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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

IAEA Consultants' Meeting on "Requirements for CRP on Collection and Evaluation of Reference Thermo-Mechanical Properties of Fusion Reactor Plasma Facing Materials"

Vienna, 22-23 September 1993

SUMMARY REPORT

Prepared by R.A. Langley

February 1994

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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ABSTRACT

This report is a result of a Consultant's meeting held on "Requirements for CRP on collection and evaluation of reference thermo-mechanical properties of fusion reactor plasma facing materials" convened on Sept. 22-23, 1993 at the IAEA headquarters in Vienna This report contains a summary of the discussions held on the following topics

a) need for database
b) data to be included in database
c) data collection and evaluation
d) data format/ALADDIN
e) database participants and assignments.

The participants reached the following conclusions:

a) that the establishment of the database is needed by the fusion community in order to achieve its reactor design goals
b) agreed on data format
c) produced a list of relevant and most desirable institutions/participants
d) that the database should include information on relative erosion rates for the various candidate PFC materials

There were four participants in the meeting, three consultants and one Agency staff member. In addition one Agency staff member attended the session on data format to demonstrate the main features of the ALLADIN software package. The meeting achieved the goals set forth with both efficiency and alacrity

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1. INTRODUCTION

On recomendation of the IAEA Technical Committee Meeting (INDC(NDS)-277), with directive from the IFRC A+M Subcommittee, the A+M Data Unit organized this consultants meeting on "Requirements for CRP on Collection and Evaluation of Reference Thermo-mechnical Properties of Fusion Reactor Plasma Facing Materials". The meeting took place on Sept. 22&23, 1993 at the IAEA headquarters in Vienna, Austria. The local organizer for the meeting was R A. Langley of the IAEA. The Meeting was attended by 4 participants. The list of participants is given in Appendix 1.

This meeting was the second dealing with this general subject matter; the first was a Consultant's Meeting dealing with the Evaluation of Thermo-Mechanical Properties Data of Carbon-Based Plasma Facing Materials. The purpose of the present meeting was to formulate the requirements for a CRP dealing with the collection and evaluation of reference thermo-mechanical properties of fusion reactor plasma facing materials This subject is extremly pertinent due to the needs of the International Thermonuclear Experimental Reactor (ITER) Engineering Design Activity (EDA) which is now in its initial stage. In addition other fusion devices are being proposed to address plasma physics problems and also to test PFC materials.

2. MEETING OBJECTIVES AND PROGRAMME

The IAEA Consultants Meeting on "Requirements for CRP on Collection and Evaluation of Reference Thermo-mechanical Properties of Fusion Reactor Plasma Facing Materials" was organized with the following objectives:

(i) review the needs for such data for current and planned experiments on operating fusion machines;
(ii) identify the data needs for the design of the next generation of reactor-level fusion devices (e.g. ITER and NET)
(iii) identify data which should be included in the database

(iv) discuss data collection and evaluation

(v) determine data format

(vi) propose a CRP participants list and discuss assignments

The programme of the meeting was composed to ensure the full accomplishment of the above objectives. The meeting participants were selected to competently represent the various areas of interest The meeting programme is given in Appendix 2 and parallels the meeting objectives given above

3. SUMMARY OF DISCUSSION SESSIONS

3.1 Data to be included in database

A list of potential material properties which should be included in the database was obtained from INDC(NDS)-277, page 45, while a list of potential material properties to be included in the database was obtained from pages 46 and 47 of the same document These two tables are reproduced in Appendixes 3 & 4. In addition a somewhat expanded list of materials was also drawn from INDC(NDS)-246/MO

The participants discussed the properties list in detail and expanded it to specifically include how the properties change with neutron irradiation effects The expanded list is given in Table 1.

Table 1. Materials Properties Needed for Database

COMMON INFORMATION

Description of materials (including crystal structure)
Production history (heat treatment, impurities)
Limitations

BASELINE PHYSICAL PROPERTIES

Melting temperature
Boiling temperature
Vapor pressure
Heat of fusion
Heat of vaporization
Thermal conductivity (T)
Specific heat (T)
Density (T)
Coefficient of thermal expansion (T)
Electrical resistivity (T)
Viscosity
Emissivity (T, surface condition)

BASELINE MECHANICAL PROPERTIES

Elastic modulus (T)
Shear Modulus (T)
Poison ratio (T)
Ultimate strength (T)
Yield strength (T)
Uniform elongation (T)
Total elongation (T)
Reduction of area (T)
Creep (T,σ)
Fatigue (T,σ)
Fatigue crack growth (T)
Fracture tougness (T)

RADIATION EFFECTS (ϕ, ϕt, T)

- Physical properties:
  - Thermal conductivity
  - Specific heat
  - Coefficient of thermal expansion
  - Electrical resistivity
- Swelling
- Mechanical properties:
  - Ultimate strength
  - Yield strength
  - Uniform elongation
  - Total elongation
  - Reduction of area
  - Creep (during irradiation and after irradiation)
  - Fatigue
  - Fracture toughness (Ductal-Brittle Transformation Temperature)
- Residual activity (after heat)

CORROSION/CHEMICAL EFFECTS

- Hydrogen/Tritium
  - Solibitlity
  - Diffusivity
- Helium transport/trapping

CORROSION/ENVIRONMENTS

(Structural material/coolant compatability)

COMPONENTS PROPERTIES:

- Joining, including influence of radiation

The participants also discussed the materials list in detail and expanded it to include not only PFC's but also internal structual materials. In addition, it was noted that not all of the properties were needed for all the materials so some judgement must be made as to what data is significant for each material, determined by its function. The expanded materials list is given in Table 2 along with a perceived priority.

Table 2. Priorities of Materials Data Generation and Evaluation

MATERIALS	PRIORITY (Depends on material use)
I. Plasma Facing Materials	
A. Low-Z materials	
Be, CFC (1D, 2D, 3D)	1
PG, C+Ti, C+B	2
SiC, BeB, BeC (composites)	3
B. High-Z materials	
W (plasma sprayed)	2
Mo, Nb, Ta	3
C. Medium-Z materials	
V (V5Cr5Ti and VCrTiSi)	2
SS (316, 9Cr1Mo, 9Cr2VTaW)	
Ni-based (625, 718)	
D. Advanced materials	
Liquid metals (Li, Ga)	2
BeC, SiC	
II. Heat Sink Materials	
Cu, Nb	1
Mo, Mo/Re, TZM	2
III. Coolants	
H_2O, He	1
Liquid metals (Li, Ga)	2
IV. Armor / Heat Sink Bonding	1

4. DATA COLLECTION AND EVALUATION

The participants discussed the various possibilities for the collection of data The sources which were suggested for beginning the database were:

1) IEA material data bank
2) Japanese Fusion Materials Database
3) CEC-High Temperature Material Database
4) IAEA Plasma-Surface Interaction Database
5) Beryllium Database-Russian/Barabash

It was suggested that the CRP include as one of its major functions the evaluation of the data

5. PROPOSED CRP PARTICIPANTS AND AREA OF EXPERTISE

The meeting participants discussed the possible CRP participants considering the expertise of the individual/institution, e.g material and/or properties, the attachment to a specific database system, and participation with a major fusion project, e.g. ITER.

A list of suggested potential CRP participants with their affilation and connection with the CRP was formulated and is given:

1)	Masato Akiba/ M. Seki	Japan/JAERI-Materials Database
2)	V. Barabash	Russia/Efremov Institute-Beryllium Database
3)	Tim Burchell	USA/ORNL-Carbon materials
4)	John Davis	USA/McDonnell Douglas-US Fusion Materials Database, especially Mo,Nb,W,Ta
5)	Rich Mattas	USA/ANL-Blanket & Structural,Vanadium
6)	Nobuaki Noda	Japan/NIFS-PFC Materials
7)	Micheal Pick	Great Britian/JET-Beryllium Database
8)	Peter Smith/Fred Puhn	ITER/JCT-ITER In Vessel Components Database
9)	Ivica Smid	Austria/Sieberdorf Labs-Carbon
10)	Mike Ulrickson	USA/SNLA-PFC Materials
11)	G. Vieider	ITER/NET-Structural Materials
12)	P. Schiller	ISPRA/EC

6. MEETING CONCLUSIONS AND RECOMMENDATIONS

This meeting was characterized by very open discussions and an exchange of ideas which lead to the completion of the objectives in slightly less than the alloted time of two days

The participants at the meeting agreed to the following conclusions and recomendations.

1. The initiation of a thermo-mechanical database for plasma facing components was desired and could serve a useful purpose both for the ITER program and other fusion programs.
2 That the ALLADIN formate was an appropiate formate for the database. (This has already been demonstrated for the atomic and molecular and plasma-surface interaction databases It was necessary that definitions be adopted in order to allow the material properties data be put into the ALLADIN format) This should make the data easily avaliable to fusion laboratories
3. That the scope of the initial database be somewhat limited so as to provide at least some data in a very timely manner.
4. That the initial database include at least some information gathered from the PSI database, e.g a relative erosion rate which could be used by reactor designers to compare the erosion of various materials.
5. That the input data should be obtained from the many databases presently avaliable which deal with subjects other than fusion but also include the information for very restrictive databases already prepared by various groups within the fusion community.
6. That the agency contact the ITER project directly so that a productive interface can be built between the ITER project and the IAEA A&M Data Unit
7. That the conclusions and recomendations set forth in INDC(NDS)-246/MO be used as a guide for the organization and objectives of the proposed CRP The labelling schemes set forth in the report should be used as a starting point for further edification.

Appendix 1

Consultants' Meeting on
"Requirements for CRP on collection and evaluation of reference Thermo-mechanical properties of fusion reactor plasma facing materials"

22-23 September 1993, Vienna, Austria

LIST OF PARTICIPANTS

Dr. V.R. Barabash	D.V. Efremov Scientific Research Institute of Electrophysical Apparatus, P.O. Box 42, St. Petersburg 189631, NIIEFA, RUSSIAN FEDERATION
Dr. J.W. Davis	McDonnell Douglas Corporation, Mail Code 3064204, P.O. Box 516, St. Louis, MO 63166, U.S.A.
Dr. B. McGrath	Sandia National Laboratories, P.O. Box 5800, Albuquerque, NM 87185, U.S.A.
Dr. R.A. Langley	A+M Data Unit, Nuclear Data Section, IAEA

Appendix 2

Consultants' Meeting on
"Requirements for CRP on collection and evaluation of reference Thermo-mechanical properties of fusion reactor plasma facing materials"

22-23 September 1993, Vienna, Austria

MEETING AGENDA

Wednesday, September 22 Room: **A-23-40**

09:30 - 09:45	- Opening (R.A. Langley, A+M Data Unit) - Adoption of Agenda
09:45 - 12:00	- Discussion of Data to be included in database
12:00 - 13:30	**Lunch**
13:30 - 17:00	Discussion on data collection and evaluation

Thursday, September 23 Room: **A-23-40**

09:30 - 12:00	Discusssion on data format/ALADDIN (J. Botero)
09:45 - 12:00	- Discussion of Data to be included in database
12:00 - 13:30	**Lunch**
13:30 - 17:00	Discussion on database participants and assignments

Priorities of Materials Data Generation and Evaluation

MATERIALS	PRIORITY
I. Plasma Facing Materials	
A. Low-Z materials	
Be, CFC	1
PG, C+Ti	2
C+B, SiC, BeB	3
B. High-Z materials	
W	2
Mo, Nb, Ta	3
C. Medium-Z materials	
V, SS, Ni-based	2
D. Advanced materials	
liquid metals	2
II. Heat Sink Materials	
Cu, Nb	1
Mo, SS	2

Materials Properties Needed for Database

COMMON INFORMATION

Description of materials
Production history

BASELINE PHYSICAL PROPERTIES

Melting temperature
Boiling temperature
Vapor pressure
Heat of fusion
Heat of vaporization
Thermal conductivity (T)
Specific heat (T)
Density (T)
Coefficient of thermal expansion (T)
Electrical resistivity (T)
Viscosity

BASELINE MECHANICAL PROPERTIES

Elastic modulus (T)
Poison ratio (T)
Ultimate strength (T)
Yield strength (T)
Uniform elongation (T)
Total elongation (T)
Reduction of area (T)
Creep (T,G)
Fatigue (T,G)
Fracture toughness (T)

RADIATION EFFECTS (ϕ, ϕt, T)

Physical properties:
- Thermal conductivity
- Specific heat
- Coefficient of thermal expansion
- Electrical resistivity

Swelling

Mechanical properties:
- Ultimate strength
- Yield strength
- Uniform elongation
- Total elongation
- Reduction of area
- Creep
- Fatigue
- Fracture toughness

Residual activity

CORROSION/CHEMICAL EFFECTS

Hydrogen/Tritium
- Solibitlity
- Diffusivity

Helium transport/trapping

CORROSION/ENVIRONMENTS

COMPONENTS PROPERTIES:

Joining, including influence of radiation