



EUROPEAN COMMISSION

5th EURATOM FRAMEWORK PROGRAMME 1998-2002

KEY ACTION : NUCLEAR FISSION

HTR-E

High-Temperature Reactor Components and Systems

CONTRACT N°
FIKI-CT-2001-00177

HTR-E work program WP2 recuperator

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Dissemination level : RE
Document N°: HTR-E-02/03-D-2-0-1
Status : Preliminary
Deliverable n°11



Date : 20/05/2002

DIRECTION DE LA RECHERCHE TECHNOLOGIQUE

Nombre de pages : 21

DEPARTEMENT DES TECHNOLOGIES POUR LES ENERGIES NOUVELLES

Laboratoire d'Etude Efficacité Energétique pour l'Industrie

Identification	GRETh 02/826 (Document provisoire)
Titre	HTR-E work program WP2 recuperator
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Résumé :

Ce document présente le programme de travail du WP 'Recuperator' du projet HTR-E. Le rôle des partenaires et les interactions sont décrites.

Abstract :

This documents presents the work program of the WP Recuperator of the HTR-E project. The description of the sub-tasks are described as well as the interactions between the partners.

Mots clés	HTR, Recuperator
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N° FA/N°Contrat	
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	Nom	Visa
Rédaction	B. Thonon	
Vérification	F. Pra	
Approbateur	B. RAGUÉ	

Classification				
Libre	DR	CC	CD	SD
	X			

Modifications

Revision	Date	Modifications
A	May 2002	First issue

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- Annex 1 Description of the work, HTR-E project; ref: FIKI-CT-2001-20177

1. Objective of the Work Package

The recuperator is a helium/helium heat exchanger inserted in the primary circuit to recuperate a part of the remaining energy at the turbine outlet to preheat the helium at the core inlet. This component is specific to the direct cycle and its main function is to increase as high as possible the efficiency of the cycle. The competitiveness of a modern HTR is directly linked to the feasibility of this key component. But there is no industrial experience of such exchanger for the HTR typical operating conditions (inlet temperature over 500 °C, differential pressure up to 50 bar, high heat transfer efficiency, important compactness required,...).

The objective is to define firstly typical operating conditions and functional requirements, and then to assess with exchanger designers or manufacturers the potential for reaching these objectives, with an evaluation of technologies to be used and validation tests.

2. Description of the tasks

The contractual objective of the Work Package is to produce nine documents, which are identified D11 to D19 (D11 is the present document entitled 'Recuperator. Work plan report').

2.1 Deliverable D12

The title of the document is " Recuperator. Specification of typical operating conditions for HTR".

The objective of the document is to establish the typical steady state and transient conditions operating conditions of the recuperator. Two basic cases will be first considered: the GT-MHR and the PBMR. This report will specify

the thermal and hydraulic steady state conditions (temperature, pressure, efficiency...)

typical transient conditions

the environment and the quality of fluid (particles)

the life time

the safety requirements

inspection requirements during manufacturing and operation

space requirements

loss of efficiency accepted

design rules

The organisation of the document can be found in table 1. The document will be revised according to the progress made within this project.

2.2 Deliverable D13

The title of the document is " Recuperator. Technological survey of high temperature heat exchangers ".

The objective of this document is to establish the state of the art in term of high temperature heat exchangers used in various industries; both nuclear and non nuclear applications will be considered. Recuperator for gas turbine systems will be closely examined as well as specific developments realised for other high temperature nuclear reactors such as the GT-MHR, PBMR or Japanese project. Information from past projects in Europe and USA will also be collected.

The organisation of the document can be found in table 2. One draft version of this document will be issued at the end of the first year and revised at the end of the project.

2.3 Deliverable D14

The title of the document is " Recuperator. Consultation of manufacturers ".

Based on the documents D12 and D13, a list of potential manufacturers for the recuperator will be established. Each technology identified will be analysed and evaluated versus a list of objective criteria such as:

Degree of maturity of the technology

Technological risk

Thermal and hydraulic performances

Compactness

Flexibility of the design and integration in the PCV

Reliability of the manufacturer

Cost

Reliability of the product

The organisation of the document can be found in table 3.

2.4 Deliverable D15

The title of the document is " Recuperator. Engineering studies-CFD calculations ".

The organisation of the document can be found in table 4. Two draft versions of this document will be issued.

2.5 Deliverable D16

The title of the document is " Recuperator. Selection of reference concepts ".

Based on the previous deliverables (D12, D14 and D15), one or two reference concepts will be selected, the evaluation criteria are :

Degree of maturity of the technology

Technological risk

Thermal and hydraulic performances

Compactness

Flexibility of the design and integration in the PCV

Reliability of the manufacturer

The organisation of the document can be found in table 5. One draft version of this document will be presented at the mid-term meeting (january 2004).

2.6 Deliverable D17

The title of the document is " Recuperator. Definition of small scale units and realisation ".
Based on the engineering studies (D15), a small scale unit will be designed and manufactured according to the required the initial operating conditions and to the capacity of the test rig.

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

2.7 Deliverable D18

The title of the document is " Recuperator. Adaptation of the test rig ".

A gas-gas test rig operating at ambient pressure will be adapted for testing the small scale prototype manufactured previously (D17). Fouling tests will be performed for adiabatic conditions on small samples.

The organisation of the document can be found in table 7. Two draft versions of this document will be issued.

2.8 Deliverable D19

The title of the document is " Recuperator. Validation tests ".

The small scale prototype will be tested on the gas-gas test rig. The objectives of the tests are to validate the steady state performances of the small scale prototypes for several operating conditions and to simulate transient conditions representative of case identified in D12.

The organisation of the document can be found in table 8. Two draft versions of this document will be issued.

3. Definition of the tasks of each partner

The partners involved in the Work Package are :

- Framatome ANP France (1),
- CEA (2),
- NRG (4)
- FZJ (5),
- Ansaldo (10),
- Heatric (12)
- Borsig Energy (16),

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

	D12	D13	D14	D15	D16	D17	D18	D19	Others	Total	Proposal rev2
FRA (1)	3		2.8		1					6.8	
CEA (2),		2	1	2	1		3.5	8	1	18.5	
NRG (4)				7.8						7.8	
FZJ (5)	2.9									2.9	
Ansaldo (7)	1.5				1					2.5	
Heatric (12)						3				3	
Borsig (16)		2								2	
Total	7.4	4	3.8	9.8	3	3	3.5	8	1	43.5	

Remarks :

The numbers in the columns are man months.

The column "others" means the time devoted to coordination of the WP and participation to the reporting procedures.

The volume reserved for each partner are approximately the same as those in the proposal, at the exception of Borsig (ex BDT), which has reduced its participation.

The repartition of the manpower per year is given in table 10.

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 8, related to the different documents.

5. Future meetings

The next WP meeting is scheduled Tuesday November 26th at Heatric (UK) or Framatome (France).

6. Planning

Task title	D	2002				2003				2004				2005			
Specification	12																
S&T survey	13																
Consultancy of manufacturers	14																
Eng. Studies	15																
Selection of a ref. concept	16																
Definition-manufacturing	17																
Adaptation	18																
Tests	19																
Meetings		*			*			*		*		*		*		*	

7. Manpower breakdown

Partner	2002	2003	2004	2005	Total
Framatome	4	1.3	1	0.5	6.8
CEA	2.5	2	5.5	8.5	18.5
NRG	2	4	1.5	0.3	7.8
FZJ	2	0.3	0.3	0.3	2.9
Ansaldo	1	1	0.25	0.25	2.5
Heatric	0.5	0.5	2		3
Borsig	1	1			2
Total	13	10.1	10.55	9.85	43.5

8. Tables

List of Tables

Table 1 : deliverable 12

Table 2 : deliverable 13

Table 3 : deliverable 14

Table 4 : deliverable 15

Table 5 : deliverable 16

Table 6 : deliverable 17

Table 7 : deliverable 18

Table 8 : deliverable 19

Table 1

Deliverable 12

DELIVERABLE 12

Title " Recuperator. Specifications of typical operating conditions for HTR "

Schedule January 2002 – July 2002

Responsible Framatome ANP (1)

Partners FZJ (5), Ansaldo (10)

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	Ansaldo	Inspection	May 2002
	FZJ	PBMR	May 2002
	Fra	GT-MHR	May 2002
Version A	Fra		July 2002
Revised	Fra		Dec 2005

Links with the He purification: inputs needed for graphite particles and pebbles.

Fra will specify the inspection, safety, design rules and loss of efficiency accepted.

Table 2

Deliverable 13

DELIVERABLE D13

Title " Recuperator. Technological survey of high temperature heat exchangers "

Schedule March 2002 –May 2003

Responsible CEA (2)

Partners Borsig (16), FZJ (5)

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	CEA	Non tubular HX	Nov 2002
	Borsig	Tubular design	Nov 2002
	FZJ	Public data	Nov 2002
Draft	CEA		Dec 2002
Version A	CEA		July 2003
Revised	CEA		Dec 2005

BDT will issue a separate report for its contribution.

Table 3
Deliverable 14

DELIVERABLE 14

Title " Recuperator. Consultation of manufacturers "

Schedule September 2002 – February 2003

Responsible Framatome – ANP (1)

Partners CEA (2)

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	Fra	Criteria	Sept 2002
	CEA	List	Sept 2002
		D12	July 2002
		D13 draft	Dec 2002
	Fra+CEA	Evaluation	Feb 2003

Table 4

Deliverable 15

DELIVERABLE 15

Title " Engineering studies

Schedule August 2002 – July 2004

Responsible NRG (4)

Partners CEA (2)

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	CEA, Fra, Heatric	Typical geometric data	Sept 2002
	NRG	CFD calculation	July 2003
	NRG	FEM calculation	July 2004

From January 2003 to July 2003: first evaluation by CFD of manifolds and flow distribution

From July 2003 to July 2004: 2nd evaluation by CFD and FEM analysis

Table 5

Deliverable 16

DELIVERABLE 16

Title " Recuperator. Selection of reference concepts "

Schedule Sept 2004

Responsible FRA-ANP (1)

Partners CEA (2)

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	NRG	CFD calculation	July 2003
	Fra	D14	Feb 2003
Version A	Fra+CEA		July 2002
	NRG	D15	July 2004
Version B	Fra+CEA		Sept 2004

Table 6

Deliverable 17

DELIVERABLE 17

Title " Recuperator. Definition of small scale units and realisation "

Schedule February 2005

Responsible Heatric (1)

Partners

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	Heatric	Pre-design+integration	Dec 2002
	NRG	CFD calculation	July 2003
	CEA	Test conditions	July 2003
	Heatric	1 st HX	July 2003

A mock for fouling tests will be realised for Dec 2002.

Table 7
Deliverable 18

DELIVERABLE 16

Title " Recuperator. Adaptation of the test rig "

Schedule October 2004 – January 2005

Responsible CEA (2)

Partners

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	CEA	High temperature tests	July 2003
	CEA	Fouling tests	Dec 2002

Table 8
Deliverable 19

DELIVERABLE 16

Title " Recuperator. Validation tests "

Schedule February 2005 – December 2005

Responsible CEA (2)

Partners

DOCUMENT ORGANISATION

INDEX	RESPONSIBLE	INPUT NEEDED	DATE
	CEA	D18	July 2003
	Heatric	D17	July 2003

LISTE DE DIFFUSION

Le Client :

A. BREUIL (Framatome Lyon)

1 exemplaire

DEN/

D. BARBIER (Cadarache)

1 exemplaire

DTEN/Dir

J. DANROC
JF NOWAK

1 exemplaire
1^{ère} page

DTEN/GRETh/Dir

B. RAGUE
B. THONON

1 exemplaire
1 exemplaire

GRETh /L3EI

P. BANDELIER
F. PRA

1 exemplaire
1 exemplaire