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Quality Assurance for the IAEA International Database on Irradiated Nuclear Graphite Properties

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Abstract

This report considers the process of Quality Assurance applied to data entered into current versions of the IAEA International Database on Irradiated Nuclear Graphite Properties. Originally conceived simply as a means of collecting and preserving data on irradiation experiments and reactor operation, the data are increasingly being utilised for the preparation of safety arguments and in the design of new graphites for forthcoming generations of graphite-moderated plant. Under these circumstances, regulatory agencies require assurances that the data are of appropriate accuracy and correctly transcribed, that obvious errors in the original documentation are either highlighted or corrected, etc., before they are prepared to accept analyses built upon these data. This report describes the processes employed in data transcription and offers proposals for categorisation of data and for error reporting by Database users.

March 2008

TABLE OF CONTENTS

1. Introduction

The original declared purpose of the IAEA International Database on Irradiated Nuclear Graphite Properties[1] at the time of its inception was to ensure that useful data upon the irradiation behaviour of nuclear graphites, derived both from reactor operational experience and from irradiation test facilities, would be preserved and made available to future generations of designers and operators of graphite-moderated reactors. On that basis, the Technical Steering Committee, containing representation from all participating Member States, Database Sponsors and other interested Observers, determined that data should be transferred from original sources without additional interpretation or analysis, in the interests of maximising the data-collection rate. With this collection process now considered to be around 85% complete, attention has turned more recently to the requirements of the data users, most particularly in their need to meet 21st-century standards of quality assurance.

This decision to review and to set standards for data input usefully coincided with a changed strategy in the filing system for the Database. Initially the Database was constructed around a custom Microsoft Access application, with embedded programming sufficient to enable use of the CD-ROMs previously supplied without any need for an independent installation of the Access program. Debate about the adequacy of this platform has continued for several years at annual meetings of the Technical Steering Committee, initially striving for enhanced search functionality consistent with a fully relational Database (which it is not, in its current form), whilst alternate opinion, residing mainly with some nuclear graphite specialists, felt that they preferred to make their own selections of data based upon their personal experience and that all that was really required was a scanned or archived copy of original research reports.

The Technical Steering Committee was unable to find a way forward which encompassed these significant divisions of opinion and, to enable further data input to continue in the most efficient manner and at the same time recognising the disadvantages of the Access-based system, it was resolved at the meeting in March 2005 to revert to issuing updates of the Database as a collection of Microsoft Excel spreadsheets based upon a consistent input template previously agreed by the committee.

This template allows a significant improvement in the nature of ancillary information presented, in comparison to the previous method of entry into to the Access system by ‘volume’ (meaning an individual technical source or report). In the early stages of the Database development, if a ‘volume’ was on a specific graphite type, for example ***gilsocarbon***, then that information was probably contained in the report title, or was deemed to be evident from the application (often UK Advanced Gas-Cooled Reactors in this instance) and so the term ‘***gilsocarbon***’ would not appear in any part of the input of the data, thus preventing future searching on graphite type. Consequently, all pre-existing records have now largely been updated to ensure that such information, covering a wide range of features relating to the material such as manufacturer, coke source, method of forming etc. are now added to the information, whilst all new data inputs are carefully checked to ensure that such information is now always available.

Thus, although the collections of Excel files will not be amenable to sophisticated searches unless re-compiled into some future fully relational system, all the information that can realistically be foreseen to be of potential importance to users will be present within the Excel files in readiness for this possible future development. Meanwhile, specialist users of the compilations of Excel files will have necessary information available to assist them in correctly interpreting the appropriate application of the data.

This present report covers three important areas in the ‘QA’ process:

[1] The qualification for and obligations of membership of the IAEA International Database on Irradiated Nuclear Graphite Properties are contained in the ‘Working Arrangement’ which is available on the IAEA website at http://www-mdis.iaea.org/graphite/reports/Graphite_Database_Arragement.pdf

(i) Procedures applied when reviewing data being input into the Database for the first time (and when upgrading previous input);

(ii) Categorisation of data in terms of the competency of its source, its traceability / auditability, the appropriateness of the material tested etc., with the intent of providing future users with an objective and justified assessment of the data's relative worth; *and*

(iii) A system for 'error reporting' on the part of users.

In order to demonstrate consistency in the QA approach with future developments in the design of graphite-reactor cores and components, care has been taken to ensure that the methodology applied here is consistent with the requirements of GenIV [1].

2. Quality Assurance of Data Input Procedure

1. The person preparing a new Excel file for the first time must first ensure that the appropriate category of the data is being employed and that the file is created in the appropriate part of the Database – namely, Unclassified, Restricted, or L2 Restricted. The information necessary to reach this decision will come from the *Data Provider*.

2. The source of the information will then be reviewed:

    a. If the source is a report, it should be verified that it is a final report and not a draft following which data may have been changed or upgraded: if it is a draft report, the *Data Provider* should be requested to supply a final report: if a draft report is the only source, it is possible that it was never formally issued, and this should be recorded as such: the bibliographic details of the source report are to be recorded in the data file;

    b. Where no report exists, and the data are being taken from laboratory records, it should be verified that these records have authority – *e.g.* the notebook author is known to have been a significant participant in the experiment and was appropriately qualified: as much information as is reasonable available about the source is to be recorded in the data file;

    c. These issues relating to the source report are re-visited by the Technical Steering Committee in the 'Categorisation of Data' described in the next section: however they appear here also on the grounds that if there are doubts about the authenticity of the information at this initial stage, the data-input process should be halted and the data referred back to the Technical Steering Committee or the Data Provider for advice.

    d. All remaining proscribed QA activities in respect of Data Input relate to the *Data* rather than the *Report*.

3. The nature of the data will then be reviewed. It is the Database policy that only direct measurements should be recorded, or parameters calculated directly from a direct measurement, rather than data which have been 'normalised' or otherwise treated. In particular, it should be verified that the data are true measurement records and have not been interpolated from curves drawn through few or inadequately spaced data points. In some instances, especially in older reports and in published papers from some sources, only curves relating parameters are available, or data points are presented graphically with no numerical tables shown. In other circumstances, original laboratory records were never transcribed fully into the published documents. In this instance, it *is* permissible to use interpolated points[2]

[2] An identified computer program for digitising points on a graph or a curve shall be used, with appropriate care being taken to orient axes precisely.

provided that it is made unambiguously clear in the Excel file that this has been done, and thus that the reliability of the record is potentially impaired.

4. The adequacy of the data in terms of its applicability to analysis will then be reviewed. Frequent examples have been found where measurements which are sensitive to irradiation and/or measurement temperature (or temperature range) have no such information recorded. In most cases it will be appropriate to reject these records. A similar decision must be made where details of local fluence at the sample(s) is lacking. The definitive fluence unit in the Database is 'dpa' (displacements per atom) and other units should be converted before data entry using the evaluated conversion factors endorsed by the Technical Steering Committee[3]. Irradiation temperature is a particular problem, especially in custom-built irradiation rigs, since it has frequently been estimated but not verified, or a range is given. Such uncertainties must be clearly 'flagged' to the data user. Attention must also be paid to temperatures which are expressed as 'equivalent temperatures' (such as DIDO-equivalent or Calder-equivalent in the United Kingdom): in all cases, where it is possible to do so, *actual* irradiation temperatures should be recorded although the availability of the converted temperature should also be indicated to the data user[4].

5. The provenance and appropriateness of the samples should be verified. For example, data from material implied as representing a particular reactor type should be production material and not from experimental or pre-production batches. Whilst data from such sources *are* appropriate for inclusion, they must be appropriately identified. Where sample orientation is important (for most commercial materials which will have some degree of anisotropy) then this shall be expressed in terms of angle to the grain direction (usually parallel or perpendicular). Grain direction is parallel to the extrusion direction in extruded materials, and perpendicular to the applied pressure in pressed materials. It shall be verified that sample measurements which are orientation-sensitive are definitively described[5]. It must be ensured that information on graphite manufacturer, coke source, production process, etc. is included in the Database to assist future search functionality.

6. The data in the original document will then be examined. It is often the case in older documents that they have been typed up from handwritten information by secretaries who were not familiar with the information, and that typographical errors are frequently present as well as significant mistakes entering tables such as incorrect powers of ten, numbers of leading zeros, column headings misplaced relative to the data within them, missing or incorrect units, etc. In most cases it will be obvious to a nuclear-graphite specialist reviewing the information where such errors lie and, because they are often typographical, it is also often the case that they have *not* been carried forward into analyses or graphs and that the correct information can still appear in these positions, making confirmation of the error fairly straightforward. When in the opinion of the reviewer the nature of the error is completely clear, it shall be corrected at the stage of input to the Database, and a 'remark' made to this effect. Other common errors encountered in older reports prepared when QA systems were not in place include calculational errors. Therefore, a representative sample of accessible calculations in the original report will be checked, and the nature of the check (*e.g.* "10% calculations of parameters X and Y confirmed") shall be recorded.

7. At this stage, the transcription of data to the agreed template can be made. The Technical Steering Committee applies priorities to data and it is possible that not all information present

[3] The endorsed conversion factors are including in the Database DVD as a separate Table.
[4] It is becoming increasingly clear that the concept of 'equivalent temperature' may be faulty.
[5] Examples are found where the words 'perpendicular' and 'parallel' may mean different things, such as relative to the original block long axis, to the sample as cut from it, to the extrusion direction, to the grain, etc. etc., and there is thus much scope for confusion. The agreed procedure for the use of the terms in the Database is relative to the preferred orientation of the grains in the material in question.

in a report will immediately be included in the Database[6]. Where additional information remains in a report which is not entered, this should be recorded in a remark.

8. After transcription into the Excel file, an independent check of the input should be made. This shall include, but should not be limited to, such issues as displacement of tabular information compared with the original, powers of ten, leading zeros, recalculation of units where required, and a sample of internal calculations where they can be checked. This overall check should compare the Excel file with the original document. A copy of the original document should be retained (see Item 10).

9. In a minority of situations, data are presented directly by the Data Provider in templated form. Such data also require careful validation to ensure that similar standards to the rest of the data are maintained. This will be the responsibility of the person compiling new data for the issue of the next update of the Database, working with the original data provider. Examples of issues which have been noted in such pre-prepared templates include incompatible character sets resulting in irrelevant symbols appearing as data input, different standards with respect to (for example) sample orientations, etc. etc.

10. Unless permission is explicitly withheld by the Data Owner, a copy of the original report document should be included in the DVD[7] and should be hyperlinked from the appropriate data table. Where data are copyright, permission should first be obtained from the copyright holder.

11. Restricted and L2 Restricted Data tables, and sources, shall be password protected.

12. Before issue in an updated DVD, the Technical Steering Committee shall review all new input information at its annual meeting. This review shall also address issues relating to the Categorisation of Data, as discussed in Section 3.

3. Categorisation of Data

Resulting from debates within the Technical Steering Committee[8] and in Member State's user groups (especially within the United Kingdom), it has been determined that regulatory authorities will gain confidence if each sheet of data (to be referred to in the future as a 'report' rather than a 'volume' following a committee decision) is accompanied by an assessment of its provenance, reached collectively by the Technical Steering Committee at its annual meeting. The objective is to give a transparent "weighting" to the data in each report[9], using an evaluation system agreed collectively by the nuclear graphite specialists who make up the committee. This will remove 'subjectivity' from the use of data.

After a trial period, it was further agreed that the Categorisation of Data should be applied retrospectively – *i.e.* after data users have had the opportunity to explore and to utilise newly-input data for a period. The convenient arrangement which has been adopted is that the Technical Steering Committee should at its annual meeting address the data which were added in the previous year[10].

The following factors were deemed after preliminary discussions to be significant in arriving at an evaluation for a particular dataset:

[6] Up to the present time, preference has been given to mechanical and physical-property changes resulting from neutron damage effects.
[7] The size of the Database, with scanned reports included, has outgrown the original CD-ROM format.
[8] Particularly from the very large meeting held in the United Kingdom in September 2004, when a wide range of opinions was received from observers.
[9] Or to sub-sets of the data if there are inconsistencies within a single report.
[10] At the conclusion of the project, a special final meeting may be needed for this purpose.

1. The source of the material (graphite) used in the experiments (special graphite, production material or pre-production batches) in regard to the application for which the data are now being utilised[11];
2. Traceability of the data (auditability);
3. The quality of the irradiation parameters and the experimental practice;
4. The nature of the testing methodologies used for determining the irradiation effects;
5. The nature in which the results are reported and any QA undertaken at the time;
6. Available without need for additional interpretation or editing of information;
7. Data points available – not just relational curves;
8. Quality of the organisation originally reporting the data.

Some of these categories may generate sub-attributes, as discussed below.

Consideration of this initial list leads to the conclusion that item (1) cannot legitimately appear as a 'rated' item, it rather being assumed that a potential data user will make a selection of data which *are* appropriate for the purpose in hand.

DATA QUALIFICATION FOR REPORT ref:

Version 2: May 2007

1 Traceability of Data

a) QA Records Available and Verifiable, traceable to specific and authoritative lab or source
b) Origins of Data Unambiguous but no audit trail
c) Consistent with Verified Data on Similar Material but Basis of Data unclear
d) Source of data unclear (effectively this eliminates data from inclusion)

2/3 Quality of Irradiation Parameters

2	**3**
a) Actual Irradiation Temperature	a) Accurate True Fluence
b) Estimated (real) Irradiation Temperature	b) Estimated True Fluence
c) Equivalent Temperature Given	c) Equivalent Fluence Given
d) Equivalent Temperature Estimated	d) Equivalent Fluence Estimated
e) Irradiation Temperature not Specified	

4 Quality of Experimental Practice

a) MTR Experiment, Established Team
b) MTR Experiment, 'One-Off' Test
c) Facility Irradiation, *e.g.* Ion Beam, Gamma Source with Competent Dosimetry
d) Reactor Irradiation, Accurate Dosimetry Confirmed
e) Reactor Irradiation, Estimated Parameters
f) Reactor Location where PRECISE Calibration Difficult *e.g.* Hollow Fuel Assembly

5 Testing Methodologies

a) ASTM Methodology, or National Equivalent
b) Other Modern Technique with Uncertainties Specified
c) Custom Method, Uncertainties Unclear
d) Poor Information on method or Accuracy

[11] This may be difficult to assess in a general sense since it is likely to be dependent upon the user's particular interests.

6 Nature of Reporting and Quality Assurance

(i) Data from Technical Reports or Laboratory Sources

a) Authorised Report, Verified Data with QA Methodology Specified
b) Authorised Report, No Verification Evident
c) Draft Report, Verified Data with QA Methodology Specified
d) Draft Report, No Verification Evident
e) Laboratory Notebook or Personal Record, with Evidence of Verification
f) Laboratory Notebook or Personal Record with No Evidence of Verification

(ii) Data from Published Papers in Learned Journals or Conference Proceedings

g) Refereed Paper
h) Non-refereed paper
i) Known to have been Peer Reviewed
j) Known to have been Accepted Previously for (*e.g.*) Safety-Case Usage

7 Extent of Errors (Arithmetic, Typographical etc.) Found during Assessment

a) None
b) Minimal
c) Moderate
d) Extensive

8 Nature of Data Points

a) Original Data points Available for All Results Given
b) Some Interpolation from 'Normalised' or 'Corrected' Data Necessary
c) Interpolation from Curves necessary, individual results not available

9 Nature of Reporting Organisation

a) National or International Accredited Nuclear Facility (*e.g.* ISO 9001)
b) Established National or International Nuclear Facility without Accreditation
c) Reactor Operator Interpreting Own Information with SQEP Staff
d) Technical University with Established Experience in Field (as Experimentalists)
e) Technical University Interpreting Data from Other Source
f) Data Analysed by External Contractors or Similar
g) Unattributed Reference in Other Document

10 Remarks

11 Committee Members Participating in this Evaluation

A worked example of the derivation of the data string is given for the report known as 'BNWL 1672:

1. Traceability of Data: Origins of Data Unambiguous but no audit trail ***Result***: (b)
2. Irradiation Temperature: Actual (a)
3. Irradiation Fluence: Accurate true fluence (a)
4. Quality of Experimental Practice: MTR Experiment, Established Team (a)
5. Testing Method: *originally "Custom Method, Uncertainties Established": this now merged with preceding category following committee discussion so result is now:* Other modern technique with uncertainties specified (b)

6. Nature of Reporting and QA: authorised report, no verification evident (c)
7. Extent of Errors: none (a)
Note: I have reversed the order of this section in version 2 so that the best result is always "a" in each category, for consistency when viewing the shorthand form of the results
8. Nature of Data Points: original data points available for all results (a)
9. Nature of Reporting Organisation: establish national facility without accreditation (b)
---
10. Remarks (none)
11. Participating Committee Members (initials inserted)

This then creates the following data string: 1b2a3a4a5b6c7a8a9b

4. Error Reporting

Whilst every care will be taken in the input of data to the Excel spreadsheets as detailed in earlier Sections of this report, it is important that any errors found are reported by users and corrected in future issues of the Database files.

The route for this process should be through the Member State's representative on the Technical Steering Committee.

A clear statement in writing (or e-mail record) of the error found, possibly by a highlighted amended copy of the file if this can be achieved without contravention of the Working Arrangement in relation to data security requirements, should be prepared by the data user and sent to the appropriate Steering Committee Representative for the Member State.

This should then be forwarded to the IAEA Co-ordinator for the project, currently *(March 2008)* Mr. Denis Humbert, who will:

(a) inform all other Technical Committee representatives of the error so that it can be communicated to their own Database users, *and;*

(b) ensure that the next compilation of the DVD has the error corrected, through liaison with the person currently performing that function (who may be a member of the Technical Steering Committee or an independent contractor to the IAEA appointed at the recommendation of the Technical Steering Committee).

5. Compatability with GenIV Requirements

The quality management guidelines recently issued by the GenIV International Forum (GIF) [1] are based upon, or at least related back to, three competent sources of QA procedure:

The IAEA Safety Series No. 50-C/SG-Q (1996) "Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations";
The American Society of Mechanical Engineers (ASME) NQA-1-2004 "Quality Assurance Requirements for Nuclear Facility Applications"; *and*
ISO-9001-2000 "Quality Management Systems,"

The sections of the GIF document on 'Data Gathering and Analysis', 'Data Reduction and Analysis', 'Document Control', 'Quality Assurance Records' and 'Quality Audits and Assessments' have been carefully examined and compared with the Database procedures. The GIF proposals apply principally

to research and development activities rather than mere data archiving but, in general, it is considered that the procedures documented here for the IAEA Database are appropriate in the GIF context. The potential weakness is perhaps in the audit area, since the Technical Steering Committee itself constitutes the audit of the data-input process but itself controls the document categorisation without further external confirmation. However, sufficient records of decisions taken and their basis is believed to exist to allow external data users, regulating bodies etc., to obtain adequate assurances of the procedures undertaken.

The Technical Steering Committee will be pleased to receive any comments about the QA procedures followed for the IAEA Database from GenIV members, data users, or any other competent persons, and will consider them as appropriate.

REFERENCE

[1] Generation IV International Forum, "Quality Management System Guidelines"; GIF/QMS/2007, July 2007

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