

GA-A23811

GT-MHR COMMERCIALIZATION STUDY

Technical Progress and Cost Management Report for the Period
November 1 through November 30, 2003

by
GT-MHR Staff

Contact: A. S. Shenoy

Prepared under
Oakland Operations Office
Program DE-AC03-01SF22343
for the U.S. Department of Energy

General Atomics Project No. 30103
DATE PUBLISHED: December 2003

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

GA-A23811

GT-MHR COMMERCIALIZATION STUDY

Technical Progress and Cost Management Report for the Period
November 1 through November 30, 2003

by
GT-MHR Staff

Contact: A. S. Shenoy

Prepared under
Oakland Operations Office
Program DE-AC03-01SF22343
for the U.S. Department of Energy

GENERAL ATOMICS PROJECT No. 30103
DATE PUBLISHED: December 2003

Table of Contents

| | <u>Page</u> |
|---|--------------------|
| Part1 - Technical Progress | 1 |
| Summary | 1 |
| Task 1 - Fuel Irradiation | 1 |
| Task 2 - Fuel Manufacturing Process Improvement | 2 |
| Task 3 - NRC Interaction | 2 |
| Task 4 - Plant Cost Evaluation | 2 |
| Task 5 - Waste Disposal Assessment | 2 |
| Task 6 - Final Report and Recommendations for Further Development Activities | 2 |
| Task 7 – DOE Fuel Plan | 2 |
| Task 8 – MHR-2 Fuel Specification | 2 |
| Task 10 – Advanced Fuel Plan | 3 |
| Task 11 – VHTR Materials Survey | 4 |
| Part 2 - Cost Management | 5 |

**GT-MHR Commercialization Study
Monthly Technical Progress and Cost Management Report
for November 2003**

Contract No. DE-AC03-01SF22343
Submitted to: DOE - Oakland Operations Office
By: General Atomics

PART 1 – Technical Progress

Summary

- A copy of the original Memorandum of Understanding (MOU) between the U.S. and the E.U. for the HFR-EU2 (formally MHR-1) fuel irradiation test was sent to DOE-HQ. The startup of the HFR-EU2 test will likely be delayed until September 2004 depending on completion and check out of the fission gas sweep loop.
- The initial core nuclear design study using advanced fuel was completed for a Very High Temperature Reactor (VHTR). This study assessed the nuclear effects of replacing the silicon carbide layer of the TRISO particle with a zirconium carbide layer (TRIZO particle). The study determined that zirconium behaves like a non-burnable poison and to achieve fuel cycle lengths equivalent to those with TRISO fuel, the fixed burnable poison would have to be adjusted. The core nuclear design study is documented in report General Atomics report number PC-000514.
- A test plan was completed that describes a series of screening tests to provide the technical basis for selecting and qualifying an advanced coated-particle fuel for the VHTR. The test plan is documented in General Atomics report number PC-000510.

Task 1 – Fuel Irradiation

A copy of the original Memorandum of Understanding (MOU) between the U.S. and the E.U. for this fuel irradiation test, the HFR-EU2 (formally MHR-1) test, was sent to DOE-HQ (Dr. M. Feltus) per her request. The MOU was signed in July 2001 between GA and the Joint Research Center at Petten. The HFR-EU2 Pre-Irradiation Test report was also sent to DOE-HQ as per our agreement with Dr. Feltus.

The status of the HFR-EU2 irradiation test is as follows:

- The high-temperature brazing of the thermocouple and self-powered neutron detector penetrations through the top head of the irradiation capsule have now been successfully completed.
- The graphite sleeves in which the fuel compacts will reside during the irradiation test have been successfully machined.
- The startup of the HFR-EU2 test will likely be delayed until September 2004 (previously due to startup in July -August 2004) depending on the installation of the fission gas sweep loop.
- The startup of the companion irradiation test, HFR-EU1 bis (Chinese and German fuel spheres), will be delayed until February -March (previously due to start in January of 2004) due to administrative delays.

Task 2 – Fuel Manufacturing Process Improvement

This task has been completed.

Task 3 – NRC Interaction

This task is not currently funded.

Task 4 – Plant Cost Evaluation

This task has been completed.

Task 5 – Waste Disposal Assessment

This task has been completed.

Task 6 – Project Management and Project Development

This task covers all of the commercialization study project management and project development activities. During November, routine reviews of project activities were performed and the monthly report for October was prepared. A request for a no cost extension through January 31, 2004 was submitted in December and verbal approval was provided by the Program Manager and Contracting Officer.

Task 7 – DOE Fuel Plan

This task has been completed.

Task 8 – MHR-2 Fuel Specification

This task has been completed.

Task 9 – This task number not currently used***Task 10 – Advanced Fuel Studies***

The initial core nuclear design study using advanced fuel was completed for a Very High Temperature Reactor (VHTR) to assess the nuclear effects on replacing the silicon carbide layer of the TRISO particle with a zirconium carbide layer (TRIZO particle). The core nuclear design study is documented in report General Atomics report number PC-000514. The study determined, using a two-dimensional GAUGE analysis model, that zirconium behaves like a non-burnable poison, and to achieve TRIZO fuel cycle lengths the same as those for TRISO fuel (425 EFPD), the initial cycle will require a 12% decrease in Fixed Burnable Poison (FBP), while the reload cycles may require up to a 14% decrease in FBP. This equivalent B-10 worth is 0.24 kg and 0.23 kg for the initial and reload cycles, respectively. The larger capture cross-sections for zirconium compared to silicon in fast energy groups 3 and 4 are directly responsible for a ~1% decrease in uranium-238 capture cross-section in the same energy groups, simulating the effect of a neutron poison for the TRIZO fuel core.

In the report of the analysis results, the following additional studies are recommended:

- Optimization of control rod group insertion patterns by applying radial peaking data, in order to better determine FBP loadings for the TRIZO core.
- Optimization of FBP loadings by core segment and axial/radial zoning factors.
- The higher core temperatures in a VHTR will require the use of carbon-carbon composite control rods, which have greater thermal resistance. This would allow control rod placement in the inner reflector and dramatically increase the core power-shaping capabilities. Such a change would require a complete new GAUGE model and burnup analysis.
- Extending the physics modeling to a full three-dimensional core design, and performing assessments of fuel performance and fission product release.
- Apply the detailed three-dimensional peaking factors to the thermal conductivity code POKE to calculate maximum and average fuel and graphite temperatures.
- Use of the final nuclear design output to calculate peak fuel temperatures during conduction cool down.

A test plan was completed entitled "Screening Tests for Selection of VHTR Advanced Fuel". The test plan is documented in General Atomics report number

PC-000510. The test plan describes a series of screening tests to provide the technical basis for selecting and qualifying an advanced coated-particle fuel for the VHTR. The plan is a subset of, and a precursor of, an umbrella development plan for Advanced High Temperature coated-particle fuels which is proposed to satisfy the Design Data Needs for the VHTR in three related areas: (1) fuel process development, (2) fuel materials performance, and (3) fission product transport.

Task 11 – VHTR Materials Survey

This task has been completed.

Part 2 - Cost Management

| Item | Total Expenditures, K\$ | |
|---|-------------------------|---|
| | November 2003 | Inception to Date ¹ , Totals |
| Task 1 – MHR-1 Fuel Irradiation | 4.0 | 160.0 |
| Task 2 – Fuel Manufacturing Process Improvement | 0.0 | 204.0 |
| Task 3 – NRC Interaction | 0.0 | 143.8 |
| Task 4 – Plant Cost Evaluation | 0.0 | 87.3 |
| Task 5 – Waste Disposal Assessment | 0.0 | 103.2 |
| Task 6 – Project Management and Development | 0.2 | 141.6 |
| Task 7 – DOE Fuel Plan | 0.0 | 140.6 |
| Task 8 – MHR-2 Fuel Specification | 0.8 | 56.7 |
| Task 10 – Advanced Fuel Plan | 71.4 | 289.7 |
| Task 11 – VHTR Materials Survey | 0.1 | 22.9 |
| Totals | 75.4 | 1,349.8 |
| | | |

Note:

1. Work started December 18, 2001.