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High-Temperature Reactor Physics and Fuel Cycle Studies
(EC-funded Projects: FIKI-CT-2000-00020 & FIKI-CT-2001-00169)

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ADDITIONAL Q.A. GUIDELINES FOR THE HTR-N PROJECT
(Quality Assurance Requirements on Nuclear Data)

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1. SCOPE

This document provides Quality Assurance related guidelines applicable primarily to the reactor physics computational activities for the HTR-N project [1] and, in particular, to the development of a few basic rules for the data processing through data bases (DB), the data entry and updating, the methods and extension of DB testing, the check rules for the DB quality status control.

It also provides guidance and suggests measures adequate to guarantee reliable and consistent generation, certification, exchange and maintenance of data and information originated inside the HTR-N Project with specific assessments in connection with procedures for documentation processing between the HTR-N Project entrusted Partners.

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2. BACKGROUND AND INTRODUCTION

The HTR-N project [1] foresees the participation of a large number of partners and the set up of a number of data bases both for performing the analytical activities, which will require continuous update and exchange of basic input data sets between the different organizations, and for constituting referential data systems, which are intended to collect former background on specific fields of the HTR technology and to include additional information and data coming from the present research (i.e. data on wastes, on fuel corrosion, fuel disposal etc.).

With the aim of assuring an adequate level of consistency and reliability, it is necessary to define general guidelines and procedures for assisting the preparation of the data bases, the data entry and updating, the maintenance and security of the information recorded in connection with software/hardware platforms that the DB's responsible organizations decide to use.

In addition to assuring the participants on the correctness and usefulness of data utilized, they also entitle the project with valuable and qualified data sets and results.

In order to comply with requirements which may be considered responding and qualified in the framework of the ISO 9001 [2] standard, the following project activities are considered relevant under a Q.A. regime:

- project input and definition of methods of analysis
- design check/control
- filing system
- data transfer management and control.

It is noted that when operating in agreement and consistently with a selected Q.A. system, i.e. the ISO 9001 in this case, the different organizations which are participating to the RTD project do not need a specific certification themselves, being their current standards acceptable in that they may be supporting and in substantial compliance with the required project Q.A. system.

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3. FIELD OF APPLICATION

3.1 General Topics

The Q.A. related guidelines provided in the next sections primarily focus on the calculation related aspects that constitute the by far dominant portions of workpackage 2 (Identification of Needs for Improved Nuclear Data) and workpackage 3 (Physics Analysis of HTR Concepts with Different Fuel Cycles).

Both workpackages heavily rely on the use of nuclear data libraries (such as JEF-3, ENDF/B-VI, JENDL-3.2, EAF4) which are assumed to be set-up and updated from time to time by different organizations and on the use of a large number of reactor physics computer programs which are also developed and moreless continuously improved by different organizations. Both libraries and computer programs are being extensively used, by the organizations participating to the HTR-N project, through many computer run cases starting from common and specific input conditions (geometrical data, materials and associated physical properties, fuel irradiation history, system data).

Moreover, concerning nuclear data, it is also noted that it is sometimes technically feasible to work out, directly from raw data, data sets specifically suited for a given application.

While this evidently provides a large degree of flexibility to the analyst, it may originate difficulties and inconveniences in properly assessing the consistency and reliability of the calculated results.

Based on the above observations it appears therefore necessary and adequate to focus the Q.A. related guidelines on:

1. data bases and libraries adoption and management
2. computer programs identification and management
3. data bases and computer programs maintenance and security
4. identification of problem input data, preparation and exchange of input data sets
5. information to be included in the reports containing the results of the performed computer runs in order to allow verification of the proper implementation of the Q.A. guidelines by each organization (this should be already part of the internal working procedures of each partner)
6. project documentation cycle
7. general operating rules

Additional aspects, such as more general requirements on project documentation issue and filing (e.g. document type, classification, status of validity, intended use) as well as requirements on the modes of interaction between the project partners, which are relevant from the Quality Assurance point of view, in the framework of the ISO 9001, are addressed in this document as principle guidelines, being assumed that they are properly identified, addressed and regulated in pertinent Project Management documents.

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3.2 Data Bases adoption and management

Data Bases adoption and management covers both the constitution of new DB's and the use of referential DB's. The HTR-N Project will make extensive use of the SINTER Network which is implemented, managed and maintained by the University of Stuttgart [3].

Four main categories may be identified:

1. bibliography DB constituted both of old paper documents (to be put into electronic form) and recent, already in e-form, being collected from worldwide HTR programs. An e-system and Internet address are defined, only one person, the DB responsible administrator, has writing access, partners (and observers) may access by reading only through access password, additional documents may be included in the DB by the DB responsible, the DB should implement an hypertext index for fast accession through document selection (this implementation is actually going to be furtherly developed in SINTER);
2. nuclear data libraries (NL-DB): both standard open nuclear data libraries and commercially supplied ones are assumed to be accessible by reading only when Partners are performing calculations, so that consistency is eventually kept between analyses addressing same library type/version. It is assumed that the NL-DB's are currently kept and maintained at the Partners' organisations, so that they are generally governed by the Partner organisation internal Q.A. while keeping the harmonisation requirements of the HTR-N Q.A. guidelines. A specific issue could concern the set up of a specific SINTER area for sharing between Partners common libraries which may eventually be made available under specific provision agreement for the HTR-N Project Partners;
3. working input/output DB's (1÷2 specific SINTER working areas accessible by Partners) implementing common data sets for computer programs base decks ("inputs" DB containing reference design parameters, applied variations, material composition, properties, etc.) and for collection of code computation results ("outputs" DB, to be agreed on common data set forms and parameters) useful for carrying out intercomparisons between performances of different concept/design; Partners should have access to these DB's by reading only to avoid/limit misoperations, while one responsible only (possibly not more than one per WP, e.g. the WP manager) should have access in writing, date and updating/change being recorded when and where occurred. This issue is being addressed through definition of suitable common input and output parameters, while parameter values used in calculations by the Partners shall have to be supported and traceable by suitable and reliably references on which the HTR data DB is built on;
4. DB for collecting the issued documentation relevant to the HTR-N project: a 2-3 level hypertexted archiving system (being organised through SINTER) is to be set up for both restricted section of this DB or, alternatively of the "output" DB, should be reserved for gathering and exchanging the working draft of the documents under preparation/review.

The life of the DB's specific to the HTR-N project has to be assured, as a minimum, for all the project duration.

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3.3 Computer Programs Identification and Management

In order to assure reliability, consistency, reproducibility and traceability, the computer programs and nuclear libraries used in the HTR-N Project calculations (see Appendix A for a comprehensive list) shall have validation and certification status:

- a. identification and validation of Partners' tools
 - a.1 as a general rule for the HTR-N Project, proven and "frozen" certified program versions must be used and referenced by the Partners (program name, version, EDP and OS system on which the program is mounted and "run")
 - a.2 computer programs should not be generally modified (use of fixed "sources") but in case of specific needs, detailed documentation and certification must be prepared by the performing Partner, filed in his organisation and provided to the HTR-N Project Partners in order that possible program modification, needed for addressing cases which would not otherwise be possible to treat in a different way, can be clearly referenced and traced both for present use and information to HTR-N Partners, as well as for keeping track in HTR-N development history;
- b. identification and validation of libraries
 - b.1 the neutronic libraries used in the project, both standard open nuclear libraries and commercially acquired, are assumed to be accessible by reading only (i.e. without modifications) by Partners when performing calculations, so that consistency is eventually kept between different Partners' analyses addressing same library type/version. Partners are assumed to use and maintain NL's (which are assumed to be originally certified by the supplying organisation, either on public or on a private basis, according to their internal Q.A. systems, while fulfilling requirements for harmonising coherency in the exchange of data/results and comparisons inside the HTR-N Project system under the HTR-N Q.A. guidelines;
 - b.2 the libraries (both open and commercially supplied) used in the calculation must be referenced (name, version) in connection with the pre-processor programs used to prepare them in the form suitable for the employed neutronic program chain (deterministic/MC):
 - b.2.1 in case of deterministic computer code systems the number of energy groups has to be referenced, while in case of MC programs, use of continuous or discrete group libraries must be addressed
 - b.2.2 the temperature level at which the libraries have been processed must be referenced
 - b.2.3 the method for treating the resonances (resolved/unresolved) must be referenced
 - b.2.4 in case of non-standard libraries processing (i.e. developed or in use by the Partner, other than originally supplied by the code/library developer), both for processor programs and data manipulation, the methods and procedures used must be reported as tested-qualified and referenced

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b.2.5 in case of the use pre-processed libraries (as may generally apply for commercially supplied codes and processed libraries) a reference should be made to the relevant documentation certified by the supplier

c. identification and validation of HTR-N Project common tools / libraries

c.1 a specific issue could concern the set up of a SINTER area for sharing between Partners common code tools/libraries which may eventually be made available under specific provision agreement for the HTR-N Project Partners; in this case the certification shall be processed as per the HTR-N Project Q.A. context.

The general goal is to assure that, for a given data input set to be analysed according to a selected computer programs chain, the reliability and reproducibility of the obtained results can be guaranteed for whoever user may want to perform reevaluations with that programs chain system.

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3.4 Preparation and Exchange of Input Data Sets

The following categories of input data sets are considered to be primarily relevant for the HTR-N Project:

1. geometrical and dimensional data
2. structural material specifications
3. fuel and material specifications
4. operational conditions
5. irradiation histories and reactivity controlling

The Partners need to agree on common formats for exchanging the information on these data categories which are actually going to constitute sort of specification sets and data sheets useful to define the system configuration and operation. The data sets must be unambiguously determined; eventually, a suitable numbering system can be identified, as also useful for addressing different sensitivity/perturbation cases from a main basic input data set.

These data sets have to contain and cover, in principle, all the data needed for preparing the input decks for the different computer program systems being used in the HTR-N project in order to assure the basic coherence of the reference parameters between HTR-N Partners (and, possibly, future users) while acknowledging that the procedure for generating an input deck for a specific code from the basic data is covered by the internal Q.A. procedures of the Partner performing the calculation.

In case data specific to a given programs system are needed, these may be in principle assessed by the specific user on a case by case basis, also with the possible concurrence of the other Partners.

In order to address possible inconsistencies on input data sets, the data sources must be referenced: possibly, the most qualified data sources should be used. Reasons and/or rationales for assessing data for which little or no reference exists should be reported.

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3.5 Calculation Assessments and Analyses Result Reporting

As a general rule, all the design activities performed in the project should be consistently documented by suitable reports prepared by following a standard documentation cycle (see next section).

As a minimum, a technical report should contain and/or discuss the following topics:

- scope of the study
- background knowledge
- problem/purpose
- applicable standards
- referenced input data sets
- rationales and justifications for input data not supported by adequate references
- analyses tools and methods: computer programs, DB's, calculation assumptions
- results and discussion
- references

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3.6 Project Documentation Cycle

3.6.1 Main Cycle Processing Steps

Details on the documentation processing implementation are elaborated in a different HTR-N Q.A. document [4], while general principle are summarised in this section. It is here underlined that contributing Partners should initially fulfill the process approve the documents in accordance with their internal QA procedures..

Main cycle steps to the formal issuing of documentation may be summarised in the following:

- a. identify document category with the applicable type of document (report, data, scheme/drawing etc.):
 - a.1 deliverable document for the EC (deliverable, meeting minutes, progress report)
 - a.2 support document (management, methodology, data set, drawing, test specification, simulation/calculation note...
- b. definition of document life cycle stage (both for Partner organisations and, in general, for the HTR-N Project):
 - b.1 WD, Working Draft (personal contribution, shared contribution, harmonising document, etc)
 - b.2 RD, Reviewing Document (document in the review stage)
 - b.3 AD/I, Approving&Issuing Document (document in the final form)
- c. Partners and HTR-N Project parallel actions supporting the document cycle (to be exploited, as far as the HTR-N Project Q.A. is concerned, to the extent possible through e-mailing communication and SINTER meta-data/filing system):
 - c.1 check listing etc.
 - c.2 formal certification processing & filing

3.6.2 General Procedures

The general procedures for the project documentation cycle may be grouped into three main parts and activities relevant to Q.A.:

- a. general rules for operating teams, reviewers, controllers, emission/archiving;
- b. formation of operating team/controller groups (see more specifically the following section 3.6.3);
- c. formal interaction between them.

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3.6.3 Document Processing

A number of rules must be set and followed in the Project documentation cycle for complying with basic Q.A. requirements. In particular, requirements have to be defined in connection with project document types and forms (reports, drawings, data sets, specifications, etc.): these must be in fact reflecting the Q.A. process along with the editing/checking/approving stages but do not necessarily need to acquaint the final document reader/user, to whom all the earlier Q.A. procedure could be made transparent pending its actual implementation and recording through suitable filing system.

In this connection, the HTR-N forms (front/cover and second page) being used for the final report can be acceptable if a correspondent reliable and traceable recording through suitable check forms implementing the Q.A. process is adopted and the check forms may follow the document (provisionally attached to it) during all the drafting/reviewing/checking/controlling stages so that to provide clear indications on the draft revision number, current date and, in particular, the preparation stage of the document.

The document status may be seen to develop through three main stage, i.e. the working draft and harmonizing draft stage, the checking/reviewing draft stage and the approving/issuing document stage. The following status indications should be tentatively given for each stage of the document:

1. WD - working draft document : in addition to the standard final form, indications should be given for WD document status, succeeding number of version, exact date (day, month, year), author(s) and organisation(s);
2. RD - harmonized draft reviewing document : after having fixed the last WD (eventually harmonised between different Partners, if this case applies), the document goes through the checking/reviewing stage (indication of RD status must be hence given), reference to the reviewers (which must not include any of the authors) may be also given;;
3. AD/I - document in the approving/issuing stage : indication is given on the A/I status and reference to the controllers (which should exclude both previous teams, authors and reviewers, and include the responsible person dealing with project management for endorsing according to general contractual compliance);
4. FD – final document : the document is fixed, ready for issuing, archiving and distribution.

On practical purposes, stages #3÷4 may actually coincide; in this stage the Q.A. tracking process check form(s) is dropped and filed, the approval date (day, month, year) is impressed on the document official form, the document is electronically archived in the appropriate SINTER area (DB# 4), notification of the formal emission of the document is sent via e-mailing according to the applicable distribution list with indication of where and how the document may be obtained through the SINTER system for those recipients who are entitled to accessing it (by reading only).

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3.6.4 Forms and Formats for Q.A. Process Certification

A number of side-forms and formats (such as check lists, review report, distribution lists, reviewing/controlling teams, etc.) for application of the Q.A. procedure shall be applied. These may be collected in a suitable SINTER area (as a section of DB#4) and made traceable to the documentation preparation/issuing process.

3.7 General Operating Rules

General operating rules should address interactions between the different Partners, WP manager and Project Coordinator inside, and between, the different WP's of the HTR-N project. More specifically, the following aspects should be considered:

- procedures: e-mailing, Internet-based system (SINTER), workplace, DB's
- records: chrono e-filing protocol for the e-mail relevant to the project exchanged between the partners
- referring system: mailing/distribution lists (SINTER forum sub-sets should be adequate, e-mail address should be also made apparent to users besides the SINTER meta-referencing).

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4. ACRONYMS AND DEFINITIONS

DB	Data Base
RTD	Research and Technological Development
NL	Nuclear data Library
EDP	Electronic Data Processing
OS	Operating System
MC	Monte Carlo
WD	Working Draft
RHD	Reviewing Harmonised Draft
AD	Document under Approval
FID	Final Issue Document
WP	Work Package

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5. REFERENCES

- [1] “High-Temperature Reactor Physics and Fuel Cycle Studies”, Annex I to Contract FIKI-CT-2000-00020, Rev.6, 20/06/2000, FZJ-TTB No.E0125.01.99.
- [2] ISO 9001 International Standard “Quality systems – Model for quality assurance in design, development, production, installation and servicing”.
- [3] “SINTER Network - The Sustainable & Innovative Nuclear Technology Evolution - R&D Network”, <http://www-is.ike.uni-stuttgart.de/sinter/>.
- [4] “HTR-N Project Q.A. Requirements”, Ansaldo Nucleare, STU-HTRN - 0002 00, Rev.0, June 2002.

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Appendix A

Reactor Physics Codes Applied in HTR-N

Code Acronym	Type of Codes	Application Target	WP	Partner
APOLLO2	DT,MG,1D/2D,SS/BU,CH	resonance self-shielding & lattice calculations; cross section homogenizing & collapsing	1,2,3	CEA
CRONOS2	DD,3D,SS/TR/PK,TH	core calculations; point kinetics	1,3	CEA
TRIPOLI4	MC,CE	lattice and core neutronic calculations; shielding	1	CEA
AMPX77	DR/CS,XS/RS/CH	spectrum and homogenize cross section calculation	1	FZJ
TOTMOS	DT,MG,1D,SS,CH	calculation of cell-homogenized cross sections	1	FZJ, Siemens
MARCOPOLO	DT,MG,1D,CH	calculation of anisotropic diffusion constants	1	FZJ
CITATION	DD,MG,3D,SS	nuclear reactor core analysis (neutronics only)	1	FZJ
DORT	DT,MG,2D,SS	2-D cell calculations, 2-D neutron transport	1, 3	FZJ,IRI,IKE, ANS/UNIP, Siemens
TORT	DT,MG,3D,SS	3-D neutron transport	1	FZJ,IRI,IKE
MCNP (several versions)	MC,CE	detailed full core neutron transport calculations	1, 3	FZJ,IRI,IKE,A NS/UNIP, Siemens, PSI
VSOP	CS/DR,DD,2D/3D, SS/BU/CL,RS/CH,TH	reactor physics and fuel cycle simulation	1,3	FZJ
WIMS8	DT,1D/2D,SS/BU, RS/CH	cross section database generation for PANTHERMIX	1,3	NRG
PANTHERMIX	DR/CS,DD,3D, SS/TR/BU/CL,TH	reactor physics, fuel cycle and transient simulation	1,3	NRG
CSS1SMAT	BU,UP	uncertainty propagation in burnup calculations	2	NRG
FISPACT-4.0	BU	detailed burnup/nuclide inventory calculation	2	NRG
INAS	DR/CS,MC,DT/DD, MG/CE,1D/2D/3D, SS/BU,XS/RS/CH	Set of command procedures to run large reactor physics code packages like NJOY, SCALE, MCNP, SAS6 etc.	3	IRI
NJOY (several versions)	XS	generation of basic cross section libraries for several other codes and code packages	2	IRI,IKE
NSLINK	XS	cross section library format conversion in INAS	3	IRI
SCALE (several versions)	DR/CS,DT/MC,MG, 1D/2D/3D,SS/BU, XS/RS/CH	general reactor physics calculations (contains several modules)	3	IRI,IKE,ITU
ORIGEN (several versions)	BU	detailed burnup/nuclide inventory calculation	3	IRI,IKE,ITU
BOLD-VENTURE	DD,MG,2D/3D,SS	2- and 3-D core neutronics	3	IRI
SAS6	DR/CS,DT,MG,2D, BU,RS/CH	2-D burnup calculations	3	IRI
RSYST	DR/CS, DT/DD, 1D/2D/3D, SS/BU, XS/RS/CH	general reactor physics calculations (contains several modules)	3	IKE
SUSD	UP	sensitivity calculation	2,3	IKE
DANTSYS	DT,1D/2D/3D	neutron transport calculation	3	IKE
TRANSX-2	XS	cross section processing	3	IKE
2DB	...	...	-	PSI
TWODANT	DT,MG,2D,SS	...	-	PSI
PERT-V	...	...	-	PSI

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Acronyms

Neutron transport modelling MC: Monte carlo code, DT: Deterministic transport code DD: Deterministic diffusion code <i>Neutron energy discretisation</i> MG: Multigroup CE: Continuous energy <i>Dimensionality</i> 1D: 1-dimensional 2D: 2-dimensional 3D: 3-dimensional	Time dependence SS: Steady-state TR: Transient PK: Point kinetics BU: Burnup calculation CL: Core life follow <i>Data processing</i> XS: Basic cross section library generation COV: Covariance data processing RS: Resonance self shielding CH: Group collapse and homogenisation (generation of broad group library/database)	Miscellaneous TH: Thermal Hydraulics Code UP: Uncertainty processing /propagation CS: Code sequence/Code system (contains several modules, which are codes in themselves) DR: Code driver (in modular code system)
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