

EUROPEAN COMMISSION 5th EURATOM FRAMEWORK PROGRAMME 1998-2002 KEY ACTION : NUCLEAR FISSION



## **High-Temperature Reactor Components and Systems**

<u>CONTRACT N°</u> FIKI-CT-2001-00177

WP5 Work Plan Report for : " Tribology in Helium Environment"

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 $\label{eq:Dissemination level: RE} Document \ N^\circ: HTR-E-\ 02/03 - D - 5-\ 0-1$ 

Status : Preliminary **Deliverable D36** 



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MODIF	MODIFICATIONS							
INDEX	DATE	1						
A 29/03/2002								
		Work Plan :						
DISTR	IBUTION							
Protect	tion level :	1	H	TR-E/WP5				
NORM (normal) FILT (filtered)		Tribology in Helium conditions						
VEV								
AEY-	WUKUS		(D					
Tribolog Mat THTR 300 HTTR – D AGR – HT HTR	y - Helium - terials - – HHt - AVR Dragon project R10 – HTR Modules	Customer : E Reference : 7	European Commission 72H.AFW0009	n	Type of	Document : R		
D	DISTRIBUTIO	N	FUNCTION	NAME	VISA	DATE		
NV – E. Breui	l coordinator of HT	R-E	writer	1. BOBIN VASTRA	184	28/03/02		
European Com	umission : V. Bhatn	agar	verifier	J. Ph VERNOT	FCK	29/03/02		
FANP-T: M. Lecomte - C. Lataille - D. Hittner		approver	G. BERTHOLEON	Disa	23/03/2002			
TFCW: G. Me	rle – TFCM: C. Fal	cand			1			
Partners: NNC	, FANP GmbH, BD	OT, CEA, FZJ						
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Page 3 / 18

## **Modifications**

Revision	Date	Modifications
А	29 <sup>th</sup> March 2002	First issue



### Contents

1.	OB	BJECTIVES OF THE WORK PACKAGE WP5	7
2.	DE	SCRIPTION OF THE TASKS	7
	2.1.	DELIVERABLE D37	7
	2.2.	DELIVERABLE D38	7
	2.3.	Deliverable D39	8
	2.4.	Deliverable D40	8
	2.5.	Deliverable D41	8
	2.6.	Deliverable D42	9
3.	DE	FINITION OF THE TASKS OF EACH PARTNER	9
4.	ID	ENTIFICATION OF THE INTERFACES WITH THE OTHER WORK PACKAGES	10
5.	FU	TURE MEETINGS	10

## List of tables

Table 1 Deliverable 37	11
Table 2 Deliverable 38	12
Table 3 Deliverable 39	13
Table 4 Deliverable 40	14
Table 5 Deliverable 41	15
Table 6 Deliverable 42	16
Table 7 Manpower per year	17
Table 7 Schedule	18



Page 6 / 18

## List of references

(1) European contract: "High temperature reactor components and systems" – Project FIKI – CT-2001-20177 "HTR-E" – August 2001 – Annex 1

# WP5 Work Plan Report

## **<u>1. Objectives of the Work Package WP5</u>**

The objective of WP 5 of HTR-E is to firstly realise an up-dating of the tribological problems met in former HTRs, to review and identify the corresponding tribological environments and finally find possible materials or coatings able to bring a reliable answer to these situations through elementary tests in a representative and tribological Helium environments close to identified components such as control rods, stator seals or hot gas duct.

### 2. Description of the tasks

The contractual objective of the Work Package is to produce seven documents, which are identified D36 (work plan), D37, D38, D39, D40, D41 and D42.

### 2.1. Deliverable D37

The title of the document is "Review of tribological problems on former HTRs and on FBR technology".

The objective of the document is to establish through the feed-back experience from several HTRs, and from the know-how on FBR technology, a review of different cases of failure and problems on components and materials. The corresponding operating conditions will be related to the failed component. This study concerns the following reactors:

- Dragon project (UK)
- THTR 300 (Germany)
- Fort Saint Vrain (USA)
- FBR reactors in France

The organisation of the document can be found in table 1. This document will be issued in November 2002.

### 2.2. Deliverable D38

The title of the document is "Review and identification of typical HTR tribology conditions of components".



#### 2.3. Deliverable D39

The title of the document is "Review of existing materials and coatings".

A bibliography will be made on the basis of knowledge in new materials, materials used in aerospace industry, power generation (gas turbine), combined cycle plants, and **in connection with HTR-M and HTR-M1**.

A list of materials, of materials of coating and associated coating processes will be given on the basis of this bibliography and use in HTR or previous tribological tests to provide a first classification of materials before further tests.

The organisation of the document can be found in table 3. This document will be issued in June 2003.

#### 2.4. Deliverable D40

The title of the document is "Proposal of elementary tests".

Based on the results of the previous bibliography (deliverables 37, 38 and 39), a synthesis will be made to suggest elementary tests in an Helium environment, anticipating new problems. This will imply the choice of:

- Which components of GTMHR or PBMR reactor types.
- The correlated tribological conditions defining the choice of the tribology facility (type of contact, type of motion, and applied contact pressure)
- The environment conditions (P, T)
- Composition of the Helium environment (presence of other gas such as methane, steam, ... and to be related to WP6 work.
- The definition of a common methodology between CEA and FRA-ANP (material procurement, size of the samples, test duration or number of cycles (depending on the device), surface preparation before test (cleanliness, roughness related to the component surface state).
- The instrumentation to allow :
  - in-situ measurements of speed, normal, tangential load, composition of gas as parameters

measurements of wear evolution, friction coefficient, mass changes as results The organisation of the document can be found in table 4. This document will be issued in November 2003.

#### 2.5. Deliverable D41

The title of the document is "Realisation of elementary tests".

From the previous document D40, tests will be performed on the available facilities in FRA-ANP and CEA. The choice of the test configuration will be made according to the facility characteristics. The tests will be made in an Helium environment as close as possible to the final He environment. It will be limited to a selection of preferred materials.

The document will describe (see table 5):

- The test facilities
- The tests conditions
- The testing procedure
- The analysis of results in terms of friction coefficient, wear or mass changes.

The document giving the results of the performed tests will be issued in May 2005.

#### **2.6.** Deliverable D42

The title of the document is "Tribology: a compendium of recommendations".

From the whole bibliography results and analysis of test results, recommendations related to the studied components will be given. Remaining uncertainties will be defined. The guidelines of a further work will be suggested beyond the FP5 program.

The organisation of the document can be found in table 6.

This document will be issued in November 2005.

### 3. Definition of the tasks of each partner

The partners involved in the Work Package are :

- Framatome ANP France (1),
- ◆ CEA (2),
- ♦ FZJ (5),
- NNC (7),
- BDT (16),

The proposal of the repartition of the budget by document and partner is the following :

	D36	D37	D38	D39	D40	D41	D42	Total	Delta /
									Proposal
									rev1
FRA ANP (1)	1	1	1	1	1	3	0.8	8.8	0
CEA (2),	0	2	1	0	1	3	0.8	7.8	0
FZJ (5)	0	1.9	0	0	0	0	0	1.9	0
NNC (7)	0	2	1	2	1	1	1	8	0
FANP GmbH		2	0	0	0	0	0	2	+2
(15)									
BDT (16)	0	0	0	2	0	0	0	2	-3.8
Total	1	8.9	3	5	3	7	2.6	30.5	-1.8

Remarks :

- 1. The numbers in the columns are man months.
- 2. The volume reserved for each partner are approximately the same as those in the proposal, reference (1), at the exception of :
  - partner 16 (BDT) whose volume was decreased, because of its contribution to deliverables D37, D38, D40 and D41 was suppressed.
  - partner 15 (FANP GmbH) whose volume was increased because of its new contribution on document D37

The repartition of the manpower per year is given in table 8.

## 4. Identification of the interfaces with the other Work Packages

The main input deliverables coming from the other workpackages are listed in the tables 1 to 6, related to the different documents. These interfaces are connected to WP6 Helium purification and to HTR-M and HTR-M1 "Materials".

### 5. Future meetings

The next meeting will be held on 23<sup>rd</sup> October 2002, in Lyon in accordance with the WP6 coordinator.



Page 11 / 18

# Table 1Deliverable 37

**DELIVERABLE 37** 

Title"Review of tribological problems on former HTRs and on FBR technology"ScheduleJanuary 2002 – November 2002ResponsibleFramatome ANP S.A.S (1)PartnersCEA (2), FZJ (5), NNC (7), FANP GmbH (15)

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles			
<ul> <li>Feed-back experience from former HTRs, AGR, tests facilities,</li> <li>FBR, giving :</li> <li>The component description</li> <li>The involved materials or coatings</li> </ul>			
<ul> <li>The tribological conditions (contact pressure, speed,)</li> <li>The environment conditions (gas pressure, nature of gas, T, presence of impurities,)</li> <li>Operating and upset conditions</li> </ul>			
Dragon project, AGR,	NNC		Draft available in June 2002
THTR 300, HHT, AVR, VHTR (Japanese reactor)	FZJ		Draft available in June 2002
FBR (Phénix, Superphénix, PFR)	CEA	<ul> <li>From NNC for PFR</li> <li>From FRA-ANP, for Phénix and SPX</li> </ul>	Draft available in June 2002
Fort St Vrain (USA), HTTR, HTR10,	Framatome-ANP	From HTTR and HTR10 (HTR TN agreements)	Draft available in June 2002
HTR modul (tests)	FRA- GmbH		Draft available in June 2002
Conclusion: synthesis of documents	Framatome-ANP		Draft : Sep 2002 for partner comments Final : Nov 2002



Page 12 / 18

# Table 2Deliverable 38

**DELIVERABLE D38** 

Title "Review and identification of typical HTR tribology conditions of components" *Schedule January 2002 –November 2002* 

Responsible Framatome ANP S.A.S (1)

PartnersCEA (2), NNC (7)DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles			
Document listing the information required in the text, will concern the following types of reactors: • GTMHR • PBMR			
PBMR	NNC		Document available in June 2002
GTMHR <ul> <li>Internals</li> <li>Hot gas duct</li> </ul>	CEA		Document available in June 2002
GTMHR <ul> <li>Stator seals</li> <li>Control rods</li> <li></li> </ul>	Framatome-ANP		Document available in June 2002
Conclusion: synthesis of documents	Framatome-ANP		Draft : Sep 2002 for partner comments Final : Nov 2002



Page 13 / 18

# Table 3Deliverable 39

**DELIVERABLE 39** 

Title"Review of existing materials and coatings"ScheduleMarch 2002 - September 2002 postponed to January 2003 - June 2003ResponsibleFramatome - ANP (1)PartnersNNC(7), BDT(16)

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles		From HTR-M and HTR-M1	January 2003
Data will concern:			
• materials from			
previous HTR			
• materials from			
aerospace			
• materials from			
combined cycle			
plants			
• coating materials			
<ul> <li>coating processes</li> </ul>			
• material			
recommendations			
from HTR-M and			
M1			
• Data coming from	NNC		Avaibility in April
gas reactor			2003
experience			
• Data from HTR-M			
and HTR-M1			
Data basis on coatings	BDT		Avaibility in April
aimed to heat			2003
exchangers			
Data from aerospace,	Framatome-ANP		Avaibility in April
turbines, specific			2003
coatings			D 6 M 2002
Conclusion: synthesis	Framatome-ANP		Draft : May 2003
of documents			for partner
			comments
			Final : June 2003

Page 14 / 18

# Table 4Deliverable 40

**DELIVERABLE 40** 

Title" Proposal of elementary testsScheduleOctober 2002 – November 2003ResponsibleFramatome-ANP (1)PartnersCEA (2), NNC (7)

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles		WP6 results on Helium purification – preliminary results	
		Results from D37, D38	November 2002
		Results from D39	June 2003
<ul><li>Choice of</li><li>Components</li></ul>			
• Environment			
• Methodology			
• Test facilities			
<ul> <li>Analysis of the type of motion concerning one type of component (sliding, bearing, fretting)</li> <li>Recommendation of test for the preferred coupled materials</li> <li>Analysis of the type of motion concerning one type of component (sliding, bearing, fretting)</li> <li>Recommendation of test for the preferred coupled</li> </ul>	CEA Framatome-ANP		Available in June 2003 Available in June 2003
Experience from NNC test	NNC		Available in June
facility			2003
Conclusion: synthesis of documents	Framatome-ANP		Draft : Sept 2003 for partner comments
			Final : Nov 2003



Page 15 / 18

# Table 5Deliverable 41

DELIVERABLE 41 Title "Realisation of elementary tests" Schedule January 2004 – May 2005 Responsible CEA (2) Partners FRA-ANP (1) – NNC (7)

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles			
Tests realised with the same		Document D40	November 2003
material procurement,			
methodology and			
procedures			
Definition of Helium		Final results from WP6	December 2003
environment			
Tests on a facility allowing:	CEA		Available in January
• Tests at high Helium			2005
pressure (5 bar on the			
tribometer up to 70 bar			
on the loop) and at high			
temperature (up to			
1000°C)			
• Flat to flat surface			
contact tests (sliding)			
Tests on a facility allowing			Available in January
:	Framatome-ANP		2005
• Tests at low pressure			
and 650°C temperature			
• Flat to flat surfaces or			
sphere onto flat surface			
contact (sliding)			
Analysis of results based on	NNC		Available in January
previous experience.			2005
Conclusion: synthesis of	CEA		<u>Draft</u> : March 2005
documents			for partner comments
			<u>Final :</u> May 2005



Page 16 / 18

# Table 6Deliverable 42

DELIVERABLE 42

Title"Tribology: a compendium of recommendations"ScheduleJune 2005 – November 2005ResponsibleFramatome-ANP (1)PartnersCEA (2) – NNC (7)

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
General principles			
Comparison of experimental results and feed-back experience on former HTRs	CEA	D37, D41	Available in July2005
Analysis of the application of the results on GTMHR design: recommendations	Framatome-ANP	D39, D41	Available in September 2005
Analysis of the application of the results on PBMR design: recommendations	NNC	D39, D41	Available in September 2005
Conclusion: synthesis of the documents and recommendations	Framatome-ANP		<u>Draft</u> : October 2005 for partner comments
			<u>Final :</u> November 2005

Page 17 / 18

Table 7
Manpower per year

	Year one	Year two	Year three	Year four	Total
FRA ANP (1)	3	2	2	1.8	8.8
CEA (2)	3	1	2	1.8	7.8
FZJ (5)	1.9	0	0	0	1.9
NNC (7)	3	3	0.6	1.4	8
FANP GmbH	2	0	0	0	2
(15)					
BDT (16)	0	2	0	0	2
Total	12.9	8	4.6	5	30.5

The numbers are in man months.

