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**COMMERCIAL-SCALE DEMONSTRATION OF THE  
LIQUID PHASE METHANOL (LPMEOH™) PROCESS**

**TECHNICAL PROGRESS REPORT NO. 9**

**For The Period**

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## Table of Contents

ACRONYMS AND DEFINITIONS.....	4
Executive Summary.....	5
A. Introduction.....	7
B. Project Description.....	8
C. Process Description.....	9
D. Project Status.....	9
Task 1.2 Permitting.....	9
Task 1.3 Design Engineering.....	10
Task 1.4 Off-Site Testing (Definition and Design).....	10
Task 1.5 Planning and Administration.....	12
Task 1.5.1 Product-Use Test Plan.....	12
Task 1.5.2 Commercialization Studies.....	12
Task 1.5.3 DME Design Verification Testing.....	13
Task 1.5.4 Administration and Reporting.....	16
Task 2.1 Procurement.....	20
Task 2.2 Construction.....	20
Task 2.3 Training and Commissioning.....	21
Task 2.4 Off-Site Testing (Procurement and Construction).....	22
Task 2.5 Planning and Administration.....	22
E. Planned Activities for the Next Quarter.....	23
F. Summary.....	23
APPENDICES.....	25
APPENDIX A - SIMPLIFIED PROCESS FLOW DIAGRAM.....	25
APPENDIX B - PROJECT EVALUATION PLAN FOR BUDGET PERIOD NO. 2.....	26
APPENDIX C - TASK 1.5.2 - PROCESS ECONOMICS STUDY - OUTLINE.....	27
APPENDIX D - TASK 1.5.3 - DME MILESTONE PLAN.....	28
APPENDIX E - TASK 1.5.4 - CONTINUATION APPLICATION.....	29
APPENDIX F - TASK 1.5.4 - PROJECT REVIEW MEETING.....	30
APPENDIX G - TASK 1.5.4 - MILESTONE SCHEDULE STATUS AND COST MANAGEMENT REPORTS.....	31
APPENDIX H - TASK 2.3 - DEMONSTRATION TEST PLAN.....	32
APPENDIX I - TASK 2.3 - COMMISSIONING & STARTUP SCHEDULE.....	33

## Acronyms and Definitions

Acurex	-	Acurex Environmental Corporation
Air Products	-	Air Products and Chemicals, Inc.
AFDU	-	Alternative Fuels Development Unit - The "LaPorte PDU."
Balanced Gas	-	A syngas with a composition of hydrogen (H <sub>2</sub> ), carbon monoxide (CO), and carbon dioxide (CO <sub>2</sub> ) in stoichiometric balance for the production of methanol
Carbon Monoxide Gas	-	A syngas containing primarily carbon monoxide (CO); also called CO Gas
DME	-	dimethyl ether
DOE	-	United States Department of Energy
DOE-PETC	-	The DOE's Pittsburgh Energy Technoloh Center (Project Team)
DOE-HQ	-	The DOE's Headquarters - Clean Coal Technology (Project Team)
DTP	-	Demonstration Test Plan - The four year Operating Plan for Phase 3, Task 2 Operation
DVT	-	Design Verification Testing
Eastman	-	Eastman Chemical Company
EIV	-	Environmental Information Volume
EMP	-	Environmental Monitoring Plan
EPRI	-	Electric Power Research Institute
HAPs	-	Hazardous Air Pollutants
Hydrogen Gas	-	A syngas containing an excess of hydrogen (H <sub>2</sub> ) over the stoichiometric balance for the production of methanol; also called H <sub>2</sub> Gas
IGCC	-	Integrated Gasification Combined Cycle, a type of electric power generation plant
IGCC/OTM	-	An IGCC plant with a "Once-Thru Methanol" plant (the LPMEOH™ Process) added-on.
KSCFH	-	Thousand Standard Cubic Feet per Hour
LaPorte PDU	-	The DOE-owned experimental unit (PDU) located adjacent to Air Product's industrial gas facility at LaPorte, Texas, where the LPMEOH™ process was successfully piloted.
LPDME	-	Liquid Phase DME process, for the production of DME as a mixed coproduct with methanol
LPMEOH™	-	Liquid Phase Methanol (the technology to be demonstrated)
MTBE	-	methyl tertiary butyl ether
NEPA	-	National Environmental Policy Act
OSHA	-	Occupational Safety and Health Administration
Partnership	-	Air Products Liquid Phase Conversion Company, L.P.
PDU	-	Process Development Unit
PFD	-	Process Flow Diagram(s)
ppb	-	parts per billion
Project	-	Production of Methanol/DME Using the LPMEOH™ Process at an Integrated Coal Gasification Facility
psia	-	Pounds per Square Inch (Absolute)
psig	-	Pounds per Square Inch (gauge)
P&ID	-	Piping and Instrumentation Diagram(s)
SCFH	-	Standard Cubic Feet per Hour
Sl/hr-kg	-	Standard Liter(s) per Hour per Kilogram of Catalyst
Syngas	-	Abbreviation for Synthesis Gas
Synthesis Gas	-	A gas containing primarily hydrogen (H <sub>2</sub> ) and carbon monoxide (CO), or mixtures of H <sub>2</sub> and CO; intended for "synthesis" in a reactor to form methanol and/or other hydrocarbons (synthesis gas may also contain CO <sub>2</sub> , water, and other gases)
Tie-in(s)	-	the interconnection(s) between the LPMEOH™ Process Demonstration Facility and the Eastman Facility
TPD	-	Ton(s) per Day
WBS	-	Work Breakdown Structure
wt	-	weight

## Executive Summary

The Liquid Phase Methanol (LPMEOH™) Demonstration Project at Kingsport, Tennessee, is a \$213.7 million cooperative agreement between the U.S. Department of Energy (DOE) and Air Products Liquid Phase Conversion Company, L. P. (the Partnership). The LPMEOH™ Process Demonstration Unit is being built at a site located at the Eastman Chemical Company (Eastman) complex in Kingsport.

On 4 October 1994, Air Products and Chemicals, Inc. (Air Products) and Eastman Chemical Company (Eastman) signed the agreements that would form the Partnership, secure the demonstration site, and provide the financial commitment and overall management for the project. These partnership agreements became effective on 15 March 1995, when DOE authorized the commencement of Budget Period No. 2 (Mod. A008 to the Cooperative Agreement). The Partnership has subcontracted with Air Products to provide the overall management of the project, and to act as the primary interface with DOE. As subcontractor to the Partnership, Air Products will also provide the engineering design, procurement, construction, and commissioning of the LPMEOH™ Process Demonstration Unit, and will provide the technical and engineering supervision needed to conduct the operational testing program required as part of the project. As subcontractor to Air Products, Eastman will be responsible for operation of the LPMEOH™ Process Demonstration Unit, and for the interconnection and supply of synthesis gas (syngas), utilities, product storage, and other needed services.

The project involves the construction of an 80,000 gallons per day (260 tons per day (TPD)) methanol unit utilizing coal-derived synthesis gas from Eastman's integrated coal gasification facility. The new equipment consists of synthesis gas feed preparation and compression facilities, the liquid phase reactor and auxiliaries, product distillation facilities, and utilities.

The technology to be demonstrated is the product of a cooperative development effort by Air Products and DOE in a program that started in 1981. Developed to enhance electric power generation using integrated gasification combined cycle (IGCC) technology, the LPMEOH™ process is ideally suited for directly processing gases produced by modern-day coal gasifiers. Originally tested at a small, DOE-owned experimental unit in LaPorte, Texas, the technology provides several improvements essential for the economic coproduction of methanol and electricity directly from gasified coal. This liquid phase process suspends fine catalyst particles in an inert liquid, forming a slurry. The slurry dissipates the heat of the chemical reaction away from the catalyst surface, protecting the catalyst and allowing the methanol synthesis reaction to proceed at higher rates.

At the Eastman complex, the technology is being integrated with existing coal-gasifiers. A carefully developed test plan will allow operations at Eastman to simulate electricity demand load-following in coal-based IGCC facilities. The operations will also demonstrate the enhanced stability and heat dissipation of the conversion process, its reliable on/off operation, and its ability to produce methanol as a clean liquid fuel without additional

upgrading. An off-site product testing program will be conducted to demonstrate the suitability of the methanol product as a transportation fuel and as a fuel for stationary applications for small modular electric power generators for distributed power.

The four-year operating test phase will demonstrate the commercial application of the LPMEOH™ process, to allow utilities to manufacture and sell two products: electricity and methanol. A typical commercial-scale IGCC coproduction facility, for example, could be expected to generate 200 to 350 MW of electricity, and to also manufacture 45,000 to 300,000 gallons per day of methanol (150 to 1000 TPD). A successful demonstration at Kingsport will show the ability of a local resource (coal) to be converted in a reliable (storable) and environmentally preferable way to provide the clean energy needs of local communities for electric power and transportation.

This project may also demonstrate the production of dimethyl ether (DME) as a mixed coproduct with methanol if laboratory and pilot-scale research and market verification studies show promising results. If implemented, the DME would be produced during the last six months of the four-year demonstration period. DME has several commercial uses. In a storable blend with methanol, the mixture can be used as a peaking fuel in gasification-based electric power generating facilities, or as a diesel engine fuel. Blends of methanol and DME can be used as chemical feedstocks for synthesizing chemicals, including new oxygenated fuel additives.

The project was reinitiated in October of 1993, when DOE approved a site change to the Kingsport location. DOE conditionally approved the Continuation Application to Budget Period No. 2 (Design and Construction) in March of 1995 and formally approved it on 1 June 1995 (Mod M009). Since then the project has been in Phase 1 - Design activities; and also moved into Phase 2 - Construction activities in October of 1995. The project required review under the National Environmental Policy Act (NEPA) to move to the construction phase. DOE prepared an Environmental Assessment (DOE/EA-1029), and subsequently a Finding of No Significant Impact (FONSI) was issued on 30 June 1995. The demonstration unit is scheduled to be mechanically complete at the end of December of 1996.

During this quarter, the Continuation Application was submitted, requesting authorization to transition from Budget Period No. 2 (Design and Construction) to the final Budget Period (Commissioning, Startup, and Operation). The Project Evaluation Report for Budget Period No. 2 was prepared. A recommendation for approval is being reviewed by the DOE.

A draft Topical Report on Process Economics Studies is being prepared. This report shows that methanol coproduction, with IGCC electric power utilizing the LPMEOH™ process technology, will be competitive in serving local market needs. The results will also be incorporated into a paper "Fuel and Power Coproduction", being prepared for presentation at the DOE's 5th Annual Clean Coal Technology Conference.

A decision on whether to continue with DME design verification testing is to be made, by the participants, in December of 1996. The laboratory R & D results are confirming that the new Liquid Phase Dimethyl Ether (LPDME) catalyst system will have reasonable long-term activity and stability. The market application of DME is promising, for example as diesel

engine transportation fuels, either directly as DME, or indirectly by conversion to liquid additives for the diesel fuel pool. A recommendation to continue with DME design verification testing is likely.

The off-site product testing plan is to be updated by May of 1997. During this quarter, Air Products and Acurex were developing a list of contacts for product methanol fuel-use testing. Prospective Federal, State, and University product test participants, involved in fuel cell, transportation, and stationary power plant developments, are being included.

A project review meeting was held in Kingsport in early September. The vent stack was at the site, and all of the other equipment was installed. The construction and operation permits have been obtained. The operator training, commissioning, startup, and initial operation plans were reviewed.

An updated cost forecast shows \$38 million for the Kingsport portion of the LPMEOH™ Process Demonstration Project for the Phase 1 and 2 tasks. This is an increase of about 10% from the cost plan submitted at the start of Budget Period No. 2. The increase is off-set by lower costs for the Project pre-award work, and by projected lower Phase 3 Operation costs. The total Project cost remains the unchanged at \$213.7 million.

Construction (Task 2.2) is 72% complete, as of the end of September of 1996. The targeted completion date has slipped by about three weeks, to 31 December 1996. Commissioning activities (Task 2.3) will start in mid-October of 1996, and should be completed in mid-January of 1997. Startup of the utility systems is scheduled to begin in late January.

Eighty-one percent (81%) of the \$38 million of funds forecast for the Kingsport portion of the LPMEOH™ Process Demonstration Project for the Phase 1 and Phase 2 tasks have been expended (as invoiced), as of 30 September 1996.

### **A. Introduction**

The Liquid Phase Methanol (LPMEOH™) demonstration project at Kingsport, Tennessee, is a \$213.7 million cooperative agreement between the U.S. Department of Energy (DOE) and Air Products Liquid Phase Conversion Company, L. P. (the Partnership). A demonstration unit producing 80,000 gallons per day (260 TPD) of methanol is being designed and constructed at a site located at the Eastman Chemical Company (Eastman) complex in Kingsport. The Partnership will own and operate the facility for the four-year demonstration period.

This project is sponsored under the DOE's Clean Coal Technology Program, and its primary objective is to "demonstrate the production of methanol using the LPMEOH™ Process in conjunction with an integrated coal gasification facility." The project will also demonstrate the suitability of the methanol produced for use as a chemical feedstock or as a low-sulfur dioxide, low-nitrogen oxides alternative fuel in stationary and transportation applications. The project may also demonstrate the production of dimethyl ether (DME) as a mixed coproduct with methanol, if laboratory- and pilot-scale research and market verification

studies show promising results. If implemented, the DME would be produced during the last six months of the four-year demonstration period.

The LPMEOH™ process is the product of a cooperative development effort by Air Products and the DOE in a program that started in 1981. It was successfully piloted at a 10-TPD rate in the DOE-owned experimental unit at Air Products' LaPorte, Texas, site. This demonstration project is the culmination of that extensive cooperative development effort.

## **B. Project Description**

The demonstration unit, which will occupy an area of 0.6 acre, will be integrated into the existing 4,000-acre Eastman complex located in Kingsport, Tennessee. The Eastman complex employs approximately 12,000 people. In 1983, Eastman constructed a coal gasification facility utilizing Texaco technology. The synthesis gas generated by this gasification facility is used to produce carbon monoxide and methanol. Both of these products are used to produce methyl acetate and ultimately cellulose acetate and acetic acid. The availability of this highly reliable coal gasification facility was the major factor in selecting this location for the LPMEOH™ Process Demonstration. Three different feed gas streams (hydrogen gas, carbon monoxide gas, and balanced gas) will be diverted from existing operations to the LPMEOH™ demonstration unit, thus providing the range of coal-derived synthesis gas ratios (hydrogen to carbon monoxide) needed to meet the technical objectives of the demonstration project.

For descriptive purposes and for design and construction scheduling, the project has been divided into four major process areas with their associated equipment:

- *Reaction Area* - Synthesis gas preparation and methanol synthesis reaction equipment.
- *Purification Area* - Product separation and purification equipment.
- *Catalyst Preparation Area* - Catalyst and slurry preparation and disposal equipment.
- *Storage/Utility Area* - Methanol product, slurry, and oil storage equipment.

The physical appearance of this facility closely resembles the adjacent Eastman process plants, including process equipment in steel structures.

- *Reaction Area*

The reaction area will include feed gas compressors, catalyst guard beds, the reactor, a steam drum, separators, heat exchangers, and pumps. The equipment will be supported by a matrix of structural steel. The most salient feature is the reactor, since with supports, it is approximately 84-feet tall.

- *Purification Area*

The purification area features two distillation columns with supports; one is approximately 82-feet tall, and the other 97-feet tall. These vessels resemble the columns of the

surrounding process areas. In addition to the columns, this area includes the associated reboilers, condensers, air coolers, separators, and pumps.

- *Catalyst Preparation Area*

The catalyst preparation area consists of a building with a roof and partial walls, in which the catalyst preparation vessels, slurry handling equipment, and spent slurry disposal equipment are housed. In addition, a hot oil utility system is included in the area.

- *Storage/Utility Area*

The storage/utility area includes two diked lot-tanks for methanol, two tanks for oil storage, a slurry holdup tank, a trailer loading/unloading area, and an underground oil/water separator.

### C. Process Description

The LPMEOH™ demonstration unit will be integrated with Eastman's coal gasification facility. A simplified process flow diagram is included in Appendix A. Synthesis gas is introduced into the slurry reactor, which contains a slurry of liquid mineral oil with suspended solid particles of catalyst. The synthesis gas dissolves through the mineral oil, contacts the catalyst, and reacts to form methanol. The heat of reaction is absorbed by the slurry and is removed from the slurry by steam coils. The methanol vapor leaves the reactor, is condensed to a liquid, sent to the distillation columns for removal of higher alcohols, water, and other impurities, and is then stored in the day tanks for sampling before being sent to Eastman's methanol storage. Most of the unreacted synthesis gas is recycled back to the reactor with the synthesis gas recycle compressor, improving cycle efficiency. The methanol will be used for downstream feedstocks and in off-site fuel testing to determine its suitability as a transportation fuel and as a fuel for stationary applications in the power industry.

### D. Project Status

The project status is reported by task, and then by the goals established by the Project Evaluation Plan for Budget Period No. 2 (see Appendix B). Major accomplishments during this period are as follows:

#### ***Task 1.2 Permitting***

For this task the Project Evaluation Plan for Budget Period No. 2 establishes these goals:

- Issue the final Environmental Information Volume (EIV) to support the DOE's Environmental Assessment/Finding of No Significant Impact.
- The NEPA review was completed 30 June 1995 with the issuance of an Environmental Assessment (DOE/EA-1029) and Finding of No Significant

Impact (FONSI). The DOE's comments on the May 1996 Draft EIV were incorporated into the EIV in August. The DOE approved the final EIV on 29 August 1996, and copies of the final EIV were distributed in September of 1996.

- Obtain permits necessary for construction and operation.
  - The construction and operation permits have been obtained.

### ***Task 1.3 Design Engineering***

For this task the Project Evaluation Plan for Budget Period No. 2 establishes these goals:

- Prepare the Environmental Monitoring Plan (EMP).
  - The DOE's comments on the May 1996 draft of the EMP were incorporated into a final draft EMP, which was released for review on 1 August 1996. The DOE approved this final draft EMP on 29 August 1996, and copies of the final EMP were distributed in September of 1996.
- Complete the design engineering necessary for construction and commissioning. This includes Piping and Instrumentation Diagrams, Design Hazard Reviews, and the conduct of design reviews.
  - The focus of attention for the project has transitioned from detailed design to construction. This Task 1.3 Design Engineering is 99% complete, with only a few items remaining. During this quarter, the programming of the Honeywell Digital Control System (DCS) continued, and was 80% completed. The last two construction bid packages; (Final Grading and Painting) were completed, and are now out for bid.

### ***Task 1.4 Off-Site Testing (Definition and Design)***

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Prepare the fuel-use demonstration plan for Phase 3, Task 4 Off-Site Product Use Demonstration. This off-site test plan will be incorporated into an updated, overall (fuel and chemical) product-use test plan (in Phase 1, Task 5).

### **Discussion**

The fuel-use test plan, developed to support the demonstration at the original Cool Water Gasification Facility in 1992, has become outdated. Since the site change to Eastman, the original fuel-use test plan under-represents new utility dispersed electric power developments, and possibly new mobile transport engine developments. The updated fuel-use test plan will attempt for broader market applications and for commercial fuels

comparisons. The objective of the fuel-use test plan update will be to demonstrate commercial market applications for the "as produced" methanol as a replacement fuel and as a fuel supplement. Fuel economics will be evaluated for the "as produced" methanol for use in municipal, industrial and utility applications and as fuel supplements for gasoline, diesel, and natural gas. These fuel evaluations will be based on the U.S. energy market needs projected during the 1998 to 2018 time period when the LPMEOH™ technology is expected to be commercialized.

The fuel-use test plan will be developed to enhance the early commercial acceptance of central clean coal technology processing plants, making coproducts of electricity and methanol, to meet the needs of the local community. One of those local needs will be for clean fuels (see Part Four - Methanol Fuel Applications, on page 4 of the outline in Appendix C). One of the advantages of the LPMEOH™ process, for coproduction from coal-derived syngas, is that the as-produced, stabilized (degassed) methanol product is of unusually high quality (e.g. less than 1 wt. % water). This quality may be suitable for the premium fuel applications. Cost savings (10 to 15%) of several cents per gallon of methanol can be achieved, if the suitability of the stabilized product can be demonstrated. The applications: as a hydrogen source for fuel cells, and as a clean transportable, storable fuel for dispersed power, will require testing of the product to confirm its suitability.

A limited quantity (up to 400,000 gallons) of the methanol product as produced from the demonstration unit will be made available for fuel-use tests. Fuel-use tests will be targeted for an approximate 18 to 30-month period, commencing in the second year of demonstration operations. The methanol product from the demonstration unit will be in Kingsport, Tennessee. Air Products, Acurex Environmental Corporation (Acurex), and the DOE will develop the final fuel-use test plan.

#### Activity during this quarter

- The fuel-use test plan is targeted to be updated by May of 1997. This will allow 12 months for proper implementation of the tests, which will be conducted for an 18 to 30 month period commencing in May of 1998. The Demonstration Test Plan (see Task 2.3) indicates methanol for testing (as-produced from CO-rich syngas) will first be produced in May of 1998. Air Products and Acurex are developing a list of contacts for methanol fuel-use testing. The DOE's Office of Energy Efficiency and Renewable Energy is being utilized for guidance in developing the list. Air Products and Acurex are planning a meeting for November of 1996, to review fuel-use test prospects, and to establish milestones, priorities, and responsibilities for developing the updated plan.

## **Task 1.5 Planning and Administration**

### **Task 1.5.1 Product-Use Test Plan**

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Update the (fuel and chemical) product-use test plan to better meet the technical objectives of the project and serve the needs of commercial markets.
  - Air Products and Eastman have updated plans for the on-site product-use demonstrations. The schedule for on-site product-use tests was established for August to October of 1997. Methanol product from the LPMEOH™ Process Demonstration Unit will be used as a chemical feedstock. Eastman will perform fitness-for-use tests on the methanol product for use as a chemical feedstock and provide a summary of the results.

### **Task 1.5.2 Commercialization Studies**

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Complete economic studies of important commercial aspects of the LPMEOH™ process to enhance IGCC electric power generation. These studies will be used to provide input to the LPMEOH™ Process Demonstration Unit operating test plan (Phase 2, Task 3).

### Discussion

A number of areas have been identified as needing development to support specific commercial design studies. These design options include: a) Product Purification; b) Front End Impurity Removal; c) Catalyst Addition/Withdrawal; and d) Plant Design Configuration. Plant sizes in the range of 300 TPD to 1800 TPD and plant design configurations for the range from 20% to 70% synthesis gas conversion will be considered. The Kingsport demonstration unit design and costs will be the basis for value engineering work to focus on specific cost reduction targets in developing the initial commercial plant designs.

### Activities during this quarter

- Completion of the high priority design work for Task 1.3 (Design Engineering) has allowed significant progress on Task 1.5.2 to be made during this quarter. The Process Economics Study - Outline was updated, and is included in Appendix C. The four-part outline addresses several needs for this Task 1.5.2 Commercialization Study:

- a) to provide process design guidance for commercial plant designs.
  - b) to meet the Cooperative Agreement's technical objectives requirement for comparison with Gas Phase Methanol technology. This preliminary assessment will help set demonstration operating goals, and identify the important market opportunities for the Liquid Phase technology.
  - c) to provide input to the Demonstration Test Plan (Task 2.3).
  - d) to provide input to the Off-site Testing (Task 1.4) fuel-use test plan update.
- Part One of the Process Economics Study - Outline, "Coproduction of Methanol", has been completed, and is being distributed, for review and comment, as a draft Topical Report. This Topical Report develops plant design options for the LPMEOH™ process, as an add-on to IGCC power plants for the coproduction of methanol and power. Part One also compares the LPMEOH™ (LP) process with gas phase (GP) methanol process. Surprisingly, the LP technology can coproduce methanol at less than 50 cents per gallon, even at relatively small (400 to 1200 TPD) methanol plant sizes. LP's advantage over GP is 6 to 9 cents per gallon. Therefore, when baseload IGCC power is viable, the LP technology makes coproduction viable.
  - The Demonstration Test Plan (Task 2.3) has been updated to include all the important commercial aspects that were identified by this study.
  - Part Four of the Outline - "Methanol Fuel Applications", is being used as the basis to update the fuel-use test plan (see Task 1.4).
  - Part Two of the Outline - "Baseload Power and Methanol Coproduction", will be developed during the next quarter, for incorporation into the paper, "Fuel and Power Coproduction". This paper will be prepared for presentation at the DOE's Fifth Annual Clean Coal Technology Conference in January of 1997.

### ***Task 1.5.3 DME Design Verification Testing***

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Perform initial Design Verification Testing (DVT) for the production of dimethyl ether (DME) as a mixed coproduct with methanol. This activity includes laboratory R&D and market economic studies.

### Discussion

The first Design Verification Testing decision milestone, on whether to continue with DME DVT, is targeted for 1 December 1996. DVT is required to provide additional data for engineering design and demonstration decision-making. The essential steps required for decision-making are: a) confirm catalyst activity and stability in the laboratory, b) develop engineering data in the laboratory, and c) confirm market(s), including fuels and chemical

feedstocks. The DME Milestone Plan, showing the DVT work and the decision and implementation timing, is included in Appendix D.

Action during this quarter included Market Economic Studies and Laboratory R&D.

### *Market Economic Studies*

Work on the feasibility study for the coproduction of DME and electric power continued. The product DME would be used as a domestic liquid cooking fuel, to replace imported LPG, for the China and Pacific Rim regions.

The market application of DME for diesel engine transportation fuels is promising, either directly as DME, or indirectly by conversion to liquid additives to the diesel fuel pool. DME is an ultra clean (high Cetane) diesel fuel; and an 80% DME mixture with methanol and water is now being tested by others. A blend of oxygenated compounds derived from DME chemistry is being studied under the DOE's (DOE Contract No. DE-FC22-95PC93052) Liquid Fuels Program. The concept of adding a blend of oxygenated compounds to diesel fuel in order to enhance Cetane value and cold start properties is being investigated.

### *Laboratory R&D*

Synthesis of DME concurrently with methanol in the same reactor was viewed as a way of overcoming the synthesis gas conversion limitations imposed by equilibrium in the LPMEOH™ process. Higher synthesis gas conversion would provide improved design flexibility for the coproduction of electric power and liquid fuels from an IGCC facility. The liquid phase DME (LPDME) process concept seemed ideally suited for the slurry-based liquid phase technology, since the second reaction (methanol to DME) could be accomplished by adding a second catalyst with dehydration activity to the methanol-producing reactor. Initial research work determined that two catalysts, a methanol catalyst and an alumina-based dehydration catalyst, could be physically mixed in different proportions to control the yield of DME and of methanol in the mixed product. Proof-of-concept runs, in the laboratory and at the Alternative Fuels Development Unit (AFDU), confirmed that a higher synthesis gas conversion could be obtained when a mixture of DME and methanol is produced in the liquid phase reactor.

Subsequent catalyst activity maintenance experiments have shown the catalyst system utilized in the proof-of concept runs experienced relatively fast deactivation compared to the LPMEOH™ process catalyst system. Further studies of the LPDME catalyst deactivation phenomenon were therefore initially undertaken under DOE Contract No. DE-FC22-95PC93052, and are being continued under Task 1.5.3. This LPDME catalyst deactivation research has determined that an interaction between the methanol catalyst and the dehydration catalyst is the cause of the loss of activity. Parallel research efforts--a) to determine the nature of the interaction; and b) to test new dehydration catalysts--was undertaken. In late 1995, the stability of the LPDME catalyst system was greatly improved, to near that of an LPMEOH™ catalyst system, when a new aluminum-based (AB) dehydration catalyst was developed. This new AB catalyst development showed that modification of the LPDME catalyst system could lead to longer life. During this quarter,

laboratory work concentrated on developing the LPDME catalyst system based on the AB series of catalysts.

#### *Summary of Laboratory Activity and Results*

- Laboratory testing of the dual catalyst system containing the new aluminum-based (AB) dehydration catalyst continued to show promise. The Liquid Phase DME (LPDME) test run using AB series 05 catalyst was stopped after 934 hours on stream. Catalyst activity remained much higher than the standard system. However, the methanol catalyst showed increased deactivation in the latter part of the run. Efforts are being made to understand a) if this is an experimental artifact, b) if not, what the real cause is, and c) if this deactivation pattern holds for catalyst systems containing other AB series dehydration catalysts.
- The performance of the AB dehydration catalysts shows a strong dependence on preparation parameters. Increased washing did not improve performance, while changing calcination temperature improved performance in one of three tests. A systematic study of the preparation variables is underway.
- The methanol catalyst from the LPDME aging test using AB05 has been analyzed. The results show that the accelerated catalyst deactivation is not due to a) the quality of the slurry oil, nor b) caking or crusting of the catalysts caused by the loss of oil. Based on elemental and x-ray diffraction analyses, contamination and sintering of the methanol catalyst were ruled out as possible causes. The problem could be due to the rehydration of the catalyst surface. Modifying the calcination temperature of the catalyst during preparation, with the goal of generating a more rehydration-resistant surface, did not improve the stability of the methanol catalyst.
- The LPDME run using catalyst mix AB06 was continued, but at different conditions. Changing space velocity, or the feed gas composition, showed significant effects on the methanol catalyst deactivation. A correlation is yet to be established.
- Observation that catalyst aging is enhanced using (Texaco-type) syngas as the feed allows the aging experiments to be performed faster so that the long-term aging for catalysts previously tested can be examined. No improvement in catalyst stability using catalyst mix AB01 was obtained. This test demonstrates that the aging observed in previous experiments is real and not an artifact of a single preparation.
- Development and testing of the LPDME catalyst system will be continued, but in the next fiscal year (e.g. - next quarter) under the DOE Contract No. DE-FC22-95PC93052, Alternative Fuels Program. Laboratory work under this Task 1.5.3 will end in fiscal year 1996.

### **Task 1.5.4 Administration and Reporting**

The Continuation Application for Budget Period No 3 was submitted on 2 August 1996. The Project Evaluation Report for Budget Period No. 2 was prepared and submitted with the Continuation Application. A copy of the Continuation Application letter, and of the Project Evaluation Report, are included in Appendix E.

A project review meeting was held on 4 and 5 September 1996 in Kingsport. Attendees from Air Products, Eastman, and DOE participated. The project status was reviewed. The Design and Procurement tasks were essentially complete, and the Construction task was 61% complete at the time of the meeting. The construction site was visited, where the process building steel was now installed. The commissioning and startup plans and schedule were reviewed. The status of the updated fuel-use test plan, of the DME design verification testing, and other matters were also reviewed. The meeting notes, extracts from the meeting handouts, and the meeting agenda are included in Appendix F.

The monthly reports for July, August and September, were submitted. These reports include the Milestone Schedule Status Report, the Project Summary Report, and the Cost Management Report.

The Milestone Schedule Status Report and the Cost Management Report, through the period ending 30 September 1996, are included in Appendix G. These two reports show the current schedule, the percentage completion and the latest cost forecast for each of the Work Breakdown Structure (WBS) tasks. The demonstration unit is scheduled to be mechanically complete at the end of December of 1996. Construction progress photographs, taken on 1 October 1996, are also included in Appendix G. Eighty-one percent (81%) of the \$38 million of funds forecast for the Phase 2 tasks have been expended (as invoiced), as of 30 September 1996.

The schedule, for completion of the major Phase 2 Construction Tasks, has slipped about three weeks. Construction (Task 2.2) is now forecast for completion by 31 December 1996 (originally 2 December 1996). Commissioning activities (Task 2.3) will commence in mid-October of 1996, and will be completed in mid-January of 1997 (originally 23 December 1996). Start-up (Phase 3, Task 1) is forecast to be initiated on 20 January 1997 (originally 27 December 1996), and to be completed by 25 February 1997 (originally 1 February 1997). Methanol Operation (Phase 3, Task 2.1) is now scheduled to start on 17 February 1997 (originally 26 January 1997).

The construction schedule slipped three weeks due to the late completion of the design and fabrication of the process building structural steel. The process building structure for the main reactor is 30-feet wide by 30-feet long and 121-feet tall. It supports the reactor process equipment and piping. The final design of the steel members took longer than anticipated, because the piping loads, imposed by the high temperature process piping, were larger than normal. This added to the sizing of the steel members, and some special order items were required. The sizing and stress analysis of the safety relief valves and vent header piping also took longer than scheduled. The overall impact was a delay in finalizing the process building steel design, its fabrication, and delivery to the site. The overall impact to the

project has been an increase to engineering and construction costs plus a delay to completion of these efforts.

### July 1996 Cost Forecast

The reactor and steel delivery delays were discussed at the DOE Project Review Meeting in June of 1996. From that meeting, an action item was to complete a major cost forecast update in late July, after the remaining major construction uncertainties were resolved. The remaining uncertainties were: a) the reactor was delivered and erected, b) the process building structural steel was delivered to the site, c) the insulation bids were received, and d) the schedule and manpower loading impacts on the Mechanical and the Instrument & Electrical Contractors were resolved.

These uncertainties are now resolved. Unfortunately, the Construction costs could not be brought in under budget to off-set cost growth experienced in Engineering areas. A major cost forecast update of all of the Phase 3 - Operation tasks, as well as of the cost to complete the Kingsport Project Design and Construction Phase tasks, was completed in July. This updated forecast was submitted (on 8 August 1996 as the preliminary Annual Cost Plan for fiscal year (FY) -1997) and used for the estimated project costs submitted with the Continuation Application. The updated cost forecast is also included in the Cost Management Report in Appendix G. In summary, the total Project Cost of \$213.7 million is adequate to complete construction of the facility and operation as defined in the Demonstration Test Plan.

### Discussion of Cost Forecast changes

The updated cost forecast (FY-1997 Cost Plan) is compared to the FY-1995 Cost Plan submitted (in September of 1994) with the Continuation Application for Budget Period No. 2. These two Cost Plans are summarized in the Cost Forecast Summary Table, included at the end of this section. There was no change in the total cost forecast for the Project. However, there were significant variations within the Work Breakdown Structure (WBS) tasks, as shown in the Table, and discussed in the following.

### Non-Kingsport Portion of Project

The costs for the non-Kingsport portion of the Project have been reduced by about \$1.0 million. About half of this reduction reflects costs incurred prior to the site change to Kingsport (prior to Mod 002). The costs for the earlier period now reflect the final audited costs. The other half of the cost reduction reflects the lower off-site testing costs for the updated fuel-use test plan (see Task 1.4).

<b>Cost Forecast Summary Table</b>	<u>FY - 1997</u>	<u>FY - 1995</u>	<u>Change in</u>
(Costs in \$1,000's)	<u>Cost Plan (Prel)</u>	<u>Cost Plan</u>	<u>Forecasted</u>
Task // Date Submitted:	8 Aug. 1996	26 Sept. 1994	<u>Costs</u>
<b>Non-Kingsport Portion of Project:</b>			
1.1 Pre-award & Proj. Def. (Prior to Mod 002):	\$ 16304	\$ 16851	\$ (547)
1.4 Off-site Testing (Plan and Design)	\$ 276	\$ 324	\$ (48)
2.4 Off-site Testing (Construction)	\$ 256	\$ 305	\$ (49)
3.4 Off-site Testing (Operation)	\$ 3451	\$ 3792	\$ (341)
Sub-Total; Non-Kingsport Portion of Project:	\$ 20287	\$ 21272	\$ (985)
<b>Kingsport Portion of Project (Phase 1 &amp; 2):</b>			
1.1 Project Definition	\$ 1051	\$ 1230	\$ (179)
1.2 Permitting	\$ 238	\$ 288	\$ (50)
1.3 Design Engineering	\$ 11335	\$ 8206	\$ +3129
1.5 Planning, Admin. & DME DVT	\$ 2870	\$ 1663	\$ +1207
2.1 Procurement	\$ 9703	\$ 10953	\$ (1250)
2.2 Construction	\$ 11550	\$ 11500	\$ +50
2.3 Training & Commissioning	\$ 1115	\$ 897	\$ +218
2.5 Planning & Admin.	\$ 1015	\$ 681	\$ +334
Sub-Total; Kingsport Phase 1 & 2 Portion:	\$ 38877	\$ 35418	\$ +3459
<b>Kingsport Portion of Phase 3 Operation:</b>			
3.1 Startup	\$ 680	\$ 3435	\$ (2755)
3.2.1 Methanol Operation	\$146485	\$147287	\$ (802)
3.2.2 DME Design, Mod., Oper. at Kingsport*	\$ 1790	\$ 2340 *	\$ (550)
3.2.3 LPMEOH Dismantlement	\$ 515	\$ 425	\$ +90
3.3 On-Site Testing	\$ 4	\$ 4	\$ 0
3.5 Data Analysis & Reports	\$ 2670	\$ 1926	\$ +744
3.6 Planning & Admin. & DME at LaPorte**	\$ 2392 **	\$ 1593	\$ +799
Sub-Total; Phase 3 (Operation at Kingsport)	\$ 154536	\$ 157010	\$ (2474)
Total Project Cost Forecast	\$ 213700	\$ 213700	\$ 0

Notes: \* The FY-95 Plan inadvertently included the LaPorte DME test run in Task 3.2.2 (\$860K). This should, per the Statement of Work, have been included in Task 3.6.

\*\* The FY-97 Plan includes the LaPorte DME test run in Task 3.6 (\$875K).

Kingsport Portion of Project (Phase 1 & 2)

Summary: The Kingsport Portion of the Project (Phase 1 & 2) for Design and Construction has a cost growth of \$3.5 million, or about 10%. The cost growth is due to the higher Engineering and Administration costs for Tasks 1.3, 1.5, and 2.5, and is partly off-set by the lower Procurement (Task 2.1) costs.

The Project Definition (Task 1.1) and Permitting (Task 1.2) tasks are now complete. These costs are reduced by about \$0.2 million. The reduction in Tasks 1.1 and 1.2 at Kingsport reflect the good cooperation of the three (DOE/Eastman/Air Products) participants in defining the scope and the management basis for the Project at Kingsport, and the early completion of these Budget Period No. 1 tasks.

The Design Engineering (Task 1.3), and the Planning, Administration, & DME-DVT (Tasks 1.5 and 2.5) tasks are about completed. The cost forecast for these tasks was increased by about \$2.0 million in the December of 1995 Cost Management Report, was up \$0.4 million in March of 1996; and an additional \$0.7 million in the June of 1996 Cost Management Reports. The overall Engineering and Administration cost increase reflects the following:

a) The impact of the unexpected 3 to 4-month delay in transitioning from Budget Period No. 1 to Budget Period No. 2. The project team was kept together during the transition approval period, in order to not lose momentum, and to try and hold the schedule for start-up in December of 1996. Some initial process design work was accomplished during this transition period, but the delay in initiating Procurement (Task 2.1) necessarily delayed the availability of the engineering details of the process equipment needed to initiate the foundation and structural engineering design. This required extra engineering design revision, as the final equipment design details differed from the preliminary designs incorporated in the construction bid packages.

The overall schedule anticipated by the FY-95 Schedule Plan was 25 months overall (Budget Period No. 2 approval in December of 1994, and Methanol Operation in December of 1996). The schedule as currently forecast is 23 months overall (approval in March of 1995, Methanol Operation forecast for February of 1997). Spending extra engineering effort up front did improve the overall schedule. Part of that improvement has been lost toward the end of construction, with late design changes and delivery of materials to the site.

b) The detailed engineering design requirements were underestimated in the initial Cost Plan budget. The first-of-a-kind, pioneer plant design effort that was needed to provide the scale-up to commercial size was underestimated. The acquisition of the operational data to support future engineering designs, as better defined in the Environmental Monitoring Plan and in the Demonstration Test Plan (DTP) documents, added an unanticipated engineering effort for the final design.

Procurement (Task 2.1) is now complete. The cost forecast is reduced by about \$1.2 million, reflecting actual expenditures, and commitments. The reduction in the cost forecast reflects the good initial process scope definition (from Task 1.1), and favorable competitive bidding.

There were small, off-setting, changes in the other WBS tasks. The commissioning work (Task 2.3) has been better defined during the DTP development, and some of the work estimated to be in the Start-up (Task 3.1) should have been included in Task 2.3. The Phase 3 cost reflects the lower cost for Start-up (Task 3.1). The Construction costs (Task 2.2) were lower due to favorable bidding on the early construction bid packages, but the late design and procurement deliverables schedule has adversely impacted the later costs.

### Kingsport Portion of Phase 3 Operation

The Kingsport portion of the Phase 3 (Operation) costs are lower by about \$2.5 million, due primarily Eastman's lower syngas costs, and to the better defined Demonstration Test Plan. The start-up (Task 3.1) costs were adjusted to reflect the Demonstration Test Plan, by moving the syngas costs for catalyst reduction and initial shakedown operation, to Task 3.2.1 (Methanol Operation). The reporting and administration cost forecast (Tasks 3.5 and 3.6) was increased slightly, to reflect the higher costs for these tasks as experienced during Phases 1 and 2. Overall, the lower Phase 3 cost have off-set the Phase 1 and 2 cost increases.

### **Task 2.1 Procurement**

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Complete the bidding and procurement for all equipment and Air Products-supplied construction materials.
  - The 230-foot vent stack arrived at the site in August, and will be erected in October. All of the other equipment items have been received, and are installed.
  - The final sections of prefabricated structural steel, for the reactor building and for the catalyst building, were received at the site. The bulk materials (prefab piping, valves, instrumentation, and electrical) have also been received on site.
  - Task 2.1 Procurement was essentially completed during this quarter.

### **Task 2.2 Construction**

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Provide construction management for contractor coordination and compliance with design, construction, and quality control standards.
  - Air Products construction site manager, lead electrical superintendent, lead mechanical superintendent, clerk, and secretary are now overseeing the construction activities at the site. Construction activities are at a peak.

- Erect the major equipment and structural steel. Install the large bore piping, electrical, and insulation such that instrument checkout and equipment commissioning work can be completed during the 60-day Continuation Application approval period.
  - The reactor was off loaded and erected into position on 2 July 1996. The reactor was passivated in place in August. The erection of the process building structural steel for all areas was essentially completed during this quarter. Minor punch list work remains. The Mechanical Contractor has 21 large bore piping spools (out of 640) left to install. Installation of small bore piping is 65% complete. Pressure testing of some of the piping circuits should begin by mid-October.
  - The Instrument and Electrical (I&E) Contractor is completing work in the areas west of the main process building. This area will be ready for Instrument Loop Checking by mid-October. The Honeywell distributed control system (DCS) cabinets were installed in the DCS room. Installation of cable trays and wiring is continuing in the reactor and distillation areas of the facility. Overall, the I&E work is 52% complete.
  - The Insulation and Fireproofing Contractor began work in early September, insulating equipment items. Work on piping insulation will begin in late October.
  - The last two construction contracts are out for bid, and will be awarded in October. These two small contracts are for Final Grading and Paving, and for Painting.
- Complete mechanical construction so that checkout and commissioning can be started in Budget Period No. 3.
  - Overall, Construction is 72% complete as of the end of September of 1996. The targeted completion date has slipped about three weeks, to 31 December 1996. Commissioning activities are scheduled to start in mid-October, and should be complete by mid-January. Startup activities are scheduled to begin 20 January 1997. Methanol operation is scheduled to start in February of 1997.

### ***Task 2.3 Training and Commissioning***

The Project Evaluation Plan for Budget Period No. 2 establishes the following goals for this task:

- Prepare a four-year test plan for Phase 3, Task 2 - Operation.
  - Comments received on the (May of 1996) draft Demonstration Test Plan (DTP) were incorporated into a revised final draft, which was released for review in July of 1996. The (July of 1996) final draft DTP was approved on 3 September 1996 for issue as final. The final DTP was distributed on 27 September 1996. The DOE approval letter, and a summary (Table 5-1) of the four-year schedule and test plan are included in Appendix H.

- Prepare the operating manual and initiate the operator training program.
- Operator training is scheduled for four one-week sessions, from 28 October through 22 November, 1996. The operating manuals are being prepared.

The main commissioning effort, instrument loop checking and commissioning of equipment by area, will begin in mid-October. Commissioning of the steam and utility systems will be in January of 1997. The Commissioning and Startup Schedule is included in Appendix I.

#### ***Task 2.4 Off-Site Testing (Procurement and Construction)***

The Project Evaluation Plan for Budget Period No. 2 establishes the following goal for this task:

- Prepare the final off-site product-use test plan.
- The off-site product-use test plan update is being reported under Task 1.4 Off-Site Testing (Definition and Design).

#### ***Task 2.5 Planning and Administration***

The Project Evaluation Plan for Budget Period No. 2 establishes the following goals for this task:

- Prepare annually an updated (Partnership) plan for the remaining activities. The first annual plan will update the remaining Phase 1 and Phase 2 activities, and the second will include an updated Phase 3 Demonstration Test Plan.
- The first update of the Partnership Annual Operating Plan was prepared and submitted in September of 1995 (see Quarterly Technical Progress Report No. 5). The main goal and objective for this first annual plan is to continue construction so that the LPMEOH<sup>TM</sup> demonstration unit will be ready for commissioning and start-up in 1996; and to complete the Project Evaluation Report for Budget Period No. 2 and submit it to the DOE along with the Continuation Application for Budget Period No. 3.
- The second update of the Partnership Annual Operating Plan was being prepared during this quarter, and will be submitted in October of 1996.
- Submit all Project status, milestone schedule, and cost management reports as required by the Cooperative Agreement.
- The DOE reporting tasks are being performed and reported under Task 1.5.4 (Administration and Reporting).

### E. Planned Activities for the Next Quarter

- Complete the erection of the vent stack, and installation of piping and instrumentation.
- Complete operator training.
- Initiate commissioning of the equipment, by area of the facility.
- Make a recommendation on whether to continue with DME design verification testing.
- Initiate contacts for off-site fuel-use test planning (Acurex and Air Products).
- Issue the first draft of the Process Economics Study as a Topical Report.
- Issue the second update of the Partnership's Annual Operating Plan.
- Modify the Cooperative Agreement, authorizing the transition to Budget Period No. 3.
- Submit the final version of the "Fuel and Power Coproduction" paper for the 5th Annual Clean Coal Technology Conference.
- Hold a Project Review/Update Meeting at the construction site in December.

### F. Summary

The Continuation Application was submitted on 2 August 1996, requesting authorization to transition from Budget Period No. 2 (Design and Construction) to the final Budget Period (Commissioning, Startup, and Operation). The Project Evaluation Report for Budget Period No. 2 was prepared. A recommendation for approval is being prepared and reviewed by the DOE.

A draft Topical Report on Process Economics Studies was being prepared. This shows that methanol coproduction, with IGCC electric power utilizing the LPMEOH™ process technology, will be competitive in serving local market needs. The results will also be incorporated into a paper "Fuel and Power Coproduction", being prepared for presentation at the DOE's 5th Annual Clean Coal Technology Conference.

A decision on whether to continue with DME design verification testing is to be made, by the participants, in December of 1996. The laboratory R & D results are confirming that the new LPDME catalyst system will have reasonable long-term activity and stability. The market application of DME is promising, for example as diesel engine transportation fuels, either directly as DME, or indirectly by conversion to liquid additives for the diesel fuel pool. A recommendation to continue with DME design verification testing is likely.

The off-site product testing plan is to be updated by May of 1997. During this quarter, Air Products and Acurex were developing a list of contacts for product methanol fuel-use testing. Prospective Federal, State, and University product test participants, involved in fuel cell, transportation, and stationary power plant developments, are being included.

A project review meeting was held in Kingsport in early September. The vent stack was at the site, and all of the other equipment was installed. The construction and operation

permits have been obtained. The operator training, commissioning, startup, and initial operation plans were reviewed.

An updated cost forecast shows \$38 million for the Kingsport portion of the LPMEOH™ Process Demonstration Project for the Phase 1 and 2 tasks. This is up about 10% from the Budget Period No. 2 Cost Plan. The increase is off-set by lower actual costs for the Project pre-award work, and by lower projected costs for Phase 3 Operation. The total Project cost remains the same at \$213.7 million.

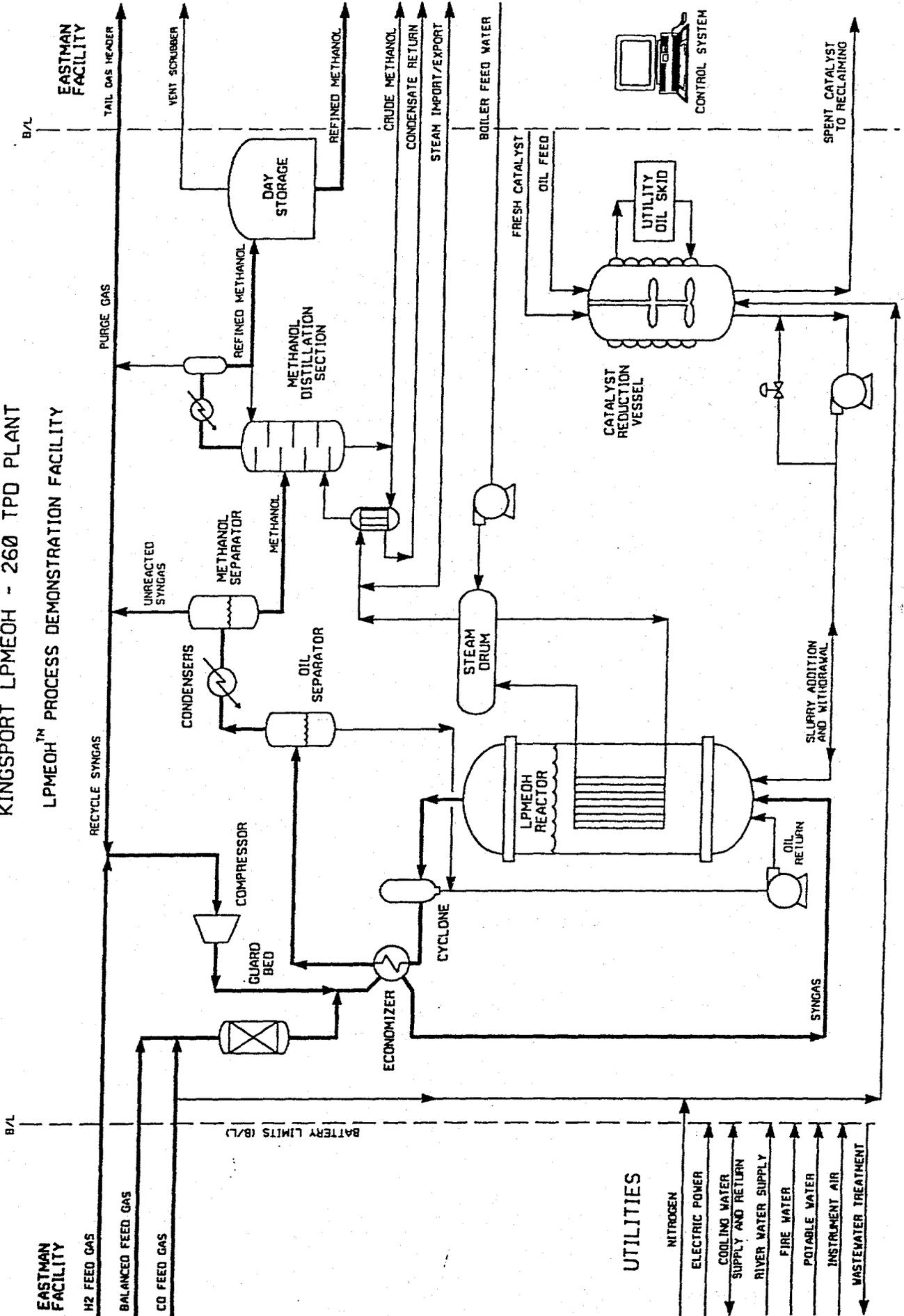
Construction (Task 2.2) is 72% complete, as of the end of September of 1996. The targeted completion date has slipped by about three weeks, to 31 December 1996. Commissioning activities (Task 2.3) will start in mid-October of 1996, and should be completed in mid-January of 1997. Startup, of the utility systems, is scheduled to begin in late January.

Eighty-one percent (81%) of the \$38 million of funds forecast for the Kingsport portion of the LPMEOH™ Process Demonstration Project for the Phase 1 and Phase 2 tasks have been expended (as invoiced), as of 30 September 1996.

**APPENDICES**

**APPENDIX A - SIMPLIFIED PROCESS FLOW DIAGRAM**

**SIMPLIFIED PROCESS DIAGRAM  
KINGSPORT LPMEOH - 260 TPD PLANT  
LPMEOH™ PROCESS DEMONSTRATION FACILITY**



**APPENDIX B - PROJECT EVALUATION PLAN FOR BUDGET PERIOD NO. 2**

COMMERCIAL-SCALE DEMONSTRATION  
OF THE  
LIQUID PHASE METHANOL (LPMEOH™) PROCESS  
COOPERATIVE AGREEMENT  
NO. DE-FC22-92PC90543

**PROJECT EVALUATION PLAN FOR BUDGET PERIOD NO. 2**

The work to be performed during Budget Period No. 2 consists of Phase 1 Design and Phase 2 Construction of the LPMEOH™ Process Demonstration Facility at Eastman Chemical Company's integrated coal gasification facility located in Kingsport, TN. Completion of these Budget Period No. 2 activities will essentially ready the LPMEOH™ Process Demonstration Facility for commissioning, startup, and operation to begin in the final Budget Period No. 3. The Statement of Work for the Project subdivides these Phase 1 and Phase 2 activities into Tasks. This Project Evaluation Plan for Budget Period No. 2 will meet the following criteria aligned by the Statement of Work tasks:

**1. Phase 1 - Task 2 - Permitting**

- Issue the final Environmental Information Volume to support the U.S. Department of Energy's (DOE's) Environmental Assessment/Finding of No Significant Impact.
- Obtain permits necessary for construction and operation.

**2. Phase 1 - Task 3 - Design Engineering**

- Complete the design engineering necessary for construction and commissioning. This includes Piping and Instrumentation Diagrams, Design Hazard Reviews, and conducting design reviews.
- Prepare the Environmental Monitoring Plan.

**3. Phase 1- Task 4 - Off-site Testing (Definition and Design)**

- Prepare the fuel-use demonstration plan for Phase III, Task 4 Off-site Product Use Demonstration. This off-site test plan will be incorporated into the overall product-use test plan (in Phase 1, Task 5).

**4. Phase 1 - Task 5 - Planning, Administration and DME Verification Testing**

- Update the (fuel and chemical) product-use test plan, that will better meet the technical objectives of the Project and serve the needs of commercial markets.
- Complete economic studies of the important commercial aspects of the LPMEOH™ Process to enhance Integrated Gasification Combined Cycle (IGCC) electric power generation. These studies will be performed by Air Products and Chemicals, Inc. and the Electric Power Research Institute, and used to provide input to the LPMEOH™ Process Demonstration Facility operating test plan (Phase 2, Task 5).
- Perform initial Design Verification Testing for the production of dimethyl ether (DME) as a mixed coproduct with methanol. This activity includes laboratory R&D and market economic studies.
- Submit all Project status, milestone schedule, and cost management reports as required by the Cooperative Agreement.

**5. Phase 2 - Task 1 - Procurement**

- Complete the bidding and procurement for all equipment and Air Products supplied construction materials.

## 6. Phase 2 - Task 2- Construction

- Complete mechanical construction so that checkout and commissioning can be started in Budget Period No. 3.
- Erect the major equipment and structural steel. Install the large bore piping, electrical, and insulation such that instrument checkout and equipment commissioning work can be completed during the 60-day Continuation Application approval period.
- Provide construction management for contractor coordination and compliance with design, construction, and quality control standards.

## 7. Phase 2 - Task 3 - Training and Commissioning

- Prepare a four (4)-year test plan for Phase 3, Task 2-Operation.
- Prepare the operating manual and initiate the operator training program.

## 8. Phase 2 - Task 4 - Off-Site Testing (Procurement and Construction)

- Prepare the final off-site product-use test plan.

## 9. Phase 2 - Task 5 - Planning and Administration

- Prepare annually an updated plan for the remaining activities. The first annual plan will update the remaining Phase I and Phase II tasks. The second annual plan will include an updated Phase III Operating Plan, identifying specific goals and milestones for the first twelve months of operation, and a general plan for the remaining years to achieve the Project's market penetration objectives.
- Submit all Project status, milestone schedule, and cost management reports as required by the Cooperative Agreement.

Completion of the above work activities will essentially ready the LPMEOH™ Process Demonstration Facility for commissioning, startup, and operation to begin in the final Budget Period No. 3. These criteria will be the basis of the Project Evaluation Report which shall be submitted to the DOE for approval along with the Project Continuation Application, at least 60 days before the end of Budget Period No. 2. Construction of the Facility will be essentially completed during the 60-day approval period for the Continuation Application.

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At the time that the Project Evaluation Report for Budget Period No. 2 is submitted with the Continuation Application; Air Products will also prepare an update on the expected technical and economic performance of the mature unit. This update will demonstrate the commercial potential of the LPMEOH™ process technology to enhance IGCC electric power generation with coproduct methanol. This IGCC enhancement is expected to reduce the cost of electricity for retrofit, repowering, replacement, and new applications for electric power generation from coal.

WRB/jjs/Proeva.

**APPENDIX C - TASK 1.5.2 - PROCESS ECONOMICS STUDY - OUTLINE  
(Draft - four pages)**

**including**

**Part Four - Methanol Fuel Applications  
(for Task 1.4 - Off-site Testing Plan)**

# Process Economics Study - Outline

## LPMEOH™ Process, as an add-on to IGCC for Coproduction

### Part One - Coproduction of Methanol

#### 1. Introduction

##### 1.1. Process Design Options.

- Develop process flow diagram and plant design options for the LPMEOH™ process, for design variables such as: a) feed gas pressure, b) feed gas compositions, and c) % syngas conversion.

#### 2. Liquid Phase (LP) Methanol Advantage versus Gas Phase (GP) Methanol.

##### 2.1. Syngas Conversion Cost for Methanol Production from CO-Rich syngas.

- For the various LPMEOH™ process (LP) design options (from 1.1) develop plant capital and conversion costs derived from the Kingsport Project costs and design basis. Develop conversion costs for:
  - 500 t/d Plant size, with 500 psi feed gas pressure;
  - 500 t/d Plant size, with 1000 psi feed gas pressure
  - Impact of Plant Size on Conversion Costs
- Summarize in a series of graphs, conversion costs, in cents per gallon over the range of syngas conversion from 18% (LP - Once-through) to 94% (GP), for baseload annual coproduction operation. This will show LP's advantage at higher feed pressures and lower conversions; and will highlight areas for LP design development/demonstration improvements. *(For future: include plant size impact on product distribution (freight) cost, assuming that local markets are served. Freight cost will increase with plant size, as the distribution radius increases.)*

##### 2.2. Methanol Product Purification Cost.

- Develop capital and operating costs for these product purification design alternatives:
  - MTBE Grade;
  - Fuel Grade;
  - Chem. Grade;

Over a range of feed gas compositions, summarize LP's advantage versus the GP process (in cents per gallon), especially for MTBE and Fuel Grade from CO-rich feed gas at low syngas conversions.

##### 2.3. Feedgas (Syngas) Composition Variations: (Impact on LP vs. GP).

- Higher Sulfur content in the feedgas will have a negative cost impact on LP at low syngas conversion, relative to GP at high conversions. Conversely, higher feedgas inert content will have a negative relative cost impact on GP.
  - Sulfur content variation; over the above range of syngas conversion
  - Inert gas content variation; over the above range of syngas conversion

##### 2.4. Syngas Usage (Btu per Gallon) - Impact on IGCC Power Plant.

- Summarize differences in syngas utilization (Btu per gallon of methanol), and in mass flow loss/gain to the combustion turbine (kwh production loss/gain per gallon of methanol); for the cases in 2.1 above.

# Process Economics Study - Outline

## LPMEOH™ Process, as an add-on to IGCC for Coproduction

### 2.5. Summary of Cost Advantage(s) - (LP Vs GP).

- Summarize the cost impact (cents per gallon) of the above design variables and syngas utilization differences. Show the impact of methanol plant size on the conversion costs. Also (separately show) the impact of 90% and 70% annual load utilization for use with Section 4. - "Intermediate Load Coproduction and Stored Energy" of this Economics Study.

### 2.6. Recommendations for Further Study.

- Recommend areas for process design value engineering work; and areas for demonstration at Kingsport.

## Part Two - Baseload Power and Methanol Coproduction

### 3. Baseload Coproduction with Methanol Sales - Impact on Electric Power Cost -

For baseload coproduction, the gasifier must be sized for both the power and methanol products. The results of Part One indicate the LP technology can make coproduction economic, even at small methanol plant sizes (400 to 1200 TPD) suitable to serve local markets near the power plant.. The LP technology's advantage (over GP) is also greatest at the lower (up to 34%) Syngas Conversions which are consistent with these methanol plant sizes. A matrix of power plant and methanol plant sizes of interest, at up to 34% Syngas Conversion to methanol, is shown in the following tables. These examples are based on Advanced Gas Turbine Technology (*reference (G.E.'s) published paper*) with the base gasification plant sized for two gasifiers, of about  $1525 \times 10^6$  Btu(HHV)/hr. output each.

#### 3.1 Gasification Plant Size Fixed

- With a given gasification plant size, the methanol plant and power plant can be sized to accommodate a range of Methanol to Power output ratio's.

Syngas Conversion	Power Plant Size	Methanol Plant Size	Methanol to Power Ratio	Gasification Plant Size
0 %	500 MW	0 T/D	0 T/D per MW	Base
20%	400 MW	651 T/D	1.6 T/D per MW	Base
33%	333 MW	1086 T/D	3.3 T/D per MW	Base

#### 3.2 Power Plant Size Fixed

- With a given power plant size, the gasifier size may be increased to accommodate the coproduction of methanol. For Gasification Plant size increases of up to 50% (to say, three x  $1525 \times 10^6$  Btu(HHV)/hr. gasifiers), the methanol to power coproduction ratio's could be:

Syngas Conversion	Power Plant Size	Methanol Plant Size	Methanol to Power Ratio	Gasification Plant Size
0.0 %	500 MW	0 T/D	0 T/D per MW	1.00 x Base
16.7 %	500 MW	651 T/D	1.3 T/D per MW	1.20 x Base
25.0 %	500 MW	1086 T/D	2.2 T/D per MW	1.33 x Base
33.3 %	500 MW	1629 T/D	3.3 T/D per MW	1.50 x Base

- The impact of coproduction on electricity generation costs will be shown in graphs of electricity cost Vs. methanol net back price.

### End of Part Two.

# Process Economics Study - Outline

## LPMEOH™ Process, as an add-on to IGCC for Coproduction

### Part Three - Coproduction for Intermediate Electric Load Following.

#### 4. Intermediate Load Coproduction and Stored Energy.

##### 4.1. Syngas Value.

###### 4.1.1 Syngas value as a function of (time of day) Power Value.

Our earlier load following work indicates that an LPM coproduction add-on optimizes for intermediate peak-load power in the 1000 to 2500 hr./yr. range. This means the methanol plant operates during "off-peak" power in the 7760 (88% utilization) to 6260 (71% utilization) hr./yr. range (8760 hr./yr. = 100% = total hr./yr.), with up to 200 annual daily stop/start operations for the daily on/off peaks.

- *Time of day example: A given Lambda Curve might provide data at 2000 and 1500 peak hr./yr. such as: a) 3.4 cent off-peak power (6760 hr.) plus 7.8 cent intermediate-peak power (2000 hr.) equals 4.4 cent baseload power (8760 hr.). b) 3.5 cent off-peak (7260 hr.) plus 8.6 cents intermediate-peak power (1500 hr.) equals 3.6 cent baseload power (8760 hr.). Time of day syngas values can be derived, based on the alternative value of using syngas for power (in CC or CT power plants).*

###### 4.1.2. Syngas value as function of seasonal opportunity fuels/feeds.

- *Natural gas may be available seasonally, for use in the CC power plant, allowing syngas to be used for conversion in an LPM add-on. Other feeds?*

#### 4.2. Intermediate Load Coproduction - for Methanol Sales.

- For all intermediate load coproduction cases, redundant investment to utilize syngas on/off-peak is required; so that when the methanol plant shuts down during peak power periods, all of the syngas can be converted to electric power. There are many intermediate load coproduction power plant design choices; a) CC power plant turned down, or b) baseload CC power plant with CC or CT power plant(s) for peak; which may be combined with c) many methanol plant choices such as size/% conversion/and on-off operating hours. To do these studies properly, we need to have good time of day power values (also called Lambda Curves) as well as the Section 2. (above) Methanol Plant design choices completed.

#### 4.3. Intermediate Load Stored Energy Production, with Methanol Fuel for Peak Power Production.

- The design optimization for this is quite complex. The IGCC/OTM plant design has an additional variable: the peaking power plant size and hours of operation is an independent variable. We may be able to use a specific ( - - ) study with a published paper as a goal. An alternative study option is to compare ourselves (IGCC/OTM) to the various published EPRI (IG-Cash, et. al.) studies, which provide Lambda Curve examples for energy storage.

When other back up fuels are not available, or are too expensive, then methanol may also be used to enhance power plant availability. Coproduction with multiple gasifier trains may also be used to enhance power plant availability. (e.g. - Three by 50%, where Baseload Power = 2 x 50%; Peaking Power = 1x 50% plus methanol fuel; Methanol Plant = 1 x 50%, but operates only when all three gasifiers are operating and peak power is not required.)

#### 4.4. Intermediate Load Stored Energy Production, with Methanol for Dispersed Energy.

- Methanol transported to remote existing or new power plants on the Utilities grid system.

### End of Part Three.

# Process Economics Study - Outline

## LPMEOH™ Process, as an add-on to IGCC for Coproduction

### Part Four - Methanol Fuel Applications

#### 5. Premium Methanol Fuel Applications

- At 46 cents per gallon, methanol as a fuel (\$6.90 per mmBtu) will not compete with oil in most applications (\$20/bbl crude = \$3.30/mmBtu; \$24/bbl diesel = \$4.00/mmBtu). However, methanol coproduced at a central IGCC power station, may be a valuable premium fuel for two evolving developments: as an economical Hydrogen source for small fuel cells, and as an environmentally advantaged fuel for dispersed electric power.
  - "Central clean coal technology processing plants, making coproducts of electricity and methanol; to meet the needs of local communities for dispersed power and transportation fuel" - meets the DOE Clean Coal Technology Program's objectives. Serving (initially) small local fuel markets also builds on LP's (the LPMEOH™ process) strengths; good economics at small methanol plant sizes, fuel grade product distillation savings, and a freight advantage in local markets vis a vis large off-shore remote gas methanol. Baseload methanol coproduction studies show that 46 cent per gallon methanol can be provided from an abundant, non-inflationary local fuel source.. *We need to show when (at what oil price) we can compete, and to arrange fuel tests to confirm the dispersed energy environmental advantage.*
- 5.1. Hydrogen Source for
- Hydrogen fuel cells, being developed for transportation applications, can achieve 65% system efficiency, as compared to 45% for diesel IC engines and 32% for gasoline IC engines. Methanol is a storable, transportable liquid fuel which can be reformed under mild conditions to provide H<sub>2</sub>. For small H<sub>2</sub> applications, *and at low utilization factors*, methanol reforming is a more economical source of hydrogen than : a) natural gas reforming, b) distillate (oil) reforming; and is cheaper than LH<sub>2</sub>.
- 5.1.1. Fuel Cells for Transportation
- 5.1.2. Fuel Cells for Stationary Power  
(See also dispersed power below).
- 5.1.3. Industrial Applications - Small Hydrogen Plants  
Small pressurized methanol reformers for transportation applications may be suitable for adapting to meet the needs of small commercial hydrogen gas requirements.

#### 5.2. Dispersed Power

- Dispersed power is getting a lot of favorable publicity. . The world wide package (0.2 MW to 10 MW) power plant market is large. A variety of technologies (combustion turbine, internal combustion engine, fuel cell) are being packaged to provide power and heat locally, at the use point. Environmental and Economic advantages include Methanol for Fuel Cells = clean stationary local power; no need for natural gas pipelines; no new high voltage power lines.

#### 5.3. *Dimethyl Ether as an Enhancement to Methanol in Premium Fuel Applications*

*Can coproduced mixtures of methanol and dimethyl ether improve upon methanol, in the above?*

### End of Part Four.

**APPENDIX D - TASK 1.5.3 - DME MILESTONE PLAN**

## TABLE 5-2

### DME MILESTONE PLAN

#### 1. Design Verification Testing:

- A. Laboratory R&D, Verification
  - 1. Catalyst Activity and Stability Testing, and Engineering Data Mar. '95 - Aug. '96
- B. Market Verification
  - 1. Up to 3 wt% DME, as M-100 Diesel Replacement Engine Tests - (SCAQMID) - and Market Acceptance Study by Jan. '96  
\*\* Completed \*\*
  - 2. Up to 8 wt% DME for GCC Energy Storage by Aug. '96
    - a. Re-review economics
  - 3. About 80 wt% DME with Methanol, as a Diesel Replacement Fuel, or as Chemical Feedstock at Kingsport by Aug. '96
    - a. Economics, process basis study
- C. Decision to Continue or Drop Demonstration by Dec. '96

#### 2. Process Development Unit Design Verification Test (Provisional):

- A. LaPorte AFDU Tests by Sep. '97
- B. Decision to Continue or Drop Demonstration by Mar. '98

#### 3. Implementation (Provisional) Plan:

- A. Design, Procurement, and Construction at Kingsport, of Add-on Equipment, and Operation Start July '98 to Jan. '01

**APPENDIX E - TASK 1.5.4 - CONTINUATION APPLICATION  
(2 August 1996 Letter)**

**and**

**PROJECT EVALUATION REPORT - FOR BUDGET PERIOD NO. 2  
(1 August 1996)**

W. R. Brown

Air Products Liquid Phase Conversion Company, L. P.  
7201 Hamilton Boulevard  
Allentown, PA 18195-1501  
Telephone (610) 481-7584



August 2, 1996

Mr. Robert M. Kornosky  
PETC Technical Project Manager  
CT-10, Mail Stop 920-L  
U.S. Department of Energy/PETC  
P. O. Box 10940  
Pittsburgh, PA 15236

Subject: DOE Cooperative Agreement No. DE-FC22-92PC90543  
Liquid Phase Methanol Demonstration Project  
Continuation Application for Final Budget Period

Dear Bob:

As required by Article VIII, paragraph B of the subject agreement, the Participant - Air Products Liquid Phase Conversion Company, L.P. (the Partnership) - requests that the U.S. Department of Energy (DOE) obligate funds and provide approval to proceed to the final Budget Period No. 3.

Justification

The Project Evaluation Report for Budget Period No. 2 provides the justification upon which this Continuation Application request is being made. During Budget Period No. 2, the Partnership subcontractors, Air Products and Chemicals, Inc. (Air Products) and Eastman Chemical Company (Eastman) have essentially completed the Phase 1 Design and Phase 2 Construction activities of the Liquid Phase Methanol (LPMEOH™) Process Demonstration Facility at Eastman's integrated coal gasification facility located in Kingsport, TN. Completion of these Budget Period No. 2 activities meets the Project Evaluation Plan's criteria: to have essentially readied the LPMEOH™ Process Demonstration Facility for commissioning, startup and operation to begin in the final Budget Period No. 3.

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The following exhibits support this request:

- \*The Project Evaluation Report for Budget Period No. 2.
- \*The updated Project Management Plan, Cost Plan, and Milestone Schedule.
- \*The Environmental Monitoring Plan
- \*The Demonstration Test Plan
- \*The Statement of Work and the Statement of Joint Objectives (both are unchanged).

The Project Evaluation Report for Budget Period No. 2, the updated Cost Plan, the updated Milestone Schedule, and the Notice of Energy RD & D Project are enclosed. The updated Project Management Plan will be submitted shortly. Additional supporting information, including the update on the technology's commercial potential, is being prepared. The Partnership, Air Products and Eastman appreciate the need to work with you to provide any additional information to satisfy your requirements to approve this Continuation Application for the LPMEOH™ Demonstration Project.

#### Budget Period No. 3 - Activities, Costs and Schedule

The Statement of Work clearly outlines the tasks and goals for the final Budget Period's Phase 3 - Operation. The primary technical objective of the Project is to demonstrate the commercial scale production of methanol using the LPMEOH™ Process. Through a four (4)-year operating period, the commercial feasibility of the Process technology for expected commercial use with clean coal technology integrated coal gasification combined cycle (IGCC) electric power plants for both repowering and new applications will be demonstrated. The Demonstration Test Plan and the Environmental Monitoring Plan describe the overall test program goals, the strategies for achieving these goals, and the sequencing of individual tests. These two complementary plans provide for the monitoring and reporting of the engineering, the operational, the environmental and the safety data base necessary for successful commercialization. Air Products, as subcontractor to the Partnership, will supply technical and engineering support to direct the operation testing program. Eastman, as subcontractor to Air Products, will be responsible for operating the LPMEOH™ Process Demonstration Facility and will supply the synthesis gas and necessary services to operate the LPMEOH™ Process Demonstration Facility.

For this Continuation Application, the Participant requests that the DOE obligate the remaining \$67,138,458 of the Government cost-share funds. The total estimated project

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cost of \$213,700,000, and the Government's total cost share of \$92,708,370, are unchanged. The Budget Period No. 3 dates are unchanged; starting October 1, 1996 and ending December 31, 2001. Phase 3 - Operation is projected to start January, 1997.

#### Project Success - Interim Report Card

Before starting the Design and Construction Phases of the Project, the three participants, (DOE/Air Products/Eastman) prepared a "Success Factors" poster (copy attached), so that all those who would work on the Project could remain focused on the essentials for success. Now that we are at the end of the Design and Construction Phases, and about to embark on the Operations Phase, an interim report card against the "Success Factors" provides these judgments:

- The relationships between the three participants are excellent. There is one team at work on this project, and we are all pitching together to meet the common goals.
- The Demonstration Test Plan and the updated Cost Plan for the Operations Phase give us confidence that we can perform the operating tests needed to successfully demonstrate the technology, in a safe and environmentally sound manner, within the budget and schedule expectations.
- The ultimate Project success will be: obtaining industry acceptance and commercializing the technology. Our economic studies confirm the commercial potential of the LPMEOH™ process technology to enhance IGCC electric power generation with coproduct methanol. The CCT Programs other demonstration projects of IGCC will confirm and enhance the commercial prospects. Air Products is very excited about realizing this potential.

The participants are eager to get on with Phase 3 - Operation, where the Projects true success can be demonstrated. We are anxious to proceed, and determined to make this Project a success. We look forward to continuing our team's work.

Sincerely,

*Bill*

William R. Brown  
DOE/CCT Program Manager  
LPMEOH™ Demonstration Project

Air Products Liquid Phase Conversion Company, L. P.  
7201 Hamilton Boulevard  
Allentown, PA 18195-1501  
Telephone (610) 481-7584



cc: D. P. Drown - Air Products  
B. J. Halper - Air Products  
W. Jones - Air Products  
W. C. Jones - Eastman Chemical  
W. R. Mundorf - DOE/PETC



DOE/Air Products/Eastman  
SUCCESS FACTORS  
LPMEOH™ DEMONSTRATION PROJECT



The three participants will judge the project success on the following factors:

- SAFE AND ENVIRONMENTALLY SOUND OPERATION
- DEMONSTRATE THE NEW TECHNOLOGY:
  - RESOLVE ALL TECHNICAL ISSUES
  - ACQUIRE SUFFICIENT ENGINEERING DATA FOR COMMERCIAL DESIGNS
  - OBTAIN INDUSTRY ACCEPTANCE
- FOR EASTMAN OPERATION AT KINGSPORT:
  - NO ADVERSE IMPACT DURING DEMONSTRATION
  - VALUABLE PLANT ASSET AT END
- MEET BUDGET AND SCHEDULE EXPECTATIONS
- POSITIVE WORKING RELATIONSHIPS BETWEEN THE PARTICIPANTS

Bob Kowesky

Bill Brown

Bill Jones



COMMERCIAL SCALE DEMONSTRATION  
OF THE  
LIQUID PHASE METHANOL (LPMEOH™) PROCESS

COOPERATIVE AGREEMENT  
NO. DE-FC22-92PC90543

PROJECT EVALUATION REPORT - FOR BUDGET PERIOD NO. 2

(1 August 1996)

This report will provide a "concise detailed description of the current status of the project." It will detail the extent to which each of the items in the Project Evaluation Plan for Budget Period No. 2 (PEP) have been completed.

The work to be performed during Budget Period No. 2 consists of Phase 1 Design and Phase 2 Construction of the LPMEOH™ Process Demonstration Facility at Eastman Chemical Company's integrated coal gasification facility located in Kingsport, TN. Completion of these Budget Period No. 2 activities will essentially ready the LPMEOH™ Process Demonstration Facility for commissioning, startup, and operation to begin in the final Budget Period No. 3.

The Statement of Work for the Project subdivides these Phase 1 and Phase 2 activities into Tasks. This Project Evaluation Report for Budget Period No. 2 will align the Project Evaluation Plan criteria into: A) those Tasks to essentially ready the LPMEOH™ Process Demonstration Facility for commissioning, startup and operation; and B) Planning and Administration Tasks. (The PEP criteria are shown in italics, and current status report is shown non-italicized):

## A. Tasks to Ready the Facility

### *PEP #1. Phase 1 - Task 2 - Permitting*

- *Issue the final Environmental Information Volume to support the U. S. Department of Energy's (DOE's) Environmental Assessment/Finding of No Significant Impact.*

The NEPA review was completed 30 June 1995 with the issuance of a Finding of No Significant Impact (FONSI). The final EIV draft was submitted, comments received and the final EIV to support the FONSI will be issued in August.

- *Obtain permits necessary for construction and operation.*

The construction permits and the operation permits have been obtained.

### *PEP #2. Phase 1 - Task 3 - Design Engineering*

- *Complete the design engineering necessary for construction and commissioning. This includes Piping and Instrumentation Diagrams, Design Hazard Reviews, and conducting design reviews.*

The Piping and Instrumentation Diagrams, Design Hazard Reviews, and the design reviews are completed. Design engineering is 99% complete. The remaining work is to issue the final two construction bid packages: for Painting and for Final Grading & Paving, and complete the pipe loop drawings for checkout and commissioning. This work will be completed by the end of August.

- *Prepare the Environmental Monitoring Plan.*

The Environmental Monitoring Plan (EMP) has been prepared. The initial draft was submitted in October 1995, and subsequent reviews and updates have resulted in an agreed upon final plan. The final EMP will be issued in August for DOE review and approval.

Because of the complementary nature of the EMP and the Demonstration Test Plan, the same simplified consolidated flow sheets showing the sampling locations, are used in both documents. The two complementary plans provide for the monitoring and reporting of the engineering, the operational, the environmental and the safety data base necessary for successful commercialization. The EMP describes the monitoring to obtain the

environmental and health data base and experience necessary to meet the LPMEOH™ Process commercialization objectives. The environmental impacts of operating the LPMEOH™ process demonstration unit, (including the impact of process stream upset conditions), are identified and the analytical methods, and the frequency of measurements are included in the EMP.

*PEP #5. Phase 2 - Task 1 - Procurement*

- *Complete the bidding and procurement for all equipment and Air Products supplied construction materials.*

The bidding and procurement for all equipment and Air Products-supplied construction materials is complete. All of the equipment (except the C-120 Vent Scrubber) is at the construction site. The construction materials (steel, pre-fabricated large-bore piping) are arriving in a timely manner to meet the final construction schedule.

*PEP #6. Phase 2 - Task 2 - Construction*

- *Provide construction management for contractor coordination and compliance with design, construction, and quality control standards.*

Air Products' has provided an on-site construction management team; consisting of a construction site manager, a clerk, a secretary, and lead superintendents as necessary to manage compliance and coordinate the contractors work. This team is supported by a home office (Allentown) construction team.

- *Erect the major equipment and structural steel. Install the large bore piping, electrical, and insulation such that instrument checkout and equipment commissioning work can be completed during the 60-day Continuation Application approval period.*

The major piece of equipment, the reactor, was erected on July 2, 1996. The process building steel, in the reactor area, is now being erected. All of the equipment has been installed, with the exception of items to be located on the elevated floors of the process building. The piperack steel is complete. Completion of the final instrumentation and electrical work is forecast for December. Commissioning work (Physical checkout of the plant, instrument loop checks) is expected to start in October; will progress by areas, and be completed in January. Functional turnover of the Facility to operations is anticipated for early January.

- *Complete mechanical construction so that checkout and commissioning can be started in Budget Period No. 3.*

The forecast for the mechanical completion is mid-December, when the instrumentation and electrical work is completed. Checkout and commissioning will start in October and be completed in January; allowing for Phase 3, Task 1 startup in January, 1997.

#### *PEP #7. Phase 2 - Task 3 - Training and Commissioning*

- *Prepare a four (4)-year test plan for Phase 3, Task 2-Operation.*

The final draft test plan (Demonstration Test Plan) was submitted July 8, 1996, for review and approval.

The goals of the Test Plan are structured to meet the commercialization objectives for the LPMEOH™ Process. The Test Plan describes the overall test program goals, the strategies for achieving these goals, and the sequencing of individual tests. The plan provides a detail discussion of test matrices, procedures for sampling and analysis, and data manipulation methods. The demonstration tests will provide the data base and experience necessary for the detailed design, operation, control and maintenance of large-scale commercial plants for coproduction at Integrated Gasification Combined cycle power plant complexes. The Test Plan is consistent with the Statement of Work and with the technical objectives of the Project.

- *Prepare the operating manual and initiate the operator training program.*

The operator training program is being prepared, and operator training classes will start in late October. The Standard Operating Procedure (manual) is being prepared and should be finished by late August.

*Completion of the above work activities will essentially ready the LPMEOH™ Process Demonstration Facility for commissioning, startup, and operation to begin in the final Budget Period No. 3.*

## B. Planning and Administration Tasks

### *PEP #3. Phase 1 - Task 4 - Off-site Testing (Definition and Design)*

- *Prepare the fuel-use demonstration plan for Phase III, Task 4 Off-site Product Use Demonstration. This off-site test plan will be incorporated into the overall product-use test plan (in Phase 1, Task 5).*

The methanol Fuel-use and Product-use testing document has been prepared. Completion of the Demonstration Test Plan (PEP #7 - Phase 2, Task 3) shows that typical as produced methanol for testing will not be available until May 1998. The testing document identifies two premium methanol fuel applications which will be targeted for fuel-use testing: a) as a hydrogen source for fuel cells, for both transportation and stationary power; and b) for dispersed electric power applications.

Discussions are underway (for example - with the DOE's Energy Efficiency programs in Fuel Cells and Alternative Fuels) and specific test plans will be developed with appropriate milestones for testing in 1998 to 2000.

### *PEP #8. Phase 2 - Task 4 - Off-site Testing (Procurement and Construction)*

- *Prepare the final off-site product-use test plan.*

The final (detailed) off-site product use test plan to meet testing from May 1998 through 2000, will not be required until late in 1997. The final detailed test plan will be submitted for approval prior to that time.

### *PEP #4. Phase 1 - Task 5 - Planning, Administration and DME Verification Testing; and PEP #9 Phase 2 - Task 5 - Planning and Administration*

- *Prepare annually an updated plan for the remaining activities. The first annual plan will update the remaining Phase I and Phase II tasks. The second annual plan will include an updated Phase III Operating Plan, identifying specific goals and milestones for the first twelve months of operation, and a general plan for the remaining years to achieve the Project's market penetration objectives.*

The first update of the Partnership Annual Operating Plan was prepared and submitted in September 1995. The second annual plan update is being developed, and will be submitted on schedule in September 1996. The second annual update will be based on the January 1997 startup and the Demonstration Test Plan schedule, and will be consistent with the cost plan and milestone schedule submitted with the Continuation Application

- *Update the (fuel and chemical) product-use test plan, that will better meet the technical objectives of the Project and serve the needs of commercial markets.*

Eastman will perform fitness-for-use tests on the methanol product for use as a chemical feedstock and provide a summary of the results. The on-site product use test schedule establishes completion of these tests prior to October 1997. (The off-site product-use test plans are discussed in PEP #3 and #8, above).

- *Complete economic studies of the important commercial aspects of the LPMEOH™ Process to enhance Integrated Gasification Combined Cycle (IGCC) electric power generation. These studies will be performed by Air Products and Chemicals, Inc., and the Electric Power Research Institute, and used to provide input to the LPMEOH™ Process Demonstration Facility operating test plan (Phase 2, Task 5).*

Part One - "Coproduction" of the Process Economics Study has been outlined and a draft is being reviewed. The economic studies include commercialization issues, which are to be addressed in the final Project report; such as the technical objective for comparison with conventional Gas Phase Methanol technology. A final draft of Part One will be issued in August. Input was provided, and used in preparing the final operating test plan. This study will be used to prepare an update on the commercial potential of the LPMEOH™ process technology.

- *Perform initial Design Verification Testing for the production of dimethyl ether (DME) as a mixed coproduct with methanol. This activity includes laboratory R&D and market economic studies.*

The initial Design Verification Testing for the production of dimethyl ether (DME) as a mixed coproduct with methanol is being performed. Laboratory testing of the dual catalyst system containing a new aluminum based (AB) dehydration catalyst is promising. The LPDME run using AB series 05 was stopped after 934 hours on stream. Catalyst activity remained much higher than the standard system. However, the

methanol catalyst showed increased deactivation in the latter part of the run. Efforts are being made to understand a) if this is an experiment artifact, b) if not, what the real cause is, and c) dehydration catalysts. The performance of the AB dehydration catalysts shows a strong dependence on preparation parameters. A systematic study of the catalyst preparation variables is underway.

The project milestone schedule continues to show the first decision point, on whether to continue with DME DVT, is targeted for December 1996.

- *Submit all Project status, milestone schedule, and cost management reports as required by the Cooperative Agreement.*

The monthly (the Milestone Schedule Status Report, the Project Summary Report, the Cost Management Report) reports have been issued and are up to date.

The quarterly Technical Progress Report status is:

- #3 and #4 are done final.
- #5, 6, and 7 - have been submitted for review.
- #8 is due 15 August, #9 is due 15 November
- #1 and #2 - are being revised final.

Topical Report No. 1 (Peroxide Formation) is being revised for final issue.

The Project Management Plan is being updated, and will be submitted by mid-August.

The final Technical Report - Outline is due 30 September.

**APPENDIX F - TASK 1.5.4 - PROJECT REVIEW MEETING  
(4 & 5 September 1996)**

NOTES FROM MEETING

DISTRIBUTION (NAME/ORGANIZATION) *Unable to attend. **Chairman		COPIED FOR INFORMATION ONLY	
Bill Brown* - APCI	Barry Street - EMN	Frank Frenduto - APCI	
Bob Kornosky* - DOE	Dave Drown* - APCI	Dan Canning - APCI	
Bill O'Dowd - DOE	Laurie Paulonis* - EMN	Barry Halper - APCI (FYI)	
Ed Heydorn - APCI	Doug Archer - DOE	Sue Kasinecz - APCI	
Van Eric Stein - APCI	Bob Moore - APCI	Bernie Toseland - APCI	
		William C. Jones - EMN	
* with attachments			

FROM William R. Brown	ORGANIZATION APCI - Program Manager	EXTENSION X7584	TODAY'S DATE 12 September, 1996
--------------------------	----------------------------------------	--------------------	------------------------------------

DATE OF MEETING	WEEKDAY	TIME		LOCATION
Sept. 4 & 5, 1996	Wednesday Thursday	STARTED 12:15 PM	ENDED 11:30 AM	Eastman (EMN), Kingsport

SUBJECT AND/OR PURPOSE  
**Project Review Meeting with DOE, Eastman, and Air Products**

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
1	DPD	9/30/96	<p><u>Design Procurement and Construction - Status</u></p> <p>The Project Status, for design procurement and construction was reviewed, per Attachments: 1 (seven pages) and 2 (two pages). The transition date for turnover of the facility from Construction to Operations, is Dec 20.</p> <p><u>Action:</u> Provide a write-up on the Phase 1 and 2 cost changes, by Task, from the original plan.</p>
2			<p><u>Commissioning Training &amp; Start-up Schedule and Plans</u></p> <p>These were reviewed per Attachment 3 (three pages). The main commissioning effort, on instrument loop checking and commissioning of equipment by area, will begin in mid-October. Operator training will be held in four by one-week sessions, from October 28th through November 22nd. The transition date for turnover of the facility, from Construction to Operations, is Dec 20, 1996. The final prestart-up safety review is scheduled for Jan. 7th and 8th, and Phase 3, Task 1 start-up for Jan. 13th with Carbonyl Burnout, the plant operational, Test 1 "Shakedown", is scheduled for six weeks starting on Feb 07, 1997.</p>

NOTES FROM MEETING  
CONTINUATION

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
3	DPD		<p><u>Action:</u> For the next issue of the Commissioning and Start-up Schedule, include the Demonstration Test Plan's Test 1 - "Shakedown" (six weeks, commencing Feb 07), as the first line item under Task 2.1 Operation.</p> <p><u>Phase 3, Task 2 - Operation - Plans</u></p> <p>The plans and goals for the first year were reviewed. The first 16 months of Operation provides for Task 2.1.1 Plant Shakedown, and Catalyst Addition and Aging. Specific tests with fresh catalyst, and while catalyst is aging, will also be performed. These include determining the maximum slurry level, high space velocity and high inlet velocity tests, achieving free draining slurry return, and determining maximum catalyst loading.</p>
4	ECH	9/30/96	<p><u>Action:</u> Set up a milestone schedule plan, for use in monthly reports during the first 12 months of operation.</p> <p><u>DOE Reporting Requirements</u></p> <p>The B.P. No. 2 reporting log (Attachment 4 - seven pages) was reviewed. Action:</p>
	WRB	9/30	<ul style="list-style-type: none"> <li>The final Quarterly Technical Progress Reports will be completed by 9/30/96.</li> </ul>
	DPD	12/96	<ul style="list-style-type: none"> <li>A fifth "Topical Report" on recommendations for future Reactor Design and Fabrication, will be prepared as an unpublished document.</li> </ul>
	ECH/FSF	9/30/96	<ul style="list-style-type: none"> <li>The final DTP, EIV and EMP are to be distributed.</li> </ul>
	WRB	10/15	<ul style="list-style-type: none"> <li>The Final Technical Report Outline is to be prepared.</li> </ul>
	WRB	10/15	<ul style="list-style-type: none"> <li>The AIChE conference (Mar 97) paper should be added to the reporting log.</li> </ul>
	WRB	9/30/96	<ul style="list-style-type: none"> <li>The updated PMP is to be issued.</li> </ul>

NOTES FROM MEETING  
CONTINUATION

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
5	RBM	9/30/96	<ul style="list-style-type: none"> <li>• First draft of Part One of the Process Economics Study (the overall Outline is in Attachment 5), is to be issued.</li> </ul>
	BAT	11/15/96	<ul style="list-style-type: none"> <li>• Draft Topical Report on Syngas Testing is to be issued; including an appendix with the Process Engineering report on the earlier tests.</li> </ul> <p><u>Other Phase 1, Task 5 Subtasks</u></p> <p>a) <u>Fuel Use Demo Plan</u></p> <ul style="list-style-type: none"> <li>• The updated plan is now targeted for April of 1997. The actual fuel-use testing will be conducted from May of 1998 through January of 2000.</li> <li>• The fuel-use test plan will be developed to meet the initial LPMEOH™ process commercialization needs. The initial needs are for central clean coal technology processing plants, making coproducts of electricity and methanol, to meet the needs of local community. One of the advantages of the LPMEOH™ process is that the as-produced, stabilized (degassed) methanol product may be suitable for many applications. Production cost savings of several (4 to 6) cents per gallon can be achieved, if the suitability of the stabilized methanol product can be demonstrated. One application, as a feedstock for MTBE production, can be confirmed by laboratory tests. Other premium methanol fuel applications; as a hydrogen source for fuel cells and for dispersed power, will require testing of the product to confirm its suitability. Attachment 5 (page 4 of the Process Economics Study-Outline) summarizes these premium fuel applications. The updated plan will utilize DOE's Office of Energy Efficiency and Renewable Energy program in these areas.</li> <li>• Many methanol applications require Chemical Grade product (Formaldehyde for glue for plywood; and Acetyls are the largest) off-site product testing will not be required. The Eastman application for Acetyls at Kingsport will confirm that the distillation of LPMEOH™ product is adequate.</li> </ul> <p>b) <u>DME Demo Plan</u></p>

NOTES FROM MEETING  
CONTINUATION

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
6	<p>BAT, et al</p> <p>WRB</p> <p>ALL</p>	<p>11/11/96</p> <p>11/11/96</p> <p>12/4/96</p>	<ul style="list-style-type: none"> <li>The first Design Verification Testing decision milestone to proceed with testing of the LaPorte AFDU is December, 1996.</li> </ul> <p><u>Action:</u> The draft Topical Report on DME (Lab and Market) is to be issued.</p> <p>A recommendation (probable) to proceed with testing in late FY-97 at the LaPorte AFDU will be issued. The testing at LaPorte would be in conjunction with the DOE's Alt. Fuels program.</p> <p>A decision on the recommendation will be made, by the participants, at the next Project Review meeting.</p> <ul style="list-style-type: none"> <li>The laboratory R &amp; D results are confirming the new LPDME catalyst system. The market application of DME for diesel engine transportation fuels is promising, either directly as DME, or indirectly by conversion to liquid additives to the diesel fuel pool.</li> </ul> <p>The recommendation for approval of the Continuation Application is being reviewed at PETC. A draft of the recommendation is <sup>was</sup> to be submitted to HQ on August 30, 1996; PETC expects to formally submit the recommendation for approval to HQ by September 9, 1996. HQ approval (through 4 levels) by the ASFE is required.</p>
7			<p>The next meeting will be held Tues &amp; Weds, Dec 3rd &amp; 4th at the LPMEOH™ facility in Kingsport. The agenda will include the normal review of status and plans for the various Tasks; and will, also, include the DME - DVT milestone decision.</p>

**KINGSPORT LPMEOH DEMONSTRATION PROJECT**  
**SEPTEMBER 4, 1996 STATUS OVERVIEW**

for DOE ✓

9/4/96 DPO's  
revised lunch

**DESIGN**

DETAIL DESIGN ESSENTIALLY COMPLETE  
PAINTING CONSTRUCTION PACKAGE TO ISSUE IN SEPTEMBER

**PROCUREMENT**

C-120 VENT STACK PIECES ON SITE  
99% OF PREFAB PIPE ON SITE  
LAST OF PROCESS BUILDING STRUCTURAL STEEL ON SITE BY 9/06/96

**CONSTRUCTION**

61% COMPLETE OVERALL ON CONSTRUCTION  
CATALYST BUILDING STRUCTURAL STEEL BEING COMPLETED  
PIPING & ELECTRICAL WORK STARTED IN REACTOR STRUCTURE

**COST FORECAST**

\$39.3MM INCLUDING EMN & G&A FOR PHASE 1 & 2 (POST MOD 3)

**SCHEDULE**

PLANT MECHANICALLY COMPLETE IN LATE DECEMBER  
BEGIN CARBONYL BURNOUT MID-JANUARY







# LPMEOH DEMONSTRATION PROJECT

## PHASE 1&2 CURRENT SPENDING THRU <sup>7</sup>4/30/96 POST MOD 003

<u>Phase 1</u>	<u>Contract Value. \$M*</u>	<u>Current Forecast</u>	<u>Spent to Date. \$M**</u>	<u>% Spent</u>
1.1.1 Project Definition	1021	1044	1044	100
1.1.2 Permitting	246	298	237	80
1.1.3 Design Engineering	9960	10,593	9509	90
1.1.4 Off-site Testing	320	267	12	4
1.1.5 Planning, Admin., & DME DVT	<u>1892</u>	<u>2738</u>	<u>2486</u>	<u>91</u>
Subtotal:	13,439	14,942 ✓	13,288	89
<u>Phase 2</u>				
1.2.1 Procurement	9783	9,446	8,461	90
1.2.2 Construction	11,200	12,467	4,314	35
1.2.3 Training and Commissioning	1197	1110	1	0
1.2.4 Off-site Testing	261	256	0	0
1.2.5 Planning and Admin.	<u>681</u>	<u>1,113</u>	<u>349</u>	<u>31</u>
Subtotal:	23,122	24,390	13,125	54
Total:	36,561	39,332	26,413	67

\*From 10/01/95 Cost Plan

\*\*Actual spending and not committed.

*\* Thru July 31<sup>st</sup>*

# KINGSPORT LPMEOH PROJECT

## REACTOR INFORMATION

### TIME AND MONEY

<u>Phase</u>	<u>Time, Weeks</u>	<u>Cost, \$M</u>
Rev. P. PFD → Process Spec	15	?
Mechanical Spec	11	75
Bid → Award	10	
Design → Fabricate → Test	84	855
Inspect & Expedite	50	50
Shipping	4	85
Erect	< 1	150
Passivate	< 1	40
Totals	130	1255

### SIZE

	<u>Shell</u>	<u>Internal Heat Exchanger</u>
Dimensions	7-1/2' i.d. x 74'	78- 1-1/2" dia. pipe 2212 sq. ft.
Materials	ss clad over c.s.	duplex 2205
Design Conditions	1000 psig 600° F	640 psig 600° F

### WEIGHT

275M lbs

### FABRICATOR

Detail design & fabrication by Joseph Oat Corporation of Camden, NJ

# KINGSPORT LPMEOH PROJECT

## PLANT SIZE

	<u>LPMEOH</u>
Production, TPD	260
No. Equip. Items	98
Cu. Yds. Concrete	1400
Tons of Structural Steel	315
No. L.B. Pipe Lines $\geq 2\frac{1}{2}$ "	229
No. S. B. Pipe Lines $\leq 2$ "	435
No. Manual Valves	1504
No. Instruments	978
No. PSV's	59
No. P&ID Sheets	67

# LPMEOH DEMONSTRATION PROJECT

## Eastman Process and Services Tie-In Status

---

WRB  
9/4/96  
LP's handout

- Engineering 100% Complete
- Construction 95% Complete
- Overall 98% Complete
- Distributed Control System
  - Database 100 % Complete
  - Logic 50% Complete
  - Graphics 40% Complete
  - Data Acquisition System on Order
  - Data Highway Installed and DCS Cabinets Relocated

Mid October  
Power on, for loop checks

LPMEOH DEMONSTRATION PROJECT  
Eastman Process and Services Tie-in  
Remaining Work

---

- Installation and Field welding of 29C-120
- Order 2 Personnel Computers
- Install Fire Alarm Panel
- Final Tie-in of 4160v Service

# MEETING NOTICE



PLEASE NOTE: Security badges required for visitors in all buildings and employees in R&D buildings.

DISTRIBUTION (NAME/ORGANIZATION) <i>(If unable to attend, contact originator)</i>		COPIED FOR INFORMATION ONLY
William C. Jones - EMN ✓	Barry Street - EMN ✓	Frank Frenduto - APCI
Bill Brown - APCI ✓	Dave Drown - APCI ✓	Dan Canning - APCI
Bob Kornosky - DOE ✓	Laurie Paulonis - EMN ✓	<i>Barry Halper - APCI - (FYI)</i>
Bill O'Dowd - DOE ✓	Doug Archer - DOE ✓	
Ed Heydorn - APCI ✓	Bob Moore - APCI ✓	
Van Eric Stein - APCI ✓	Sue Kasinecz - APCI	

FROM William R. Brown <i>WRB</i>	ORGANIZATION APCI - Program Manager	EXTENSION 17584	TODAY'S DATE 22 August 1996
-------------------------------------	----------------------------------------	--------------------	--------------------------------

DATE OF MEETING Sept. 4 & 5, 1996	WEEKDAY Weds. & Thurs.	TIME FROM TO 12:15 PM 11:30 AM	LOCATION Eastman (EMN), Kingsport
--------------------------------------	---------------------------	--------------------------------------	--------------------------------------

SUBJECT AND/OR PURPOSE  
**• Project Review Meeting with DOE, Eastman, and Air Products**

DESIRED RESULTS/OUTCOMES  
 Review Project status; prepare for Commissioning, Startup and Operation.

REFERENCE MATERIAL/OTHER

**AGENDA                      LPMEOH™ Project Review Meeting Agenda - (Draft 8/18/96)**

- A. Meet and Lunch.      Wednesday - Sept. 4th - About 12:15 PM**  
*(DOE flight arrives at 11:33 AM., they should arrive about 12:15 PM.)*
- B. Status Updates:                      1:30 PM**
  - 1. Design, Procurement, Construction (Schedule/Cost F/C)                      DPD/LBP
- C. Visit Construction Site:      2:30 PM+.**                      All
- D. End of (work) Day                      5:30 PM.**
- Dinner and early to bed (?)
- E. Status Updates (Cont'd.)                      8:30 AM. Thursday - Sept. 5th.**
  - 2. Training, Commissioning & Startup                      ECH/BTS/VES/DPD  
 Plan/Schedule(see Milestone Schedule, attached)/Staffing
  - 3. Phase 3, Task 2 - Operations *12-14 months: Shakedown + Aging. Clarity Level*
    - a. First year plans/goals (DTP), - Engineering Support needs *High Spreadsheets High mtd*                      ECH/BTS
  - 4. DOE Reporting Requirements - *Evolution (100 hours) then last location*
    - a. Due in B.P. No. 2: (EMP, DTP, Quarterlies #5, 6, 7, 8; Topicals)                      WRB/ -
    - b. Phase 3 Reports/Reporting Plan (EMP/DTP basis)                      ECH/VES
  - 5. Other Phase I, Task 5 Tasks - Status
    - a. Fuel-use demo plan      Schedule/Budget for Ph. 3                      WRB
    - b. DME demo plan      Schedule/Budget for Ph. 3                      ECH/WRB
  - 6. Continuation Application for Budget Period No. 3
    - a. Status, support needs, timing.                      RMK/ -
  - 7. Make Plans for: a). Next Project meeting *Dec 3rd 4th T+W 11:45 2:00 ME too. 12:45*                      All
  - b). Other
- F. Depart                      12:30 PM. Thursday - Sept. 5th**  
*Many of the DOE and Air Products participants have return flights departing at 2:03 PM..*

**APPENDIX G - TASK 1.5.4 - MILESTONE SCHEDULE STATUS AND COST  
MANAGEMENT REPORTS**

**and**

**Construction Progress Photographs  
(at 1 October 1996)**

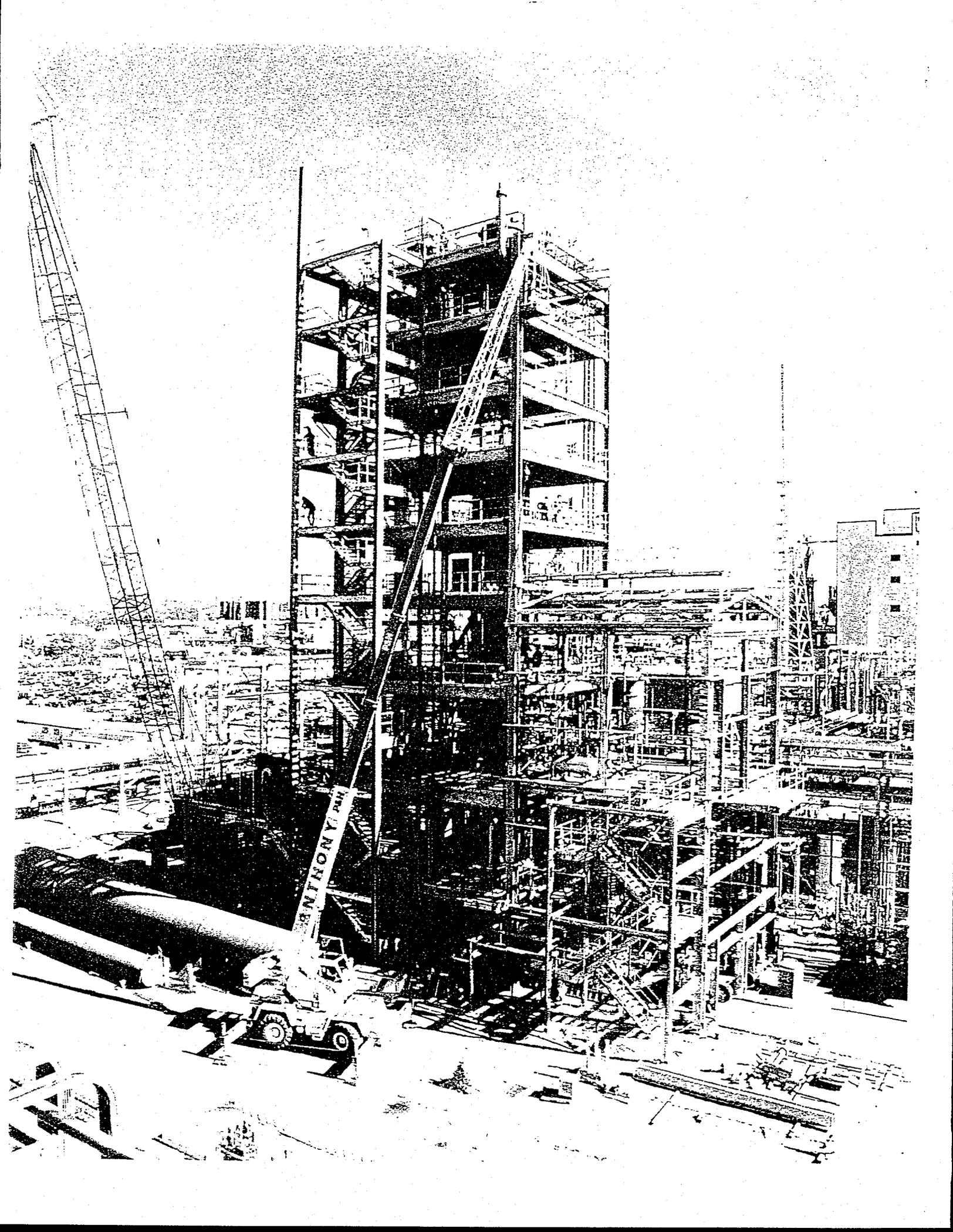
# MILESTONE SCHEDULE STATUS REPORT

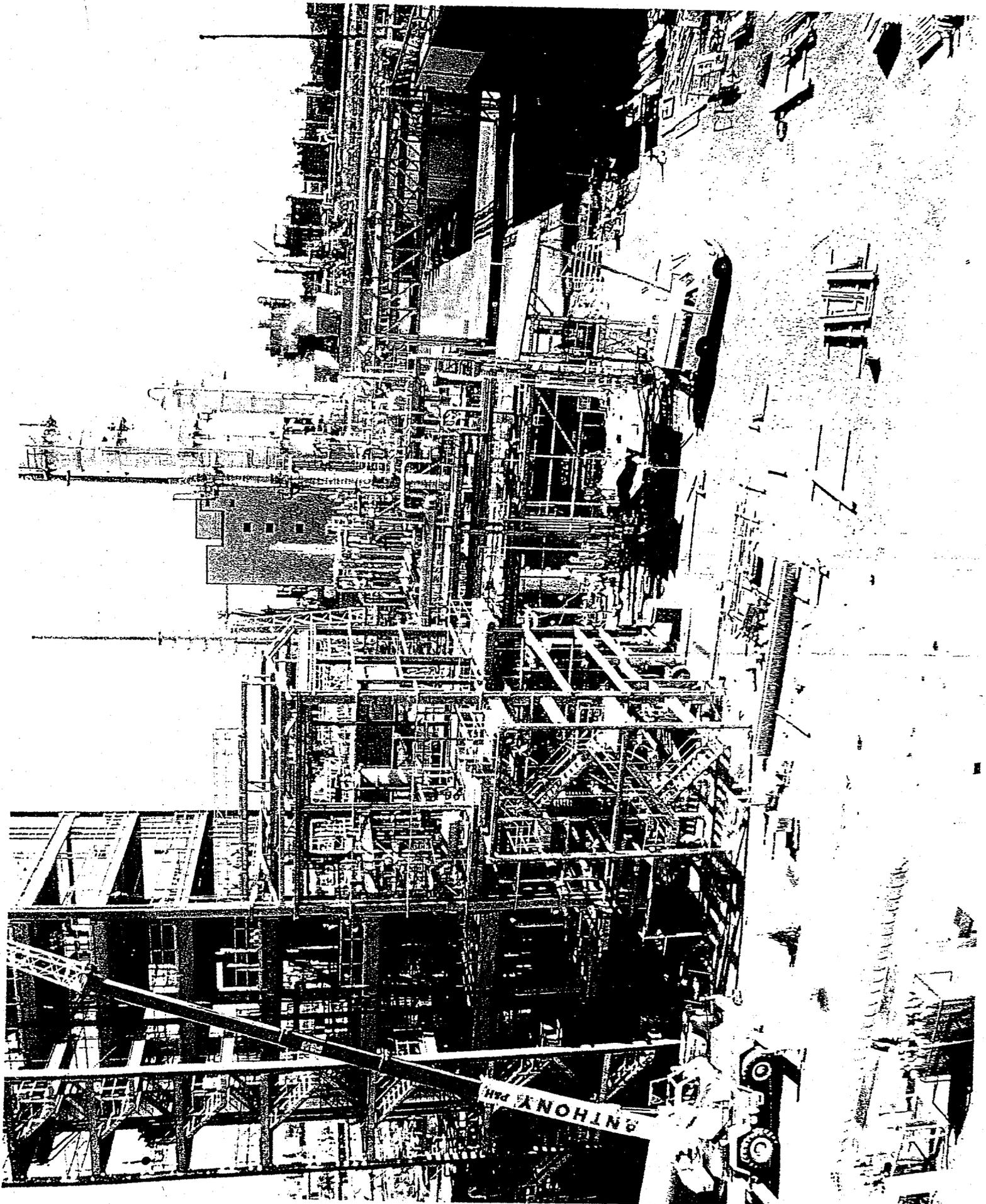
## LIQUID PHASE METHANOL DEMONSTRATION

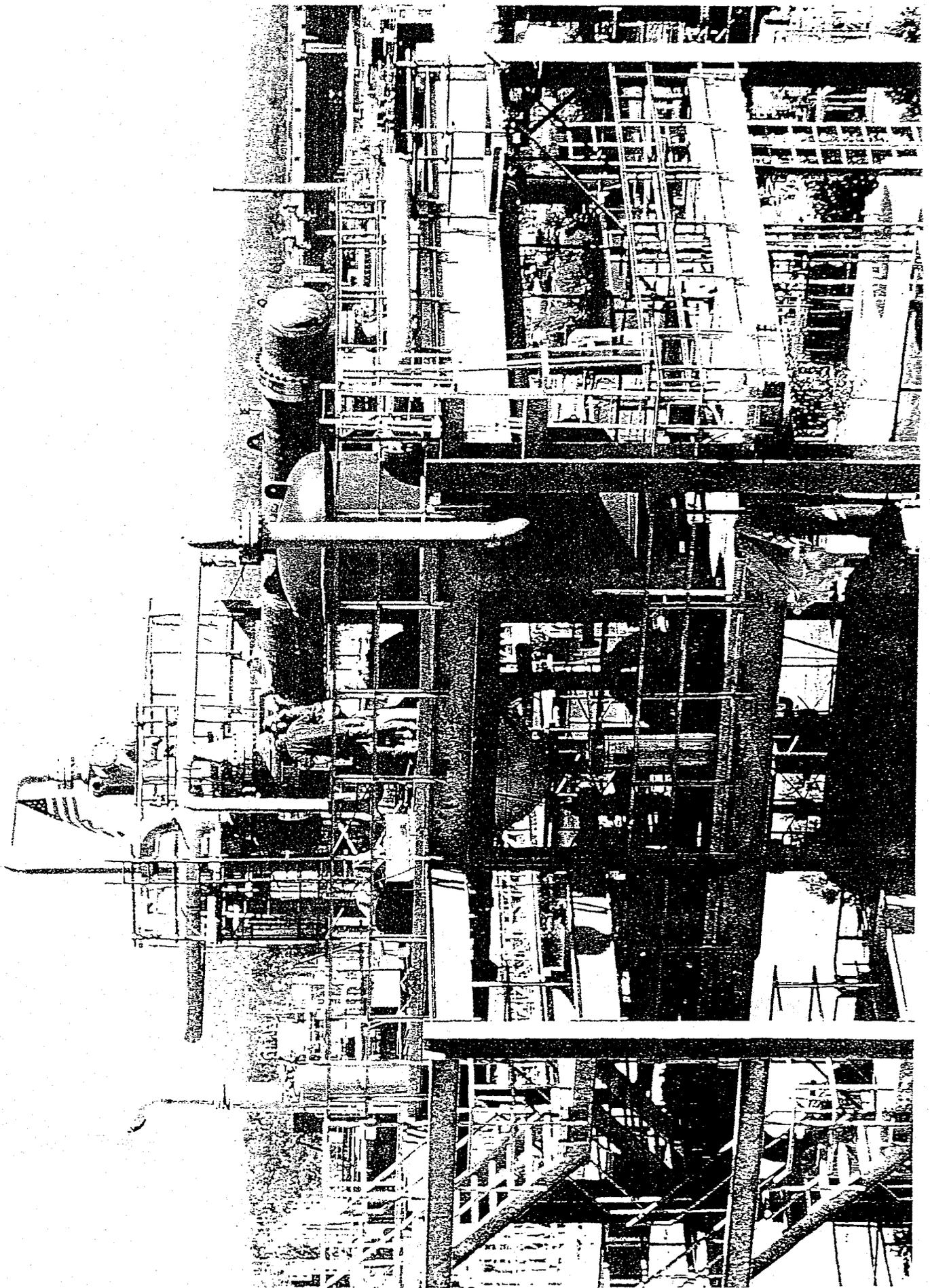
### DE-FC22-92PC90543

Task Name	Duration	Start	End	% Comp	% Sched	Years												
						93	94	95	96	97	98	99	0	1	2			
<b>PHASE 1: DESIGN</b>																		
PROJECT DEFINITION(TASK 1)	51.20 m	Oct/01/93	Dec/30/97	97	88													
CONTINUATION APPLICATION(B.P.#2)	12.04 m	Oct/01/93	Sep/30/94	100	100													
PERMITTING(TASK 2)	9.00 d	Aug/02/94	Aug/10/94	100	100													
NEPA FONSI APPROVAL	33.95 m	Nov/17/93	Sep/10/96	100	100													
DESIGN ENGINEERING(TASK 3)	0.00 d	Jun/30/95	Jun/30/95	100	100													
VENDOR ENGINEERING	27.71 m	Apr/15/94	Aug/01/96	100	100													
OFF-SITE TESTING(TASK 4)	23.79 m	Aug/10/94	Jul/30/96	100	100													
UPDATED FUEL TEST PLAN APPROVAL	46.35 m	Feb/25/94	Dec/30/97	10	65													
DECISION TO CONTINUE DME TESTING	0.00 d	Apr/30/97	Apr/30/97	0	0													
PLANNING, ADMIN & DME DVT(TASK 5)	0.00 d	Dec/05/96	Dec/05/96	0	0													
<b>PHASE 2: CONSTRUCTION</b>																		
PROCUREMENT(TASK 1)	39.16 m	Oct/01/93	Dec/30/96	97	89													
CONSTRUCTION(TASK 2)	42.66 m	Oct/17/94	May/01/98	60	64													
TRAINING & COMMISSIONING(TASK 3)	21.54 m	Oct/17/94	Jul/30/96	100	100													
OFF-SITE TESTING(TASK 4)	15.08 m	Oct/02/95	Dec/31/96	72	78													
PLANNING & ADMINISTRATION(TASK 5)	16.53 m	Sep/05/95	Jan/17/97	35	75													
CONTINUATION APPLICATION(B.P.#3)	9.00 m	Aug/02/97	May/01/98	0	0													
<b>PHASE 3: OPERATION</b>																		
START-UP(TASK 1)	35.17 m	Jun/01/95	May/01/98	65	45													
METHANOL OPERATION(TASK 2.1)	3.20 m	May/31/96	Sep/04/96	100	100													
DISMANTLE PLANT(TASK 2.3)	59.51 m	Jan/20/97	Dec/28/01	0	0													
ON-SITE PRODUCT USE DEMO(TASK 3)	1.22 m	Jan/20/97	Feb/25/97	0	0													
OFF-SITE PRODUCT USE DEMO(TASK 4)	49.00 m	Feb/17/97	Mar/13/01	0	0													
DATA ANALYSIS/REPORTS(TASK 5)	6.96 m	Jun/01/01	Dec/28/01	0	0													
PLANNING & ADMINISTRATIVE(TASK 6)	2.08 m	Aug/01/97	Oct/02/97	0	0													
<b>PROVISIONAL DME IMPLEMENTATION</b>																		
DME DVT(PDU TESTS)(TASK 3.6)	20.00 m	May/15/98	Jan/11/00	0	0													
DECISION TO IMPLEMENT	56.35 m	Jan/20/97	Sep/23/01	0	0													
DESIGN, MODIFY & OPERATE(TASK 3.2.2)	59.51 m	Jan/20/97	Dec/28/01	0	0													
	49.02 m	Apr/01/97	Apr/25/01	0	0													
	9.57 m	Apr/01/97	Jan/15/98	0	0													
	0.00 d	Mar/01/98	Mar/01/98	0	0													
	33.98 m	Jul/01/98	Apr/25/01	0	0													

1. TITLE	2. REPORTING PERIOD		3. IDENTIFICATION NUMBER		4. ESTIMATED ACCRUED COSTS												
	September 01, 1996 through September 30, 1996		DE-FC22-92PC90543		December 31, 2001												
2. PARTICIPANT NAME AND ADDRESS	5. COST PLAN DATE		6. START DATE		7. COMPLETION DATE												
	October 01, 1995		January 1, 1990		December 31, 2001												
8. ELEMENT 9. REPORTING ELEMENT	10. ACCRUED COSTS			11. ESTIMATED ACCRUED COSTS				12. Total Contract Value		13. Variance							
	Reporting Period	Cumulative to Date		a. Subsequent Repub.	b. Balance of Fiscal Year	c. FY 1997 (1)	FY 1998 (2)	FY 1999 (3)	d. Subsequent FYs (4)	Total	Total	Variance					
a. Actual	b. Plan	c. Actual	d. Plan	ing Pubd	Year				(4)	Value	Value						
Prior to Mod 2	0	0	16,304	16,289	0	0	0	0	0	16,304	16,289	15					
1.1.1 Project Definition	0	0	1,051	1,021	0	0	0	0	0	1,051	1,021	30					
1.1.2 Permitting	0	0	238	246	0	0	0	0	0	238	246	(8)					
1.1.3 Design Engr.	229	56	10,034	9,564	0	1,301	0	0	0	11,335	9,960	1,375					
1.1.4 Off-site Testing	0	4	12	74	0	175	89	0	0	276	320	(44)					
1.1.5 Planning, Admin. & DME Verif. Testing	99	42	2,707	1,892	0	163	0	0	0	2,870	1,892	978					
1.2.1 Procurement	482	276	9,220	8,517	0	483	0	0	0	9,703	9,783	(80)					
1.2.2 Construction	1,884	368	7,444	9,413	0	4,106	0	0	0	11,550	11,200	350					
1.2.3 Train. & Commissioning	25	149	117	1,164	0	998	0	0	0	1,115	1,197	(82)					
1.2.4 Off-Site Test - Proc. & Constr.	0	0	0	0	0	120	136	0	0	256	261	(5)					
1.2.5 Planning & Admin	10	46	721	613	0	285	9	0	0	1,015	681	334					
1.3.1 Startup	0	0	0	0	0	680	0	0	0	680	3,435	(2,755)					
1.3.2 Operations	0	0	0	0	0	0	0	0	0	0	0	0					
1.3.2.1 Methanol Operation	0	0	0	0	0	20,321	34,240	38,689	51,235	146,485	147,287	(802)					
1.3.2.2 DME Design, Mod., Oper.	0	0	0	0	0	0	0	0	0	1,790	2,340	(550)					
1.3.2.3 LPMEOH Disinfectant	0	0	0	0	0	0	0	0	0	515	425	90					
1.3.3 On-Site Product Use Demo	0	0	0	0	0	2	2	0	0	4	4	0					
1.3.4 Off-Site Product Use Demo	0	0	0	0	0	0	1,233	1,972	246	3,451	3,840	(389)					
1.3.5 Data Analysis & Reports	0	0	0	0	0	390	520	500	1,260	2,670	1,926	744					
1.3.6 Planning & Admin.	0	0	0	0	0	520	800	280	792	2,392	1,593	799					
14. TOTAL	2,729	941	47,848	48,793	0	29,544	37,029	42,008	57,271	213,700	213,700	0					
15. DOLLARS EXPRESSED IN: Thousands																	
16. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE: <i>[Signature]</i> 10/21/96																	
17. SIGNATURE OF PARTICIPANT'S AUTHORIZED FINANCIAL REPRESENTATIVE AND DATE: <i>[Signature]</i> 10/22/96																	







**APPENDIX H - TASK 2.3 - DEMONSTRATION TEST PLAN**

**(3 September 1996 Approval Letter)**

**and**

**Table 5-1 - Demonstration Test Plan  
(Four Year Summary Table)**



## Department of Energy

Pittsburgh Energy Technology Center  
P.O. Box 10940  
Pittsburgh, Pennsylvania 15236-0940

September 3, 1996

Mr. Edward C. Heydorn  
Air Products and Chemicals, Inc.  
7201 Hamilton Boulevard  
Allentown, PA 18195-1501

Subject: Cooperative Agreement No. DE-FC22-92PC90543  
Draft Final Demonstration Test Plan

Dear Ed:

The Department of Energy (DOE) has reviewed the Draft Final Demonstration Test Plan (July 1996) submitted by Air Products and Chemicals, Inc. and Eastman Chemical Company for the Liquid Phase Methanol Demonstration Project. The Draft Final Demonstration Test Plan (July 1996) has been revised to reflect the comments supplied by DOE and can be issued as final. Please make the appropriate copies and distribute to the relevant parties as required by the Subject Cooperative Agreement.

Sincerely,

A handwritten signature in cursive script that reads "William O'Dowd".

William O'Dowd  
Office of Clean Coal Technology

cc:

W. Brown, Air Products  
W. Jones, Eastman

Test Run #	Test Run Description	Temp (Deg C)	Wt% Cat	H2/CO Ratio at Inlet	Space Velocity (SI/hr-kg)	MeOH (tpd)	Fresh Feed		Recycle Gas (KSCFH)	Inlet Sup. Velocity (ft/sec)	Time Period (weeks)	Elapsed Time (incl. outages) (weeks)	Start of Test
							Balanced (KSCFH)	CO Gas (KSCFH)					
<b>Task 2.1.1 - Process Shakedown and Catalyst Aging:</b>													
1.	Initial Shakedown; and Design Production Tests	250	28	2.42	8,000	260	900	50	40	1,800	6	6	Feb-97
							(varies, to maintain syngas utilization.)						
2.	Gassed Slurry Level	Part of other tests											
3.	Reactor Feed: Texaco-Type Syngas	250	28	0.67	9,240	202	650	95 (*)	0	2,612 (*)	2	9	Mar-97
4.	Early Testing @ High Superficial Velocity	250	28	2.54	10,300	TBD	1,200 (**)	50	40	2,520 (*)	2	12	Apr-97
5.	Check @ Test 1 Conditions	250	28	2.42	8,000	< 260	900	50	40	1,800	2	15	May-97
6.	Catalyst Addition and Aging	250 or less	28 - 40	2.51	Dec. from 8,000	237	765	40	45	Max (2,700)	18	41	May-97 to Nov-97
	<i>(Note: Kingsport Complex Outage during this test)</i>												
7.	Free-Drain Entrained/ Condensed Oil to Reactor	250 or less	28 - 40	2.51	Dec. from 8,000	237	765	40	45	Max	During Test 6		
8.	Operation @ Design Feed Gas Rates	250	40	2.42	4,000	260	900	50	40	1,800	2	43	Nov-97
9.	Check for Limitation on Catalyst Slurry Concentration	250	> 40	2.51	Varies	TBD	765	40	45	Max (2,700)	6	50	Dec-97
10.	Catalyst Addition to Reach Max Productivity	250 or less	Target 45	2.49	3,320	256	765	40	45	2,605	12	68	Jan-98
				2.29	3,500	293	900	50	40	2,520	2		
				TBD	TBD	TBD	1,110 (**)	50	40	2,520	2		

Test Run #	Test Run Description	Temp (Deg C)	Wt% Cat	H2/CO Ratio at Inlet	Space Velocity (SI/hr-kg)	MeOH (tpd)	Fresh Feed		Recycle Gas (KSCFH)	Inlet Sup. Velocity (ft/sec)	Time Period (weeks)	Elapsed Time (incl. outages) (weeks)	Start of Test
							Balanced (KSCFH)	CO Gas (KSCFH)					
<b>Task 2.1.2 - Process Operational Test Phase:</b>													
Note: At this time, need to produce some "typical" product methanol for off-site fuel tests. Also need to reassess the optimum operating conditions for the remaining tests (e.g. feed gas allocation for commercial design/optimal performance).													
11.	Catalyst Addition/Withdrawal Test	250	Target 45	2.49	3,320	256	765	40	2,605	0.79	6	74	May-98
12.	Test 11 Conditions with No CO Make-up	250	Target 45	4.97	3,282	229	765	0	2,605	0.78	2	76	Jul-98
13.	Test 11 Conditions with No H2 Make-up	250	Target 45	1.98	3,277	252	765	40	2,605	0.78	2	79	Jul-98
14.	Test 11 Conditions with No H2 or CO Make-up	250	Target 45	5.03	3,238	232	765	0	2,605	0.77	2	81	Aug-98
15.	Repeat of Test 11 Conditions	250	Target 45	2.49	3,320	256	765	40	2,605	0.79	2	83	Aug-98
16.	Design Fresh Feed Operation Test	250	Target 45	2.29	3,500	293	900	50	2,520	0.81	2	86	Sep-98
17.	Testing @ High Superficial Velocity	250	Target 45	TBD	TBD	TBD	1,110 (**)	50	2,520	0.86	2	88	Oct-98
18.	Turndown and Ramping	250	Target 45	3.30	1,825	151	450	25	1,364	0.44	4	92	Oct-98
19.	Load-Following, Cyclone, & On/Off Tests		Target 45	Balanced, CO-Rich	To be Defined						6	99	Nov-98
20.	Reactor Feed: Texaco-Type Syngas	250	Target 45	0.69	2,870	207	650	85 (**)	2,195	0.67	4	103	Jan-99

Test Run #	Test Run Description	Temp (Deg C)	Wt% Cat	H2/CO Ratio at Inlet	Space Velocity (SI/hr-kg)	MeOH (tpd)	Fresh Feed			Recycle Gas (KSCFH)	Inlet Sup. Velocity (ft/sec)	Time Period (weeks)	Elapsed Time (Incl. outages) (weeks)	Start of Test
							Balanced (KSCFH)	CO Gas (KSCFH)	H2 Gas (KSCFH)					
21.	Reactor Feed: Destec-Type Syngas	250	Target 45	1.01	2,770	215	670	65 (***)	0	2,147	3	106	Jan-99	
22.	Reactor Feed: BGL-Type Syngas	250	Target 45	0.52	2,165	137	485	200 (***)	0	1,568	3	109	Feb-99	
23.	Repeat of Test 15 Conditions	250	Target 45	2.49	3,320	256	765	40	45	2,605	2	112	Mar-99	
24.	Reactor Feed: Nat. Gas Reformer-Type Syngas	250	Target 45	4.98	1,978	197	765	0	30	1,264	3	115	Apr-99	
25.	Reactor Feed: Shell-Type Syngas with Steam Injection and 1:1 Recycle	250	Target 45	0.53	1,471	101	238	400 (***)	50	842	3	118	Apr-99	
26.	Repeat of Test 15 Conditions	250	Target 45	2.49	3,320	256	765	40	45	2,605	2	121	May-99	
27.	Repeat of Test 16 Conditions	250	Target 45	2.29	3,500	293	900	50	40	2,520	2	123	Jun-99	
28.	Reactor Operation @ 260 deg C	260	Target 45	2.51	3,320	248	765	40	45	2,605	2	125	Jun-99	
29.	Repeat of Test 26 Conditions	250	Target 45	2.49	3,320	256	765	40	45	2,605	2	127	Jul-99	
30.	Reactor Inspection - Then, Continue Operational Tests - with Alternative Catalyst:													
31.	Plant Shakedown	240	TBD	2.42	TBD	260	900	50	40	Max(TBD)	TBD	6	137	Aug-99
32.	Reactor Feed: Texaco-Type Syngas	240	TBD	0.67	TBD	202	650	95 (*)	0	2,612 (*)	2	140	Sep-99	

Test Run #	Test Run Description	Temp (Deg C)	Wt% Cat	H2/CO Ratio at Inlet	Space Velocity (SI/hr-kg)	MeOH (tpd)	Fresh Feed		Recycle Gas (KSCFH)	Inlet Sup. Velocity (ft/sec)	Time Period (weeks)	Elapsed Time (incl. outages) (weeks)	Start of Test
							Balanced (KSCFH)	H2 Gas (KSCFH)					
33.	Catalyst Aging	240	TBD	2.50	TBD	237	40	45	2,605	TBD	16	162	Oct-99
34.	Catalyst Addition/ Withdrawal to Achieve Target Slurry Concentration	240 - 250	Target 45	Balanced	To be defined		900	40	Max(TBD)		6	168	Mar-00
35.	Reactor Feed: Texaco- Type Syngas	250	Target 45	0.69	2,870	207	85 (**)	0	2,195	0.67	4	173	Apr-00
<b>Task 2.1.3 - Extended Optimum Operation:</b>													
36.	Stable Operation	250	Target	2.49	3320	256	765	45	2605	0.79	16	200	Jun-00
		250	45	2.29	3500	293	900	40	2520	0.81	6		
		250		TBD	TBD	TBD	1,110 (**)	40	2520	0.86	2		
37.	DME Demo (Task 2.2) or Commercial Test Run (Task 2.1.3)		Balanced and CO-Rich Target 45								TBD		Dec-00 to Mar-01
Planned LPMEOH Outages (including Reactor Inspection and Fresh Catalyst Charge in Test 28)													
Syngas Outages (5%, including Kingsport complex outage during Test 6)													
Unplanned LPMEOH Outages (10/yr @ 8 hrs.)													
<b>Notes:</b>													
(*) - 700 HP motor on 29K-01 Compressor allows higher recycle gas flow than design basis.													
(**) - 1200 KSCFH of Fresh Feed Syngas can be made available for testing (per Eastman debottlenecking of gasification area). Final decision on test will depend upon carbonyl concentrations in Balanced Gas and CO Gas, since 29C-40 Carbonyl Guard Bed will have to be bypassed. For this condition, test execution is subject to availability of CO Gas.													
(***) - Subject to availability of CO Gas.													

**APPENDIX I - TASK 2.3 - COMMISSIONING & STARTUP SCHEDULE**





