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Final HTR-M1 Management Report

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National Nuclear Corporation

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European Project for the development of HTR Technology - Materials for the HTR

Final HTR-M1 Management Report

**by
D.E. Buckthorpe**

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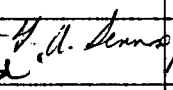
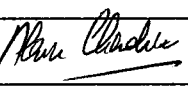
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Summary

This is the final management report for the HTR-M1 Project, “European Project for the development of HTR Technology –Materials for the HTR” funded under the Fifth Framework Programme. The document highlights the main management issues and areas of work carried out within the HTR-M1 Project.

1 Introduction

This is the management report for the HTR-M1 Project, “European Project for the development of HTR Technology –Materials for the HTR” funded under the Fifth Framework Programme. The document provides a progress report up to the end of the HTR-M1 project. Previous Management Progress Reports have been issued also jointly with the HTR-M Project. The HTR-M & HTR-M1 projects are aimed at searching suitable materials and information necessary for the development of advanced HTRs.

The HTR-M1 project concentrates on key areas affecting feasibility for:

- high temperature materials,
- graphite irradiation and oxidation.

The following sections provide a summary of the milestones and deliverables achieved and a review of the status of the overall work programme.

2 Milestones Achieved

Commencement of the work was on the 1st October 2001.

The HTR-M1 project Kick-off meeting was held on 21st & 22nd December 2001 at CEA (Ref. 1), Grenoble, France. A further five progress meetings (linked with HTR-M meetings) plus a 7th HTR-M1 Progress Meeting and several specialist meetings have been held (see Table 1) and minutes of these meetings are available on the SINTER web site (Refs. 1 to 15 and 42 to 45).

Presentations on the HTR-M & M1 Project progress and results have been made at several International Conferences (Refs. 15 to 27).

Previous Management Reports plus Technical Annual Reports issued are given in Refs. 28 to 38.

The Technical Implementation Plan for the HTR-M1 Project is given in Ref. 39.

A contract extension to the end of December 2005 was requested by the partnership and approved by the Commission (see section 5 & Refs. 40 to 41).

Twelve technical deliverables have been issued, six on each work package, dealing with testing of turbine materials and graphites for the core. (Refs. 46 to 57). The Final Report is given in Ref. 58.

3 Deliverables Status & Results To-date

A list of the deliverables identified in the HTR-M1 contract is given in Table 2.

A list of documents issued under the HTR-M1 project is given in Table 3.

3.1 High temperature Materials

The materials chosen for the turbine test programme are as follows:

Turbine disc:	UDIMET 720
Turbine blade:	IN 792 DS
	CM 247 LC DS

Short-term tests in four simulated environments are carried out:

- As received with ageing heat treatment – I
- Decarburised – II
- Carburised – III
- After the carburisation or decarburisation heat treatment – I(mod)

The treatment of the specimens was made in a specialised rig at JRC.

Results on as received heat-treated material were reported in HTR-M (Ref. 36) covering creep tests up to 3000 hours on turbine blade and disc materials.

Further short term and intermediate creep testing on treated specimens have been carried out within HTR-M1 in parallel with any remaining short-term test of HTR-M and the results reported.

3.2 Graphite

Work done in Germany on the development of SiC coatings for graphite materials (mainly pebbles) for protecting against oxidation from air or steam ingress under severe accident has been reviewed and reported. Tests confirmed the suitability of a coating for the Japanese IG 110 graphite.

Further corrosion tests were performed on the graphites chosen for the irradiation tests. Results showed NBG 20 graphite (selected as a piggy back) to be unsuitable in its current condition. Subsequent discussions with the manufacturer and further investigations have shown the issue to be complex and work to understand the anomalous behaviour of this graphite is to continue within the Raphael-IP (6FP).

For the graphite investigations the main activity has been on the irradiation testing of currently available graphites at 750°C up to around 8 dpa followed by PIE.

Minutes of meetings and reports covering the discussions with graphite manufacturers and the selection of graphites and experimental needs for the HTR-M1 graphite irradiation tests have been issued. Four main graphites have been selected for the tests, two iso-moulded and two extrusion moulded manufactured from pitch and petroleum coke sources, plus Japanese IG-110 (reference graphite) currently used in the HTTR and HTR-10 test reactors. A further number of piggy-back grades have also been introduced to widen the range of graphites covered. The five main plus piggy-back graphites were supplied to NRG who performed the necessary characterisation tests. X-ray tomography has also been performed at Manchester University as part of a modelling activity.

The irradiation rig and specimens were inserted into the core of the HFR early in 2004 and the irradiation test started at the HFR reload in February 2004. The samples received an irradiation fluence of approximately 8 dpa during the 5FP. PIE of the specimens began from July 2005. Specimens will be re-inserted and the tests continued at this temperature during

the Raphael-IP (6th Framework Programme) in order to describe a full curve behaviour beyond turn-round for each of the main graphites tested.

4 Resource Utilisation

For this final period of the HTR-M1 project the technical activities have mainly been focussed on completing the test programmes.

Significant progress on the treatment tests at JRC was made and results were obtained on the effects of carburisation on high temperature strength properties. These results provide a lower bound estimate for the fully corroded condition.

The irradiation test on the graphite materials has been completed and the results reported for the graphites for the first phase of the 750°C tests (Ref. 52).

5 Project Co-ordination

The overall co-ordination of the project was successfully achieved through the main progress meetings. Separate technical meetings in between the main co-ordination meetings have taken place where needed. These have involved graphite material issues and material procurement for the high temperature materials experiments plus meetings on progressing the irradiation experiments. Further specialist meetings on graphite selection criteria and C/C Composite materials development will continue within the 6th Framework as part of the Raphael-IP.

Due to the late insertion of the graphite specimens into the HFR as a result of an extended characterisation process, approval was given by the Commission to extend the project by a further nine months to the end of Dec. 2005 in order to carry out a first PIE evaluation of the irradiated graphite samples (Ref. 41). This first PIE evaluation has been successfully achieved and reported and the project was concluded within the extended contract period.

Formal co-ordination with other HTR projects was carried out initially via the six monthly meetings of the HTR-C project. At these meetings a presentation on progress and future programme from each of the project co-ordinators was given. The HTR-C Project was completed in 2004. Informal co-ordination also took place through direct contact with the other project co-ordinators and through the additional attendance by the HTR-M & M1 co-ordinator and other partners at HTR-L, HTR-N and HTR-F meetings and for HTR-E at PMT meetings and WP5 meetings. The scheduling of HTR project meetings in order to maximise opportunities for exchange of information has improved co-operation and co-ordination. Throughout the project the co-ordinator and other partners have attended HTR-E meetings and discussed issues associated with irradiated properties, coatings, purification of helium atmosphere and turbine design.

5.1 HTR-M & M1 Observers

The following organisations have been accepted as observers to HTR-M & M1 meetings by the Commission and by each of the individual partners.

To attend graphite meetings: - Graphite Manufacturers Graftech (formerly UCAR)
SGL

To attend full meetings: British Nuclear Fuels Ltd. (BNFL), UK
Electricite De France (EdF), France
Paul Scherr Institute (PSI), Switzerland.
Alstom Power , UK

6 Overall Work Programme status

The programme description is given in Figure 1.

Overall the projects have progressed largely to programme except for the need for a contract extension to the end of 2005 to complete the graphite irradiation tests. The graphite tests produced are the first available in the world for the newly manufactured graphites and the results are expected to make a significant impact on the Raphael-IP and the Gen IV VHTR graphite materials programmes. The short term tests on the turbine blade and disc materials have been largely reported including the effects of corrosion and only a few long term tests remain which will be reported in the Raphael-IP.

Turbine

HTR-M1 activities on the as-received and fully treated specimens are reported and the results confirm a notable effect on fatigue and strength due to corrosion.

Graphite

The work on graphite coatings and the additional oxidation tests of HTR-M1 have been completed. The results from the 750°C irradiation tests provide a valuable platform for the second phase tests and the higher temperature tests of Raphael-IP.

7 International Collaboration

7.1 Generation IV

The VHTR is recognised within the Generation IV International Forum (GIF) as a new innovative system with important near term deployment potential and a prototype (NGNP) has been identified for construction within the GIF programme in the US capable of generating hydrogen. The members of GIF are from the US, Canada, Japan, South Korea, France, UK, Switzerland, Republic of South Africa, Brazil, Argentina and more recently EU through Euratom. A joint programme of activities is being developed in order to share R & D on this system through a structure of International panels and project management boards (PMBs). Within Europe it is intended to use the results from the 5FP & 6FP Framework Programmes on VHTR as part of the EU contribution to Generation IV (subject to agreement and release by the partners).

Task sheets and the corresponding draft R& D programme are being drawn up within Generation IV to establish a coherent International programme. For Generation IV VHTR materials and components, D. Buckthorpe of NNC (co-ordinator of the HTR-M & M1 projects) has been appointed the Euratom representative on the Materials & Components Project Management Board (PMB). Euratom task sheets reflecting the present HTR-M & M1 Project programmes have been established and submitted to Generation IV on behalf of Euratom.

An internal meeting on materials was held within Europe to discuss the overall European Programme (Ref. 64). The first Materials & Components Project Management Board meeting was held on 4-6 May 2004 at INEEL, Idaho Falls, US (Ref. 65). A second PMB meeting was held in September 2004 at NNC in UK covering graphite and C/C composite needs (Ref. 66). The third meeting was held in April 2005 at Oakridge to consider high temperature materials and design methodology and a fourth meeting at OECD, Paris in September 2005 (Ref. 67) to include test loops. At these meetings joint programmes are established on each of the specialist materials and component areas to meet the needs of the NGNP and Generation IV VHTR programme.

7.2 Exchanges with Japan, USA and China

Progress towards exchanges with these organisations and international programmes on materials continues under the HTR-TN umbrella following exchange meetings at the HTR2002 conference (Refs.59 to 61). JAERI have supplied graphite for the HTR-M1 experiments through the Japanese graphite manufacturer Toyo Tanso. Exchange of information with NRC contacts is developing following formulation of an agreement with HTR-TN. Contact with International Graphite Specialists is being achieved through an annual Nuclear Specialist Graphite Meeting organised by the chairman of the IAEA graphite database on irradiated nuclear graphite properties and specific workshops on graphite issues (e.g. recent OECD/NEA conference at JAERI, Japan). A paper on HTR-M & M1 Project results has been presented at the HTR2004 Conference at INET, Beijing, China on 22-24 September 2004 (Ref. 25).

7.3 Links with ISTC Projects

Closer links between ISTC funded GT-MHR projects and 5FP HTR projects have been developed following a joint meeting at HTR2002 conference (Ref. 62). HTR project Co-ordinators were assigned as foreign collaborators to specific ISTC Projects in order to develop co-operation. The HTR-M & M1 Project Co-ordinator was assigned as foreign collaborator for ISTC Project 1313-2001, which is concerned with the testing and investigation of materials for Turbo-compressor high temperature components. Following receipt of a progress report (Ref. 63) and agreement with HTR-M partners, ISTC project representatives from OKBM have attended a HTR-M & M1 progress meeting (as an observer) held in June 2003 at NNC Limited (Ref. 6). Presentations on the status of GTMHR issues on the vessel, turbine and graphite were given by OKBM. Further exchanges have taken place through a joint meeting between HTR-M & M1 and HTR-E WP1 on turbine properties at Oberhausen (Ref. 7). Contact with OKBM is being maintained through e-mail and formal ISTC routes. Final reports on ISTC 1261 and 1313 have now been received (Ref. 68).

8 References

Ref	Title
1	K. Peers. European Project for the development of HTR Technology Minutes of HTR-M Kick-off Meeting Report No. HTR-M-01/3-M-0-0-4
2	R.D.Bestwick European Project for the development of HTR Technology Minutes of HTR-M Progress Meeting Report No. HTR-M-01/5-M-0-0-5
3	D. E. Buckthorpe European Project for the development of HTR Technology Minutes of HTR-M1 Kick-off plus 2 nd HTR-M progress meeting Report No. HTR-M-01/11-M-0-0-26 Report No. HTR-M1 01/11-M 0 0 2
4	D. E Buckthorpe European Project for the development of HTR Technology Minutes of 3 rd HTR-M plus 1 st HTR-M1 Progress Meeting Report No. HTR-M-02/5-M-0-0-33 Report No. HTR-M1 02/5-M 0 0 5
5	D. E Buckthorpe European Project for the development of HTR Technology Minutes of 4 th HTR-M plus HTR-M1 Mid Term Meeting Report No. HTR-M-02/11-M-0-0-57 Report No. HTR-M1 02/11-M 0 0 8
6	D.E. Buckthorpe, et al. European Project for the development of HTR Technology Minutes of 5 th HTR-M plus 3 rd HTR-M1 Progress Meeting Report No. HTR-M-03/7-M-0-0-74 Report No. HTR-M1 03/7-M 0 0 17
7	D.E. Buckthorpe, et al. European Project for the development of HTR Technology Minutes of 6 th HTR-M plus 4 th HTR-M1 Progress Meeting Report No. HTR-M-03/11-M-0-0-83 Report No. HTR-M1 03/11-M 0 0 20
8	D.E. Buckthorpe, et al. European Project for the development of HTR Technology Minutes of 7 th HTR-M plus 5 th HTR-M1 Progress Meeting Report No. HTR-M-04/06-M-0-0-93 Report No. HTR-M1 04/06-M 0 0 23
9	D.E. Buckthorpe, et al. European Project for the development of HTR Technology Minutes of 8 th HTR-M plus 6 th HTR-M1 Progress Meeting Report No. HTR-M-04/11-M-0-0-104 Report No. HTR-M1 04/11-M 0 0 24

Ref	Title
10	D.E. Buckthorpe, et al. European Project for the development of HTR Technology Minutes of 7 th HTR-M1 Progress Meeting Report No. HTR-M1 05/03-M 0 0 29
11	D E Buckthorpe European Project for the development of HTR Technology Minutes of the Final HTR-M1 Progress Meeting held at NRG, Petten Report No. HTR-M1 05/10-M 0 0 33
12	H. Rantala Notes of a HTR-M & M1 Specialist Meeting on Corrosion & Carburisation Report No. HTR-M-03/7-D-2-0-72
13	D.E. Buckthorpe Minutes of 2 nd Technical Meeting at Petten on HTR-M & M1 Irradiation experiments Report No. Report No. HTR-M-03/7-D-0-0-73 Report No. Report No. HTR-M-03/7-D-0-0-16
14	A. Vreeling Notes of a HTR-M & M1 Specialist Meeting on Graphite held at NRG Petten. HTR-M1 04/04 M 2 0 22
15	J. van der Laan Presentations from Specialist Forum on C/C Composites held at NRG Petten. (available on SINTER)
16	D.E. Buckthorpe, et al. Materials for the High Temperature Reactor 16 th SMiRT Conference, Washington, USA, on 12-17 th August 2001 Report No. HTR-M-01/5-D-0-0-6
17	D.E. Buckthorpe, et al. Investigation of the High Temperature Reactor (HTR) Materials NEA/OECD, 2 nd Information Exchange meeting on High Temperature Engineering, Paris, on 10-12 October 2001 Report No. HTR-M-01/10-D-0-0-16
18	D.E. Buckthorpe, et al. Materials for the High Temperature Reactor HTR2002 Conference, Petten, Netherlands, on 21-23 April 2002 Report No. HTR-M-02/3-D-0-0-29
19	D.E. Buckthorpe, et al. High Temperature Reactor (HTR) Materials Poster paper for the 7 th Liege Conference on materials, Liege, Belgium, on 30 th September – 2 nd October 2002 Report No. HTR-M-02/3-D-0-0-30
20	D.E. Buckthorpe, et al. European project on Materials for modular HTRs

Ref	Title
	ENC2002 Conference, Lille, France, on 7- 9 th October 2002 Report No. HTR-M-02/10-D-0-0-46
21	D.E. Buckthorpe, et al. Research and Development Programme on HTR Materials. (Paper 3174). ICAPP 03 Conference, Cordoba, Spain, 4-7 May, 2003. Report No. HTR-M-03/04-D-0-0-64
22	K. Kuhn, H. Hinssen, R. Moormann Behaviour of C-Based Materials in contact to oxidising gases. (Paper 3031). ICAPP 03 Conference, Cordoba, Spain, 4-7 May, 2003 Report No. HTR-M-03/04-D-0-0-66
23	D.E. Buckthorpe, et al. Progress of HTR-M projects for the HTR. (Paper S443). 17 th SMiRT Conference, Prague, Czech Republic, 12-17 th August 2003 Report No. HTR-M-03/04-D-0-0-67
24	D.E. Buckthorpe, et al High Temperature Reactor Materials: Progress of HTR-M Projects NEA/OECD, 3 rd Information Exchange meeting on High Temperature Engineering, JAERI, Ibaraki-ken, Japan, 11-12 September 2003 Report No. HTR-M 03/10 D 0 0 79
25	D. E. Buckthorpe et al Results from EU 5th Framework HTR projects - HTR-M & HTR-M1, paper E12, HTR2004 Conference, Beijing, China, 22-24th September 2004. Report No, HTR-M 04/09 D 0 0 96
26	D. E. Buckthorpe et al Presentation of results for VHTR – results from HTR-M & HTR-M1 Projects plus future programme, EUROMAT Conference, Prague, Czech Republic, 5– 7 th September 2005 Report No, HTR-M1 05/10 D 0 0 36
27	D.E. Buckthorpe, HTR Materials & Technologies, Review of Metallic Materials used in HTRs HTR Eurocourse, CEA, Cadarache, 4-8 November 2002. Report No. HTR-M-03/04-D-0-0-68
28	D.E. Buckthorpe, et al. Eighteen month HTR-M plus six month HTR-M1 management report Report No. HTR-M-02/5-P-0-0-34 Report No. HTR-M1-02/5-P-0-0-6
29	D.E. Buckthorpe, et al. Twenty-four month HTR-M plus twelve month HTR-M1 management report Report No. HTR-M-02/12-P-0-0-59 Report No. HTR-M1-02/12-P-0-0-11
30	D.E. Buckthorpe, et al. 30 month HTR-M plus 18 month HTR-M1 management report Report No. HTR-M-03/05-P-0-0-71 Report No. HTR-M1-03/05-P-0-0-15

Ref	Title
31	D.E. Buckthorpe, et al. 36 month HTR-M plus 24 month HTR-M1 management report Report No. HTR-M-03/11-P-0-0-80 Report No. HTR-M1-03/11-P-0-0-18
32	D.E. Buckthorpe, et al. 42 month HTR-M plus 30 month HTR-M1 management report Report No. HTR-M-04/05-P-0-0-92 Report No. HTR-M1-04/05-P-0-0-21
33	D E Buckthorpe 48 Month HTR-M plus 36 month HTR-M1 Management Report Report No. HTR-M-04/10-P-0-0-104 Report No. HTR-M1-04/10-P-0-0-25
34	D.E. Buckthorpe, et al. Mid-term report for the HTR-M & M1 Projects Report No. HTR-M-02/11-P-0-0-47 Report No. HTR-M1-02/11-P-0-0-8
35	D.E. Buckthorpe, et al. 3 rd Scientific Report for HTR-M & M1 Projects Report No. HTR-M 03/11 P 0 0 81 Report No. HTR-M1-03/11-P-0-0-19
36	D.E. Buckthorpe, Final Technical Report for the HTR-M project Report No. HTR-M-04/12-P-0-0-105
37	D.E. Buckthorpe, 3 rd Scientific Report for the HTR-M1 Project Report No. HTR-M1-04/11-P-0-0-26
38	D E Buckthorpe 42 month HTR-M1 management report Report No. HTR-M1-05/03-P-0-0-32
39	D.E. Buckthorpe, et al. Technical Implementation Plan for HTR-M1 project Report No. HTR-M1-04/11-D-0-0-31
40	D. Buckthorpe et al Request for HTR-M1 Contract Extension from the Partnership Report No. HTR-M1 05/03 P 0 0 37
41	P. Fernandez Ruiz Approval of HTR-M1 Contract Extension from the Commission Report No. HTR-M1 05/03 P 0 0 38
42	J. van der Laan Minutes of 1 st Technical meeting on graphite held on 13 th Nov. 2001 at NRG Petten, Netherlands Report No. HTR-M1-02/1-M-2-0-1
43	M. W. Davies

Ref	Title
	Minutes of meeting with graphite manufacturer UCAR on 26 th March 2002, Notre Dame, France Report No. HTR-M1-02/05-M-2-0-3
44	M. W. Davies Minutes of meeting with graphite manufacturer SGL on 27 th March 2002, Chedde, France Report No. HTR-M1-02/05-M-2-0-4
45	A. Vreeling, J. van der Laan Notes of a Technical Meeting on Graphite Selection held at NRG Petten Report No. HTR-M1-05/04-M-2-0-28
46	R. Couturier HTR-M1: Report on selection of materials & testing requirements for the Turbine Report No. HTR-M1 02/9 D 1 1 7
47	M.W. Davies Report on selection of graphites and testing requirements Report No. HTR-M1 02/11 D 2 1 9
48	R. Couturier Report on specimen fabrication, procurement & testing requirements for Turbine material Report No. HTR-M1 03/03 D 1 0 12
49	A. Vreeling HTR-M1 Report on specimen fabrication and procurement for the graphite irradiation tests Report No. HTR-M1 03/04 D 2 2 13
50	R. Couturier, H Rantala HTR-M1 Report:-Intermediate report on Material Testing of Turbine Materials Report No. HTR-M1 05/07 D 1 2 30
51	R Couturier, J Calapez, H Rantala Final HTR-M1 Report on HTR blade alloy properties Report No. HTR-M1 05/11 D 1 2 35
52	J.A. Vreeling, F. Schmalz, D.S. d'Hulst, W. Molijn, P. ten Pierick HTR-M1 Report on preliminary irradiation testing of selected graphites for HTR – report on irradiation and post irradiation tests Report No. HTR-M1 05/12 D 2 3 39
53	M. Davies HTR-M1 Report on preliminary irradiation testing of selected graphites for HTR – Review of results and updating of database. Report No. HTR-M1 05/12 D 2 4 40
54	M. Davies, G. Haag, O Gelineau HTR-M1 Report on preliminary irradiation testing of selected graphites for HTR – Assessment of the results and suitability

Ref	Title
	Report No. HTR-M1 05/12 D 2 4 41
55	D Buckthorpe HTR-M1 Graphite – Final Summary report Report No. HTR-M1 05/12 D 2 5 42
56	R. Couturier HTR-M1 Turbine Results data provided on CD-Rom Report No. HTR-M1 05/12 D 1 2 43
57	D. Buckthorpe HTR-M1 Turbine Materials – Final Summary Report Report No. HTR-M1 05/12 D 1 2 44
58	D. Buckthorpe Final Report for HTR-M1 Project Report No. HTR-M1 05/12 D 0 0 46
59	D. E. Buckthorpe Notes of Meeting with JAERI on 24 th April 2002, Petten, Netherlands Report No. HTR-TN(02)-TG6-M-006
60	D. E. Buckthorpe Notes of Meeting with US NRC & D.O.E on 24 th April 2002, Petten, Netherlands Report No. HTR-TN(02)-TG6-M-004
61	D. E. Buckthorpe Notes of Meeting with US NRC on 25 th April 2002, Petten, Netherlands Report No. HTR-TN(02)-TG6-M-005
62	M. Hugon Notes of Meeting of ISTC Contact expert group on GT – MHR on 25 th April 2002, Petten, Netherlands Report No. HTR-TN(02)-TG6-M-007
63	A. Romantsov Report for ISTC Project 1313-2001. Testing and Investigations of Materials for Turbo-compressor High Temperature Components (1 st July 2001 to 30 June 2002) Report No. HTR-M 03/01 D 2 0 62
64	D. Buckthorpe Brief Notes of VHTR European materials meeting held at CEA, Paris on 4 th April 2004
65	D. Buckthorpe Brief Notes of a VHTR project Management Board Meeting on Materials & Components held at INEEL, Idaho Falls, 4-6 th May 2004
66	D. Buckthorpe Brief Notes of a VHTR project Management Board Meeting on Materials & Components held at NNC Ltd., UK 7-9 th September 2004
67	D. Buckthorpe

Ref	Title
68	Brief Notes of a VHTR project Management Board Meeting on Materials & Components held at OECD, Paris, 5-7th September 2005 A. Romantsov Final Report for ISTC Project 1313-2001. Testing and Investigations of Materials for Turbo-compressor High Temperature Components Report No. HTR-M1 05/01 D 1 0 45

Table 1 HTR-M & M1 Meetings

No.	Title	Venue	Date	Links	Ref
Progress Meetings					
1	HTR-M Kick-off	NNC Ltd., UK	21/ 22 Nov. 2000		1
2	1 st Progress	NRG, Petten, Netherlands	18/19 April 2001		2
3	2 nd Progress plus HTR-M1 Kick-off	CEA, Grenoble, France	18/19 Dec. 2001		3
4	3 rd Progress meeting	FZJ, Julich, Germany	15/17 April 2002		4
5	Mid Term meeting plus HTR-M1 progress	Framatome, Paris, France	28/29 Nov. 2002		5
6	5 th Progress meeting	NNC. Ltd., UK	10/11 June 2003	HTR-N/ N1 – on graphite + ISTC	6
7	6 th Progress meeting	FZJ, Julich, Germany	18/19 Nov. 2003	HTR-E WP1 on turbine + ISTC	7
8	7 th Progress meeting	EA, Madrid	10-12 May 2004	HTR-E WP1 on turbine	8
9	8 th Progress meeting	Framatome, Lyon	21-24 Nov. 2004	HTR-E WP1 on turbine; HTR-E WP5 on coatings	9
10	7 th HTR-M1 Progress Meeting	NNC, UK	19 th May 2005		10
11	8 th HTR-M1 Progress Meeting	NRG, Petten	4 th October 2005		11
Specialist meetings					
12	1 st specialist meeting on graphite	NRG, Petten, Netherlands	13 Nov. 2001		42
13	Specialist meeting with UCAR on graphites	Notre Dame, France	26 March 2002		43
14	Specialist meeting with SGL on graphites	Chedde, France	27 March 2002		44
15	Specialist Graphite Meeting	JRC, Petten, Netherlands	June 2003		45
16	Specialist meeting on Turbine experiments	FZJ, Julich, Germany	April 2002		12
17	Specialist meeting on Irradiation experiments	JRC, Petten, Netherlands	June 2003	Linked with HTR-F experiments	13
18	2 nd Specialist meeting on Graphite	NRG, Petten, Netherlands	16 Feb. 2004		14
19	Forum on C/C Composites	NRG, Petten, Netherlands	17/18 Feb. 2004		15
Others					
20	Meeting with JAERI	NRG Petten	April 2002	Linked with HTR 2002	59
21	Meeting with USNRC & DOE	NRG Petten	April 2002	Linked with HTR 2002	60
22	Meeting with USNRC	NRG Petten	April 2002	Linked with HTR 2002	61
23	ISTC expert contact group	NRG Petten	April 2002	Linked with HTR 2002	62

Table 2. HTR-M1 Deliverables list (Turbine Materials)

Deliverable No	Deliverable title	Delivery date	Nature	Dissemination level
D1	Report on selection of materials & testing requirements	12	Re	RE
D2	Report on specimen fabrication and procurement & testing requirements	18	Re	RE
D3	Intermediate report on material testing	37	Re / Da	RE
D4	Final report on blade alloy properties	51	Re/Da	RE
D5	Results data provided on CD-Rom-.	51	Re/ Da	RE
D6	Final report summary	51	Re	RE

Table 2. HTR-M1 Deliverables list (Graphite Materials)

Deliverable No	Deliverable title	Delivery date	Nature	Dissemination level
D7	Report on selection of graphites & testing requirements	12	Re	RE
D8	Report on specimen fabrication and procurement	18	Re	RE
D9	Report on irradiation and post irradiation tests	51	Re / Da	RE
D10	Review of results and up dating of data base	51	Re / Da	RE
D11	Assessment of results and suitability	51	Re / Da	RE
D12	Final Report Summary	51	Re	RE

Table 3	HTR-M1 Project document list
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HTR No..	Status	Final issue date	Title	Author / Org
HTR-M1 02/1 M 2.0.1	Final	April 2002	Minutes of 1 st Technical meeting on graphite held on 13 th Nov. 2001 at NRG Petten, Netherlands	J. van der Laan/ NRG Petten
HTR-M1 02/1 M.0.0.2	Final	April 2002	Minutes of the HTR-M1 Kick-off plus 2 nd HTR-M Progress Meeting on 5-7 December 2001, Grenoble	D.E. Buckthorpe/ NNC Ltd.
HTR-M1 02/5 M 2.0.3	Final	July 2002	Minutes of meeting with graphite manufacturer UCAR on 26 th March 2002, Notre Dame, France	M. W. Davies/ NNC Ltd
HTR-M1 02/5 M 2.0.4	Final	July 2002	Minutes of meeting with graphite manufacturer SGL on 27 th March 2002, Chedde, France	M. W. Davies/ NNC Ltd
HTR-M1 02/5 M 0.0.5	Final	Nov 2002	Minutes of the HTR-M / M1 Progress Meeting on 15-17 April 2002, Julich, Germany	D.E. Buckthorpe/ NNC Ltd.
HTR-M1 02/5 P 0.0.6	Final	July 2002	18month HTR-M plus 6 month HTR-M1 joint management report	D. E. Buckthorpe NNC Ltd.
HTR-M1 02/9 D 1 1 7	Final	Inserted October 2004	HTR-M1: Report on selection of materials & testing requirements for the Turbine	R. Couturier / CEA
HTR-M1 02/11 P 0 0 8	Final	April 2003	Mid-term report for the HTR-M & M1 Projects	D. E. Buckthorpe NNC Ltd
HTR-M1 02/11 D 2 1 9	Draft		Report on selection of graphites and testing requirements	M. W. Davies/ NNC Ltd
HTR-M1 02/12 M 0 0 10	Final	Inserted October 2004	Minutes of the HTR-M plus M1 Mid Term Meeting on 28-29 November; 2002, Framatome, Paris	D. E. Buckthorpe NNC Ltd
HTR-M1 02/12 P 0 0 11	Final	August 2004	24 Month HTR-M plus 12 month HTR-M1 Management Report	D. E. Buckthorpe NNC Ltd
HTR-M1 03/03 D 1 0 12	Final	Inserted October 2004	Report on specimen fabrication, procurement & testing requirements for the turbine blade material	R. Couturier/ CEA
HTR-M103/04 D 2 2 13	Draft		HTR-M1 Report on specimen fabrication and procurement for the graphite irradiation tests	A. Vreeling / NRG
HTR-M1 03/09 D 2 5 14	Draft		Graphite with Si C coatings	B. Schröder/ FZJ
HTR-M1 03/05 P 0 0 15	Final	August 2004	30 Month HTR-M plus 18 month HTR-M1 Management Report	D.E.Buckthorpe/ NNC
HTR-M1 03/07 M 0 0 16	Final	Inserted October 2004	Minutes of 2nd Technical Meeting at Petten on HTR-M & M1 Irradiation experiments	D.E.Buckthorpe/ NNC

Table 3 (cont)	HTR-M1 Project document list
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HTR No..	Status	Final issue date	Title	Author / Org
HTR-M1 03/07 M 0 0 17	Final	Inserted October 2004	Minutes of the 5th HTR-M plus M1 Progress Meeting	D. Buckthorpe, R. Bestwick, A. A. Braithwaite / NNC
HTR-M1 03/11 P 0 0 18	Final	August 2004	36 Month HTR-M plus 24 month HTR-M1 Management Report	D. E. Buckthorpe/ NNC
HTR-M1 03/11 P 0 0 19	Final	Sept 2004	Third Annual Technical Report for the HTR-M project	D.E. Buckthorpe / NNC, et al.
HTR-M1 03/12 M 0 0 21	Final	Inserted October 2004	Minutes of the 6th HTR-M plus M1 Progress Meeting at FZJ	D. E. Buckthorpe/ NNC
HTR-M1 04/05 P 0 0 22	Final	October 2004	42 month HTR-M plus 30 month HTR-M1 Management Report	D.Buckthorpe/ NNC
HTR-M1 04/07 M 0 0 23	Final	Inserted Nov. 2004	Minutes of the 7th HTR-M plus M1 Progress Meeting at EA, Madrid	D. Buckthorpe/ NNC
HTR-M1 04/11 M 0 0 24	Final	Dec. 2004	Minutes of the 8th HTR-M plus M1 Progress Meeting at Framatome, Lyon	D.Buckthorpe/ NNC
HTR-M1 04/10 P 0 0 25	Final	Dec. 2004	48 Month HTR-M plus 36 month HTR-M1 Management Report	D. Buckthorpe/ NNC
HTR-M1 04/11 P 0 0 26	Draft		3 rd Scientific Report on HTR-M1 Project	D. Buckthorpe/ NNC
HTR-M1 04/12 D 2 0 27	Draft		Comparison of the oxidation behaviour of 8 HTR-Graphites	K. Kuhn/ FZJ
HTR-M1 05/04 M 0 0 28	Draft		Notes of a technical meeting on nuclear graphite selection held at NRG Petten	A. Vreeling & J. van der Laan/ NRG
HTR-M1 05/05 M 0 0 29	Draft		Minutes of the 7 th HTR-M1 Progress Meeting held at NNC, Knutsford	D. Buckthorpe/ NNC
HTR-M1 05/07 D 1 2 30	Draft		HTR-M1 Report:-Intermediate report on Material Testing of Turbine Materials	R. Couturier/CEA H. Rantala/JRC
HTR-M1 04/11 D 0 0 31	Draft		Technical Implementation Plan for HTR-M1 Project	D. Buckthorpe/ NNC
HTR-M1 05/03 P 0 0 32	Draft		42 Month HTR-M1 Management Report	D. Buckthorpe/ NNC
HTR-M1 05/10 P 0 0 33	Draft		Minutes of the Final HTR-M1 Progress Meeting held at NRG, Petten	D. Buckthorpe/ NNC
HTR-M1 05/11 D 1 2 34	Draft		Report on results of heavily carburised U720 disk material	S Ripplinger, H Rantala, P Hahner/ JRC-IE

Table 3 (cont)	HTR-M1 Project document list
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HTR No.	Status	Final issue date	Title	Author / Org
HTR-M1 05/12 D 1 2 35	Draft		Final HTR-M1 Report on HTR blade alloy properties	R Couturier, J Calapez/ CEA H Rantala/ JRC-IE
HTR-M1 05/10 D 0 0 36	Final	Inserted October 2005	Presentation of results for VHTR – results from HTR-M & HTR-M1 Projects plus future programme, EUROMAT Conference, Prague, Czech Republic, 5–7 th September 2005	D. Buckthorpe/NNC et al
HTR-M1 05/03 P 0 0 37	Final	March 05	Request for HTR-M1 Contract Extension from the Partnership	D. Buckthorpe et el
HTR-M1 05/03 P 0 0 38	Final	March 05	Approval of HTR-M1 Contract Extension from the Commission	P. Fernandez Ruiz/ EU
HTR-M1 05/12 D 2 3 39	Draft		Report on Irradiation and post Irradiation tests	F. Schmalz, J.A. Vreeling, D.S. d'Hulst, W. Molijn, P. ten Pierick /NRG
HTR-M1 05/12 D 2 4 40	Draft		HTR-M1 Report on preliminary irradiation testing of selected graphites for HTR – Review of results and updating of database	M. Davies/NNC
HTR-M1 05/12 D 2 4 41	Draft		HTR-M1 Report on preliminary irradiation testing of selected graphites for HTR – Assessment of the results and suitability	M. Davies/NNC; G. Haag/FZJ; O Gelineau/FANP.F
HTR-M1 05/12 D 2 5 42	Draft		HTR-M1 Graphite – Final Summary report	D. Buckthorpe/NNC
HTR-M1 05/12 D 1 2 43	Draft		HTR-M1 Results data provided on CD-Rom	R. Couturier/CEA
HTR-M1 05/12 D 1 2 44	Draft		HTR-M1 Turbine Materials – Final Summary Report	D. Buckthorpe/NNC
HTR-M1 05/01 D 1 0 45	Final		Final Report for ISTC Project 1313-2001. Testing and Investigations of Materials for Turbo-compressor High Temperature Components	A. Romantsov
HTR-M1 05/12 D 0 0 46	Draft		Final Report for HTR-M1 Project	D. Buckthorpe/NNC
HTR-M1 05/12 P 0 0 47	Draft		HTR-M1 Final Management Report	D. Buckthorpe/NNC

Figure 1 HTR-M1 Description of Programme

WP 1	Turbine materials		2001				2002				2003				2004				2005			
	Task	Sub-task																				
	1	Review materials & testing needs																				
	2	Material procurement & machining																				
	3	Intermediate creep tests & testing after ageing																				
	4	Analysis & asesemnt																				
	5	Synthesis & updating of data base																				
WP 2	Graphite		2001				2002				2003				2004				2005			
	Task	Sub-task																				
	1	Review graphites & testing needs																				
	2	Material procurement & test piece manufacture																				
	3	Irradiation of specimens & post irradiation tests																				
	4	Assessment of results & suitability																				
	5	Irradiation with corrosion resistant coatings																				
	6	Synthesis of results & updating of data base																				