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Simulated Coal Gas MCFC Power Plant System Verification

**Technical Report
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For
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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	v
TASK 1. COMMERCIALIZATION	1
Subtask 1.1 Prioritize Purchaser Issues for MCFC Power Plants	1
TASK 2. POWER PLANT DEVELOPMENT	2
Subtask 2.1 Optimize Current EPRI TAG II Level CGMCFC Systems	2
Subtask 2.2 Select/Inspect Power Plant Test Site	2
Subtask 2.3 Develop Dual-Fuel Power Plant Design	2
Subtask 2.4 Develop Detailed Power Plant System Construction Plan	3
Subtask 2.5 Design, Fabrication, and Assembly of Full-Scale, Full-Height 250-kW MCFC Stack Module	3
Subtask 2.6 Power Plant System Test with Reformed Natural Gas	3
Subtask 2.7 Integrate Demonstration Test Results into Power Plant Design	4
TASK 3. MANUFACTURING FACILITIES DEVELOPMENT	5
Subtask 3.1 Maintain Tape Casting Machine and Sintering Furnace	5
Subtask 3.2 Develop Quality Assurance (QA) Procedures and Laboratory	5
Subtask 3.3 Acquire Separator Plate Mapping and Component Cutting Machines	5
Subtask 3.4 Fabricate Full-Area and Full-Height Stack Assembly Rig	6

TABLE OF CONTENTS, con't

	Page
TASK 4. TESTING FACILITY DEVELOPMENT	7
Subtask 4.1 Construct Power Plant System Test Facility Designed under Task 2	7
Subtask 4.2 Upgrading of Existing, U.S. Government-Owned, Test Facilities	7
TASK 5. STACK RESEARCH	8
Subtask 5.1 Engineering Issues	8
Subtask 5.2 Manufacturing Issues	8
Subtask 5.3 Assembly Issues	9
Subtask 5.4 Cost Issues	9
Subtask 5.5 Full-Area, Subscale Stack Tests in Support of Engineering, Manufacturing, Assembling, and Cost Issues Resolution	9
Subtask 5.6 Performance Issues	9
Subtask 5.7 Endurance Issues	10
TASK 6. ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT	11
Subtask 6.1 Reduced Contact Resistance at Cathode Separator Plate Interface	11
Subtask 6.2 Advanced MCFC Component Research	11

EXECUTIVE SUMMARY

Overview

This is the Technical Progress Report covering December 1997. Unocal prepared a estimate of the costs to dismantle and package the test facility for storage and shipment. This estimate was included in a formal work plan contained in a no cost time extension (until April 30, 1998) proposal approved by the DOE. The scope of work for the contract has been modified to accommodate the dismantling and packaging of the plant. An amendment to Sub-Contract No. MCP-9-UNO between M-C Power and Unocal has been executed which includes the Scope of Work in Unocal's cost estimate.

TASK 1. COMMERCIALIZATION

This task is complete.

TASK 2. POWER PLANT DEVELOPMENT

A draft report of the stack performance and post-test analysis has been prepared and is undergoing internal review.

TASK 3. MANUFACTURING FACILITIES DEVELOPMENT

This task is complete.

TASK 4. TESTING FACILITY DEVELOPMENT

Unocal continued maintenance of the 250-kW demonstration power plant and bid packages for plant dismantling have been prepared.

TASK 5. STACK RESEARCH

This task is complete.

TASK 6. ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

The individual final reports from the Illinois Institute of Technology, Texas A&M, and the University of Minnesota are being assembled into a complete final report.

SIMULATED COAL GAS MCFC POWER PLANT SYSTEM VERIFICATION

The overall objective of this program is the demonstration of a 250-kW MCFC power plant based on the IMHEX® stack design concept.

TASK 1. COMMERCIALIZATION

The objective of this is the development of commercialization strategies with a high probability of success, the development of well-defined goals based on market analysis, the identification of power plant development requirements for markets, and the analysis of competing systems. The base program will focus on purchaser issues.

Subtask 1.1 Prioritize Purchaser Issues for MCFC Power Plants

Objective:

To identify those issues which are most important to the potential purchasers of MCFC power plants and to prioritize those issues in terms of the users' perspective.

Discussion:

This subtask is complete.

TASK 2. POWER PLANT DEVELOPMENT

The objective of this task is to demonstrate and verify improvements in MCFC technology through component and stack design; full-area component fabrication and stack assembly; and full-scale and full-height (100-300-kW) stack testing in a complete, integrated, MCFC power plant system.

Subtask 2.1 Optimize Current EPRI TAG II Level CGMCFC Systems

Objective:

To further analyze CGMCFC steam bottoming and combined cycle systems, select the best commercially viable system and subject the chosen system to more stringent analysis. That analysis will culminate in establishment of conditions for testing of the 250-kW power plant.

Discussion:

This subtask is complete.

Subtask 2.2 Select/Inspect Power Plant Test Site

Objective:

To inspect the 250-kW power plant test site and establish site specific requirements and constraints to be incorporated in the power plant design so that it meets test objectives.

Discussion:

This subtask is complete.

Subtask 2.3 Develop Dual-Fuel Power Plant Design

Objective:

To develop a complete design and design document for the 250-kW power plant. The design will be categorized into subsystems and will include piping & instrumentation diagrams (P&IDs), flow sheets, and elementary wiring diagrams.

Discussion:

This subtask is complete.

Subtask 2.4 Develop Detailed Power Plant System Construction Plan

Objective:

To develop a detailed construction plan for the 250-kW power plant. The plan will include plot plan, general arrangement drawings, civil construction plan, module definition, materials list, and construction schedule.

Discussion:

This subtask is complete.

Subtask 2.5 Design, Fabrication, and Assembly of Full-Scale, Full-Height 250-kW MCFC Stack Module

Objective:

To complete the design of the 250-kW MCFC stack module based on the present full-area cell and full-height stack design, to fabricate separator plates and active area components, and to assemble the full-scale 250-kW module for delivery to the test site.

Discussion:

This subtask is complete.

Subtask 2.6 Power Plant System Test with Reformed Natural Gas

Objective:

To establish test goals, develop a power plant manual and operations plan, and conduct the 250-kW power plant test.

Discussion:

A draft report on the 250-kW stack performance and post-test analysis is undergoing internal review and editing for external distribution.

Subtask 2.7 Integrate Demonstration Test Results into Power Plant Design

Objective:

To integrate the results of the power plant test into strategies, schedules, and full-scale power plant project formation and into the field test program and commercial power plant offerings and configurations.

Discussion:

This subtask is complete.

TASK 3. MANUFACTURING FACILITIES DEVELOPMENT

The objective of this task is to address issues impeding development of manufacturing facilities to support MCFC stack research and power plant development.

Subtask 3.1 Maintain Tape Casting Machine and Sintering Furnace

Objective:

To develop a procedure and plan to properly maintain the government-owned tape casting machine and sintering furnace located at M-C Power's facility and to modify these machines as required to improve capabilities, quality, and production rates.

Discussion:

This subtask is complete.

Subtask 3.2 Develop Quality Assurance (QA) Procedures and Laboratory

Objective:

To develop and implement quality control procedures and plans to assure the quality of the active area MCFC components produced at M-C Power's facilities. For this purpose, M-C Power will complete equipping its QC Laboratory and select analytical service vendors to provide the required quality control support. In addition, M-C Power will construct a single cell test facility to assist in establishing quality control.

Discussion:

This subtask is complete.

Subtask 3.3 Acquire Separator Plate Mapping and Component Cutting Machines

Objective:

To acquire component mapping and cutting machines to measure and trim active area components and separator plates to replace high cost services provided by outside vendors.

Discussion:

This subtask is complete.

Subtask 3.4 Fabricate Full-Area and Full-Height Stack Assembly Rig

Objective:

To design and fabricate a rig for the assembly of full-area, full-height stacks. This rig will be installed at M-C Power's facilities and utilized to assemble the full-area stacks to be tested during the program and to assemble the 250-kW stack for the power plant test.

Discussion:

This subtask is complete.

TASK 4. TESTING FACILITY DEVELOPMENT

The objective of this task is to address issues impeding the development of testing facilities to support MCFC stack research and power plant development.

Subtask 4.1 Construct Power Plant System Test Facility Designed under Task 2

Objective:

To construct all subsystem modules and erect/complete the 250-kW power plant at a Unocal site located in Southern California and to execute shakedown and start-up activities which will culminate in turnover of the power plant to operation and execution of the approved test plan.

To design, procure, construct, install, and commission a commercial stack acceptance test facility (ATF).

Discussion:

This subtask is complete.

Subtask 4.2 Upgrading of Existing, U.S. Government-Owned, Test Facilities

Objective:

To upgrade the existing, government-owned 20-kW test facility to improve its reliability for long-term operation.

Discussion:

A work plan and estimate for dismantling and packaging the plant for further storage and ultimate shipment has been prepared by Unocal and is being reviewed by M-C Power and Bechtel. Initial comments on the bid package have been sent to Unocal for review.

Unocal has obtained vendor qualifications for possible bidders who are acceptable to M-C Power. They will distribute the revised bid packages after making the appropriate modifications. Disassembly activities will proceed upon review of the proposals and subsequent releasing of a disassembly sub-contract.

TASK 5. STACK RESEARCH

The objective of this task is to identify and resolve issues in engineering, manufacturing, assembling, cost, performance, and endurance involving the stack repeat and non-repeat components.

Subtask 5.1 Engineering Issues

Objective:

To continuously review the full-area, full-height IMHEX® design and incorporate all improvements/modifications developed during the course of the program.

Discussion:

This subtask is complete.

Subtask 5.2 Manufacturing Issues

Objective:

To obtain satisfactory separator plate life and performance by out-of-cell evaluation of materials and coatings for active area wet seal corrosion protection and evaluation and/or development of alternative joining techniques.

To utilize the technologies developed under this subtask to manufacture separator plates for use in full-area cell stack tests and in the 250-kW power plant test.

To fabricate full-size active area components to improve manufacturing techniques and to provide components required for the assembly of the full-area subscale stack tests.

Discussion:

This subtask is complete.

Subtask 5.3 Assembly Issues

Objective:

To identify the issues associated with the handling of large area thin components and evaluate the equipment necessary for their storage and handling.

Discussion:

This subtask is complete.

Subtask 5.4 Cost Issues

Objective:

To verify and scale-up copper-based anodes which resulted from initial development under EPRI Contract No. RP-3059-2 and to continue evaluation and development of binder systems which will ease start-up requirements and times.

Discussion:

This subtask is complete.

Subtask 5.5 Full-Area, Subscale Stack Tests in Support of Engineering, Manufacturing, Assembling, and Cost Issues Resolution

Objective:

To conduct a 20-kW full-area stack test under GRI sponsorship and three 20-kW full-area stack tests in support of engineering, manufacturing, assembling, and cost issues resolution.

Discussion:

This subtask is complete.

Subtask 5.6 Performance Issues

Objective:

To design and develop an effective technique to prevent anode-to-cathode gas crossover through the matrix.

To develop and evaluate novel electrolyte replenishment techniques in out-of-cell tests and to investigate approaches for increasing the electrical conductivity of oxide layers on the separator plate by reducing growth rate and by doping in out-of-cell tests. To upgrade the performance/endurance model to include improved kinetic algorithms and to develop a failure mode analysis and a cell/stack component characteristic and performance data base to be incorporated into the model to improve its functionality.

Discussion:

This subtask is complete.

Subtask 5.7 Endurance Issues

Objective:

To improve component longevity by continued development of creep-resistant anodes and cathodes, to determine the effectiveness of the strengthening mechanisms in out-of-cell tests and in bench-scale single cells, and to verify success in a stack test.

To evaluate the efficiency of doping for reduction of the cathode dissolution rate and to develop a tape casting process for continuous fabrication of stabilized cathodes.

Discussion:

This subtask is complete.

TASK 6. ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

The objective of this task is to address technology issues generic to MCFCs under Advanced Research and Technology Division funding.

Subtask 6.1 Reduced Contact Resistance at Cathode Separator Plate Interface

Objective:

To quantitatively assess contact resistance at the interface between the cathode, the cathode current collector, and the cathode side of the separator plate and to identify and evaluate approaches to reducing and stabilizing this resistance.

Discussion:

This subtask is complete.

Subtask 6.2 Advanced MCFC Component Research

Objective:

To conduct research to resolve issues relating to the improvement of the efficiency and cost effectiveness of the MCFC by improving the following: protection of the current collector plate from corrosion; reduction of cathode over potential losses; understanding the effects of electrolyte basicity and oxygen reduction kinetics to reduce cathode over potential; and measuring the wetting angles of various electrolytes to reduce the electrolyte loss/migration during the MCFC operation.

Discussion:

Final reports have been received from IIT, UMin, and Texas A&M. They are being assembled into a report for submittal to METC.