

**APPENDIX J - TASK 3.2.1 - SAMPLES OF DETAILED MATERIAL BALANCE
REPORTS**

RUN NO: K1-4/12

TITLE: Shakedown & Design Production Tests

Balance Period:

Start Date
End Date

12apr97 7:00:00
13apr97 7:00:00

Time From Start of Run (days)

Start 5.7
End 6.7

Reaction Conditions

Temperature (°F)
Pressure (psig)
Space Velocity (sL/kg-hr)
Vg (inlet)

478
719
6203
0.50

Slurry Data

Catalyst Weight (lb oxide)
Slurry Concentration (wt %)
Slurry Level (ft)
Gas Holdup (vol %)
Gassed Slurry Volume (ft3)

20,300
30.5
54.9
50.2
2306

Performance Results

Raw MeOH Production (ton/day)
Raw MeOH Production (ton/day)
Syngas Utilization (SCF/lb MeOH)

242.3 (gas measurements)
242.3 (liquid measurements)
37.6

Energy Balance

Steam Production (lb/hr)
Steam Drum Pressure (psig)
Steam Import/Export (lb/hr)
Reactor O-T-M Conversion (% LHV)
Wetted Tube Length (ft)
Heat Transfer Area (ft2)

17955
308
1185
33.1
51.1
1981

CO Conversion (total) (%)

53.3

CO Conversion to MeOH (%)

54.8

CO Conversion to H2 (%)

-1.60

Theoretical Conversion % (1 CSTR)

53.9

Atom/Mass Balance Closure (% of reactor inlet)

C
H
O
N
Total Mass

100.15
104.17
100.95
86.37
101.12

85.5
66,959
1.81
30.74
0.105

Syngas Conversion (% LHV)

Syngas Usage (BTU/gallon MeOH)

Recycle Ratio

MeOH Productivity (gmol/kg-hr)

Rxr Volumetric Productivity (ton/day-ft3)

Liquid Product Analysis (wt%)

REFINED PRODUCT

CRUDE PRODUCT

4/12
13:00

4/13
1:00

4/12
13:00

4/13
1:00

Methanol
Ethanol
Water
Oil
Total

99.98
0.01
0.02
0.00
100.01

99.99
0.01
0.01
0.00
100.00

90.19
0.25
9.18
0.15
99.77

89.00
0.25
10.52
0.15
99.92

RUN NO: K1-4/12 TITLE: Shakedown & Design Production Tests

	FRESH FEED	CO MAKEUP	H2 MAKEUP	K-01 OUTLET	REACTOR FEED	C-05 OUTLET	MAIN PURGE	DISTILL. PURGE	CRUDE PRODUCT	REFINED PRODUCT
T	70	61	61	95	306	246	80	53	227	74
P	744	857	719	742	739	714	708	6	185	142
Comp	66.44	1.93	77.66	70.23	68.63	59.66	68.84	59.05	0.00	0.00
(mol %)	31.35	97.05	9.12	14.25	20.27	12.27	13.86	8.11	0.00	0.00
N2	0.43	0.97	6.50	6.54	4.38	5.67	6.44	7.14	0.00	0.00
CH4	0.05	0.05	0.92	0.80	0.53	0.69	0.78	0.77	0.00	0.00
CO2	1.73	0.00	3.76	6.14	4.53	5.45	6.10	7.69	0.00	0.00
DME	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00
MeOH	0.00	0.00	0.06	0.25	0.32	14.81	1.87	5.15	83.50	99.98
EtOH	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.16	0.01
H2O	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	16.33	0.02
others	0.00	0.00	1.97	1.78	1.33	1.02	2.10	12.09	0.02	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mole Wt	11.013	27.501	7.770	10.693	10.874	13.746	11.119	17.882	29.822	32.038
LHV	214.3	0.0	0.0	339.9	554.3	530.6	8.6	2.2	50.4	132.9
Enthalpy	-35.75	0.00	0.00	-64.64	-91.74	-120.88	-1.72	-0.61	-21.32	-47.08
Flow	758,227	0	0	1,374,926	2,131,233	1,645,533	33,657	9,362	78,566	173,502
lbmol/hr	1,998.8	0.0	0.0	3,624.5	5,618.2	4,337.8	88.7	24.7	207.1	457.4
lb/hr	22,012	0	0	38,756	61,091	59,628	987	441	6,176	14,653

RUN NO:

K1-4/19

TITLE: Shakedown & Design Production Tests

Balance Period:

Start Date
End Date

19apr97 10:00:00
20apr97 07:00:00

Time From Start of Run (days)

Start
End

12.8
13.7

Reaction Conditions

Temperature (°F)
Pressure (psig)
Space Velocity (sL/kg-hr)
Vg (inlet)

480
709
8562
0.70

Slurry Data

Catalyst Weight (lb oxide)
Slurry Concentration (wt %)
Slurry Level (ft)
Gas Holdup (vol %)
Gassed Slurry Volume (ft3)

20,300
32.2
52.4
51.5
2202

Performance Results

Raw MeOH Production (ton/day)
Raw MeOH Production (ton/day)
Syngas Utilization (SCF/lb MeOH)

292.2
292.2
39.4

(gas measurements)
(liquid measurements)

Energy Balance

Steam Production (lb/hr)
Steam Drum Pressure (psig)
Steam Import/Export (lb/hr)
Reactor O-T-M Conversion (% LHV)
Wetted Tube Length (ft)
Heat Transfer Area (ft2)

21530
256
1171
29.2
48.6
1886

CO Conversion (total) (%)
CO Conversion to MeOH (%)
CO Conversion to H2 (%)

47.5
48.3
-0.90

Theoretical Conversion % (1 CSTR)

48.0

Syngas Conversion (% LHV)
Syngas Usage (BTU/gallon MeOH)
Recycle Ratio
MeOH Productivity (gmol/kg-hr)
Rxt Volumetric Productivity (ton/day-ft3)

82.6
66,697
2.08
36.60
0.133

Atom/Mass Balance Closure (% of reactor inlet)

C
H
O
N
Total Mass

100.03
102.41
98.65
91.46
99.92

Liquid Product Analysis (wt%)

4/19
13:00

Methanol
Ethanol
Water
Oil
Total

99.97
0.01
0.03
0.00
100.01

REFINED PRODUCT

CRUDE PRODUCT

4/19
19:00

91.30
0.25
8.44
0.15
100.14

RUN NO: K1-4/19 TITLE: Shakedown & Design Production Tests

T	P	Comp (mol %)	FRESH FEED	CO MAKEUP	H2 MAKEUP	K-01 OUTLET	REACTOR FEED	C-05 OUTLET	MAIN PURGE	DISTILL. PURGE	CRUDE PRODUCT	REFINED PRODUCT
	F	psig	73	48	47	103	305	249	83	47	226	71
			759	861	654	750	744	700	688	8	185	149
			67.00	1.93	77.66	70.32	68.75	61.69	68.44	68.33	0.00	0.00
		H2	29.81	97.05	9.12	15.34	19.82	13.00	14.98	14.92	0.00	0.00
		CO	0.43	0.97	6.50	4.01	2.87	3.58	3.89	5.54	0.00	0.00
		N2	0.04	0.05	0.92	0.46	0.32	0.41	0.44	0.46	0.00	0.00
		CH4	2.72	0.00	3.76	7.70	6.09	7.39	8.16	8.47	0.00	0.00
		CO2	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		DME	0.00	0.00	0.06	0.18	0.40	12.47	2.12	2.27	85.28	99.94
		MeOH	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.16	0.00
		EtOH	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	14.54	0.05
		H2O	0.00	0.00	1.97	2.00	1.74	1.23	1.97	0.00	0.02	0.00
		others	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
		TOTAL										
			11.026	27.501	7.770	10.958	11.130	13.468	11.601	11.641	30.074	32.033
Mole Wt		lb/lbmol	267.6	0.0	0.0	492.8	758.1	729.7	19.7	3.4	65.2	155.9
LHV		MMBTU/hr	-47.52	0.00	0.00	-109.60	-146.42	-179.85	-4.78	-0.84	-26.88	-55.29
Enthalpy		MMBTU/hr										
Flow		SCFH	958.390	0	0	1,994.104	2,941.845	2,355.218	76.896	13.373	99.415	203.592
		lbmol/hr	2,526.4	0.0	0.0	5,256.7	7,755.1	6,208.6	202.7	35.3	262.1	536.7
		lb/hr	27,856	0	0	57,602	86,310	83,620	2,352	410	7,881	17,192

RUN NO:

K5-6/30

TITLE: Recheck Test 1 Conditions

Balance Period:

Start Date
End Date

30jun97 07:00:00
01jul97 03:00:00

Time From Start of Run (days)

Start
End

84.7
85.5

Reaction Conditions

Temperature (°F)
Pressure (psig)
Space Velocity (sL/kg-hr)
Vg (inlet)

481
706
9019
0.72

Slurry Data

Catalyst Weight (lb oxide)
Slurry Concentration (wt %)
Slurry Level (ft)
Gas Holdup (vol %)
Gassed Slurry Volume (ft3)

19,500
28.1
52.5
43.9
2206

Performance Results

Raw MeOH Production (ton/day)
Raw MeOH Production (ton/day)
Syngas Utilization (SCF/lb MeOH)
Catalyst Life (eta)

198.4
198.4
43.0
0.51

(gas measurements)
(liquid measurements)

Energy Balance

Steam Production (lb/hr)
Steam Drum Pressure (psig)
Steam Import/Export (lb/hr)
Reactor O-T-M Conversion (% LHV)
Wetted Tube Length (ft)
Heat Transfer Area (ft2)
Reactor Overall U (BTU/hr-ft2-F)

12043
360
1377
19.1
48.7
1890
168

CO Conversion (total) (%)
CO Conversion to MeOH (%)
CO Conversion to H2 (%)

28.2
29.9
-1.84

Syngas Conversion (% LHV)

75.5

Syngas Usage (BTU/gallon MeOH)

69,712

Recycle Ratio

3.18

MeOH Productivity (gmol/kg-hr)

25.77

Rxr Volumetric Productivity (ton/day-ft3)

0.090

Sparger "K"-value

7.90

Atom/Mass Balance Closure (% of reactor inlet)

C
H
O
N
Total Mass

99.05
99.31
100.84
94.65
100.70

Liquid Product Analysis (wt%)

REFINED PRODUCT

CRUDE PRODUCT

6/30
19:00

7/1
7:00

Methanol
Ethanol
Water
Oil
Total

99.94
0.01
0.06
0.00
100.00

85.84
0.25
13.76
0.15
100.00

85.59
0.25
14.05
0.15
100.04

RUN NO: K5-6/30 TITLE: Recheck Test 1 Conditions

	FRESH FEED	CO MAKEUP	H2 MAKEUP	K-01 OUTLET	REACTOR FEED	C-05 OUTLET	MAIN PURGE	DISTILL. PURGE	CRUDE PRODUCT	REFINED PRODUCT
T	89	77	79	114	328	247	97	71	222	81
P	752	868	496	738	729	697	685	8	185	139
Comp	67.20	1.93	77.66	69.89	68.86	63.74	69.89	8.00	0.00	0.00
(mol %)	29.80	97.05	9.12	18.97	21.39	17.60	18.97	7.00	0.00	0.00
	0.45	0.97	6.50	3.12	2.50	2.86	3.12	2.00	0.00	0.00
	0.04	0.05	0.92	0.31	0.25	0.28	0.31	0.00	0.00	0.00
	2.51	0.00	3.76	5.01	4.42	4.61	5.01	62.00	0.00	0.00
	0.00	0.00	0.01	0.00	0.00	0.01	0.00	4.00	0.00	0.00
	0.00	0.00	0.06	0.48	0.58	8.01	0.48	10.00	77.47	99.91
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.01
	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	22.35	0.08
	0.00	0.00	1.97	2.22	2.01	2.41	2.22	7.00	0.01	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mole Wt	10.940	27.501	7.770	10.674	10.855	12.185	10.674	39.217	28.974	32.030
LHV	198.8	0.0	0.0	585.1	784.9	766.0	23.7	1.6	33.6	116.5
Enthalpy	-34.33	0.00	0.00	-108.23	-131.62	-157.68	-4.41	-3.01	-15.48	-41.26
Flow	710.737	0	0	2,262.559	2,976.850	2,596.550	91,517	8,828	56,318	152,209
	1,873.6	0.0	0.0	5,964.4	7,847.3	6,844.8	241.3	23.3	148.5	401.2
	20,498	0	0	63,661	85,180	83,403	2,575	913	4,302	12,852

**APPENDIX K - TEST AUTHORIZATION K22 - METHANOL SYNTHESIS WITH
BGL-TYPE SYNGAS**

TEST AUTHORIZATION # K22

Kingsport LPMEOH™ Plant

Sheet: 1 of 2
Date : 05/07/97
By: VES

RUN NUMBER: K22
APPROX. START DATE: 7 May, 1997

TITLE: METHANOL SYNTHESIS WITH BGL-TYPE SYNGAS

OBJECTIVE:

To evaluate the performance of the LPMEOH™ facility when fed with BGL-type (CO-rich) syngas per a typical IGCC application.

SUMMARY:

At a time when approximately 200 KSCFH of CO is available for use in Plant 29 over a multi-week period, the reactor feed composition will be adjusted to match the typical syngas composition exiting a BGL gasifier. The performance data from this test will be more directly comparable to the extensive database from the LaPorte pilot plant and more indicative of LPMEOH™'s expected market in IGCC facilities. The test will best be accomplished by maintaining essentially constant feed gas composition (SP-5), and the operators may adjust the Balanced Gas, CO Gas, and Recycle flow rates to achieve that. Liquid samples from the 29C-10 underflow should be collected periodically to test the stabilized product's suitability for fuel-grade applications.

TEST DETAILS: See page 2.

ANALYTICAL COMMENTS: See page 2.

SAFETY IMPLICATIONS:

Air Products personnel will be required to wear Nomex in the plant when syngas is present. Otherwise, Eastman safety rules (including M.O.C.) are in effect. All visitors to the facility must follow the Visitor Safety Guidelines issued by the Joint Venture.


ENVIRONMENTAL IMPLICATIONS:

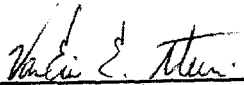
Minimal. The plant syngas purge will go to the Eastman boilers as designed.

SPECIAL REMARKS:

Because of ongoing problems with plugging in the free-draining oil return line to the reactor, the current off-design operating mode will be continued. Condensed oil will be batch transferred from 29C-05 to 29C-30 and then returned to the reactor with the 29G-30 pump.

AUTHORIZATIONS:


E. C. Heydorn - Program Manager


V. E. Stein - Lead Process Engineer

TEST AUTHORIZATION # K22

Kingsport LPMEOH™ Plant

Sheet: 2 of 2
Date : 05/07/97
By: VES

TEST DETAILS:

1. Call the PIA's and have them set up SP-2 (CO Makeup) and add it to the analysis sequence.
2. Follow the Reactor Area Start-Up Procedure S.O.P. Section II A 3 Step T - start CO makeup feed.
3. Line up CO flow through FE-010B (open valve 2025) and shut off flow through FE-010A (close valve 2026). Make sure the Honeywell DCS is set up to recognize FE-010B.
4. Slowly increase the flow on FC-010 to approximately 200 KSCFH while decreasing the flow on FC-009 to approximately 485 KSCFH. As the MW of the recycle stream begins to rise, the compressor flow will increase. Adjust it to maintain approximately 1570 KSCFH on FI-100.
5. The target feed gas composition (SP-5) in mol% (Honeywell schematic AnalD or AnalB) is: 32% H₂, 61% CO, 5% CO₂, 1% N₂. In wt% (Honeywell schematic Anal_D or Anal_B), this corresponds to 3% H₂, 83% CO, 11% CO₂, 2% N₂. Be patient when adjusting flows to match the target composition; Air Products personnel will advise.

TEST AUTHORIZATION #K22 is complete.

ANALYTICAL REQUIREMENTS:

1. Process GC sampling requirements:
 - SP-1: syngas feed;
 - SP-2: CO makeup
 - SP-4: K-01 outlet;
 - SP-5: reactor feed (highest frequency);
 - SP-6: C-05 outlet (highest frequency);
 - SP-7: main purge;
 - SP-8: distillation purge;
 - SP-3 can remain valved out.
2. Carbonyl GC sampling requirements:
 - SP-12: 29C-40 guard bed inlet;
 - SP-13: 29C-40 guard bed intermediate #1;
 - SP-14: 29C-40 guard bed intermediate #2;
 - SP-15: 29C-40 guard bed outlet.
3. Liquid sampling requirements:
 - all identified liquid sampling points per standard Eastman routine;
 - 29C-10 underflow samples may be shipped to Allentown for by-product analysis.

**APPENDIX L - METHODS OF CALCULATION FOR KEY PROCESS
PARAMETERS**

$$\text{Catalyst Age } (\eta) = k_0/k_0(t=0)$$

where:

k_0 = the pre-exponential kinetic rate constant for the methanol synthesis reaction at any time

$k_0(t=0)$ = the pre-exponential kinetic rate constant for the methanol synthesis reaction for fresh catalyst

The rate constants are determined using a proprietary model which computes the kinetic rate constant for the methanol synthesis reaction.

$$\text{CO Conversion to Methanol [\%]} =$$

$$\frac{(\text{Raw Methanol Flow} + \text{Methanol in Main Plant Purge} + \text{Methanol in Distillation Purge [all lbmol/hr]})}{\text{Carbon Monoxide in Reactor Feed [lbmol/hr]} * 0.01}$$

where:

$$\text{Methanol in Main Plant Purge [lbmol/hr]} = \text{Main Plant Purge Flow [lbmol/hr]} * \text{Methanol Concentration in Main Plant Purge [mol\%]}$$

$$\text{Methanol in Distillation Purge [lbmol/hr]} = \text{Distillation Purge Flow [lbmol/hr]} * \text{Methanol Concentration in Distillation Purge [mol\%]}$$

$$\text{Carbon Monoxide in Reactor Feed [lbmol/hr]} = \text{Reactor Feed Flow [lbmol/hr]} * \text{Carbon Monoxide Concentration in Reactor Feed [mol\%]}$$

$$\text{Gas Holdup (vol\%)} = \frac{(\text{Liquid-Solid Density [lb/ft}^3\text{]} - \text{3-Phase Density [lb/ft}^3\text{]}) * 100}{(\text{Liquid-Solid Density [lb/ft}^3\text{]} - \text{Vapor Density [lb/ft}^3\text{]})}$$

where:

Vapor Density [lb/ft³] is calculated using the composition at the Reactor Effluent, and at the measured temperature and pressure of the Reactor

$$\text{3-Phase Density [lb/ft}^3\text{]} = \frac{\text{Pressure Drop [psi]} * 144 [\text{in}^2/\text{ft}^2]}{\text{Span between Taps of Pressure Drop Measurement [ft]}}$$

Liquid-Solid Phase Density [lb/ft³] is a function of the catalyst concentration [wt%], which is iterated until the calculated weight of catalyst matches the catalyst weight in the Reactor.

Notes:

1. All terms in *Italics* refer to measured variables, either by field instruments or gas chromatographs.

$$\text{Gassed Slurry Volume [ft}^3\text{]} = \text{Reactor Cylindrical Volume [ft}^3\text{]} + \text{Reactor Head Volume [ft}^3\text{]}$$

where: $\text{Reactor Cylindrical Volume [ft}^3\text{]} = A \text{ [ft}^2\text{]} * \text{Cylindrical Height [ft]}$

$$A \text{ [ft}^2\text{]} = \frac{\pi}{4} * (\text{Reactor ID [ft]})^2 * (\text{Fraction Open Area})$$

$$\text{Reactor ID} = \text{Reactor Inside Diameter} = 7.5 \text{ ft}$$

Fraction Open Area = 0.9652 (3.48% of the cross-sectional area of the Reactor is occupied by the tubes of the internal heat exchanger)

$$\text{Cylindrical Height [ft]} = \text{Gassed Slurry Height [ft]} - \frac{(\text{Reactor ID [ft]})}{4}$$

Note: The term “(Reactor ID)/4” is the depth of the bottom head of the Reactor.

$$\text{Reactor Head Volume [ft}^3\text{]} = \frac{\pi * (\text{Reactor ID [ft]})^3}{24} - 8 \text{ [ft}^3\text{]}$$

Note: 8 cubic feet is subtracted from the Reactor Head Volume to account for the displacement of the gas sparger and the header piping for the internal heat exchanger.

$$\text{Inlet Superficial Velocity [ft/s]} = \frac{\text{Reactor Feed Flow [lbmol/hr]} * V \text{ [ft}^3\text{/lbmol]}}{3,600 \text{ [s/hr]} * A \text{ [ft}^2\text{]}}$$

where: $V \text{ [ft}^3\text{/lbmol]} = \frac{10.73 * (\text{Reactor Temperature [}^\circ\text{F]} + 459.67)}{(\text{Reactor Pressure [psig]} + 14.1)}$

$$A \text{ [ft}^2\text{]} = \frac{\pi}{4} * (\text{Reactor ID [ft]})^2 * (\text{Fraction Open Area})$$

$$\text{Reactor ID} = \text{Reactor Inside Diameter} = 7.5 \text{ ft}$$

Fraction Open Area = 0.9652 (3.48% of the cross-sectional area of the Reactor is occupied by the tubes of the internal heat exchanger)

Notes:

1. All terms in *Italics* refer to measured variables, either by field instruments or gas chromatographs.

Methanol Productivity [gmol/kg-hr] =

$$\frac{(\text{Methanol in Reactor Effluent [lbmol/hr]} - \text{Methanol in Reactor Feed [lbmol/hr]}) * 1,000 \text{ [g/kg]}}{\text{Catalyst Weight (lb oxide)}}$$

where:

$$\text{Methanol in Reactor Effluent [lbmol/hr]} = \text{Reactor Effluent Flow [lbmol/hr]} * \text{Methanol Concentration in Reactor Effluent Stream [mol\%]}$$

$$\text{Methanol in Reactor Feed [lbmol/hr]} = \text{Reactor Feed Flow [lbmol/hr]} * \text{Methanol Concentration in Reactor Feed Stream [mol\%]}$$

$$\text{Reactor O-T-M Conversion [\%]} = \frac{\text{Lower Heating Value of Raw Methanol} * 100}{\text{Lower Heating Value of Reactor Feed}}$$

Note: Lower heating values for Raw Methanol and Reactor Feed are calculated from compositions of each stream, in units of million Btu per hour.

$$\text{Reactor Volumetric Productivity [TPD/ft}^3\text{]} = \frac{\text{Raw Methanol Flow [TPD]}}{\text{Gassed Slurry Volume [ft}^3\text{]}}$$

$$\text{Space Velocity [sL/kg-hr]} = \frac{\text{Reactor Feed Flow [lbmol/hr]} * 10,175 \text{ [sL/lbmol @ 0}^\circ\text{C]}}{\text{Catalyst Weight [lb oxide]} * 0.454 \text{ [kg/lb]}}$$

Sparger Resistance Coefficient "K" =

$$\frac{\text{Sparger Pressure Drop [psi]} * \text{Reactor Feed Density [lb/ft}^3\text{]} * 10^9}{(\text{Reactor Feed Flow [KSCFH]} * \text{Reactor Feed Molecular Weight [lb/lbmol]})^2}$$

where: 10^9 is an arbitrary factor.

Syngas Usage [Btu/gallon Methanol] =

$$\frac{\text{Syngas LHV to Methanol [Btu/hr]} * 24 \text{ [hr/day]} * 6.642 \text{ [lb/gallon Methanol]}}{\text{Raw Methanol Flow [TPD]} * 2,000 \text{ [lb/ton]}}$$

where:

Syngas LHV to Methanol [Btu/hr] = the difference between the Lower Heating Value of the three feed gas streams (Balanced Gas, CO Gas, H₂ Gas) and the two purge gas streams (Main Plant Purge, Distillation Purge). Lower heating values are calculated from the compositions of each stream.

Notes:

1. All terms in *Italics* refer to measured variables, either by field instruments or gas chromatographs.

$$\text{Syngas Utilization [SCF/lb Methanol]} = \frac{(\text{Balanced Gas Flow [SCFH]} + \text{CO Gas Flow [SCFH]}) * 24 \text{ [hr/day]}}{\text{Raw Methanol Flow [TPD]} * 2,000 \text{ [lb/ton]}}$$

Notes:

1. All terms in *Italics* refer to measured variables, either by field instruments or gas chromatographs.

**APPENDIX M - TASK 3.6 - INTERIM PROJECT REVIEW MEETING
(29 & 30 April 1997)**

NOTES FROM MEETING

DISTRIBUTION (NAME/ORGANIZATION) *Unable to attend. **Chairman		COPIED FOR INFORMATION ONLY
Jo Ann Franks - APCI	Bob Senn - APCI	Bharat Bhatt - APCI
Frank Frenduto - APCI	John Shen - DOE FE-HQ	Dave Drown - APCI
Bob Kornosky - DOE - FETC	Van Eric Stein - APCI	Barry Halper - APCI
Bob Moore - APCI	Peter Tijn - APCI	Bill Jones - EMN
Bill O'Dowd - DOE - FETC	Bernie Toseland - APCI	Barry Street - EMN
X. D. Peng - APCI		

FROM Edward C. Heydorn 	ORGANIZATION APCI - Program Manager	EXTENSION 17099	TODAY'S DATE 20 May, 1997
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DATE OF MEETING	WEEKDAY	TIME		LOCATION
April 29 & 30, 1997	Tues. & Wed.	STARTED 1:30 PM	ENDED 11:15 AM	Tues. - in A3CR112K Wed. - in LNG CR A31E4

SUBJECT AND/OR PURPOSE

• Project Review Meeting - DOE and Air Products

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
1.	ECH	Updated 5/19/97	<p><u>DME Design Verification Testing - Status - Review</u></p> <p>The definition of the productivity of a commercially successful DME catalyst were reviewed. An 80%/20% methanol/DME catalyst productivity of 14 g-moles of methanol product equivalent per Kg of catalyst per hour of operation after six months of aging was defined as commercially successful for coproduction in an IGCC situation using Texaco-type of synthesis gas. Further definition includes an operating pressure of 1000 psig, a catalyst space velocity of 4000 sL/kg-hr and at 1:1 recycle: fresh feed gas ratio. The memo from R. Moore on LPDME economics is included (Attachment 1).</p> <p>Progress has been made in the laboratory effort. The latest results are included in the updated (5/19/97) DME Design Verification memo (Attachment 2). Figure 2 shows the performance for the first DME catalyst which was tested; goals from the Liquid Fuels Program are provided for reference. After further study, an improved DME catalyst (AB-05) was tested with two LPMEOH™ catalysts (S3-86 and MK-101); the results of a 700 hour life study are presented in Figure 3. When compared with the program goals (Figure 4), the catalyst performance of the newer catalyst is approaching the commercial targets.</p> <p>Large scale testing at the LaPorte AFDU will be required to confirm this productivity. Slides which provide a preliminary run plan at LaPorte and an analysis of catalyst life from the LaPorte LPMEOH™ life run are provided in Attachment 3.</p>

**NOTES FROM MEETING
CONTINUATION**

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
2.			<u>Reports</u>
	RMK/WJO	6/20/97	<u>Preliminary Public Design Report</u> : A draft version was distributed. Comments should be directed to F. Frenduto.
	WJO	6/2/97	<u>Topical Report - LPMEOH™ Process Economics</u> : W. O'Dowd will complete his review and forward comments to R. Moore.
	DPD/ECH	6/30/97	<u>Topical Report - LPMEOH™ Reactor Design</u> : An updated version will be sent to DOE for review.
	RMK ECH	Done 6/2/97	<u>Topical Report - Peroxide Formation</u> : R. Kornosky will send his latest comments for incorporation into a final version.
	RMK/ECH	6/20/97	<u>Topical Report - Catalyst Poisons</u> : A draft report under the Liquid Fuels Program was issued in March. An agreement between the Liquid Fuels and CCT Programs on the possibility of publishing under two DOE contracts is forthcoming. Any separation of publically available data must be agreed upon between the partners.
	ECH/BTS	6/20/97	
		Review Status 7/24/97	<u>Topical Report - DME</u> : In progress.
			<u>Technical Progress Reports 1 & 2</u> : F. Frenduto and R. Kornosky will work together to complete.
	ECH	6/2/97	An updated Project Management Plan will be issued.
	ECH/VES	Done 5/19/97	Upcoming reports include: - Technical Progress Report #11 - draft due mid-May.
	ECH/VES	6/6/97	- Demonstration Teechnology Start-up Report - report is issued without revision.
	ECH/BTS	8/15/97	- Environmental Monitoring Report #1 - first reporting period is April - June 1997.

**NOTES FROM MEETING
CONTINUATION**

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
3.	PJAT	5/28/97	<p><u>Updated Fuel-Use Demo Plan - Status/Schedule</u></p> <p>A review meeting between Air Products, DOE, and Acurex was held on 18 April. Attachment 4 is the summary of prospective methanol fuel test sites, testing programs, and costs. An update of the summary table will be provided to clarify the costs to the CCT program and the outside cost-sharing. A brief review of Air Products' corporate involvement with Penn State on R&D was presented. The possibility of methanol testing using some of these facilities is being investigated.</p>
	ECH	5/31/97	<p>The draft plan will be issued to DOE.</p> <p>Task 3.3 of the Statement of Work, On-Site Testing, states that Eastman will perform fitness-for-use tests on the methanol product for use as a chemical feedstock and provide a summary of the results. Further definition and timing for these tests is required.</p>
	BTS	7/24/97	<p><i>Timing for these tests is 4Q FY97; an update will be presented at the next DOE Review Meeting.</i></p>

**NOTES FROM MEETING
CONTINUATION**

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
4.			<p><u>Task 2.1 - Methanol Operation Task - Status</u></p> <ul style="list-style-type: none"> • Daily average production over the first two weeks of steady operation has been 242 - 292 tons per day (TPD), depending upon gas availability. There have been shorter time periods during which production exceeded 12.5 tons per hour, or 300 TPD. Attachment 5 contains the draft summary table and a sample of the detailed report for a particular operating day. • Gas holdup in the reactor has been about 50 vol% at 30 wt% slurry concentration. Maximum gas superficial velocity has been 0.72 ft/sec. • We are still awaiting price and delivery for repairs to the 29G-03 oil makeup pumps. • Free-draining of condensed oil and entrained oil/catalyst back to the reactor had been operating successfully until 4/25. It is unclear whether the blockage is due to catalyst or to a vapor pocket in the piping (something that has been observed in earlier operation). Eastman is currently draining oil from the 29C-05 oil separator back to the 29C-30 catalyst reduction vessel and pumping this oil back via the 29G-30 slurry pump to the reactor. Eastman is exploring options for providing a clean oil flush to the free-drain line. • The pressure drop across the gas sparger on the reactor has continued to increase over the last 2 weeks, either from catalyst migration from the reactor or construction debris from the gas inlet piping. The weakest component over the sparger design are endcaps (33 psi differential); this limitation prevents Eastman from trying to use gas pressure to pulse the sparger in an attempt to unplug it. We now expect to examine the sparger during the upcoming complex outage to determine the cause of the high pressure drop and reinforce the endcaps. The outage is scheduled to begin on 11 May and will last 2-3 weeks. • APCI personnel have been off-site since 25 April, and have been using the data link between Allentown and Kingsport to monitor plant performance and download historical data for heat and material balance calculations.

NOTES FROM MEETING
CONTINUATION

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
5.			<p><u>Report Card - Project Success Factors</u></p> <p>The Project "Success Factors" were reviewed. The DOE/Air Products/<u>Eastman Participant Relationships</u> continue to be excellent. On the performance during <u>Phases 1 and 2</u>, performance was <u>very good in absolute terms</u>, and <u>excellent when compared to other CCT programs</u>.</p>

NOTES FROM MEETING CONTINUATION

ITEM NO.	RESPONSIBLE PERSON (INITIALS)	TARGET DATE	DISCUSSION
6.			<p><u>Next Project Meeting, Dedication</u></p> <p>The next project review meeting is scheduled for the afternoon of 24 July and the morning of 25 July at the JV Trailer at Kingsport. R. Kornosky will advise if any earlier meetings to cover DME or the fuel-use program will be necessary.</p> <p>The Dedication Ceremony is scheduled for 25 July at Kingsport. Those guests travelling that day will arrive for lunch at 11:30 AM. Final details will be arranged with all parties. <i>The current agenda is included (Attachment 6).</i></p> <p>Specific questions/action items:</p> <ul style="list-style-type: none"> • Several DOE visitors have requested a tour of the gasification control room (similar to the tour at the groundbreaking ceremony). • Check the timing of the aerial photograph for the plant to see if it will be available for the ceremony. • Update JV sign from groundbreaking to remove reference to funding. • Provide list of invitees. • Coordinate the preparation of a press release so that it is ready on 25 July. • Update DOE Fact Sheet on program. • Update project "poster" by adding photographs of Wabash and Tampa, a photo of the LPMEOH™ demonstration unit, and the map which depicts the potential sites for fuel-use testing.
	BTS		
	BTS/ECH		
	BTS/ECH		
	RMK	Ongoing	
	ECH/RMK/ BTS		
	ECH	Done 5/8/97	
	RMK/JAF/ ECH		

MEETING NOTICE**(April 29 & 30, 1997)**

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

DISTRIBUTION (NAME/ORGANIZATION) (If unable to attend, contact originator)

Bob Moore - APCI	Van Eric Stein - APCI
Bill Brown - APCI	Peter Tijm - APCI
Bob Kornosky - DOE - FETC	Ed Heydorn - APCI
Bernie Toseland - APCI	Frank Frenduto - APCI
Bill O'Dowd - DOE - FETC	X. D. Peng - APCI
John Shen - DOE FE-HQ	Bob Senn - APCI

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Bharat Bhatt - APCI
Barry Street - EMN
Dave Drown - APCI
Barry Halper - APCI
Bill Jones - EMN

FROM William R. Brown <i>WLB</i> 4/23	ORGANIZATION APCI - Program Manager
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EXTENSION 17584	TODAY'S DATE 23 April 1997
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DATE OF MEETING April 29 & 30, 1997	WEEKDAY Tues. & Weds.	TIME FROM 1:30 PM	TO 10:45 AM	LOCATION Tues. - in A3CR112K Weds. - in LNG CR A31E4
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SUBJECT AND/OR PURPOSE

- Project Review Meeting, DOE and Air Products

DESIRED RESULTS/OUTCOMES

- Review Project DME "go" decision, Fuel-use test plan, reports.

REFERENCE MATERIAL/OTHER

•

AGENDA

LPMEOH™ Project Review Meeting - Agenda***Project Review - Part One 1:30 PM Tues. - April 29th**

(In Conference Room 112K, Building Admin. 3, Air Products Trexlertown)

1. DME Design Verification Testing - Status - Review

- | | |
|--|--------------|
| A. Process Economics, Goal for Catalyst System Productivity/Life | 1A - RBM/WRB |
| B. Lab R & D results, status | 1B. BAT/XDP |
| C. Recommendation for LaPorte test run - Status/Timing | 1C. PJAT |

2. Reports

- | | |
|---|---------------|
| 2A <u>Public Design Report</u> (Review initial draft) | 2A. FSF/RMK |
| 2B <u>Topical Report - LPMEOH Process Economics Draft #3</u>
(Review and comment on 3/31/97 Third Draft) | 2B WJO/RBM |
| 2C <u>Other Reports</u> | 2C RMK/et.al. |

End of (work) Day One - 4:30 PM**Project Review - Part Two 9:00 AM Weds. - April 30th**

(In LNG Conference Room, Building Admin. 3, Air Products Trexlertown)

3. Updated Fuel-use demo plan - Status/Schedule

3. RJS/PJAT

4. Task 2.1 - Methanol Operation Task - Status

4. ECH/VES

5. Report Card - Project Success Factors

5. All

6. Plans for: Next Project Meeting, Dedication, Other

6. All

End and Lunch ~ 11:15 AM .

* Agenda Questions/Additions/Deletions to Bill Brown please.

Memorandum

To: R. M. Kornosky Dept./Loc.: PETC Project Manager
From: Robert B. Moore Dept./Ext.: Program Development Engineering
Date: 22 April 1997
Subject: DME Catalyst Productivity

Distribution:

~~W. R. Brown - Eqpt & Bus Development~~ A31E9

E. C. Heydorn - Eqpt & Bus Development

P. J. A. Tijm - Eqpt & Bus Development

B. A. Toseland/X. D. Peng - GEG Reaction Tech

DOE has asked APCI to define the productivity of a commercially successful DME catalyst. There are of course many variables which effect the answer which might be given. The composition, pressure and value of the feed have major effects as well as the value and composition of the product. DME is expected to have a commercial niche in about the same applications that LPMEOHTM has for coproduction of methanol in an IGCC process. With this in mind a commercially successful catalyst might be one which can economically produce DME from a typical Texaco-type synthesis gas, consuming at least one half of the synthesis gas with the balance going to a gas turbine. This analysis compares methanol and DME/methanol production from Texaco-type synthesis gas available at 500 psig. The gas is compressed to 1000 psig and fed to a reactor along with 1:1 recycle: fresh feed gas with a catalyst space velocity of 4000 sL/kg-hr and an ETA of 0.5 (50% of new catalyst activity), to produce 500 sT/D of methanol equivalent. In the "all methanol" case the catalyst contains 100% methanol catalyst. In the "DME/methanol" case the catalyst slurry contains 80% methanol catalyst and 20% dehydration catalyst. With a feed gas cost of \$3.00/MMBTU the crude product from the "all methanol" case would cost about \$7.63/MMBTU as a liquid. The crude DME/methanol from the alternate case will be produced at about \$7.02/MMBTU, modestly less expensive than "all methanol". However, the separation and purification of the crude DME/methanol into a cooking grade DME product and into a crude methanol product will add about \$0.89/MMBTU to this cost, giving a total product cost of \$7.91/MMBTU. About 23% of this product is a separated crude methanol stream which is assumed to have the same value as DME. The 77% balance is a cooking grade DME product. To achieve these economics it was assumed that the "all methanol" catalyst productivity was 11 g-mole/kg-hr after six months of operation. The 80%/20% methanol/DME catalyst productivity was assumed to be 14 g-moles of methanol product equivalent per kg of catalyst per hour of operation (g-mole/kg-hr), after six months of operation.

In the USA where natural gas and LPG are inexpensive, typically less than \$4.00/MMBTU, DME from coal is not likely to be competitive. However, in coal based countries of the world such as inland China, the fuel value for DME is competitive with that of propane/butane at \$7 to \$8/MMBTU. This is the area where the first DME facilities might be built. With future improvements in catalyst activity and improvements in the equipment technology co-produced DME should achieve an improved market position.

The following is a summary of the two cases being compared.

500 PSIG TEXACO-TYPE SYNTHESIS GAS TO ALL METHANOL OR DME/METHANOL

	All Methanol	DME/ Methanol
Production		
Methanol, T/D	500	106
DME, T/D	0	283
Synthesis Gas Conversion, %	43	55
Catalyst Productivity, g-mole/kg-hr	11	14
Synthesis Gas Used, MMBTU/Hr (LHV)	437	443
Product, MMBTU/Hr (LHV as liquid)		
Methanol	358	76
DME	<u>0</u>	<u>272</u>
Total Product, MMBTU/Hr (LHV as liquid)	365	380
Conversion Cost, MM\$/Yr	\$21.5	\$19.2
Crude Product Cost, \$/MMBTU (LHV as liquid)	\$7.63	\$7.02
DME Purification, \$/MMBTU (LHV as liquid)		<u>\$0.89</u>
Product Cost, \$/MMBTU (LHV as liquid)		\$7.91

A graph showing the effect of size of a DME facility is attached. For Production between 300 and 1100 sT/D methanol equivalent the product cost falls in the range of \$6.40 to \$8.10/MMBTU which should be competitive with LPG. About \$3.50/MMBTU of the cost is from the Texaco-type synthesis gas which is assumed to have a value of \$3.00/MMBTU.

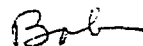
Summary:

A commercially successful DME Catalyst is defined as one that has a productivity of 14 g-moles/kg-hr after six months of operation, producing at least 75% (by heating value) DME and 25% methanol with the following reactor inlet composition and when operating with a pressure exit the reactor of 950 psig and a SV of 4000:

H ₂	25.1%
CO	52.6%
CO ₂	20.8%
Inerts	1.4%
CH ₃ OCH ₃	0.1%

Sensitivity:

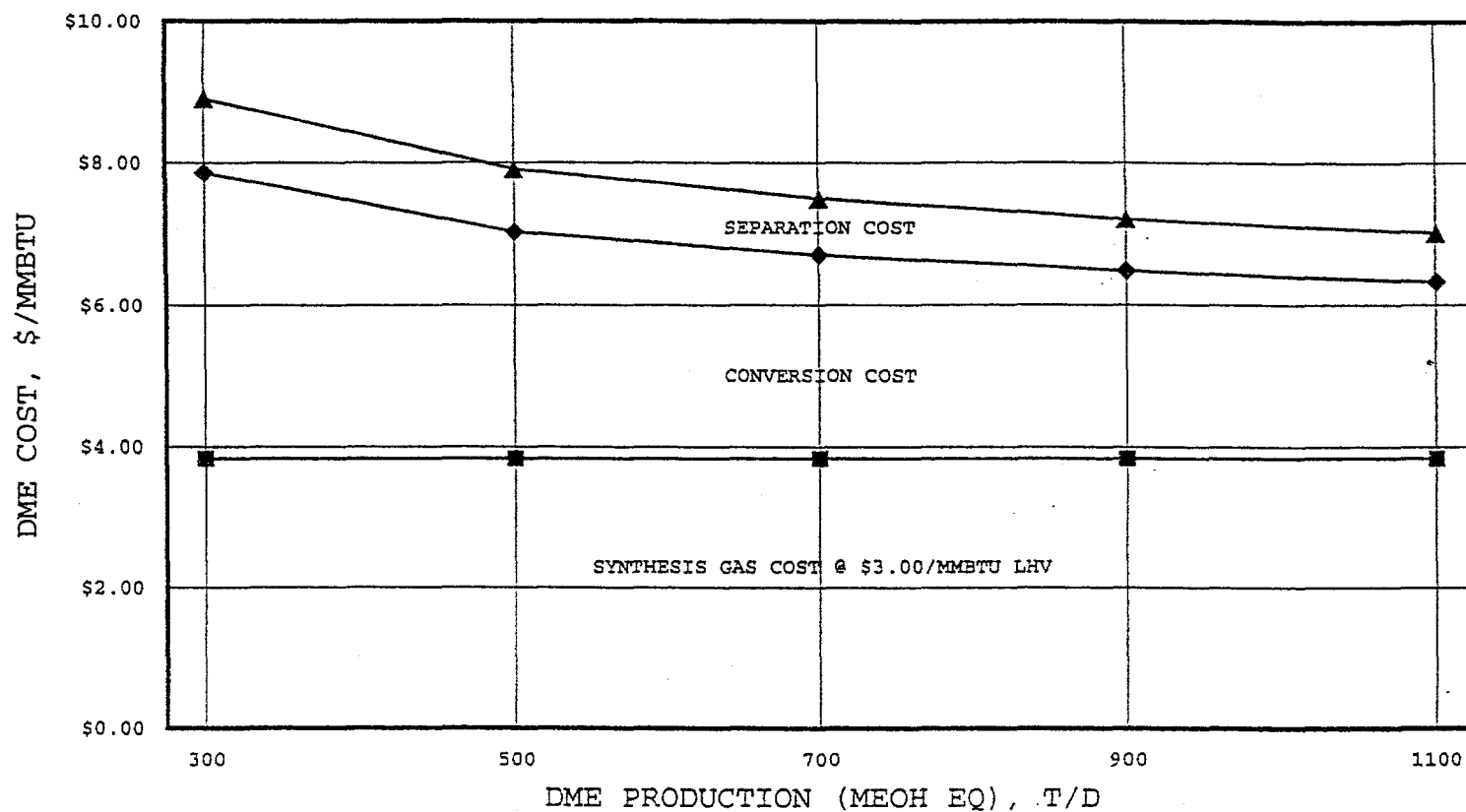
Should the catalyst productivity decline twice as fast as assumed above, twice as frequent catalyst change out would add about \$0.36/MMBTU(LHV as a liquid) to the cost of DME produced. This would likely make small facilities, less than 700 T/D methanol equivalent, not competitive with LPG.



R. B. Moore

DME COST VERSUS SIZE

TEXACO-TYPE SYNTHESIS GAS, 1:1 FEED:RECYCLE



■ SYNTHESIS GAS ONLY

◆ SYNTHESIS GAS PLUS CONVERSION

▲ TOTAL DME COST

LPDME RecommendationLPDME Design Verification Testing

From the Statement of Work : "Subject to Design Verification Testing (DVT), the Partnership proposes to enhance the Project by including the demonstration of the slurry reactor's capability to produce DME as a mixed co-product with methanol. The production of DME from synthesis gas is a natural extension of the LPMEOH™ process in that three reactions occur concurrently in a single liquid phase reactor, methanol synthesis, methanol dehydration and water-gas shift. This process enhancement can significantly improve the overall conversion of coal derived synthesis gas to a storable blend of methanol and DME. --- the enhanced (DME production demonstration is complementary to ongoing studies being sponsored by DOE's Liquid Fuels Program --) -- . -- At the conclusion of each of the DVT steps, a joint Partnership/DOE decision will be made regarding continuation of methanol/DME demonstration.."

The first DVT step (Phase 1, Task 5), to address issues such as catalyst activity and stability, to provide data for engineering design, and to verify the market through engine tests and through market and economic study, is now complete.

The LPDME Process Concept: - Three Concurrent Reactions:

- $2 \text{ CO} + 4 \text{ H}_2 = 2 \text{ CH}_3\text{OH}$ (Methanol Synthesis).
- $2 \text{ CH}_3\text{OH} = 1 \text{ CH}_3\text{-O-CH}_3 + 1 \text{ H}_2\text{O}$ (Methanol Dehydration).
- $1 \text{ CO} + 1 \text{ H}_2\text{O} = 1 \text{ CO}_2 + 1 \text{ H}_2$ (Water-gas Shift).

The overall reaction, with CO-rich Syngas, in a single liquid phase (slurry) reactor:

- $3 \text{ CO} + 3 \text{ H}_2 = 1 \text{ CH}_3\text{-O-CH}_3 + 1 \text{ CO}_2$ (DME from CO-rich syngas)

This is the "once-through" CO-rich syngas concept for the LPDME process utilizing a single slurry reactor. Conversion per pass, with CO-rich syngas, can be higher than for the LPMEOH™ process. Methanol may also be produced, as a mixed co-product with the DME, and can easily be separated and recovered. The separation of DME from CO₂ will be necessary for certain market applications.

Status of the LPDME DVT Work

The status of a) the LPDME process economics/market study work, and of b) the LPDME catalyst system R&D work, follows:

A. The market applications for DME are extensive. DME is, or may be, used as:

- Aerosol - Small, but established market. High purity DME is required.
- Cooking Fuel. Potentially a large market, to replace imported LPG. There is a lot of interest in China, and DME is on the DOE's CCT/FE China meeting (Sept. of 1997) agenda. Purity, of

about >95% DME, with <2% methanol, < 3% CO₂ is estimated. An unresolved application issue is CO emissions during cooking. How does DME purity impact this? Use testing is needed.

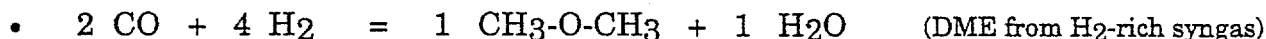
- Diesel Replacement Fuel. DME is an ultra clean (high Cetane) diesel fuel; and an 80% DME mixture with methanol and water is now being engine-tested by others (Amoco, et. al.). Market development (at least in the U.S.) faces a fuel distribution infrastructure problem. DME might more easily replace LPG in countries where LPG is already an engine fuel.
- DME Derivatives, as a Diesel Fuel Additive. Quotes from the DOE (Alt. Fuels R&D) Program quarterly report for April-June 1996: "Initial Cetane number (CN) testing of a three-component composition of 1,2-dimethoxy ethane, 1,1-dimethoxy methane and methanol blended with diesel fuel showed a 40% increase in the CN of the diesel fuel when the blend was 50/50." "The concept of adding a blend of oxygenated compounds to diesel fuel in order to enhance the Cetane value and cold start properties is being investigated. The blend of oxygenated compounds is derived from dimethyl ether chemistry, and builds on work conducted earlier --." It is early days for this DME feedstock chemistry, but CO₂ may not need to be separated from the DME.
- DME Derivatives, as Chemicals/Other Fuels. . DME is a key intermediate in a commercial synthesis gas-to-gasoline process, and is being developed as an intermediate for other chemicals and fuels as part of the DOE's Liquid Fuels (Alt. Fuels R&D) Program.

A. The economics studies, for once-through coproduction (with an IGCC power plant for example) on synthesis gas rich in carbon oxides, show that the LPDME process will have an advantage greater than the LPMEOH™ process. A once-through LPDME reactor is able to convert greater than 50% of such a syngas, whereas a once-through LPMEOH™ reactor can convert only about 30%. The economics, of course, depend upon the end-use (purity) of the DME and upon the gasification plant's coproduct mix (amount of power, methanol, DME, etc.). The same liquid phase reactor design options to increase syngas conversion (see the CCT Tampa Conference Paper); such as feed gas compression and/or CO-rich gas recycle; are also be applicable for LPDME. So, the LPDME technology should have a significant advantage for the coproduction of DME to serve local markets.

As with the LPMEOH™ process, gas phase process technology must be considered as the economic competitor. The gas phase DME process (see Haldor's patent) must run with H₂-rich syngas. In the IGCC coproduction flow sheet, gas phase technology is at an economic disadvantage, since separate shift and CO₂ removal are required. As is the case for methanol, inexpensive remote natural gas would therefore be the economic plant site choice for gas phase technology. A comparison, of IGCC/LPDME coproduction with DME imported from remote gas facilities, shows an advantage for locally produced DME relative to imported DME. The transportation cost to import DME is much higher than for methanol, and the LPDME coproduction advantage is even greater than that for LPMEOH™ (vs. methanol import; see the CCT Tampa Conference Paper). Dehydration of imported methanol to make DME is not competitive either. Therefore, for DME in local markets, LPDME coproduction should be a winner!

LPDME Recommendation

With H₂-rich syngas, the LPDME process loses its (once-through, high conversion per pass) economic advantage. The overall reaction, with (> 2:1) H₂-rich syngas is:



Since water inhibits the methanol dehydration reaction, the slurry reactor must be staged, with water removal between stages. Staging could be by high ratio gas recycle, and/or with multiple reactors; but the once-through simplicity is lost. Therefore, it is unlikely that the LPDME process would be developed for use in H₂-rich syngas applications.

A cost estimate of commercial-scale LPDME plants has been performed. This work has helped quantify the targets for the laboratory R&D program (summarized below). From these studies, a commercially successful LPDME system is defined for a Texaco-type synthesis gas (35 mol% H₂, 51 mol% CO, 13 mol% CO₂) available at 500 PSIG. At a reactor operating pressure of 950 PSIG and a space velocity of 4,000 liters/hr-kg catalyst, the LPDME catalyst system must have a methanol equivalent productivity of 14 mol/kg catalyst-hr after 6 months of operation, producing at least 75% (by heating value) DME and 25% methanol. Figure 1 shows the effect of plant size on DME cost.

B. Laboratory R&D Results (CCT Project - ended 9/96)

An LPDME catalyst system, with reasonable long-term activity, was identified and tested. The system exhibits best activity under CO-rich syngas conditions, i.e. those most likely for (IGCC) coproduction. Accelerated aging of the catalyst system is a remaining issue. Water concentrations in the LP reactor are higher with syngases richer in H₂, and its effect needs to be evaluated.

Lab work has continued under the DOE's Liquid Fuels Program. The issues, to be addressed in the lab before a LaPorte test-run decision, are:

- 1) Understanding the LPDME catalyst system's accelerated aging; and modifying the catalyst and/or the system operating conditions; and
- 2) Manufacturing scale-up of catalyst for a LaPorte run.

Progress has been made in the laboratory effort. Figure 2 shows the performance for the first DME catalyst which was tested; goals from the Liquid Fuels Program are provided for reference. After further study, an improved DME catalyst (AB-05) was tested with two LPMEOH™ catalysts (S3-86 and MK-101); the results of a 700 hour life study are presented in Figure 3. When compared with the program goals (Figure 4), the catalyst performance of the newer catalyst is approaching the commercial targets defined in Section A.

LPDME Recommendation

Initial discussions with catalyst manufacturers have been held. Once a manufacturer is selected, a laboratory-scale catalyst batch will be produced and tested in the autoclave to verify the production technique developed at Air Products. An interim 1 lb batch will then be produced and tested. Once the catalyst production techniques have been verified at this scale, the 200 lb LaPorte batch will be produced using the same methodology as for a full commercial batch. An autoclave check of this material will be performed prior to the start of the LaPorte run.

Recommendations

The catalyst system and the market applications/opportunities are sufficiently promising that proof-of-concept testing at the LaPorte AFDU is recommended. Kingsport is an unlikely site for the commercial size demonstration of LPDME, since there are limited times for CO-rich syngas testing; and H₂-rich syngas would create water buildup. Therefore, the basis for commercializing LPDME must come from:

- 1) catalyst performance (productivity, selectivity, and life) for the LPDME catalyst system under CO-rich syngas from the proof-of-concept testing at the LaPorte AFDU;
- 2) continuing work in hydrodynamics of slurry reactors (other ongoing DOE programs); and
- 3) reactor performance (methanol catalyst activity and life, hydrodynamics, and heat transfer) from the LPMEOH™ Process Demonstration Unit.

The tie-in between the laboratory and the LaPorte AFDU is important. Historically, the rate of deactivation of methanol synthesis catalyst has been greater in the autoclave than at the AFDU; this may be a result of loss of catalyst from the autoclave, or due to greater carbonyl poisoning as a result of the higher surface-to-volume ratio at the laboratory scale. Testing at the engineering scale of the LaPorte AFDU can eliminate this variable.

Recommendations:

- An LPDME test run at the LaPorte AFDU, in conjunction with the DOE's Liquid Fuels Program, would be appropriate if the LPDME catalyst system development can be completed successfully. Appendix A provides background for combining the funding from the CCT and Liquid Fuels Programs to support the LaPorte run. Up to \$875,000 of CCT Program budget support, from the LPMEOH™ Project's FY-97 Cost Plan (budget), should be made available to support a suitable LPDME test run at LaPorte.
- An implementation decision, made mutually by the DOE's CCT (DE-FC22-92PC90543) LPMEOH™ project participants, and by the DOE's Liquid Fuels (DE-FC22-95PC93052) program participants, should be made (by July of 1997) in time to implement testing at LaPorte in early 1998. *(Final dates should be recommended by the DOE's Liquid Fuels program, based on progress in developing the LPDME catalyst system).* The DOE LPMEOH™ project participants should be kept informed of the LaPorte AFDU LPDME test-run plans, so that a timely final approval can be made.

LPDME Recommendation

- In the interim, some DME product-use testing may be appropriate for the LPMEOH™ Project's Off-site Product testing.

(end).

DME COST VERSUS SIZE

TEXACO-TYPE SYNTHESIS GAS, 1:1 FEED:RECYCLE

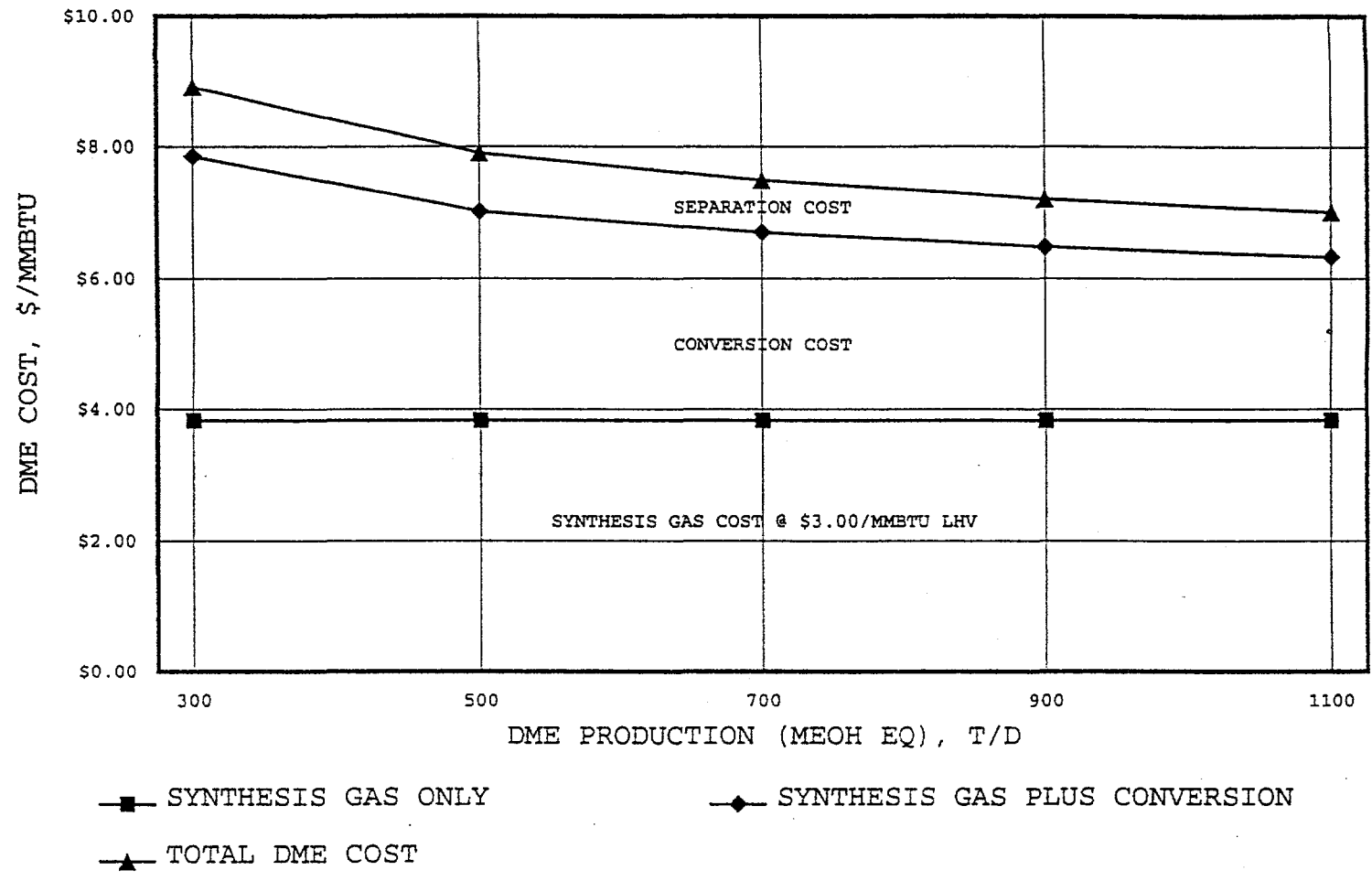


FIGURE 1

GOALS

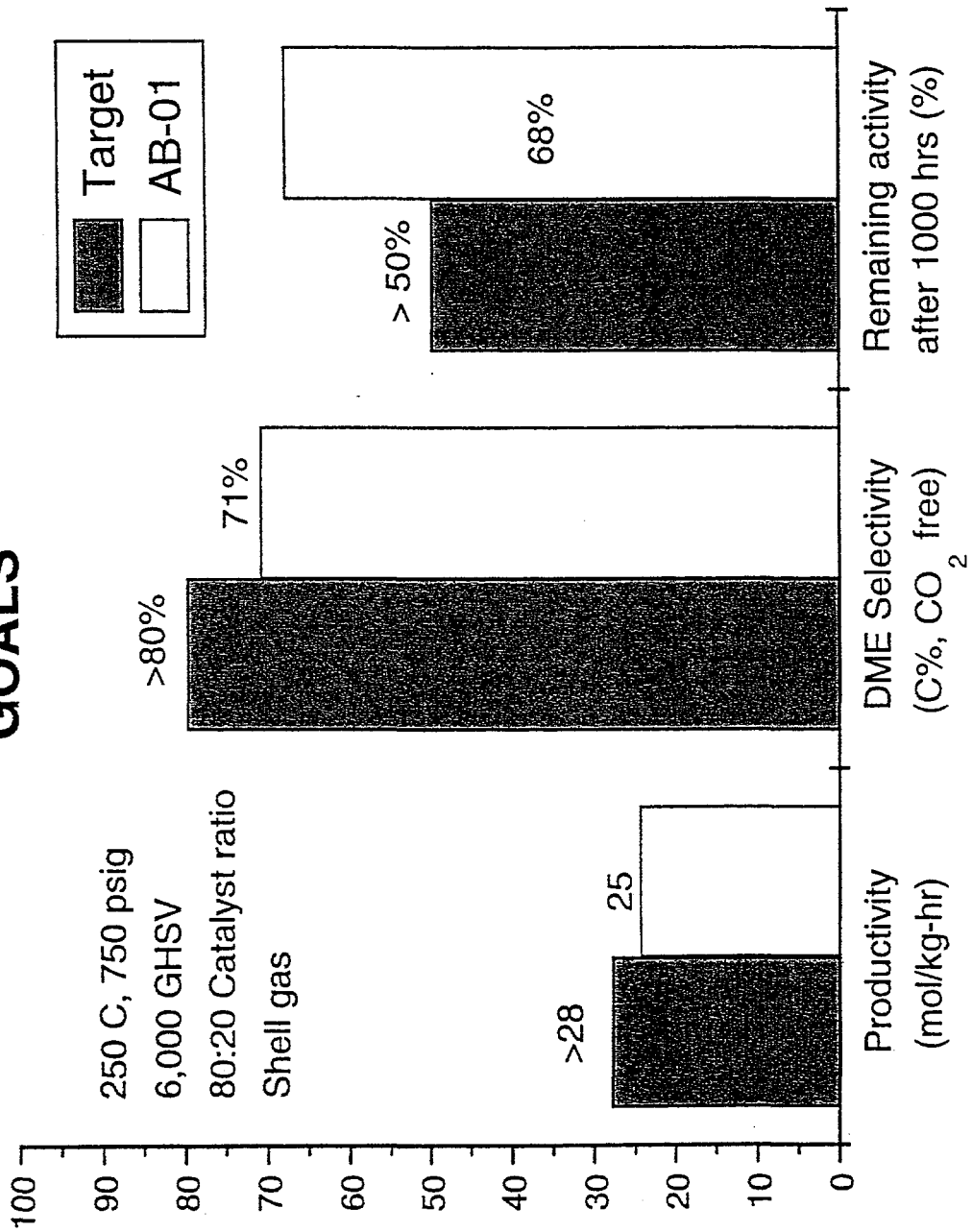
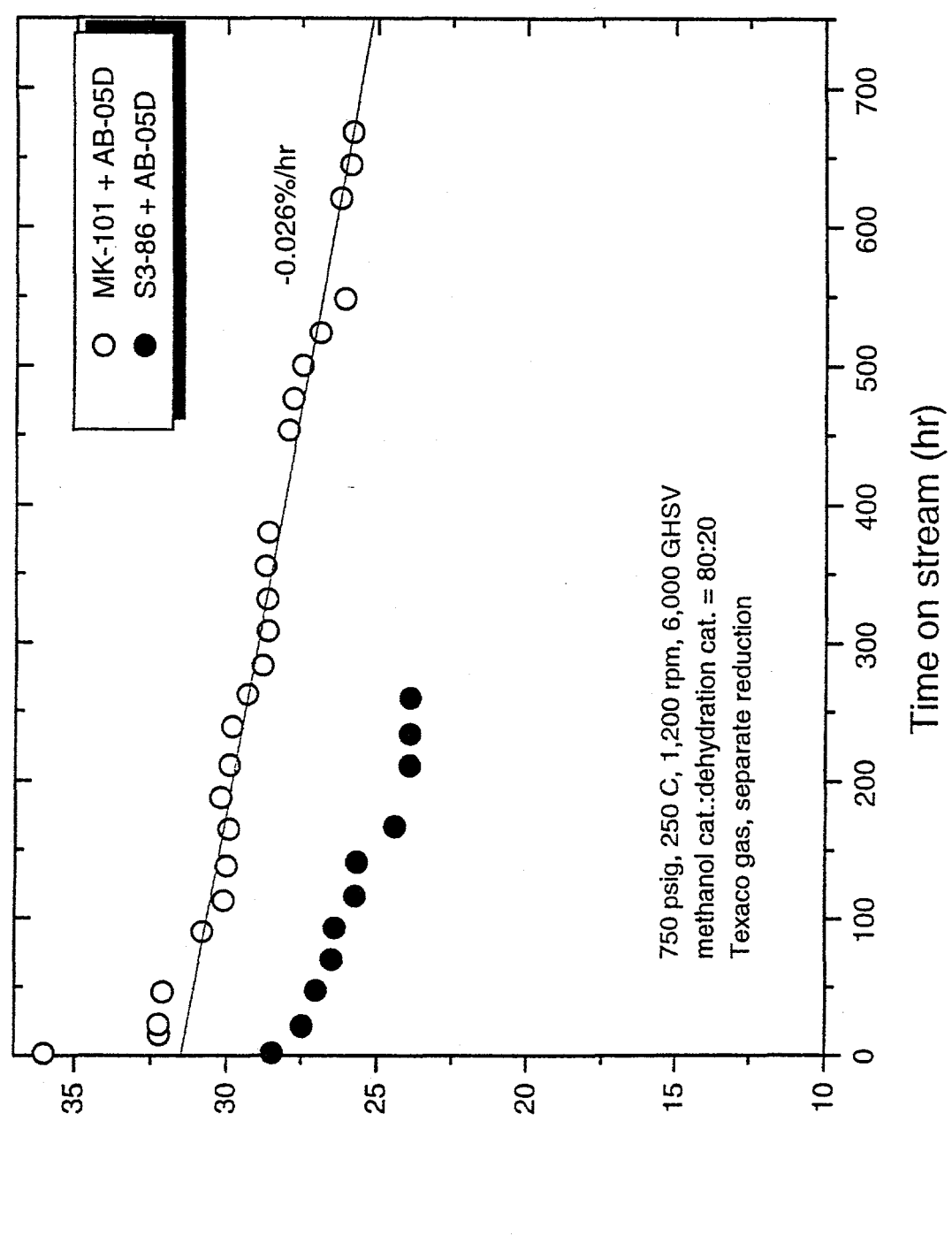


FIGURE 2

FIGURE 3



- Six catalyst samples (#1 - #6) were developed with good stability and decent activity.

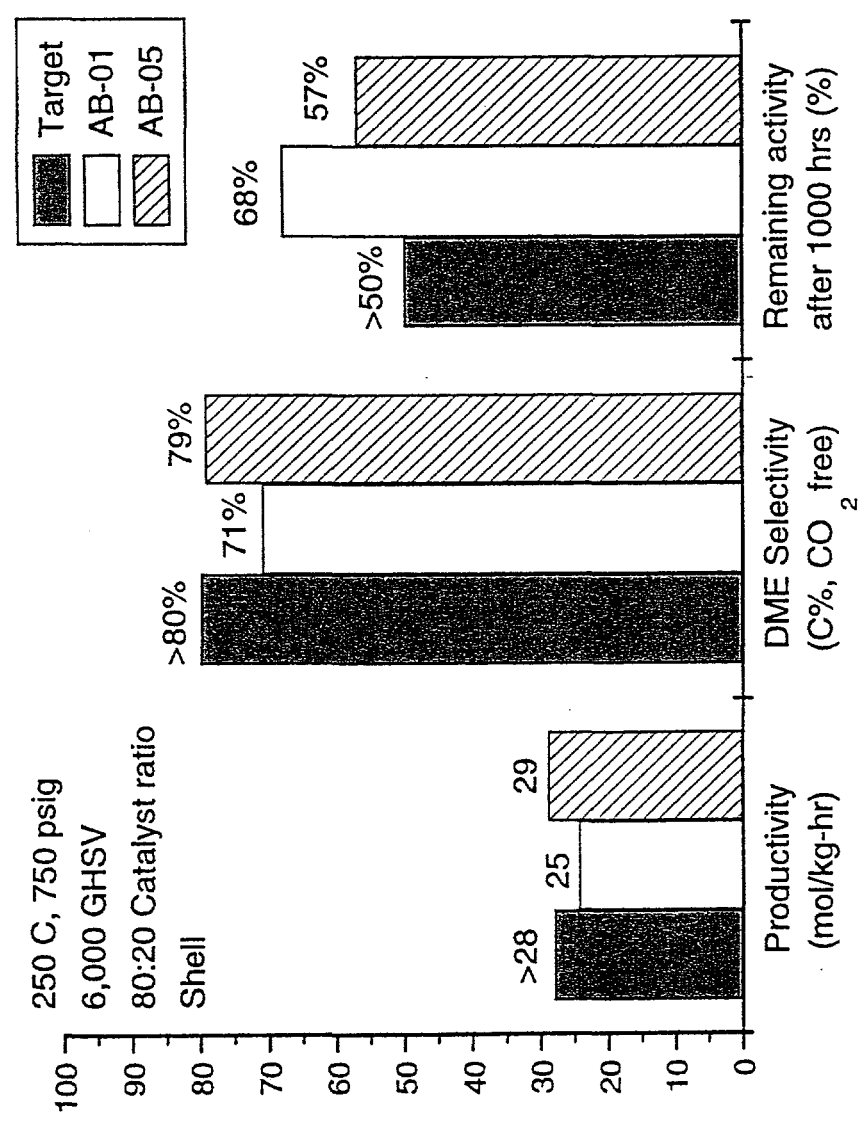


FIGURE 4

Appendix A.

Why combine the CCT and Liquid Fuels Programs for an LPDME test-run at the LaPorte AFDU?

The programs are related. The DOE Liquid Fuels Program has as one of its objectives: to investigate potential technologies for the conversion of syngas to oxygenated and hydrocarbon fuels and industrial chemicals; and to demonstrate the most promising at the LaPorte AFDU. Three slurry reactor programs are at the LaPorte AFDU demonstration stage:

1. Syngas to Fischer-Tropsch (F-T) liquids. A test-run at LaPorte in October of 1996 was partially successful, but terminated early. Analysis is underway, and a recommendation for an additional test run at LaPorte has been made. Air Products and Shell are participants.
2. Syngas to DME. An earlier (Liquid Fuels Program) LPDME test run at LaPorte showed good promise. DME is an important intermediate chemical building block for many of the Liquid Fuels Program's promising ideas. Development of a stable and active LPDME catalyst system is therefore an important part of this program.
3. Slurry Reactor Hydrodynamics. The LaPorte AFDU is the ultimate test unit to confirm laboratory (University, National Labs, Other) hydrodynamic studies. A test, planned for October of 1996 at LaPorte, was only partially executed due to the early termination of the F-T run. This needs to be rescheduled.

Budgets are limited. The DOE Liquid Fuels Program budget is limited. By combining the Liquid Fuels and the CCT Program budgets, the LPDME test-run at LaPorte can be made more extensive, and the CCT Program participants can provide experience from the Kingsport scaleup/demonstration to help in developing test-run plans.

PRELIMINARY RUN PLAN FOR A DME DEMONSTRATION RUN AT LAPORTE

Attachment 3

OBJECTIVE	CATALYST	FFED GAS	DURATION, DAYS
METHANOL WATER INJECTION STUDY	MEOH	TEXACO	7
DME LIFE STUDY	MEOH + X% DEHY.	SHELL	15
DME PROCESS VARIABLE STUDY: - HIGHER PRESSURE - HIGHER SUPERFICIAL VELOCITY - WATER INJECTION	MEOH + X% DEHY.	SHELL	7
DIFFERENT FEED GAS COMPOSITIONS	MEOH + X% DEHY.	TEXACO KINGSPORT	4
TRACER STUDY	MEOH + X% DEHY.	SHELL	3
HIGHER PROPORTION OF DEHY. CATALYST	MEOH + Y% DEHY.	SHELL	4
TOTAL			40

Analysis of 4-month LPMcOH Life Run at LaPorte

Days On-stream	Deact. Rate (a) of k ₀ , %/day	2*Std Error of (a)	2*% Std Error of (a)
113	-0.38	0.01	3
60	-0.36	0.04	11
45	-0.29	0.06	21
30	-0.44	0.10	24
22	-0.52	0.18	34
15	-0.25	0.26	106
7	0.44	0.59	132

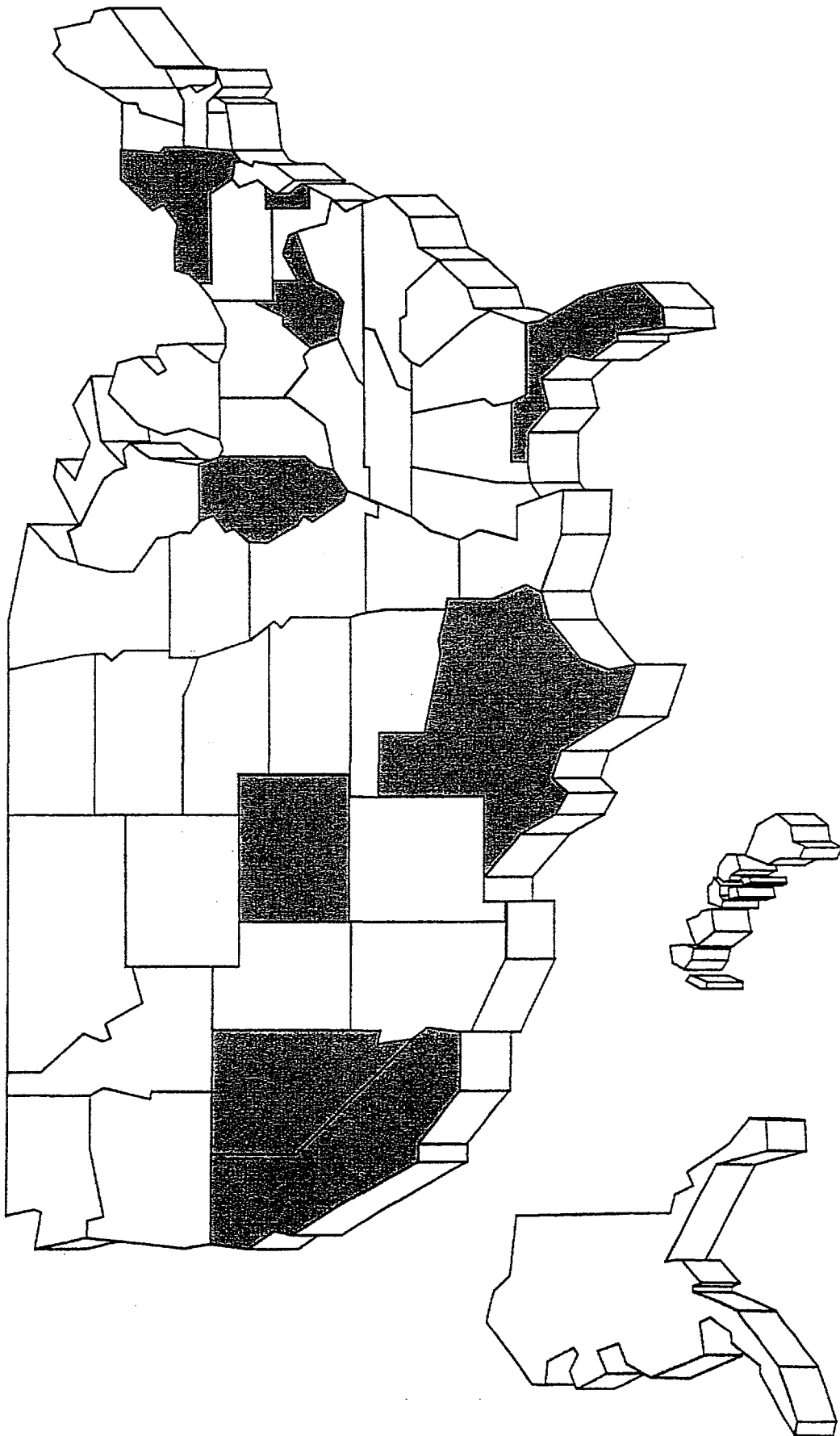
113

stable 0.05%

Days On-stream	Deact. Rate (b) of Productivity, %/day	# of Days needed to see a 2% drop
113	-0.17	12

- * Need minimum data for 15 days on-stream to check stability if catalyst is as stable as LPMcOH
- * Need data for more than 3 weeks on-stream to quantify deactivation rate.
- * Data for 60 days on-stream are enough to get fairly accurate deactivation rate.
- * Kingsport LPMcOH Life Data will be available before the LaPorte DME run

Attachment



Acurex Environmental

C O R P O R A T I O N

A Geraghty & Miller Company

April 25, 1997

Peter Tijm
Manager, Syngas Conversion Systems
Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195-1501

Reference: Acurex Subcontract under DOE Cooperative Agreement No. DE-FC22-92PC90543; Acurex Project 8438

Subject: Revised Fuel Test Plan

Dear Peter:

Glad we could meet this past April 18. I believe the meeting was quite fruitful in firming up our lines of communication and in making progress toward a final list of field test demonstration opportunities. I have enclosed a revised fuel test plan that includes the changes we agreed to at the meeting and via follow-up conversations I have held with Bob Senn. Please, call if you have any additional input. I look forward to get these quick start projects underway.

Sincerely,



Carlo Castaldini
Manager, Process Engineering

encl.

cc: John O'Sullivan (EPRI)

**Fuel Test Plan - Project Opportunities for Demonstration of LPMEOH for
Power Generation and Pollution Control In Stationary and Mobile Sources**

PROJECT NAME	TOTAL COST	AP FUNDS	COST SHARE	PRI- ORITY	MEOH START DATE	LOC- ATION	MeOH QUAN- TITY	QUICK START**	STATUS
	(\$k)	(\$k)	(\$k)				(gallons)		

COMPLETED PROJECTS & ADMIN.

LPMEOH/Dimethyl Ether Buses
Port of Long Beach
Heavy-Duty Truck
Environmental Impact Volume

TEST PLAN PROJECTS

Light Duty Vehicles	55	30	25	HIGH***	2Q 97	CA	220	yes	Ready for project initiation
Acurex FFV	0	0	0	LOW	?	CO	55	no	None
Direct Injection Stratified Charge Engines									
Hydrogen Production	475	328	147	HIGH	1Q 99	CA	2,000	no	Examine hydrogen safety concern and repropose
Methanol to Hydrogen Reformer*	0	0	0	LOW	?	CA	0	no	None
Fuel Cell Powered Vehicles w/On Board H2 Supply									
Distributed Power	122	122	0	HIGH	4Q 97	CA, NY	1,200	yes	Ready for project initiation. EPRI will pursue utilities, identify sites
Stationary Turbine for VOC Control: Phase 1	198	48	150	HIGH	2Q 98	CA, NY	3,000	no	Acurex will pursue cofunding opportunities (EPRI, AB 1890)
Stationary Turbine for VOC Control: Phase 2*	114	89	25	HIGH	3Q 97	WV	5,000	yes	Proposal received. Ready for project initiation
West Virginia Stationary Turbine									
Emulsion Fuels	273	23	250	HIGH	3Q 97	CA	55	yes	Ready for project initiation. Secure A-55 project commitment
Water/Napthal/MeOH Bus	227	227	0	HIGH	3Q 97	FL, TX	220	yes	Ready for project initiation. Coordinate with AFBs
Aircraft Ground Equipment Emulsion	160	80	80	HIGH	?	NV	330	no	EPRI will pursue with Sierra to solicit interest
Sierra Power Peak Load Power Generation									
Fuel Cells	90	70	20	HIGH	3Q 97	FL	500	yes	Proposal received. Ready for project initiation
Florida Lab Fuel Cell	500	200	300	HIGH	1Q 98	***	1,000	no	Acurex will track prototype progress
Fuel Cell Bus w/POX Reformer	1	1	0	MED	?	DC, IL	1,000	no	Acurex will maintain contacts with bus researchers
Fuel Cell Bus w/Steam Reformer	907	300	607	LOW	?	CA	0	no	None
Stationary Fuel Cell Power Generation*									
Heavy Duty Buses	75	75	0	HIGH	3Q 97	NY	3,000	yes	Proposal received. Ready for project initiation
Triborough Coach	950	250	700	HIGH	1Q 99	***	2,000	no	Acurex will pursue other possible sources of cofunding
Gas Turbine Hybrid Bus*	149	99	50	MED	3Q 97	FL	4,000	no	Proposal received.
Florida Institute of Technology Bus	200	30	170	LOW	3Q 97	CA	27,000	no	None
Methanol School Bus	0	0	0	LOW	?	CA	0	no	None
Methanol Transit Buses	0	0	0	LOW	?	***	0	no	None
Heavy-Duty Methanol Engine									
Power Production	25	25	0	HIGH	1Q 98	CA	200	no	AP/EPRI will provide Westinghouse contact
Advanced Power Generation	115	45	70	HIGH	3Q 98	IL	2,500	no	Acurex will pursue bid process with Illinois
Colfire of Coal-Fired Boiler*									
QUICK START PROJECTS	956	636	320				10,195		
HIGH & MEDIUM PRIORITY PROJECTS	3,529	1,712	1,817				26,225		
ALL TEST PLAN PROJECTS	4,636	2,042	2,594				53,280		
ALL PRIOR + TEST PLAN PROJECTS	5,330	2,316	3,014				63,280		

* - Projects require funding from other sources. Action items target bidding opportunities with CEC, ARB or FTA to receive cofunding.

** - Quick Start: "yes" indicates project ready to kickoff

*** - All projects designated as high priority are recommended.

**** - Host site not yet identified

Attachment (4)

PRIORITY: HIGH
AVAILABILITY: HIGH

Project Name: Demonstration of LPMEOHTM in Light-Duty Flexible Fueled Vehicle
(Acurex-owned)

Objective/Purpose

- Demonstrate LPMEOHTM in a light-duty flexible fueled vehicle.
- Provide cost-effective demonstration with already proven hardware.

Scope of Work

- Operate Acurex-owned Ford Taurus FFV with LPMEOHTM M85 and regular M85 for 2 months on each fuel.
- Ship, locate fuel drum at Acurex for blending LPMEOHTM-M85.
- Secure permitting and containment vessels for storage.
- Install fuel pump and dispenser.
- Track fuel economy during test periods for both fuels.
- Perform emissions testing on LPMEOHTM and M85 at CAVTC.
- Write short report containing emissions results and fuel economy comparison.

Status

- High-visibility, cost-effective project.
- Can be performed immediately.
- Possible synergy with NREL DISC engine and methanol formulations projects.

Further Actions

- Await go ahead from Air Products.
- Call NREL and identify methanol formulation interests.

Costs

Total Funds:	\$55k
AP Funds:	\$30k
Cost Share:	\$25k

PRIORITY: LOW
AVAILABILITY: LOW

Project Name: Demonstration of LPMEOHTM in DISC Engines

Objective/Purpose

- To demonstrate LPMEOHTM in new light-duty methanol Direct Injection Stratified Charge (DISC) engines under development by DOE-sponsored research companies in the United States.

Scope of Work

- Undefined.
- Demonstration would likely test LPMEOHTM versus standard M100 in a test-bench prototype engine.
- Perform bench emissions testing.
- Provide fuel for demonstration.

Status

- DISC engine currently being introduced for gasoline light-duty vehicles.
- Early development work undertaken on methanol DISC engines.
- Uncertain participation by engine developers.
- DOE already funding these sources.

Further Actions

- None. Project likelihood remote given timeframe of implementation and coordination problems with DOE and developers.

PRIORITY: LOW
AVAILABILITY: LOW

Project Name: Demonstration of Hydrogen Production from LPMEOHTM for Use in Hydrogen Powered Vehicles

Objective/Purpose

- To demonstrate local hydrogen generation for vehicle fueling and commercial hydrogen production
- To determine emissions from hydrogen production and verify low fuel cycle emissions for fuel cell powered zero emission vehicle candidates
- Verify suitability of LPMEOHTM as a feed for partial oxidation hydrogen generation systems

Scope of Work

- Review facility siting options at the UC Riverside College of Engineering Center for Environmental Research and Technology (CE-CERT).
- Purchase partial oxidation reformer configured for methanol operation
- Design system for hydrogen compression
- Obtain permits
- Prepare site
 - Electrical, controls, and equipment footings
 - Methanol and back up natural gas plumbing
- Install a methanol to hydrogen generation system
- Start up facility
 - Coordinate LPMEOHTM supply
 - Perform shake down testing
- Measure emissions from hydrogen generation system to support hydrogen as an equivalent to electric vehicles.
 - Evaluate emissions in terms of g/100scf, g/mi for fuel cell vehicle
- Install hydrogen compression equipment
 - Purchase compressor and gas storage
 - Operate facility for vehicle fueling and commercial hydrogen generation
- Prepare Final Report

Status

- Project team includes CE-CERT and Hydrogen Burner Technology
- Methanol storage tank is available at CE-CERT.
- An IC engine truck, research fuel cell vehicle, as well as commercial hydrogen are end use options
- Hydrogen compression experience with CE-CERT solar hydrogen facility.

Further Actions

- Determine cofunding opportunities from SCAQMD to fund compressor system integration.
- Review site options and hydrogen distribution options
- Certify safety of hydrogen tanks

Costs

Total Funds: \$475k
AP Funds: \$328k
Cost Share: \$147k

PRIORITY: LOW
AVAILABILITY: LOW

Project Name: Demonstration of LPMEOHTM in PEM Fuel-Cell Powered Vehicles
with On-Board Hydrogen Supply

Objective/Purpose

- Potential application of hydrogen production from methanol

Scope of Work

- Undefined.
- Operate fuel cell transit bus on LPMEOHTM and M100 in revenue service for 2 months for each fuel.
- Ship LPMEOHTM fuel to host site.
- Coordinate logistics of tracking fuel use.
- Track fuel economy during test period for both fuels.
- Provide vehicle troubleshooting and repair.
- Write report containing emissions results and fuel economy comparison.

Status

- A fleet of hydrogen powered fuel cell golf carts is operating in the city of Palm Desert (east of Los Angeles). Hydrogen is provided from solar energy. Praxair may be providing hydrogen also.

Further Actions

- None. Funding uncertainties and the large number of project participants do not make this the best opportunity to demonstrate hydrogen production from methanol.

PRIORITY: HIGH
AVAILABILITY: HIGH

Project Name: Demonstration of LPMEOHTM in Stationary Gas Turbine with VOC Control for Distributed Power- Phase I

Objective/Purpose

- To demonstrate VOC destruction and low NOx emissions using a 25 kW stationary gas turbine fired with LPMEOHTM. Phase I of a two-phased project

Scope of Work

- Select and secure a local host facility (bakery) for VOC-control demonstration
- Perform a site visit and make presentation of project
- Procure and arrange for delivery of a 25 kW Capstone turbine
- Perform engineering analysis and installation review
- Select method for VOC destruction (eg high temperature in combustor or low temperature in recuperator)
- Coordinate catalyst and other turbine modification equipment retrofit
- Install Capstone turbine at bakery demonstration host site.
- Arrange for short-term methanol storage tank.
- Ship LPMEOHTM fuel to host site.
- Operate for 2 weeks running VOC laden gas through turbine for destruction.
- Perform source emissions testing.
- Write emission test result report

Status

- Small VOC industrial sources have few VOC-destruction cost effective solutions
- California SIP has targeted bakery, and other small VOC sources, for VOC control.
- Acurex has made preliminary contact with some bakeries that are willing to explore the VOC destruction with electric power generation
- California AB1890 funds would provide cofunding for project for Phase II power generation demo.

Further Actions

- Track progress of AB1890 and bid opportunities
- Find potential host site (John O'Sullivan of EPRI will assist with finding utility)
- Explore permit issues with local air district
- Make preliminary inquiries with Capstone Turbines regarding cost and methanol conversion
- Initiate look at VOC consumption rates

Costs (PHASE I only)

Total Funds: \$122k
AP Funds: \$122k
Cost Share: \$0

PRIORITY: HIGH
AVAILABILITY: MEDIUM

Project Name: Demonstration of LPMEOHTM in Stationary Gas Turbine with VOC Control - Phase II

Objective/Purpose

- To demonstrate the long-term performance and economic validity of distributed power generation in connection with VOC destruction using a 25 kW stationary gas turbine fired with LPMEOHTM. Phase II of a two-phased project
- Project builds on Phase I installation to perform long-term power generation and economic analysis demonstration of the GT-VOC control concept

Scope of Work

- Obtain long-term operating permit from local district
- Secure Phase I host facility (bakery) for long-term distributed power & VOC-control demonstration
- Perform a site visit a make presentation of project
- Modify fuel storage for long-term demonstration
- Retrofit turbine for multiple approach to VOC destruction
- Arrange for connection to power grid and electricity sale contract
- Ship LPMEOHTM fuel to host site.
- Operate for 2 months with LPMEOH and natural gas running VOC laden gas through turbine for destruction during process operation and ambient air at all other times.
- Perform source emissions testing.
- Record power generation, fuel use, operating cycle, power sales and power usage
- Write performance and emissions test result report
- Write economic analysis and commercialization feasibility report

Status

- California AB1890 funds would provide cofunding for project for Phase II power generation demo.
- California AB 1890 promotes the use of distributed power in connection with VOC control
- Proposal preparation expected in February 1998.

Further Actions

- The execution of this project depends on the successful completion of Phase I
- Track progress of AB1890 and bid opportunities
- Find potential host site
- Explore permit issues with local air district

Costs (PHASE II only)

Total Funds: \$198k
AP Funds: \$48k
Cost Share: \$150k

PRIORITY: HIGH
AVAILABILITY: HIGH

Project Name: Demonstration of LPMEOHTM in a Water-Naphtha-Methanol Fueled Bus

Objective/Purpose

- To demonstrate viability of LPMEOHTM in a water-naphtha emulsion (A-55) containing 3% methanol.

Scope of Work

- Operate a 22 foot paratransit bus in revenue service using LPMEOHTM and M100 as an emulsion ingredient for 2 months on each fuel.
 - Daily pickup and transport for disabled persons in Sacramento
- Ship LPMEOHTM fuel to emulsion-producer for mixing.
- Coordinate logistics of tracking fuel use at host site.
- Track fuel economy during test period for both fuels.
 - Develop a fuel tracking plan
 - Coordinate with host site
- Provide vehicle troubleshooting and repair.
- Write short report containing fuel economy comparison between fuels and with control vehicles.

Status

- Acurex managed bus project already exists and revenue service will begin in late spring.
- Emulsion-producer is interested in potential sources of cheaper methanol.

Further Actions

- Call A-55 to confirm participation and coordinate details of emulsification process.

Costs

Total Funds: \$273k
AP Funds: \$23k
Cost Share: \$250k

PRIORITY: HIGH
AVAILABILITY: HIGH

Project Name: Demonstration of LPMEOHTM in a Diesel/Methanol Emulsion Fuel for Aircraft Ground Support and Stationary Power Generation Equipment

Objective/Purpose

- To demonstrate diesel/LPMEOHTM emulsion in AGE equipment at Air Force Bases
- To monitor the emission and performance of the emulsion fuel in comparison with conventional diesel

Scope of Work

- Secure a host facility at a US AFB
- Perform a site visit to finalize scope and site support
- Select emulsion fuel supplier (e.g. A-55)
- Identify/engineer engine modifications needed
- Select fuel storage option and arrange for fuel tank installation
- Prepare a test plan
- Perform field test consisting of emissions and performance evaluation
- Analyze data
- Prepare test report

Status

- USAFB at Tyndall has expressed significant interest
- AGE and power generation equipment is high on priority list for NOx reduction
- Completed preliminary contact with Tyndall AFB in Florida
- Obtained agreement from the Air Force to in principle participate in the demonstration
- Expression of interest from Environics Directorate
- Preliminary contact with emulsified fuel supplier completed
- Defined an initial scope of work pending approval

Further Actions

- Explore with US AFB at Tyndall (FL) and Brooks (TX) on AF support
- Formulate a preliminary level of effort and present it to Tyndall personnel for agreement
- Make preliminary arrangements

Costs

Total Funds: \$227k
AP Funds: \$227k
Cost Share: \$0k

PRIORITY: HIGH
AVAILABILITY: LOW

Project Name: Demonstration of LPMEOHTM in Fuel-Cell Powered Bus with POX Reformer

Objective/Purpose

- To determine viability of LPMEOHTM as a fuel for fuel cell powered buses operating with multifuel POX reformers.

Scope of Work

- Coordinate methanol operation with demonstration site and vehicle developers.
- Install above ground fueling station
- Ship LPMEOHTM fuel to host site.
- Coordinate logistics of tracking fuel use.
- Operate fuel cell transit bus on LPMEOHTM and M100 in revenue service for 2 months for each fuel.
- Track fuel economy during test period for both fuels.
- Provide vehicle troubleshooting and repair.
- Perform chassis emissions testing on diesel, LPMEOHTM, and M100.
- Write report containing emissions results and fuel economy comparison.

Status

- Very high visibility project with excellent potential for vehicle use of methanol.
- Currently, DARPA-funded project for development of fuel cell/reformer technology is underway. Program for testing PEM fuel cell bus has not been finalized.
- Though project appears to have initial support from fuel cell developer, they will not operate on-road bus until late 1998. The bus is designed for multifuel operation; however, modifications to the fuel system would be necessary for methanol operation.

Further Actions

- While project has high visibility value, current hardware development plans will not allow demonstration to start until 1999. Excellent project for follow-on funds.
- Monitor project development and inquire regarding the possibilities for methanol operation

Costs

Total Funds: \$500k
AP Funds: \$200k
Cost Share: \$300k (Contingent)

PRIORITY: HIGH
AVAILABILITY: LOW

Project Name: Demonstration of LPMEOHTM Fuel-Cell Powered Bus with Steam Reformer

Objective/Purpose

- To determine viability of LPMEOHTM as a fuel for fuel cell powered buses operating with steam reformers
- Demonstrate LPMEOHTM use in breadboard and bus operation

Scope of Work

- Follow-on to Florida Lab 25kW Fuel Cell project.
- Operate fuel cell transit bus on LPMEOHTM and M100 in revenue service for 2 months for each fuel.
- Ship LPMEOHTM fuel to host site.
- Coordinate logistics of tracking fuel use.
- Track fuel economy during test period for both fuels.
- Provide vehicle troubleshooting and repair.
- Write report containing emissions results and fuel economy comparison.
- Provide fuel for Phase IV developments.

Status

- Very high visibility project with excellent potential for vehicle use of methanol.
- IFC and Ballard are developing methanol steam reforming fuel cell powered buses for Georgetown University. The IFC system uses a high temperature (1500F, Ni Catalyst) reformer and the Ballard system uses a low temperature (500F, Cu/Zn Catalyst) reformer. The high temperature system should be able to reform all types of alcohols while the low temperature system may not convert hydrocarbons and other alcohols.
- The project steps include system design, breadboard development, vehicle integration, and field demonstration. Actual operation on methanol in buses is several years away.
- Demonstration sites have not been identified at this time

Further Actions

- Provide input to IFC and Ballard on LPMEOHTM specifications and availability. Inquire if the fuel is feasible for vehicle operation. Provide samples for laboratory testing.

PRIORITY: LOW
AVAILABILITY: MEDIUM (Contingent)

Project Name: Demonstration of LPMEOHTM in Stationary Fuel Cell Power Generation Applications

Objective/Purpose

- To demonstrate the viability of LPMEOHTM for stationary fuel cell distributed power generation

Scope of Work

- Identify demonstration site and cost sharing
- Design modifications for methanol operation
- Procure fuel cell
- Procure and install above ground fuel tank and fuel supply system
- Prepare site and electrical generation interface
- Install fuel cell
- Perform emission testing on methanol and natural gas
- Collect operating data
- Prepare final report

Status

- IFC/ONSI fuel cells (PC25) operate on natural gas and LPG. There are about 60 installations around the world. The IFC system uses a high temperature (1500°F) steam reformer to produce hydrogen. This catalyst system could operate well on any grade of methanol.
- The IFC fuel cell system has not been configured to operate on methanol for stationary applications.
- DOE is supporting R&D for PEM fuel cells for vehicles and building cogeneration. The hydrogen generation will most likely be with a partial oxidation system that can operate on gasoline, natural gas, diesel, ethanol, and methanol.
- PEM fuel cell power generation system will not be available from the DOE program for 3 years.

Further Actions

- Monitor developments with stationary fuel cell projects. Make contact with EPRI, IFC, and project participants and explore opportunities for LPMEOHTM demonstration.
- Seek funding under AB1890 to fund a project
- Discuss requirements for methanol operation with IFC

Costs

Total Funds: \$907k
AP Funds: \$300k
Cost Share: \$607k (contingent upon AB1890 and other funding)

PRIORITY: HIGH
AVAILABILITY: MEDIUM (Contingent on funding and participation)

Project Name: Demonstration of LPMEOHTM in Gas Turbine Powered Hybrid Bus

Objective/Purpose

- To determine viability of LPMEOHTM as a fuel for turbine powered hybrid buses.

Scope of Work

- Install Capstone turbines in an Orion Bus Industries hybrid-electric bus.
- Install methanol fuel system on bus.
 - Determine appropriate design considerations
 - Identify, purchase, and install parts
- Reconfigure electronic control for operation with gas turbine.
 - Develop software modifications
 - Create hardware for interface between master controller and turbine
- Operate bus in revenue service using LPMEOHTM for 12 months.
- Ship LPMEOHTM fuel to host site.
- Coordinate logistics of tracking fuel use.
- Track fuel economy during test period.
 - Develop field, performance, and emissions test plan
 - Implement data collection procedures
- Provide vehicle troubleshooting and repair.
- Write report containing vehicle development description, vehicle demonstration results, emissions results and fuel economy comparison to control vehicles.

Status

- Extremely visible, high-potential project.
- Initial response from Capstone, OBI, and CE-CERT is very positive.
- Requires commitment of several participants and extra funding from local, state or federal agencies. Funding could come from FTA or ARB. Requires development of partnership with involved parties.

Further Actions

- Clarify interest of partners for project plan.
- Identify additional funding from other agencies, such as ARB or FTA.

Costs

Total Funds: \$950k
AP Funds: \$250k
Cost Share: \$700k (Contingent)

PRIORITY: LOW
AVAILABILITY: HIGH

Project Name: Demonstration of LPMEOHTM in Methanol Fueled School Bus

Objective/Purpose

- To determine viability of LPMEOHTM as a fuel for school buses.

Scope of Work

- Operate school buses in revenue service using LPMEOHTM and M100 for 2 months on each fuel.
- Ship LPMEOHTM fuel to host site.
- Collect data from on-board data acquisition systems and operating records:
 - Vehicle speed/mileage
 - Fuel consumption
 - Engine speed
 - Foot brake activation
 - Percent engine load
 - Percent throttle
 - Idle time
- Provide vehicle troubleshooting and repair.
- Interview drivers with evaluation questionnaire.
- Track fuel economy during test period for both fuels.
- Write short report containing fuel economy comparison between fuels and with control vehicles.

Status

- Host site Antelope Valley Schools Transportation Agency (AVSTA) reacted positively to idea.
- 15 MeOH buses are part of CEC demonstration -- fuel source change requires CEC approval.
- Approval of bus manufacturer (Carpenter) required to protect warranty
- 12,000 gal MEOH tank onsite for school bus fueling

Further Actions

- Get fuel specification sheet and MSDS for AVSTA, CEC, Carpenter, DDC, and OSHA needs
- Verify fuel compatibility for Carpenter M100 schoolbuses
- Contact CEC
- Contact Carpenter and estimate fuel quantity needs

Costs

Total Funds: \$200k
AP Funds: \$30k
Cost Share: \$170k

PRIORITY: LOW
AVAILABILITY: LOW

Project Name: Demonstration of LPMEOHTM in Transit Buses with DDC 6V-92TA Engines

Objective/Purpose

- Demonstrate LPMEOHTM use at transit agencies operating DDC 6V-92TA engines.
- Prove viability of LPMEOHTM in heavy-duty transit bus applications.

Scope of Work

- Operate methanol transit buses on LPMEOHTM and M100 for period of two weeks.
- Ship fuel to transit agency methanol storage tank.
- Coordinate refueling efforts.
- Track fuel economy during test periods for both fuels.
- Perform emissions testing on LPMEOHTM and M100 at LACMTA chassis dynamometer.
- Write short report containing emissions results and fuel economy comparison.

Status

- Already measured emissions from an MTA bus operating on M100, LPMEOHTM and LPMEOHTM with DME mixtures (December 1994) in cooperation with Air Products.
- LACMTA's fleet of methanol buses is making a transition to ethanol operation. MTA's organization is complex and the logistics of integrating LPMEOH use with a large fleet of buses would be costly.
- Kenawah Valley (KVRTA) was a planned site for methanol bus operation but they are no longer operating buses on methanol.

Further Actions

- None. Extensive efforts with transit bus operation are not warranted given the availability of methanol engines and the logistics of fueling and data collection at transit agencies.

PRIORITY: LOW
AVAILABILITY: LOW

Project Name: Demonstrate of LPMEOHTM in Caterpillar Heavy-Duty Methanol Engine

Objective/Purpose

- To demonstrate LPMEOHTM in a new M100 heavy-duty engine currently under development by Caterpillar.
- Prove viability of neat-LPMEOHTM in heavy-duty methanol engines.

Scope of Work

- Undefined.
- Test LPMEOHTM versus standard M100 in a test-bench prototype engine.
- Perform bench emissions testing.

Status

- Caterpillar bench prototype engine will not be available within a year's time.
- Not certain if Caterpillar would be interested in demonstration of LPMEOHTM in their new engine.

Further Actions

- None.

PRIORITY: HIGH
AVAILABILITY: LOW

Project Name: Demonstration of LPMeOHTM for Advanced Power Generation Equipment

Objective/Purpose

- To test LPMeOHTM in the fuel cell reformer and gas turbine in advanced power cycle equipment being developed under DOE program
- To compare the performance and cost of the power plant with more conventional combined cycle fuels

Scope of Work

- Re-contact Solar R&D group later this year regarding progress and schedule
- Obtain agreement and firmup schedule
- Visit the site and secure final agreement
- Develop test plan and get it approved
- Arrange for delivery of LPMeOHTM and storage
- Monitor the testing and data gathering effort
- Obtain data from the site
- Analyze data
- Write a test report

Status

- Acurex will take advantage of an ongoing project sponsored by DOE and performed by Solar Turbines Division of Caterpillar and Westinghouse where an advanced power generation cycle consisting of GT and fuel cell combination will be used to generate electricity with overall efficiency exceeding 65 percent. The equipment and technology is currently being assembled at Solar Turbines and is scheduled for multifuel testing later this year and in 1998
- Solar will consider methanol firing, including LPMeOHTM
- Preliminary contact made with Solar Turbines. Agreement in principle. Further negotiations are necessary

Further Actions

- Acurex will confirm the feasibility of the project later this year
- If deemed feasible to pursue, Acurex will continue contact to coordinate the scope of work and schedule

Costs

Total Funds: \$25k
AP Funds: \$25k
Cost Share: \$0

PRIORITY: HIGH
AVAILABILITY: MEDIUM

Project Name: Demonstration of LPMeOHTM Cofire/Startup for Coal-Fired Boiler

Objective/Purpose

- To demonstrate the use of LPMeOHTM as a cofire or startup fuel for existing coal-fired industrial and small-scale power generation boilers in the Midwest. The LPMeOHTM fuel will be used in minimal amounts to support improved boiler operation, minimize emissions, and in general improve the reliability and performance of the boiler continuing its viability as a coal-fired boiler. The boiler that will be selected will be among the population of boilers recently retrofitted under the GRI gas cofire program. This will ensure that the boiler is already equipment ready for installation and firing of methanol fuel with minor modification of existing burner equipment

Scope of Work

- Define site selection criteria
- Survey boiler population for site selection
- Undertake phone search for site selection and securing preliminary agreement
- Make site visit and secure host facility for the demonstration
- Prepare a retrofit, equipment modification and test plan
- Subcontract the burner vendor to make modifications to the burner for methanol ready firing
- Arrange for delivery, storage, and hookup of fuel
- Perform startup and initial diagnostic tests
- Perform emission and performance tests in line with the test plan
- Arrange for site equipment to return to normal
- Analyze test data
- Write report

Status

- Acurex has made preliminary contacts with the Illinois Clean Coal Institute (ICCI) to explore the interest in this demonstration. Heman Feldmann. Preliminary interest pending on the economic viability of LPMeOHTM as a cofire fuel compared with alternatives.

Further Actions

- Acurex will further explore interest in this demonstration following approval from all project stakeholders. The viability of the project will also hinge on securing cofunding using the open submittal of project ideas under the current ICCI open solicitation mechanism. Stakeholder approval and award of contract from ICCI following submittal of Acurex proposal will be followed up with the proposed scope of work described above. Level of ICCI cofunding is limited to \$250,000 per project.

Costs

Total Funds: \$115k
AP Funds: \$45k
Cost Share: \$70k

DATA SUMMARY FOR LPMEOH DEMONSTRATION UNIT

Case	Date	Gas Type	Temp (Deg C)	Pres. (psig)	Balanced				Recycle			Space Velocity (l/hr-kg)	Slurry Conc. (wt% ox)	Gas Holdup (vol%)	Gassed Slurry Hgt (ft)	Catalyst Inventory (lb)	CO Conv. (%)	Reactor O-T-M Conv. (%)	Syngas Util. (SCF/lb)	Raw MeOH Production (TPD)	Catalyst MeOH Prod. (gmol/hr-kg)	Reactor Vol. Prod. (TPD/Cu ft)
					Gas (KSCFH)	CO Gas (KSCFH)	H ₂ Gas (KSCFH)	Gas (KSCFH)	Gas Velocity (ft/sec)	Intet Sup. Velocity (ft/sec)	Gas (KSCFH)											
1	12-Apr-97	Balanced	248	719	758	0	0	0	1.375	0.50	1.375	6.203	30.5	50.2	54.9	20,300	54.8	33.1	37.6	242.3	30.74	0.105
1	13-Apr-97	Balanced	249	716	792	0	0	0	1.536	0.55	1.536	6.783	30.8	50.6	54.9	20,300	52.5	31.7	37.5	253.8	32.19	0.110
1	14-Apr-97	Balanced	249	705	789	0	0	0	1.619	0.58	1.619	7.014	30.9	52.0	56.1	20,300	50.5	30.5	37.5	252.4	32.00	0.107
1	15-Apr-97	Balanced	249	705	818	0	0	0	1.601	0.58	1.601	7.019	30.8	50.9	55.1	20,300	51.7	31.2	37.9	258.9	32.84	0.112
1	16-Apr-97	Balanced	248	705	904	0	0	0	1.527	0.59	1.527	7.094	30.9	50.7	54.5	20,300	55.8	33.6	38.5	281.9	35.82	0.123
1	17-Apr-97	Balanced	249	704	887	0	0	0	1.746	0.63	1.746	7.629	32.1	53.0	54.3	20,300	49.8	30.0	39.4	270.5	34.35	0.119
1	18-Apr-97	Balanced	249	705	841	0	0	0	1.843	0.64	1.843	7.762	32.0	51.9	53.4	20,300	48.2	29.1	37.8	267.0	33.86	0.119
1	19-Apr-97	Balanced	249	703	964	0	0	0	1.779	0.66	1.779	7.970	32.0	52.2	53.8	20,300	51.1	30.7	40.0	288.8	36.80	0.128
1	20-Apr-97	Balanced	249	709	958	0	0	0	1.994	0.70	1.994	8.562	32.2	51.5	52.4	20,300	48.3	29.2	39.4	292.2	36.60	0.133
1	21-Apr-97	Balanced	249	708	913	0	0	0	2.114	0.72	2.114	8.771	30.3	50.5	55.8	20,300	47.1	26.4	39.8	275.5	34.77	0.117
1	22-Apr-97	Balanced	249	709	859	0	0	0	2.122	0.71	2.122	8.635	29.4	50.4	58.0	20,300	47.5	25.6	39.5	261.1	32.84	0.107
1	24-Apr-97	Balanced	249	709	793	0	0	0	2.106	0.69	2.106	8.376	29.3	49.0	56.7	20,300	49.0	24.6	39.2	242.7	30.66	0.102
1	25-Apr-97	Balanced	249	702	865	0	0	0	2.024	0.70	2.024	8.419	29.9	50.7	57.0	20,300	44.6	26.2	39.8	261.0	33.17	0.109
1	26-Apr-97	Balanced	248	700	835	0	0	0	1.921	0.67	1.921	8.019	31.8	45.6	47.5	20,300	44.6	26.2	40.4	248.2	31.58	0.125
1	26-Apr-97	Balanced	246	694	864	0	0	0	1.877	0.67	1.877	7.980	32.8	46.0	45.8	20,300	41.6	26.0	41.9	247.8	31.38	0.129

DRAFT

Attachment (5)

RUN NO: K1-4/25 TITLE: Shakedown & Design Production Tests

	FRESH FEED	CO MAKEUP	H2 MAKEUP	K-01 OUTLET	REACTOR FEED	C-05 OUTLET	MAIN PURGE	DISTILL. PURGE	CRUDE PRODUCT	REFINED PRODUCT
T	72	57	59	103	303	250	84	51	226	75
P	748	857	635	743	737	693	683	9	185	151
Comp	66.94	1.93	77.66	71.19	69.63	63.20	68.25	32.94	0.00	0.00
(mol %)	30.16	97.05	9.12	15.41	19.78	13.43	14.93	8.53	0.00	0.00
N2	0.42	0.97	6.50	4.38	3.17	3.86	4.15	30.36	0.00	0.00
CH4	0.04	0.05	0.92	0.53	0.38	0.46	0.50	0.72	0.00	0.00
CO2	2.43	0.00	3.76	6.57	5.26	6.31	6.32	23.84	0.00	0.00
DME	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
MeOH	0.00	0.00	0.06	0.29	0.39	11.23	4.22	3.62	82.65	99.98
EtOH	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.16	0.01
H2O	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	17.18	0.02
others	0.00	0.00	1.97	1.64	1.39	1.40	1.62	0.00	0.01	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Mole Wt
LHV
Enthalpy

lb/lbmol
MMBTU/hr
MMBTU/hr

Flow
SCFH
lbmol/hr
lb/hr

10.997	27.501	7.770	10.541	10.753	12.841	23.324	29.703	32.039
234.0	0.0	0.0	482.6	717.5	692.9	3.3	47.0	140.8
-40.73	0.00	0.00	-96.07	-126.27	-155.95	-2.76	-20.09	-49.88
835.142	0	0	1,920,870	2,755,353	2,261,917	21,842	73,896	183,832
2,201.5	0.0	0.0	5,063.6	7,263.4	5,962.7	57.6	194.8	484.6
24,211	0	0	53,376	78,102	76,569	1,343	5,786	15,526

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PLANNING DETAILS
LIQUID PHASE METHANOL DEDICATION CEREMONY
25 JULY 1997 - KINGSPORT, TENNESSEE

SCHEDULE OF EVENT: (Approximately 50 People)

11:30 A.M. - 12:30 P.M. - Arrive/Lunch*

*Lunch time to be slightly extended due to key contact individuals seated together at lunch tables to allow for discussion.

(Peter, Stan, Ed), (Peter, Sarkus, Jones), etc.

ECH & B. Kornosky (FETC) - JAF/Jean Kendrick

12:40 P.M. - 1:10 P.M. - Remarks - 10 minutes each: Eastman, Air Products, DOE

1:15 P.M. - 1:35 P.M. - Dedication Ceremony (Ribbon cutting, 3 scissors)

Photo Opportunity

1:40 P.M. - Finish Dedication/Photos

1:45 P.M. - 2:45 P.M. - Tours** - Trailer/Control Room/Walk Around

(Split into groups of 10 people maximum

** 20 minutes (subject to change depending on key contact meetings and Eastman's ideas

Tour Guides: ECH/Van Eric Stein/Frank Frenduto/Barry Street

3:00 P.M. - Conclusion/Leave if want

- APCI to show DOE gasifier - if requested. (Not to be part of written agenda)

ACTION ITEMS:

Eastman: (Jean Kendrick)

- Find location for dedication ceremony, prefer outside at site. Need to have rain option.
- Food - Plan catered lunch (Air Products sponsored)
- Transportation to & from airport (Air Products sponsored)
- Other ideas/suggestions - awaiting to hear from Jean Kendrick (literature, etc.)
- Safety items - hard hats, safety glasses. For APCI: nomex suits, however ECH checking on waive option.

Air Products:

- APCI invitee list to be reviewed and finalized - (2 weeks) - PJAT/ECH - JAF keeping updated listing. ECH to receive DOE's finalized invitee listing on 5/9 from B. Kornosky (FETC).
- Invitations - Distribution date: Early June (6 weeks prior to event)

Semi formal: JAF to draft: suggested first page photo: completed plant snapshot -need negative from Barry Street (Eastman).

Any theme? Gary Stiegel suggested to BJH: "Industry Partnering with Government".

To be approved by PJAT/ECH/BJH Rsvp name in invitation: Rochelle Oswald

Invitations to be sent/monitored by Rochelle.

Formal to Pat Godley - BJH/JAF to draft. ECH to send to Godley.

- Corporate jet reserved (done) - JAF
- JAF to check with A. Katsaros regarding number of executives to fly together on corp. jet.
- Plan Dedication Ceremony - Ribbon with 3 scissors - JAF ordered thru Shirley Miller
 - Remarks/speeches - ECH to prepare & work up for v.p.'s
 - Obtain Jean Kendrick's thinking/timing for speeches at ribbon cutting.
- Update APCI/DOE poster - PJAT/ECH/JAF- APCI & Bob Kornosky- DOE/Eastman
 - Draft changes: #2 photo: include aerial close-up photo - ECH
 - #3 photo: slight changes to technology deploy
 - #4 photo: change photo to Destec & Tampa per B. Kornosky
 - #5 photo: change bus photo, want message to portray various types of technology usage through schematics for chemistry, transportation, stationary power, fuel bus, etc (B. Kornosky)
 - Poster to be displayed (location? on easel? qty of copies?
 - Need glossy sheets made (to be available in trailer/folder)- qty?
 - Is this one poster enough? Any more needed elsewhere?
- DOE fact sheet - ECH to update Clean Coal sheet with B. Kornosky (FETC)
- Name tags, additional info., etc. - Eastman & Air Products - Jean/JAF
- News Release/Photographer needed - Greta Campbell
- Literature packet/folder - Jean/JAF
- Elements/items: - 1-Agenda/2-Press Release/3-Updated DOE Fact Sheet on Clean Coal/4-Eastman's newsletter for startup (April edition)/5-Glossy copy of updated poster/ (no biographies needed)
- Completed plant stickers for front page of literature packets - JAF
- Update ground sign at facility by removing dollar figures - ECH
- Giveaways: Acrylic block with LPMEOH flask & liquid methanol - JAF ordered thru Shirley Miller, Shirley checking, will advise.
- Make new vinyl banner to hang on fence near trailer (can copy from groundbreaking event) - JAF
- 14 photographs representing each month's progress to be displayed in trailer - ECH
- Order megaphone rather than phone walkie talkies for plant tours - ECH

**APPENDIX N - TASK 3.6 - MILESTONE SCHEDULE STATUS AND COST
MANAGEMENT REPORTS**

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			
PHASE 1: DESIGN																	
PROJECT DEFINITION(TASK1)	51.20 m	Oct/01/93	Dec/30/97	98	95												
CONTINUATION APPLICATION(B.P.#2)	12.04 m	Oct/01/93	Sep/30/94	100	100												
PERMITTING(TASK2)	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	27	82												
DECISION TO CONTINUE DME TESTING	0.00 d	Jun/30/97	Jun/30/97	0	0												
PLANNING, ADMIN & DME DVT(TASK 5)	0.00 d	Dec/04/96	Dec/04/96	100	100												
PHASE 2: CONSTRUCTION																	
PROCUREMENT(TASK1)	39.85 m	Oct/01/93	Jan/20/97	100	100												
CONSTRUCTION(TASK 2)	42.66 m	Oct/17/94	May/01/98	97	79												
TRAINING & COMMISSIONING(TASK 3)	21.54 m	Oct/17/94	Jul/30/96	100	100												
OFF-SITE TESTING(TASK 4)	16.10 m	Oct/02/95	Jan/31/97	100	100												
PLANNING & ADMINISTRATION(TASK 5)	17.88 m	Sep/05/95	Feb/27/97	100	100												
CONTINUATION APPLICATION(B.P.#3)	9.00 m	Aug/02/97	May/01/98	0	0												
PHASE 3: OPERATION																	
START-UP(TASK 1)	35.17 m	Jun/01/96	May/01/98	93	66												
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	4												
ON-SITE PRODUCT USE DEMO(TASK 3)	2.31 m	Jan/23/97	Apr/02/97	100	100												
OFF-SITE PRODUCT USE DEMO(TASK 4)	48.07 m	Apr/02/97	Mar/28/01	4	4												
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												
PROVISIONAL DME IMPLEMENTATION																	
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	7	7												
	51.36 m	Apr/01/97	Jul/05/01	0	0												
	12.54 m	Apr/01/97	Apr/15/98	0	0												
	123.00 d	Mar/01/98	Jul/01/98	0	0												
	36.32 m	Jul/01/98	Jul/05/01	0	0												

[illegible]

U.S. DEPARTMENT OF ENERGY
COST MANAGEMENT REPORT

COPY

1. TITLE	2. REPORTING PERIOD	3. IDENTIFICATION NUMBER	ESTIMATED ACCRUED COSTS										12. Total Contract Value	13. Variance
			10. ACCRUED COSTS				11. Subsequent Reporting Period				12. Subsequent FY's			
8. ELEMENT	9. REPORTING ELEMENT		Reporting Period	Cumulative to Date	a. Subsequent Reporting Period	b. Balance of Fiscal Year	c. FY 1998	d. FY 1999	e. FY 2000	f. Subsequent FY's	Total			
			a. Actual	b. Plan	c. Actual	d. Plan		(1)	(2)	(3)	(4)			
	Prior to Mod 2		0	0	16,304	16,289	0	0				16,304	16,289	
1.1.1	Project Definition		0	0	1,039	1,021	0	0	0	0	0	1,039	1,021	
1.1.2	Permitting		0	0	253	246	0	0	0	0	0	253	246	
1.1.3	Design Engr.		36	0	10,896	10,865	27	36	0	0	0	10,979	9,960	
1.1.4	Off-site Testing		1	20	36	169	20	155	65	0	0	276	320	
1.1.5	Planning, Admin, & DME Verif. Testing		0	0	2,984	2,055	0	0	0	0	0	2,984	1,892	
1.2.1	Procurement		4	0	10,173	9,000	0	153	0	0	0	10,326	9,783	
1.2.2	Construction		72	0	11,629	13,519	0	0	0	0	0	11,629	11,200	
1.2.3	Train. & Commissioning		0	0	588	2,162	0	0	0	0	0	588	1,197	
1.2.4	Off-Site Test - Proc. & Constr.		0	0	0	0	20	100	136	0	0	256	261	
1.2.5	Planning & Admin		0	15	966	853	15	90	0	0	0	1,071	681	
1.3.1	Startup		1	0	1,445	680	0	0	0	0	0	1,445	3,435	
1.3.2	Operations													
1.3.2.1	Methanol Operation		2,058	2,546	6,503	12,685	2,545	34,240	38,689	40,061	8,700	145,730	147,287	
1.3.2.2	DME Design, Mod., Oper.		0	0	0	0	0	0	567	1,223	0	1,790	2,340	
1.3.2.3	LPM/OH Dismantlement		0	0	0	0	0	0	0	0	515	515	425	
1.3.3	On-Site Product Use Demo		0	0	0	2	0	2	0	0	0	4	4	
1.3.4	Off-Site Product Use Demo		0	0	0	0	0	1,233	1,972	246	0	3,451	3,840	
1.3.5	Data Analysis & Reports		15	60	18	208	61	310	500	553	707	2,670	1,926	
1.3.6	Planning & Admin.		49	80	346	220	100	74	280	282	510	2,392	1,593	
14. TOTAL			2,236	2,721	63,180	69,974	2,788	15,933	42,008	42,365	10,432	213,700	213,700	
15. DOLLARS EXPRESSED IN:														
Thousands														
16. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER			AND DATE			DATE			17. SIGNATURE OF PARTICIPANTS AUTHORIZED FINANCIAL REPRESENTATIVE AND DATE					
[Signature]			7/21/97			7/21/97			[Signature]					

APPENDIX O - PRESS RELEASE (21 MAY 1997) AND PRESS COVERAGE

Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195-1501

97089

Media Contacts: Greta C. Campbell/Air Products
Phone: (610) 481-4986
E-mail: campbegc@apci.com

Mark S. Wright/Eastman
(423) 229-1861
mswright@eastman.com

**CLEAN COAL DEMONSTRATION PROJECT IN KINGSPORT, TENN. NOW
PRODUCING COMMERCIAL QUANTITIES OF METHANOL**

**Novel Process Offers Power Generation Flexibility
In Integrated Gasification, Combined-Cycle Facilities**

LEHIGH VALLEY, Pa. (May 21, 1997) -- A first-of-a-kind demonstration facility is now producing methanol from coal-derived synthesis gas on a commercial scale at Eastman Chemical Company, using Air Products and Chemicals, Inc.'s patented liquid phase technology.

The demonstration facility, which started up in early April at Eastman's Kingsport, Tenn. site, quickly achieved one of its initial performance targets by producing methanol at an 80,000 gallon-per-day rate, confirming the 25 to 1 size scale-up of the liquid phase reactor. The reactor's stability and flexibility have also been confirmed during more than 700 hours of stable operation at varying feed rates. The methanol has met all purity specifications and is being used directly as chemical feedstock.

The liquid phase methanol project is a cooperative effort between the Air Products Liquid Phase Conversion Company — a limited partnership formed by Air Products whose technology is being tested and the Eastman Chemical Company whose integrated coal-gasification facility in Kingsport is the host site for the demonstration — and the U. S. Department of Energy, who is funding 43 percent of the project's total cost under its Clean Coal Technology Demonstration Program.

The liquid phase methanol technology is designed to lower electricity costs and improve the flexibility of electric power generation in integrated gasification, combined-cycle (IGCC)

-more-

facilities. It accomplishes this by allowing the manufacture and sale of two products: electricity and methanol. The liquid phase methanol process can take advantage of periods of low electricity power demand by producing and storing methanol. This methanol is immediately available to generate electricity when the utility faces its next period of high power demand. This step will increase the utilization of gasifier capacity and lower the utility's costs. Several potential domestic and international customers are currently studying the possibility of incorporating the technology in their gasification systems.

The demonstration facility has met all of its early operational expectations. The next operational goal is to maximize the methanol production rate beyond 80,000 gallons per day and to demonstrate long-term catalyst life while operating on coal-derived synthesis gas. A carefully developed test plan that will be implemented over the next four years will assure that the technology is tested over a wide range of operating conditions and synthesis gas compositions to demonstrate its commercial advantages. Test operations will simulate electricity demand load-following by demonstrating the reliable off/on operation that the enhanced stability and heat dissipation of the liquid phase reactor provides.

The liquid phase methanol process differs significantly from commercial methanol processes because of its integrated reactor and heat removal system. Typically, methanol is made by passing synthesis gas mixtures with a very specific composition of hydrogen and carbon monoxide through a fixed bed of dry catalyst pellets. In the "liquid phase" process, fine particles of the temperature-sensitive methanol catalyst are suspended in an inert liquid. The liquid dissipates the heat of the chemical reaction away from the catalyst surface, protecting it and allowing the gas-to-methanol reaction to proceed at higher rates.

Because of its superior heat management, the process is able to directly handle the synthesis gas typically produced from the gasification of coal, petroleum coke, residual oil, wastes, or other hydrocarbon feedstocks. The liquid phase process readily converts a portion of the synthesis gas produced by the gasifier to methanol, allowing the remainder of the unconverted gas to be used to make other chemicals, for hydrogen recovery, or as a fuel for a gas turbine combined-cycle electric power plant.

Air Products expects to market the liquid phase methanol technology and its other liquid phase technologies through licensing, "own and operate" or tolling arrangements. As a world leader in the design, construction and operation of high-pressure oxygen plants for gasification applications, the company also can serve other commercial roles in IGCC projects, including the supply of equipment or on-site oxygen, and the clean-up and recovery of hydrogen and other gases.

Eastman Chemical Company manufactures and markets chemicals, fibers and plastics. Eastman employs 17,500 people in more than 30 countries and had 1996 sales of \$4.8 billion. Corporate headquarters are in Kingsport, Tennessee.

Air Products and Chemicals, Inc. is a \$4 billion global company with leading market positions in industrial gases and selected chemicals. Through innovative engineering, technology and marketing, the company provides products and services that help its customers win in markets around the world.

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To: DISTRIBUTION

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From: G. Campbell

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Date: 6 June 1997

Subject: LIQUID PHASE METHANOL PUBLICITY

cc: B. M. Arndt
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P. B. Sullivan
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cc: FSF ✓
VES ✓
DPD ✓
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FJW ✓
B. J. Street (FMW) ✓
R. M. Kornowky (DOE) ✓

10 June 97

Attached is the initial coverage we have received on the start-up of the liquid phase methanol demonstration plant in Kingsport, Tenn. As we receive additional coverage of this project over the next several weeks, I'll pass the clippings on to you.

Attach.

See C.

A hive of activity

PROCESS

The drive for greater energy efficiency, environmental friendliness, reduced downtime and improved profit margins sets ever increasing challenges to the methanol technology suppliers – and increasingly new plants have to be tailored to the specific project case.

While methanol is one of the most basic petrochemical products with some 25m tonne produced each year, there appears to be an upturn in methanol project activity worldwide. At least three large-scale projects are being progressed in the Middle East (Al Jubail, Saudi Arabia; Kharg Island, Iran; Umm Said, Qatar), two in Trinidad and one each in Indonesia and Chile, all with a feedstock cost advantage. Here in Europe there are new project proposals on both sides of the North Sea. In Norway a second plant is under consideration by Statoil, while in the UK project development company International Offshore Chemicals is pursuing a world-scale integrated methanol and ammonia plant – although the choice of location remains contentious. Many other smaller projects and revamps are underway. All will undoubtedly incorporate some new technological aspects.

Leading methanol synthesis licensor Lurgi has widely touted its developments in methanol reactor design in recent months, while Kvaerner John Brown, a leading approved contractor for ICI Katalco methanol catalyst and systems technology, is understood to be working quietly on new process enhancements following the recent signing of an agreement on reformer technology with BP. An announcement on the new process is expected towards the end of the year.

At the same time, other technology developers strive to commercialise alternative novel routes – the first commercial-scale demonstration plant to produce methanol from coal-derived synthesis gas came onstream at Eastman Chemical's Kingsport site in March, while Lurgi and catalyst partner Süd-Chemie have developed a reactor and catalyst system to produce methanol from carbon dioxide and hydrogen. Others strive to improve the conversion rates of more conventional processes – Twente University of

Contractors and producers are looking at improved ways of making methanol. Susan Royse takes a look at the many innovations currently taking place in the methanol industry.

Technology in the Netherlands has developed a pilot-scale process which obviates the need for a recycle loop and could achieve a conversion of over 97% (ECN 5 May), while the idea of floating methanol plants continues to be pursued by, amongst others, ICI Katalco despite the apparent indefinite postponement of previously announced major projects planned for Oman, Argentina and Indonesia.

Methanol is conventionally manufactured from synthesis gas (a mixture of carbon monoxide and hydrogen), produced from steam-reformed natural gas (or oil associated gas) and carbon dioxide. The methanol is synthesised in a catalytic process and the crude product is purified by distillation. While the synthesis reac-

tor and catalyst system are clearly at the heart of the process, and where much of the recent development effort has been focused, the whole process scheme provides numerous opportunities for design improvements. For example, optimum utilisation of the reaction heat offers cost advantages and energy savings for the overall plant.

Two types of reactor dominate the industrial methanol market: gas-cooled (quench reactors or gas-cooled tubular reactors) and steam-raising reactors, where the reaction heat is transferred to boiling water.

Lurgi, a leading proponent of the steam-raising type, notes a trend towards steam-raising reactors of various design. Such reactors are also now offered by Linde, Toyo Engineering, Mitsubishi Gas Chemical and ICI-approved contractors.

Lurgi's Herman Goehna explains the trend in terms of a growing focus on the control of the methanol-producing reaction in light of the development of more active, temperature-resistant catalysts. 'To achieve the same overall conversion efficiencies, modern catalysts require smaller recycle ratios than catalysts of the first generation, he explains. 'This results in higher partial pressures of the reaction components at the reactor inlet so that the rapid removal of the reaction heat from the methanol reactor is becoming all the more important.'

While conceding that steam-raising reactors are more expensive than gas-cooled, Goehna argues that gas-cooled reactors suffer the disadvantages of poor utilisation of the reaction heat, low catalyst yield, high byproduct generation in the case of carbon monoxide rich synthesis gas, high pressure loss due to quench gas control and the potential risk of catalyst superheating.

Europe's latest methanol plant, the 2400 tonne/day Statoil/Conoco joint venture at Tjeldbergodden, Norway, commissioned last month, incorporates Haldor Topsøe's two-stage reforming technology together with Lurgi's methanol synthesis technology based on steam-raising reactors. The plant incorporates several new features. One is a new type of burner (for the oxygen-fired secondary reformer) supplied by Haldor Topsøe. 'There have been severe problems with burners in the

■ PRODUCTION COST ESTIMATE FOR CO-PRODUCED METHANOL USING THE AIR PRODUCTS' LIQUID-PHASE CONVERSION PROCESS (PLANT CAPACITY 152 000 GAL/DAY; CAPITAL INVESTMENT, \$29 M)

	Based on
Methanol plant operation (hours/year)	7884
Methanol production (m gal/year)	49.9
Methanol production cost:	
Syngas cost:	
Feed gas @ fuel value (\$4.00/mBtu)	98.7
Unreacted (CO-rich) gas @ fuel value (\$4.00/mBtu)	(68.4)
Sub-total; net cost of syngas converted:	30.3
Operating cost:	
Catalyst and chemicals	2.6
Export steam	(2.9)
Utilities	0.9
Other (fixed) costs	4.0
Sub-total; operating costs	4.6
Capital charge:	
@ 20% of investment/year	11.6
Total methanol production cost	46.5

SOURCE: AIR PRODUCTS AND CHEMICALS

past. With flame temperatures of around 2000°C, even metal tends to vaporise. Flames can enter the refractory lining, even causing open fires,' says Peter Sogaard-Andersen, manager of Topsøe's refinery technology group.

The key to the new burner design is in controlling the flames – no backflow of hot gas towards the burner parts, a flame core located along the centre axis and an efficient recirculation in the combustion chamber zone. One such burner has operated for four years without problems at a Grande Paroisse ammonia plant in Waziers, northern France, Sogaard-Andersen claims. This compares with a typical burner life of around eight to nine months, he says, and as such should lead to significant improvements through reduced plant downtime.

A second key feature in the new plant is the back-end distillation (to purify the crude methanol), again designed and supplied by Topsøe. Here – with limits placed on carbon dioxide emissions – the focus has been on energy efficiency, with a split column design to allow use of the energy twice.

Of course, not all development relates to new plants. Modernising an existing reactor can prove a simple and effective means of upgrading production and improving performance. Methanol Casale specialises in such revamps and has recently implemented its Advanced Reactor Concept (ARC) in six projects.

The ARC is an adiabatic quench-cooled single-vessel converter which the company claims offers an improved quench mixing. It has been introduced as a revamp option for ICI's quench lozenge converter, but is equally applicable to other designs. The ARC is based on a typical peripheral mixer. A gas sparger introduces the quench gas in such a way as to generate the turbulence required for good mixing, while a deflector induces further local mixing and smooths out any temperature differences.

The \$213.7m Eastman demonstration project is a joint venture with technology supplier Air Products, supported with \$92.7m from the US Department of Energy's Clean Coal Technology Program. The aim is to produce methanol cost competitively from coal-derived synthesis gas, which tends to be rich in carbon monoxide.

Currently, less than 2% of world methanol is derived from coal. The key is in the use of a liquid-phase process employing a slurry bubble column reactor with powdered copper catalyst slurried in an inert mineral oil. This allows more controlled heat removal than conventional fixed-bed reactors operating in the gas-phase, and hence the synthesis process does not require a balanced carbon monoxide/hydrogen ratio. The slurry reactor is expected to achieve double the synthesis gas conversion rates per pass than a conventional reactor.

The process should be equally applicable to gasification of petroleum coke, residual oil or other hydrocarbon feedstocks. When added to an integrated gasification combined cycle power plant, the process converts a portion of the CO-rich synthesis gas to methanol, and the

remainder of the unconverted gas is used to fuel the gas turbine combined cycle power plant. Co-production of power and methanol via integrated gasification combined cycle could provide opportunities for energy storage for electrical demand, clean fuel for export and/or chemical methanol sales.

The 240 tonne/day demonstration plant achieved design production rates smoothly during the last week of March, according to Bill Brown, programme manager for the demonstration project. During a planned four-year operational phase, the plant will be subjected to a wide variety of test conditions. Most of the product methanol will be refined to chemical-grade quality and used by Eastman as replacement chemical feedstock. Eastman uses methanol in the manufacture of both acetic acid and dimethyl terephthalate (DMT). Use of the methanol as a feedstock for producing MTBE will also be investigated and, in the last six months of the project, the production of dimethyl ether (DME) as a co-product will also be assessed.

A commercialisation programme is set to run in parallel. 'Many refineries are looking at

"Small-scale units
should prove
competitive in local US
markets with new
world-scale overseas
methanol plants"

gasification and are interested in seeing the process demonstrated,' says Brown. In any future technology licensing deal, Air Products would be interested in being involved as the gas supplier, he says.

Plants producing around 1200 tonne/day methanol with co-production of power and/or hydrogen are envisaged. These relatively small-scale units should prove competitive in local US markets with new world-scale overseas methanol plants. Brown estimates co-production costs for the liquid phase process of less than 50 cent/gal, which compares favourably with today's total delivered US Gulf Coast methanol cost (chemical grade) of some 55-60 cent/gal (see table, left).

A second alternative methanol feedstock under investigation is the combination of carbon dioxide and hydrogen, interest in such a process has heightened, not least because of the urgent need to find ways of reducing carbon dioxide emissions into the atmosphere as concerns mount over the role of the gas in global warming. Lurgi believes that small-scale methanol production could be economically justified at locations where both byproduct hydrogen and carbon dioxide are available.

In a joint development programme with Süd-Chemie, Lurgi has developed a catalyst and reactor system to convert a mixture of carbon dioxide and hydrogen to methanol in two parallel reactions. One, exothermic, to give methanol and water, the second, endothermic, to give carbon monoxide and water. The conversion rate and methanol selectivity depend on the pressure and temperature, with methanol formation favoured at high pressure and low temperature. To optimise the process, the partners have developed a copper-bearing, low-pressure catalyst, with which the highest methanol yield is obtained at 260-270°C.

A novel synthesis configuration has been devised in which the greater part of the reaction heat is used for generating high pressure steam. The configuration differs from the conventional in that, instead of adding the makeup gas to the recycle gas, it is directly passed through the catalyst-filled tubes of an adiabatic fixed-bed reactor in the once-through mode. This can be done at full synthesis pressure without risking catalyst superheating.

The product gas is then fed to a synthesis loop equipped with a second reactor which operates under quasi-isothermal conditions. The exothermic reaction (to give methanol and water) clearly predominates and the heat liberated is used to generate high-pressure steam at up to 70bar. By controlling the steam pressure, the narrow temperature range in which optimum thermodynamic and kinetic conditions occur can be reliably adjusted. Closed-circuit operation of the isothermal reactor suppresses the formation of unwanted carbon monoxide, resulting in high conversion rates. Development work at Lurgi continues, but the process has yet to be taken up commercially.

ICI Katalco continues to remain upbeat about the potential of floating methanol plants. The idea – to make use of associated gas from offshore oilfields – has been around since the 1970s, but commercialisation has proved more difficult than originally imagined.

Essentially, difficulties have been encountered in the design of a sufficiently robust, compact, wave-insensitive steam-reforming furnace. ICI Katalco believes it may have the answer in its compact gas-heated reformer, tested as part of its LCM methanol technology at BHP Petroleum's facility at Laverton, Australia. Test results on the furnace, the oxygen burner and distillation column look favourable, and work with BHP Petroleum continues. The dream, if realised, could transform the economics of the methanol industry in the 21st century.

Animal Health

Mallinckrodt Sells Veterinary Unit to Schering-Plough

CONTINUING ITS RESTRUCTURING DRIVE, Mallinckrodt has sold its \$456-million/year animal health business to Schering-Plough (Madison, NJ) for \$405 million. Ray Holman, Mallinckrodt's chairman and CEO, says the company plans to use the proceeds from the deal—along with \$550 million from the recent sale of its stake in Tastemaker—to buy back stock and make acquisitions in the health care segment.

The move reduces Mallinckrodt to seven health care and specialty chemicals divisions. The company says it is looking at acquisitions in medical products and pharmaceuticals and that it can spend \$1.3 billion-\$1.5 billion in a combination of cash and debt. Mallinckrodt says it does not plan to make more specialty chemicals acquisitions.

Jeffrey Cianci, an analyst at Bear Stearns, says, "If Mallinckrodt acquires, it will significantly dilute its earnings per share. The company should use the proceeds for more buybacks because of the high price of health care acquisitions."

The deal catapults Schering-Plough from the 20th-largest animal health company to ninth (*table*), says Matthew Phillips of Wood Mackenzie (Edinburgh). "The acquisition will expand Schering-Plough's exposure in vaccines, building on its poultry products business and the North American pet product lines acquired from American Home Products earlier this year," he says. "The move will also considerably expand Schering-Plough's international presence, reducing its depen-

dence on the U.S. market."

The deal continues a consolidation trend in the animal health market. Since the

ANIMAL HEALTH LEADERS*

(in millions of dollars)	
COMPANY	SALES
Roche	\$1,464
Merial ¹	1,415
Pfizer	1,222
Bayer	888
Rhône-Poulenc	763
BASF	730
American Home Products	710
Novartis	680
Schering-Plough	666
DowElanco	547

* 1996; all acquisitions consolidated. 1) Joint venture between Rhône-Poulenc and Merck. Source: Wood Mackenzie Animal Health Service (Edinburgh).

beginning of this year, Merck and Rhône-Poulenc have merged their animal health, and poultry genetics businesses; American Home Products has acquired Solvay Animal Health; Bayer has acquired Pharmacia & Upjohn's vaccines business; and Boehringer Ingelheim (St. Joseph, MI) has purchased vaccines maker NOBL Laboratories.

—KERRI A. WALSH

Resins

Borden Buys Indspec Unit

BORDEN CHEMICAL HAS PURCHASED the phenol-resorcinol wood adhesive and reinforced plastic resins businesses of Indspec Chemical (Pittsburgh), a subsidiary of OxyChem. Borden will produce the adhesives and resins using phenol-resorcinol supplied by Indspec.

Borden says the acquisition will enhance its position in the rapidly expanding radiation curing segment of the wood adhesives business. The acquisition includes Indspec's patented phenol-resorcinol radiation-cured wood adhesives.

The business will be merged with Borden's

forest products unit, and Borden will manufacture the acquired product lines at its facilities in Springfield, OR and Demopolis, AL. Borden will also obtain Indspec's line of phenol-resorcinol resins used in reinforced plastic composites, which will become part of Borden's foundry and industrial products business.

Indspec is the world's largest producer of resorcinol and the only U.S. producer, with capacity for 58 million lbs/year in Petrolia, PA. OxyChem bought a 65% stake in Indspec in 1995 from New York merchant bank Castle Harlan.

—STEVEN VAMES

COMPANIES

REXENE-HUNTSMAN TALKS GET MORE FRIENDLY

Rexene has rescheduled a May 22 stockholders meeting that was to evaluate Huntsman Corp.'s \$16/share bid for Rexene. The meeting will be held June 12 to accommodate negotiations that are under way between the companies.

Rexene management scheduled the May 22 meeting after Huntsman signed a secrecy agreement in late April to gain access to confidential company information for its due diligence review.

Huntsman has since completed due diligence, and a Rexene spokesperson says both companies are proceeding with acquisition discussions in a "cooperative" manner. However, he adds, there is no guarantee that a definitive agreement will be reached. Huntsman launched its bid for the plastic resins and films maker last August.

—ROBERT WESTERVELT

TECHNOLOGY

AIR PRODUCTS, EASTMAN START COAL-TO-METHANOL UNIT

Air Products and Chemicals and Eastman Chemical have started up a demonstration plant at Kingsport, TN using novel coal-to-methanol technology. The companies say the unit is producing 80,000 gal/day of methanol.

The plant is based on Air Products' liquid-phase technology for converting coal-derived synthesis gas (syngas) into methanol (*CW*, Oct. 25, 1995, p. 41). The technology is being developed in a joint effort between Air Products, Eastman Chemical, and the Department of Energy, which is funding about 43% of the project's total cost under the agency's Clean Coal technology program.

The group says it plans to test the process during the next four years to optimize operating conditions and to demonstrate the technology's commercial advantages. If the tests are successful, Air Products expects to market the coal-to-methanol technology to other producers. Eastman plans to use the methanol produced at the plant as a chemical feedstock.

—DAVID ROTMAN

CHEMICAL MARKET R

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REPORTING THE BUSINESS OF CHEMICALS SINCE 1911

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KMH18195NORTH004 APR98
STEVE NORTH
AIR PRODUCTS & CHEM
A31F3
7201 HAMILTON BLVD # A
ALLEN TOWN PA 18195-1521
NEWSPAPER

THIS WEEK

EASTMAN CHEMICAL has opened a demonstration plant at its Kingsport, Tenn., complex that is producing methanol from coal-derived synthesis gas on a commercial scale using Air Products and Chemicals Inc.'s liquid phase technology [page 3].

IN RESPONSE to a market with tight supply and high operating rates, two chlorine producers are pushing for a \$25-per-ton price increase. If other producers follow, this would mark the third price hike this year, bringing the total increase for the product in 1997 up to \$80 [page 5].

VEBA IS ACQUIRING a 36.4 percent stake in Degussa in a move which could lead to the creation of a large new German specialty chemicals operation [page 7].

THE INTERNET has made fundamental changes in the delivery of news and information. Within the last two years, printed newspapers have made the transition from print to the interactive World Wide Web [page 18].



Hercules' production site at Brunswick, Ga., is one of the company's primary rosin resin plants.

Hercules Declares Commitment To Both Sides of Resins Unit

Capital spending, though, is focused on hydrocarbons.

By Michael McCoy

"WE ARE HERE TO STAY. Hercules is not getting out of the resins business," says R. Michael Alberts, division vice-president and general manager of Hercules Incorporated's resins division, in response to competitors who question his company's commitment to the business.

Hercules Resins is a \$500 million busi-

ness where royalties lie for a company that sells competing rosin and hydrocarbon resins.

Mr. Alberts and other Hercules Resins executives acknowledge these points but don't consider them negatives. Hercules sees itself as equal to its integrated competitors in feedstock sourcing, due to its wide range of options. The dual product lines is a

Acrylic Acid For Massive Capacity Increase

BASF is latest end-use-driven chemical. Markets remain strong.

By John Hoff

ACRYLIC ACID PRODUCERS are enjoying a massive new capacity, but market to stay relatively flat to strong demand in all markets.

BASF Corporation has announced a joint venture with Elf Atochem and Nippon Oil to build a 50-50 joint venture in the Gulf Coast. The company project to cost \$200 million to build a 120,000-metric-ton capacity unit (CMR) in 1999 and begin production in 2003.

BASF's action comes as a result of an announcement at the

company's annual meeting in Antwerp, Belgium, early in 1998. The company announced that it had formed a 50-50 joint venture with Elf Atochem and Nippon Oil to build a 120,000-metric-ton capacity unit (CMR) in the Gulf Coast. The company project to cost \$200 million to build a 120,000-metric-ton capacity unit (CMR) in 1999 and begin production in 2003.

units, the unit's product, Evatec, brought an expansion on line in January.

Sovereign Buys Laporte Unit

Sovereign Specialty Chemicals LP has agreed to purchase Laporte PLC's North American adhesives, sealants and coatings division for about £77 million (\$123 million). The Laporte unit, with sales of £77 million last year, includes Ohio Sealants Inc., Darworth Company, Mercer Products Company and Evode-Tanner Industries Inc.

The Laporte purchase is Sovereign's third within the past year. It acquired Goodrich's adhesives systems division in April 1996 and Pierce & Williams from Sherwin-Williams in August 1996. Total revenues for the combined operations will exceed \$200 million.

Laporte sold most of its European adhesives unit to Elf Atochem earlier this year for £110 million. Laporte said last week that its Italian unit will be sold to Lafarge SA for £10 million.

PQ to Enter Molecular Sieves

PQ CORPORATION is expanding its Kansas City, Kan., facility and will manufacture molecular sieves for the adsorbent and desiccant markets. The new plant will start up in late 1997 and have a capacity of 40 million pounds of formed product. The multimillion-dollar unit will supply molecular sieves for numerous end uses, including insulated glass, natural gas drying and purification, medical oxygen concentration, air purification and chemical processing. The company plans to market the products throughout the world.

Early last year, PQ restarted a zeolite plant in Kansas City, Kan., that was idled in 1994 because of lack of demand. The company is using the Kansas City site to manufacture sodium silicate, detergent zeolites, zeolite catalysts and silica gel, and says it is the preferred location for launching new products.

Borden Buys Indspec Resins

BORDEN CHEMICAL Inc. has bought the phenol resin sorcinol wood adhesive and reinforced plastic resins business of Indspec Chemical Corporation. The acquisition includes new, enhanced technology for radio-frequency curing resins systems.

Borden will merge the Indspec business with its forest products business unit and manufacture the acquired product lines at its facilities in Springfield, Ore., and Demopolis, Ala. The purchase also includes phenol resorcinol resins used in reinforced plastic composites, primarily in pultrusion, resin transfer molding and wet lay-up applications. These products will become part of Borden's foundry and industrial products business.

from a mere player, with sales last year of \$250 million, to one of the leaders in the \$10 billion worldwide animal health market.

Schering says the purchase will enable it to compete

Process Technology

Eastman Features Novel Methanol Route Using Liquid-Phase Reactor

By John Hoffman

EASTMAN CHEMICAL Company has opened a demonstration plant at its Kingsport, Tenn., complex that is producing methanol from coal-derived synthesis gas on a commercial scale using Air Products and Chemicals Inc.'s liquid phase technology.

Eastman's plant started up in early April and is already producing methanol at a rate of 80,000 gallons per day, a 25-to-1 scale-up from its initial operations. The liquid-phase reactor has run for more than 700 hours at varying feed rates, and the methanol has met all purity requirements and is being used directly as a chemical feedstock.

The liquid-phase methanol plant is a cooperative effort between Air Products Liquid Phase Conversion Company—a limited partnership between Air Products and Eastman—and US Department of Energy, which is funding 43 percent of the project's cost under its clean coal technology program.

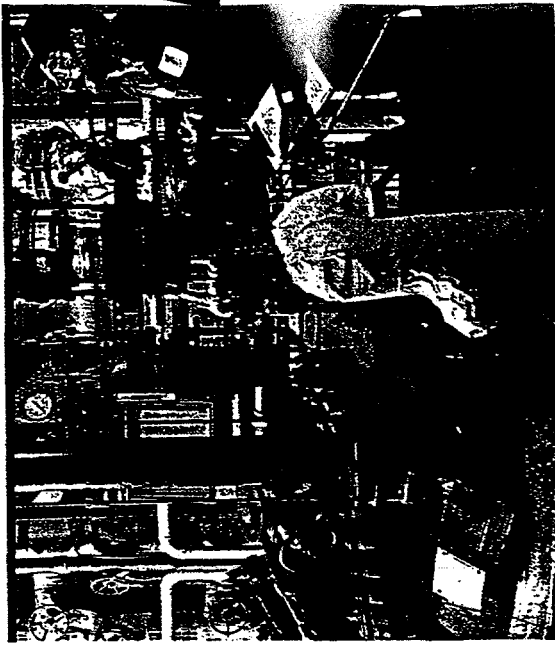
DOE expects the technology to lower electricity costs and improve the flexibility of power plants. The liquid-phase methanol process can take advantage of periods of low power demand by producing and storing methanol for consumption when electrical demand is high.

The companies say the demonstration unit has met all of its initial requirements. The next goals are to raise methanol production beyond 80,000 gallons per day and show that its catalyst can operate over the long term while running on coal-derived synthesis gas. During the next four years, the technology will be tested over a range of operating conditions and synthesis gas compositions.

The liquid-phase methanol process differs from commercial methanol processes because of its integrated reactor and heat removal systems.

Methanol is traditionally made by passing synthesis gas mixtures, with a very specific composition of hydrogen and carbon monoxide, through a fixed bed of dry catalyst pellets. In the liquid-phase process, fine particles of the temperature-sensitive methanol catalyst are suspended in an inert liquid.

Health, says MVI's research capabilities in viral vectors, gene deletion and controlled release technology hold considerable promise.



Pressure Chemical Company, Pittsburgh, Pa., has a newly available facility to benefit custom process research and pilot development programs. The plant's specialized design allows for a wide range of synthetic capabilities, the company says. Pressure Chemical specializes in high pressure chemistry and controlled polymer synthesis.

Air Products Buys ICI Alkyl Amines Business

AIR PRODUCTS AND CHEMICALS Inc. will acquire ICI Chemicals and Polymers Ltd.'s worldwide ethyl and higher amines business. Air Products says the purchase will "significantly increase" the company's global position in the alkyl amines market.

ICI's methylaniline and derivatives businesses are not included in the sale. Financial details of the transaction were not disclosed, but the business has annual sales of around £10 million (\$16 million).

ICI will continue to produce ethyl and higher amines for Air Products at its Billingham, UK, facility. The products are used primarily as intermediates for agrochemicals, water treatment, catalysis and pharmaceutical applications.

The sale comes in the wake of ICI's intent to buy Unilever NV's specialties chemical business. Insiders have said that ICI would sell other non-core businesses in addition to putting Tioxide and its ICI Australia subsidiary on the block.

MAY 4, 1997



Bacon's

11/9 New plant generates excitement for methanol created from coal

KINGSPORT — An experimental plant to make methanol from coal-derived synthesis gas has come on line. If successful, the technology could help reduce the country's dependence on imported oil.

The plant is a joint venture of the Department of Energy's Clean Coal Technology Program, Eastman Chemical Co. and Air Products and Chemicals Inc.

Eastman and Air Products provided \$121 million toward the \$213.7 million project; the DOE made up the remainder.

Construction began in late 1995 at Air Products' local complex.

The plant began operating in April and is producing 260 tons of methanol a day.

Over the next four years, the DOE will study samples of the methanol produced at the plant.

Methanol is a clean-burning liquid that can be used to power electricity-generating turbines or as a fuel for automobiles and other vehicles.

It also is used as a feedstock for a variety of chemicals.

Eastman was invited to participate in the project because of its expertise in chemicals-from-coal technology.

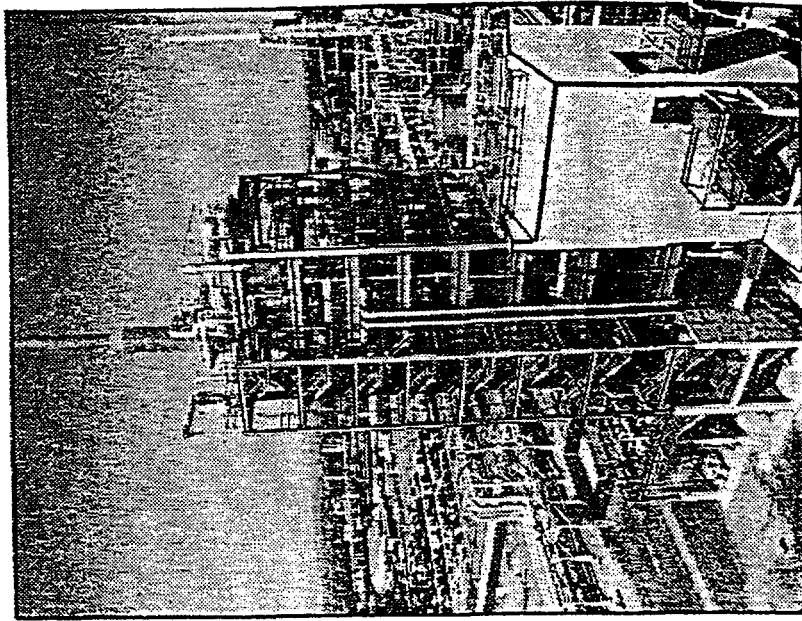
Although most methanol is produced from natural gas, Eastman pioneered at its local facility the commercial technology for producing methanol from coal.

Eastman will use a portion of the methanol produced here as a chemical feedstock in the products that eventually go into certain plastics and chemicals.

The Clean Coal Technology program is designed to demonstrate a new, more cost-effective way to make methanol. The synthesis process being used at the plant is the result of more than a decade of federally sponsored research.

If successful, the technology could significantly enhance the prospects for the use of coal-based methanol to generate electricity.

For example, it could be used to supplement fuel for gas turbines during peak energy demands or it could be sold to commercial fuel and chemical companies.



Experimental plant produces methanol //