are data published in open literature and those data offered by database Members on behalf of data supplier for free dissemination. All other data are to be regarded as "Restricted Data".

"Data Supplier" is the originating organization for data within the Member State.