

EFDA WORKPROGRAMME 2012

Call for Participation

**Material Database status and needs for DEMO conceptual
design activities**

CfP-WP12-MAT-02

Deadline for Responses: 06. Feb 2012

EFDA CSU contact person: Sehila Gonzalez

Table of Contents

Introduction..... 3

Programmatic Background4

1. WP12-MAT-02:5

 1.1 Introduction.....5

 1.2 Objectives.....5

 1.3 Work Description and Breakdown.....5

 1.4 Scientific and Technical Reports7

Introduction

An activity has been launched as part of the EFDA PPPT Work Programme 2011 to review the material database status and need for DEMO Conceptual Design Activities. The main goal of this activity is the preparation of a preliminary DEMO material assessment report, which gives the justifications and includes the recommended properties to be used for the design analysis and identify areas of uncertainties and conditions (relevant to the design) where data are instead either missing or unreliable.

The main goal of this Task Agreement is to continue in 2012 this work to consolidate the findings of the report, to continue the review the database in areas where uncertainties were identified in 2011 and provide guidance to the R&D to fill the gaps, especially in areas and materials which are important for the conceptual design activities.

The final outcome of these activities should be the preparation of a preliminary material assessment report, which gives the justifications and includes the recommended properties used for the design analysis and identify areas of uncertainties and conditions (relevant to the design) where data are instead either missing or unreliable.

Programmatic Background

As mentioned above, the main goals of the activities proposed in this Task Agreement should be the preparation of a preliminary material assessment report, which gives the justifications and includes the recommended properties used for the design analysis and identify areas of uncertainties and conditions (relevant to the design) where data are instead either missing or unreliable. An outline proposed for the Material Assessment Report for DEMO conceptual Design Activities is included in the Terms of Reference for the materials studies.

The following activities are proposed:

- Review the current material data or knowledge base for austenitic stainless steels, RAFM – steels (EUROFER), EUROFER ODS (9% Cr), ODS Ferritic steels (12-14 Cr), Tungsten and Tungsten alloys, Vanadium and Vanadium alloys, Copper alloys, and SiC/SiC composite relevant for fusion devices beyond ITER.
- Clearly and uniquely define a material (chemical composition, fabrication process, level of development, e.g. industrial available vs. lab scale), in particular:
 - Compile for each of the materials mentioned above, all physical and mechanical data needed for design. This information is also an relevant input for the Design Code studies carried out under the WP2012 in the PPPT Department (see references) ;
 - Indicate and describe fabrication processes and semi-finished products available and limitations in fabrication or machining;
 - Review data from irradiations campaigns, for displacement damage and, as far as possible, He and H /dpa ratio production levels of relevance for DEMO design. In any case clearly indicate the origin of data and irradiation conditions (irradiation source, reactor, spallation etc)
- For each material considered, generate a design space in terms of operating limits (temperature, stress levels, exposure time, life time.). Try to identify areas of safe operation versus areas definitely excluded. [Notes (i) there is no unique approach, it may depend on the material and its relative state of development (ii) in-between safe design space and areas not recommended to be used there is design space where it is up to the choice of the engineer and designer].
- Identify and clearly describe the key issues and limiting factors and/or properties (e.g. as function of parameters like maximum stress, exposure times, neutron fluence, irradiation temperature.)
- Identify R&D needs/requirements and define milestones with time period as of 5, 10, 15 years.
- Define a possible experimental and modeling IFMIF accompanying irradiation programme and in particular identify potential use of fission reactors, ion beam irradiation stations, EU spallation n-sources; potential exploitation of EVEDA, and the role of modeling.

1. WP12-MAT-02:

Task Agreement WP12-MAT-02: Material Database status and needs for DEMO conceptual design activities

1.1 Introduction

The main goal of this Task Agreement is to continue in 2012 this work to consolidate the findings of the report, to continue the review the database in areas where uncertainties were identified in 2011 and provide guidance to the R&D to fill the gaps, especially in areas and materials which are important for the conceptual design activities.

The final outcome of these activities should be the preparation of a preliminary material assessment report, which gives the justifications and includes the recommended properties used for the design analysis and identify areas of uncertainties and conditions (relevant to the design) where data are instead either missing or unreliable.

1.2 Objectives

The main goals of the activities proposed in this TA should be the preparation of a preliminary material assessment report, which gives the justifications and includes the recommended properties used for the design analysis and identify areas of uncertainties and conditions (relevant to the design) where data are instead either missing or unreliable.

1.3 Work Description and Breakdown

Structure

An outline proposed for the Material Assessment Report for DEMO conceptual Design Activities is included in the Terms of Reference for the materials studies.

The following activities are proposed:

- Review the current material data or knowledge base for austenitic stainless steels, RAFM – steels (EUROFER), EUROFER ODS (9% Cr), ODS Ferritic steels (12-14 Cr), Tungsten and Tungsten alloys, Vanadium and Vanadium alloys, Copper alloys, and SiC/SiC composite relevant for fusion devices beyond ITER.
- Clearly and uniquely define a material (chemical composition, fabrication process, level of development, e.g. industrial available vs. lab scale), in particular:
 - Compile for each of the materials mentioned above, all physical and mechanical data needed for design. This information is also an relevant input for the Design Code studies carried out under the WP2012 in the PPPT Department (see references) ;
 - Indicate and describe fabrication processes and semi-finished products available and limitations in fabrication or machining;
 - Review data from irradiations campaigns, for displacement damage and, as far as possible, He and H /dpa ratio production levels of relevance for DEMO design. In any case clearly indicate the origin of data and irradiation conditions (irradiation source, reactor, spallation etc)
- For each material considered, generate a design space in terms of operating limits (temperature, stress levels, exposure time, life time.). Try to identify areas of safe operation versus areas definitely excluded. [Notes (i) there is no unique approach, it may depend on the material and its

relative state of development (ii) in-between safe design space and areas not recommended to be used there is design space where it is up to the choice of the engineer and designer].

- Identify and clearly describe the key issues and limiting factors and/or properties (e.g. as function of parameters like maximum stress, exposure times, neutron fluence, irradiation temperature.)
- Identify R&D needs/requirements and define milestones with time period as of 5, 10, 15 years.
- Define a possible experimental and modeling IFMIF accompanying irradiation programme, and, in particular, identify potential use of fission reactors, ion beam irradiation stations, EU spallation n-sources; potential exploitation of EVEDA, and the role of modeling.

Work Breakdown

WP12-MAT-02-M01

WP12-MAT-02-M01

This activity is devoted to the assessment and discussion of the different design options for Blanket and Divertor concepts (coolant, T-window, structural materials), focusing on design requirements, and mechanical and/or physical properties will be done by European researchers at the highest level of expertise.

WP12-MAT-02-M02

WP12-MAT-02-M02

This activity is devoted to the assessment of the issues related to the presence of radiation for Blanket and Divertor materials, focusing on degradation of mechanical and physical properties, He/H production, and design limitations will be done by European researchers at the highest level of expertise.

WP12-MAT-02-M03

WP12-MAT-02-M03

This activity is devoted to review of the present status of R&D on materials (in EU and outside of EU), focusing on fabrication, machinability, mechanical and physical properties, and joining techniques. Besides that, a discussion of possible Temperature range of operation (conservative approach and possible margins), key issues and limiting factors should be given.

When lack of information is identified, a list of actions has to be proposed defining milestones for R&D

Austenitic stainless steels: To update the existing fusion materials properties database and design allowable for all austenitic steels, not only 316L(N), extend them to higher temperatures relevant to DEMO operating conditions (temperature, dose, He, ...) and include joints properties, in particular welded joints.

RAFM – steel development (EUROFER) and EUROFER ODS (9% Cr): Mechanical properties of neutron irradiated RAFM steels. The emphasis will be put on the assessment of Charpy impact, fracture toughness, tensile and low cycle fatigue properties of EUROFER97 and EUROFER ODS (9% Cr) steels irradiated up to a displacement damage dose of 80 dpa. The effects of the neutron irradiation temperature and dose will be investigated.

ODS steels (12-14 Cr): Review the mechanical and physical properties of the ODS ferritic (ODS-RAF) steels. This will be accomplished in two steps, consisting first in gathering the available data from the literature and then to discuss them. Hereafter we provide the details of the proposed activities and of the expected outcomes of the review

Tungsten and Tungsten alloys: A review of the W and W-based alloys state of art.

Copper alloys: Fusion applications of copper-based alloys.

SiC/SiC composite: A review of the SiC-based material database status for DEMO conceptual design activities.

New concepts: foils, fibre – fibre matrix interphase and matrix, etc.

WP12-MAT-02-M04

WP12-MAT-02-M04

This activity is devoted to review the existing joining techniques and their suitability.

WP12-MAT-02-M05

WP12-MAT-02-M05

This activity is devoted to review the present status of several functional materials, mainly insulators, optical materials and ceramics breeders, to identify the current needs in this field and propose an R&D programme.

WP12-MAT-02-M06

WP12-MAT-02-M06

This activity is devoted to the compilation and review of the results obtained in the modelling programmes for irradiation damage on fusion materials will be done by European researchers at the highest level of expertise.

WP12-MAT-02-M07

WP12-MAT-02-M07

This activity is devoted to the definition of IFMIF accompanying experimental programme: input note on MTR use for fusion.

JET related activities

Not applicable.

1.4 Scientific and Technical Reports

Progress Reports

At the end of each calendar year, and at intermediate times where appropriate, the Task Coordinator shall present a report on activities under the Task Agreement to the EFDA Leader for his approval. These reports shall integrate the progress made by each Association on each activity, and they shall indicate the level of achievement of the objectives, the situation of the activities, the allocation of resources and recommendations for the next year when applicable. The EURATOM financial contribution will be made through the usual procedures for baseline support through the Contract of Association.

Report of achievements under Priority Support (final report and, when appropriate, intermediate reports)

Achievement of Priority Support deliverables will be reported separately to the EFDA Leader. A final report (and intermediate reports marking substantial progress in the achievement of deliverables, if the EFDA Leader so requests) shall be prepared by the Task Coordinator and submitted to the EFDA Leader. If part of or all the activities carried out relate to JET, the Associate Leader for JET will be involved in clearing the report. These reports shall include specific sub-sections for each of the Associations involved. They shall document the degree to which the deliverables have been achieved. The EURATOM financial contribution will be made after approval by the EFDA Leader of these reports.

Milestones and Deliverables

The results obtained within the Material Database status and needs for DEMO conceptual design activities will be presented by the principal investigators and reviewed during joint monitoring meetings held twice a year. On this basis the progress accomplished by the contributing Associations will be reported by the Coordinator to the EFDA Leader.

The report on the Association activities under Priority Support will be prepared by the Coordinator to be presented to the EFDA Leader at the end of every calendar year.

The final and technical report will be submitted to the EFDA PPPT Responsible Officer for review and final approval and uploading in the IDM database.

References

Terms of Reference of the DAS material database 2011: <https://user.efda.org/?uid=2LP3P2>
Design Code Technical specification 2012: <https://user.efda.org/?uid=2M86V4>