DOE/PC/90543--T12

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

TECHNICAL PROGRESS REPORT NO. 1

For The Period

October 1, 1993 to June 30, 1994

Prepared by

Air Products and Chemicals, Inc.
Allentown, Pennsylvania

Prepared for the United States Department of Energy
Pittsburgh Energy Technology Center
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ACRONYMS AND DEFINITIONS

Acurex	-	Acurex Environmental Corporation
Air Products	-	Air Products and Chemicals, Inc.
AFDU	-	Alternative Fuels Development Unit - The "LaPorte PDU."
Balanced Gas	-	A syngas with a composition of hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2) in stoichiometric balance for the production of methanol
Carbon Monoxide Gas	-	A syngas containing primarily carbon monoxide (CO); also called CO Gas
DME	-	dimethyl ether
DOE	-	United States Department of Energy
DOE-PETC	-	The DOE's Pittsburgh Energy Technology Center (Project Team)
DOE-HQ	-	The DOE's Headquarters - Clean Coal Technology (Project Team)
DTP	-	Demonstration Test Plan - The four year Operating Plan for Phase 3, Task 2 Operation
DVT	-	Design Verification Testing
Eastman	-	Eastman Chemical Company
EIV	-	Environmental Information Volume
EMP	-	Environmental Monitoring Plan
EPRI	-	Electric Power Research Institute
HAPs	-	Hazardous Air Pollutants
Hydrogen Gas	-	A syngas containing an excess of hydrogen (H_2) over the stoichiometric balance for the production of methanol; also called H_2 Gas
IGCC	-	Integrated Gasification Combined Cycle, a type of electric power generation plant
IGCC/OTM	-	An IGCC plant with a "Once-Thru Methanol" plant (the LPMEOH™ Process) added-on.
KSCFH	-	Thousand Standard Cubic Feet per Hour
LaPorte PDU	-	The DOE-owned experimental unit (PDU) located adjacent to Air Product's industrial gas facility at LaPorte, Texas, where the LPMEOH™ process was successfully piloted.
LPDME	-	Liquid Phase DME process, for the production of DME as a mixed coproduct with methanol
LPMEOH™	-	Liquid Phase Methanol (the technology to be demonstrated)
MTBE	-	methyl tertiary butyl ether
NEPA	-	National Environmental Policy Act
OSHA	-	Occupational Safety and Health Administration
Partnership	-	Air Products Liquid Phase Conversion Company, L.P.
PDU	-	Process Development Unit
PFD	-	Process Flow Diagram(s)
ppb	-	parts per billion
Project	-	Production of Methanol/DME Using the LPMEOH™ Process at an Integrated Coal Gasification Facility
psia	-	Pounds per Square Inch (Absolute)
psig	-	Pounds per Square Inch (gauge)
P&ID	-	Piping and Instrumentation Diagram(s)
SCFH	-	Standard Cubic Feet per Hour
Sl/hr-kg	-	Standard Liter(s) per Hour per Kilogram of Catalyst
Syngas	-	Abbreviation for Synthesis Gas
Synthesis Gas	-	A gas containing primarily hydrogen (H_2) and carbon monoxide (CO), or mixtures of H_2 and CO; intended for "synthesis" in a reactor to form methanol and/or other hydrocarbons (synthesis gas may also contain CO_2, water, and other gases)
Tie-in(s)	-	the interconnection(s) between the LPMEOH™ Process Demonstration Facility and the Eastman Facility
TPD	-	Ton(s) per Day
WBS	-	Work Breakdown Structure
wt	-	weight

Executive Summary

The Liquid Phase Methanol (LPMEOH™) Demonstration Project at Kingsport, Tennessee is a $213.7 million cooperative agreement between the U.S. Department of Energy (DOE) and Air Products and Chemicals, Inc. (Air Products). The demonstration is sited at the Eastman Chemical Company (Eastman) complex in Kingsport. Air Products and Eastman are working on a partnership agreement which will form the Air Products Liquid Phase Conversion Company, L.P. As a limited partner in the venture, Eastman will own and operate the demonstration unit.

The project involves the construction of a 260 tons-per-day (TPD) or 80,000 gallon per day methanol demonstration unit utilizing an existing coal-derived synthesis gas from Eastman. The new equipment consists of synthesis gas feed preparation and compression, liquid phase reactor and auxiliaries, product distillation, and utilities.

The technology to be demonstrated was developed by Air Products in a DOE sponsored program that started in 1981. Originally tested at a small, DOE-owned experimental facility in LaPorte, Texas, the LPMEOH™ process offers several advantages over current methods of making methanol. This liquid phase process suspends fine catalyst particles in an inert liquid, forming a slurry. The liquid dissipates heat from the chemical reaction away from the catalyst surface, protecting the catalyst, and allowing the gas-to-methanol reaction to proceed at higher rates. The process is ideally suited to the type of gas produced by modern coal gasifiers. At the Eastman Chemical complex, the technology will be integrated with existing coal gasifiers to demonstrate the commercially important aspects of the operation of the LPMEOH™ Process to produce methanol.

A four-year demonstration will prove the commercial applicability of the process. An off-site product-use test program will prove the suitability of the methanol as a transportation fuel and as a fuel for stationary applications in the power industry. In future commercial facilities, advanced coal-to-methanol processes may be a cost-enhancing option for coal gasification-based power plants. Future facilities using "integrated gasification-combined-cycle technology" will produce methanol as a co-product during times of low electricity demand, allowing the gasifiers to operate at steady, peak performance.

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

The project was reinitiated in October of 1993, when DOE approved a site change to the Kingsport location. Since that time, project definition activities have been on-going. The project requires review under the National Environmental Policy Act (NEPA) to move to the construction phase, which is scheduled to begin in August of 1995. Air Products and Eastman are working on an Environmental Information Volume (EIV) which will be used by the DOE to prepare an Environmental Assessment (EA) and Finding of No Significant Impact (FONSI), which are necessary to complete this review process. The facility is scheduled to be mechanically complete in November of 1996.

A. Introduction

The Liquid Phase Methanol (LPMEOH™) demonstration project at Kingsport, Tennessee, is a $213.7 million cooperative agreement between the U.S. Department of Energy (DOE) and Air Products and Chemicals, Inc. (Air Products). A facility producing 80,000 gallons per day of methanol will be located at the Eastman Chemical (Eastman) facility in Kingsport, Tennessee. Under a proposed partnership agreement, Eastman will be a limited partner in the venture, which will own and operate the demonstration unit for the four-year operating period. This project is sponsored under the DOE's Clean Coal Technology Program and its objective is to "demonstrate, at a commercial scale, the production of methanol from coal-derived synthesis gas using the LPMEOH™ process. The project will also determine the suitability of the methanol produced for use as a chemical feedstock or as a low-sulfur dioxide, low-nitrogen oxides alternative fuel in stationary and transportation applications."

The Kingsport project may also demonstrate the production of dimethyl ether (DME) as a mixed coproduct with methanol if laboratory- and pilot-scale research shows promising results. If implemented, the DME would be produced during the last six months of the four-year demonstration period.

The LPMEOH™ process was developed by Air Products in a DOE-sponsored program that started in 1981. It was successfully piloted at a 10 TPD (3,200 gallons per day) rate in the DOE-owned facility at Air Products' LaPorte, Texas site. This demonstration project is the culmination of this extensive effort.

B. Project Description

Existing Site

The site for this demonstration is the Eastman complex located in Kingsport, Tennessee. This major chemical complex is spread over almost 4,000 acres and employs approximately 12,000 people. In 1983 Eastman constructed a coal gasification facility utilizing Texaco technology. The synthesis gas generated by this gasification facility is used to produce carbon monoxide and methanol. Both of these products are used to produce methyl acetate and ultimately cellulose acetate and acetic acid. The availability of this highly reliable coal gasification facility was the major factor in selecting this location for the LPMEOH™ Process Demonstration. The existing methanol unit (gas phase Lurgi technology) will be operated at turndown since some of the feed gas will be diverted to the LPMEOH™ demonstration unit.

The proposed project includes these four major process areas with their associated equipment:

- Reaction Area
- Purification Area
- Catalyst Preparation Area
- Storage/Utility Area

The physical appearance of this facility will closely resemble the adjacent Eastman process units, including process equipment in steel structures.

Reaction Area

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

Purification Area

The purification area will feature two distillation columns with supports; one will be approximately 82-feet tall, and the other 97-feet tall. These vessels will resemble the columns of the surrounding process areas. In addition to the columns, this area will include the associated reboilers, condensers, air coolers, separators, and pumps.

Storage/Utility Area

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

Catalyst Preparation Area

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

C. Process Description

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

D. Project Status

During the period October 1, 1993 to June 30, 1994, the project definition activities have been on-going. Major accomplishments during this period are as follows:

1. *Project Management Plan*

Reviews

- A Preliminary Hazards Review (PHR) is required by Air Products safety procedures. This review was conducted in January of 1994. The PHR report is attached as Appendix B.

Agreements

- Final partnership agreements between Air Products and Eastman are nearly in place. These agreements are a necessary part of the Continuation Application.
- The Continuation Application to move the project into the design phase is expected to be submitted in August of 1994.

2. *Technology Baseline*

Process Design

- Demonstration Unit Design basis was established.
- A demonstration plan detailing specific operating cases to cover the 208-week demonstration period was prepared for preliminary review.
- The Process Flow Diagram (PFD) was prepared to the Rev. 0 status. Efforts to develop the detailed Piping and Instrument Diagram (P&ID) were initiated.
- Process Equipment specifications are approximately 10% complete.

Design Engineering

- The compressor mechanical specification was developed and released for bid. Bids are currently being reviewed. The purchase order is expected to be placed in August of 1994.
- The reactor mechanical specification is nearly complete and will be the subject of a review meeting in early August of 1994. The compressor and reactor are the items that have most impact on the schedule.

- Discussions have taken place between Eastman's and Air Products' Machinery and Operation personnel. These discussions will produce an agreement on the basic design criteria for the machinery items.
- A preliminary plot plan was issued and included in the June 1994 Draft Environmental Information Volume (EIV) submitted to DOE.

3. ***Schedule Baseline***

- The milestone schedule, (see Appendix C), has the following key dates:
  - Complete NEPA Review — May 15, 1995
  - Begin Construction Period — July 15, 1994
  - Complete Field Construction — October 30, 1996
  - Begin Operation — October 16, 1996
  - Complete Operation — November 3, 2000

4. ***Cost Baseline***

A Cost Plan is being developed and will be submitted with the Continuation Application. A current Cost Management report is included in Appendix D.

5. ***Financial Commitment***

Air Products and Eastman are working on a Partnership Agreement that will secure the demonstration site and provide for the financial commitment and management of the Project.

6. ***National Environmental Policy Act***

- Two versions (the latest in June of 1994) of the Environmental Information Volume (EIV) have been submitted to the DOE for review and use in preparing the Project's Environmental Assessment (EA). Outstanding issues on the EIV are the off-site product-use test program and the DME provisional add-on demonstration. Both of these issues are being addressed; the off-site testing by Acurex and the DME by Air Products.

E. Planned Activities

For the next reporting period the project is expected to progress into detailed design. Air Products plans to submit the project's Continuation Application requesting DOE approval to begin detailed design and construction. Work will continue on the process equipment specification, and the distillation columns and major heat exchanger specifications should be released for mechanical design. A purchase order should be placed for the compressor, and the reactor should be released for bidding.

The P&ID should be nearing a first preliminary issue (Rev. P). A revised EIV document should be submitted. A design engineering schedule should be released.

F. Summary

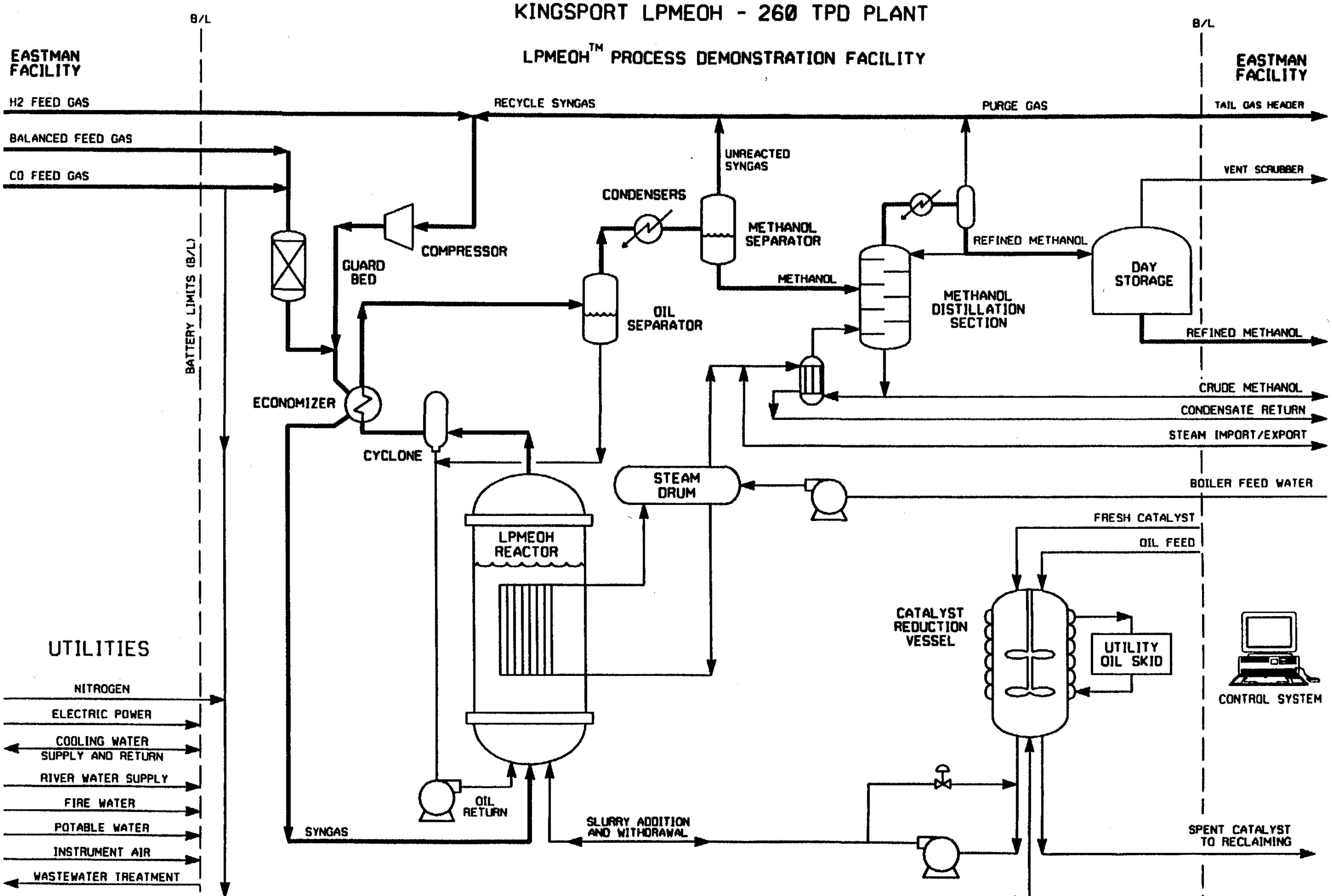
Project definition activities are proceeding with haste. Partnership arrangements between Air Products and Eastman are being developed. Specifications for the long-lead time process equipment are being prepared.

The project is proceeding as planned with no major road blocks anticipated.

APPENDIX A SIMPLIFIED PROCESS DIAGRAM 1 Page

SIMPLIFIED PROCESS DIAGRAM
KINGSPORT LPMEOH - 260 TPD PLANT

LPMEOH™ PROCESS DEMONSTRATION FACILITY



APPENDIX B PRELIMINARY HAZARDS REVIEW 26 Pages

PRELIMINARY HAZARDS REVIEW

KINGSPORT LIQUID PHASE METHANOL PROJECT

PROJECT NO. 00-3-8215

KINGSPORT, TENNESSEE

TO BE DESIGNED AND BUILT BY AIR PRODUCTS AND CHEMICALS, INC.

AND OPERATED BY EASTMAN CHEMICAL COMPANY

REVIEW DATES: 27 AND 28 JANUARY 1994

ISSUE DATE: 31 MAY 1994

<u>Review Team</u>

APCI:	D. Bernhard	E. Heydorn
	D. Bixler	R. Moore*
	W. Brown	E. Schaub
	T. Conway*	V. Stein
	A. Fleischer*	* Part-Time

Eastman Chemical Company:	L. Daniels
	W. Jones
	M. Templeton

PRELIMINARY PROCESS HAZARDS REVIEW

KINGSPORT LIQUID PHASE METHANOL PROJECT

KINGSPORT, TENNESSEE

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I. INTRODUCTION

A Preliminary Hazards Review (PrHR) was conducted on 27 and 28 January 1994 for the Kingsport LPMEOH project. This project will install a nominal 260 tons per day slurry phase methanol synthesis plant in Eastman Chemical's Kingsport, Tennessee facility.

The purpose of the PrHR is to identify major potential hazards associated with the process and plant to ensure these items will be considered during the design phase of the project.

II. SCOPE OF REVIEW

The scope of the review includes all operating sections of the LPMEOH plant. We did not review the impact of tie-ins to existing Kingsport systems connected to the LPMEOH plant. We also did not discuss any fuel demonstration scope of work. This work will be done by Eastman on-site and by Aurex offsite.

III. METHODOLOGY

The preliminary hazards review is the first safety review in a series of project reviews for the LPMEOH project. The project is in project definition phase. Preliminary PFD's were available to use as a basis for the review (Appendix 3). The review followed APCI's standard practice 1009B for Project Safety Reviews. A copy of the agenda is attached as Appendix 1. Hazards were identified and recommendations were made for consideration during the design phase of the project.

IV. PRELIMINARY HAZARDS REVIEW TEAM MEMBERS

The PrHR review team consisted of the following personnel:

APCI

D. Bernhard	PSG Engineering Safety
A. D. Bixler	PSG Engineering Technology
W. Brown	Equipment & Business Development
D. Drown	PSG Project Engineering
A. Fleischer	PSG Machinery Engineering
E. Heydorn	PSG LaPorte Production & Delivery
R. Moore	PSG Project Development
E. Schaub	PSG Process Engineering
V. Stein	PSG Process Engineering

Eastman Chemical Company

L. Daniels	Chemicals Customer Focus Team
W. Jones	Chemicals From Coal Expansion Project
M. Templeton	Plant Protection Technical Services

Team members D. Bernhard, D. Drown, E. Heydorn, and E. Schaub were knowledgeable of the hazards review method utilized, and possessed a general knowledge and understanding of the system under review. Team members E. Schaub, V. Stein, and E. Heydorn has specific detailed knowledge of, and experience with, the system under review.

V. PROCESS DESCRIPTION

Refer to the Process Description in the Estimating Scope Report document.

VI. NOTES FROM PrHR MEETING

1. D. Bernhard reviewed APCI's safety program and compared it to Eastman Chemical's. APCI's hazard criteria and safety design practices are acceptable to Eastman. APCI's hazard criteria for in-plant personnel is a fatal accident frequency rate (FAFR) of 0.4 fatalities per 100,000 exposure hours, for the total site, as well as for any isolatable individual plant. Specific risks to third parties are assessable quantitatively and reviewed and evaluated by senior management.

2. D. Bernhard reviewed APCI's Safety Plan for the LPMEOH project (Appendix 2). The following issues need to be addressed:

   a. Eastman's list of OSHA PSM documentation requirements has more details and requirements than does APCI's. APCI will issue a listing of documents that we will produce for this project that are part of the OSHA PSM documentation (D. Drown). Eastman will review this list to determine if they or APCI should develop the added EMN requirements (L. Daniels).

   b. APCI and EMN have developed internal safety standards and guidelines for designing, building, and operating industrial chemical plants. We will use APCI design standards for the LPMEOH project and some of Eastman's as requested. Eastman needs to inform APCI of any safety standard or practice which needs to be used or considered in the design of the LPMEOH plant (L. Daniels). Eastman will be issuing their P&ID Design Handbook to APCI that has a section on Guidelines for Emergency Shutdown Systems (ESD). The guideline describes instrument and electrical design of shutdown systems to prevent hazardous releases, catastrophic failures, losses in property and life, and losses of production in chemical processes. This guideline requires a separate ESD for a class 1 and class 2 events. These events are described in the EMN guideline. APCI needs to include these requirements in the design of our shutdown systems.

   c. The management of change was discussed. We need to agree on a way to document and manage change during and after plant start-up (E. Heydorn).

3. D. Bernhard discussed what he will write up for the Site Risk Assessment that was done with Eastman at Kingsport on 26 January. The following issues need to be addressed during design of this project:

   a. Location of discharge point of safety relief valves and impact on existing operations and the near-by house.

   b. Congested plant site; consider in fire protection system design and materials handling during construction.

4. E. Schaub lead a discussion of the LPMEOH process.

   a. EMN has nuclear (radiation) devices on-site and someone registered to handle them.

   b. Consider need for cooler on stream from 29E-20 to the Lurgi Distillation area (Process).

   c. Fuel grade methanol for the offsite fuel demonstrations will come form column 29C-10 underflow and go to 29D-10 or 29D-11.

   d. Process to consider raising the liquid knock-out vessels on the discharge of the reactor, so that pumps are avoided for flowing liquids back to the reactor (Process).

   e. R. Moore to look at cost of higher pressure rating on column 29C-20.

   f. The 600 psig steam tie-in to the boiler feed water for start-up should be shown on the PFD's (Process).

   g. Reduction of catalyst will occur approximately once every 10 days. Reduction is at 120 psig and 240°C. It takes 30-36 hours for reduction. The initial charge of catalyst into the reactor is approximately 10 batches from the slurry prep tank. Alternatives to a nuclear density gauge (ndg) for the slurry prep tank should be considered (Process & G. Marhefka).

   h. The economics of oil recovery from the spent catalyst should be studied (R. Moore).

5. New equipment and technology items were discussed.

   a. Reactor scale up from 13 TPD to 260 TPD was discussed.

   b. The scale up of the 29E-02 reactor feed/product economizer is an issue. Experience with the type of design proposed will be tried at LaPorte AFDU in March.

   c. APCI has experience with slurry pumps at the LaPorte AFDU. The Kingsport plant pumps will be sized for larger flow rates.

d. Catalyst poisons in the syngas to the LPMEOH plant need to be identified (Process and Analytical).

e. Spent catalyst centrifuge recovery efficiency needs to be proven.

6. The chemicals to be used or made in the LPMEOH plant were discussed.

a. Physical Properties of Concern

Materials	Property of Concern
i. Chemicals Made in Process	
Methanol	Flammability
Higher Alcohols	Flammability
Dimethyl Ether	Flammability
ii. Chemicals Used in Process	
Hydrogen	Flammability
Carbon Monoxide	Toxicity
Drakeol	Operate above flash point
iii. Catalysts & Utilities	
Catalyst	Pyrophoric if dried out, nuisance dust
Nitrogen	Asphyxiant
Cooling Water	---
Steam	Thermal Burns
Boiler Feed Water	Thermal Burns
Heat Transfer Fluid	May be above its flash point
iv. Trace quantities in feed gas streams of Carbonyls, H_2S & HS Toxicity	

b. Eastman stated they experienced a corrosion problem with one of their methanol storage tanks. Carolina Eastman had inner granular stress corrosion cracking with wet recycle methanol. The methanol had 0.1 & 0.2% formic acid and __% water.

c. Project engineering will obtain MSDS for materials used and made in the LPMEOH plant (F. Frenduto).

d. The reactions were discussed.

$2H_2 + CO = CH_3 OH$

$H_2 + CO_2 = CO + H_2O$

$2CH_3OH=CH_3OCH_3 + H_2O$ (trace amounts)

The DME reaction is limited by the amount of dehydration activity of the catalyst.

VII. IDENTIFICATION OF HAZARDS

Hazard	1/27/94 PrHR Recommendation/Follow-up
1. Loss of Containment	
a. The reactor section equipment will be designed for 1000 psig. Potential overpressure of downstream lower pressure rated equipment.	a. Determine logical pressure break for equipment and piping downstream of 29C-03 (Process).
b. The Catalyst Reduction Vessel (29C-30) will be designed for 50 psig. The reaction (at 1000 psig potential) will have piping connected in to this vessel. Potential for overpressure.	b. Consider overpressure potential in design (Process).
c. 29D-02 Slurry tank will be tied in to the reactor. Potential for overpressure.	c. Look at design rating and necessary reliefs for this tank to minimize cost and risk (Process).
d. The syngas purge is let down from the 1000 psig reactor loop. Potential for overpressure to the boilers.	d. Consider overpressure potential in design (Process). Eastman (W. Jones) to send design rating of boilers to APCI.
e. 600 psig steam will be tied in to the LPMEOH plant steam header. Potential to overpressure of units designed for 100 psig steam system.	e. Consider overpressure potential in design (Process). Consider ways to avoid 3:1 let down potential (and redundant PSV's) on downstream equipment.
f. Higher pressure in Catalyst Reduction Vessel (29C-30) than utility oil skid (29V-01) if leak occurs.	f. Consider in design (Process).
g. Pump 29G-30 is designed for pumping reduced catalyst to the reactor at high pressure. This also would feed the centrifuge.	g. Consider separate pump at a lower pressure rating to feed the centrifuge (Process).
h. Overpressure potential to slurry centrifuge and other equipment that are not designed for high pressure nitrogen.	h. Use lower pressure nitrogen for purging (Process).
i. The safety relief vents will discharge to the blowdown tank (29D-01). This will vent to the methyl acetate quench down and vent stack. A relief from the LPMEOH plant will discharge to the atmosphere with possible consequences within the Eastman facility and at the plant boundary.	i. Dispersion calculations will need to be done to determine impact at ground level and personnel that may be on the ladder to the adjacent methyl acetate distillation column (EMN).

Hazard	1/27/94 PrHR Recommendation/Follow-up
j. Backflow from LPMEOH recycle compressor into the feed streams.	j. Include instrumentation to detect reverse flow and isolate the feeds. Analyze backflow potentials for all feed gas streams (Process).
k. Reactor (29C-01) vessel failure.	k. Analyze consequences of dumping reactor on the slab to third party, to in plant personnel, and to the methyl acetate plant.
l. External fire to the reactor.	l. Design pressure protection system to prevent overpressure. Install fire protection around reactor (R. Hassel). Consider use of depressurization system to reduce reactor overpressure (G. Marhefka).
2. <u>Compressor (29K-01) Design</u>	
a. Compressor failure.	a. Consider vibration switch for shutdown of the unit (A. Fleischer).
b. Compressor seal failure.	b. Consider reliable seal design (A. Fleischer).
c. Piping failure at compressor.	c. Consider vibration in piping design.
3. <u>Reactor Design</u>	
a. Exotherm in reactor	a. Design controls for high temperature shutdowns (Systems).
b. Loss of cooling in reactor.	b. Design controls for loss of boiler feed water (Systems).
c. Tube failure in reactor.	c. Design containment system for containing slurry (Process).
d. Overfill reactor.	d. Consider potential in design of 29E-02 (Process).
e. Loss of level in the reactor.	e. Consider potential for thermal differentials and stresses in the internal exchanger (R. Koeller).
4. <u>Syngas Feed/Product Economizer (29E-02)</u>	
a. Overpressure tube sheet. (The tube sheet would be designed for a differential of 200 psig with a potential 1000 psig on either side.)	a. Analyze failure impact on the vessel shell. Evaluate cost of 1000 psig tube sheet.
b. Overfill exchanger with fluids.	b. Analyze need for protective instrumentation.
c. Separation of water or lights resulting in explosive vaporization in the reactor.	c. Document with LaPorte AFDU calculations for this event (Process/D. Bixler).
d. Plug demister pad.	d. Consider in design of instrumentation and need for bypass piping.

Hazard	1/27/94 PrHR Recommendation/Follow-up
5. Oil Make-up Pump (29G-03)	
a. Backflow of 1000 psig reactor effluent to oil storage tanks.	a. Consider in design of system (Process).
6. Methanol Product Cooler (29E-04) & Cooling Water Exchangers	
a. Failure of tubes and loss of syngas to the cooling water.	a. Consider in design of equipment and safety system to protect cooling water system (Process).
7. Pumps	
a. Mechanical failure.	a. Design pipe loads to prevent misalignment.
8. HP Methanol Separator (29C-03)	
a. Loss of cooling water to 29E-04.	a. Consider need for suction K.O. drum to compressor and instrumentation to detect the event (Process).
b. Overfill 29C-03	b. See above.
c. Loss of level in 29C-03.	c. Consider in design of instrumentation and relief system for the distillation columns (Process).
d. Fail open purge control valve to syngas boilers.	d. Consider pressure potential in syngas to the boilers (Process).
9. Distillation Columns 29C-10 and C-20	
a. Vessel failure.	a. Design protective systems to minimize potential. Install fire protection (area deluge) to minimize UVCE and pool fires (R. Hassel). Determine if this event is or the reactor failure is the controlling case for impact to third parties (Safety).
b. Loss of steam to reboilers.	b. No hazard.
c. Less of cooling to overhead condensors.	c. Consider in the design of the system. Consider high vapor flow and condensed methanol to the boilers (Process).
d. Reboiler tube failure.	d. Consider in sizing of safety relief devices (Process).
e. Loss of reflux from methanol stabilzer reflux pump (29G-11) and methanol stabilizer underflow pump (29G-12).	e. Overfill 29C-10 and 29C-20 and lift the packing. Consider in instrument design (Systems).
f. Loss of Methanol Rectifier Underflow Pump (29G-22).	f. Overfill 29C-20 and lift packing. Consider in instrument design (Systems).

Hazard	1/27/94 PrHR Recommendation/Follow-up
g. Condensor tube failure. Pressure levels unknown. Could get methanol in the cooling tower or cooling water in the distillation columns.	g. Consider in design (Process).
h. Loss of level in methanol rectifier column reflux drum (29CC-21). Demand on safety protective systems.	h. Consider vapor load to storage tanks (Process).
10. <u>Lot Storage Tanks (29D-10 and D-11)</u>	
a. Overfill tanks.	a. Overfill tanks and spill on the ground. Ground will slope to drain to interceptor sewer that goes to waste treatment plant. Include high level alarm on tanks and fire protection (Systems).
b. Loss of nitrogen to storage tanks.	b. Possible tank failure if vacuum is pulled when pumping our of tank. Consider in design of tank safeties (Process).
c. Backpressure from plant 31 scrubber to tanks.	c. Consider in system design (Process).

APPENDIX 1

KINGSPORT LPMEOH PROJECT
PRELIMINARY HAZARDS REVIEW
1/27/94

AGENDA

	Topic	Leader	Expected Time, Min.
1.	Introductions	All	5
2.	Review Project Schedule and Current Status	D. Drown	5
3.	Review of APCI and ECC Safety Program and Hazard Criteria	D. Bernhard/ M. Templeton	30 - 45
4.	Review LPMEOH Project Safety Plan	D. Bernhard	15 - 20
5.	Impact of OSHA PSM Regulations on This Project	D. Bernhard	15 - 20
6.	Discuss Format for This Report	All	5 - 10
	Process Discussion	E. Schaub	2 Hrs.
7a.	Review Project Scope of Work, Process Description and PFD's		
7b.	Identify New Equipment or Technology Items		
7c.	Chemicals to be Used or Made in the Process (discuss properties, reactivity, stability, etc.)		
8.	Feed Gas Compressor Design	A. Fleischer	10 - 15
9.	Discuss Relevant APCI Experience with LPMEOH at LaPorte	E. Heydorn	30 - 40
10.	Identify Potential Major Hazards	All	3 - 4 Hrs.
11.	Review Preliminary Plot Plan	D. Drown	15 - 20
12.	Review Scope of Work for Eastman Chemical Company	D. Drown	10 - 15

KINGSPORT LPMEOH PROJECT
PRELIMINARY HAZARDS REVIEW
1/27/94

AGENDA

	Topic	Leader	Expected Time, Min.
13.	Discuss Fire Protection, Safe Distances, Drainage and Diking, Accessibility, Electrical Classification, Waste Collection/Disposal, and Third Party Considerations	All	40 - 50
14.	Discuss Consequence to Other ECC Plants on Pipe or Vessel Failure	All	15 - 20
15.	Review Philosophy of Control System as it Relates to Safety	All	20 - 30
16.	Discuss Method for Conducting Design Hazards Review	All	30

APPENDIX 2

emorandum

AIR PRODUCTS

o:	Distribution	Dept./Loc.:	
om:	D. P. Drown/D. P. Bernhard	Dept./Ext.:	Proj. Eng./PSG Eng. Safety
ate:	17 January 1994		
ubject:	Kingsport Liquid Phase Methanol Project Safety Plan		

Distribution

APCI

A. D. Bixler	PSG Proc. Tech./A32E1
W. R. Brown	EBDD/A31E2
T. E. Conway/M. K. Wolk	PSG Sys. Eng./A32F6
M. T. DiMercurio	Proj. Eng./A42L2
S. L. Feldman	PSG Eng. Safety/A32E5
T. K. Hersh	Proj. Eng./A42L1
E. C. Heydorn	LaPorte, MC 83
R. B. Moore	Econ. Eval./A41L1
E. S. Schaub	Proc. Eng./A11B2
G. E. Schmauch	PSG Eng. Safety/A32E5
V. E. Stein	PSG Adv. Sep./A11B2
J. Unangst	Constr. Eng./A22D1

Eastman Chemical Co.

L. Daniels
W. Jones

A draft of the Safety Plan for the Kingsport Liquid Phase Methanol Project is attached for your review and comment.

DPD/DPB:cmw

Attachment

FORM 2020 (REV. 5/89)

KINGSPORT LIQUID PHASE METHANOL PROJECT

SAFETY PLAN

APCI will design and build a 250 T/D Liquid Phase Methanol (LPMEOH) plant at Eastman Chemical Company's (ECC) Kingsport, TN plant. ECC will operate the plant during the demonstration period. The Safety Plan for this project includes a discussion on the requirement for producing the OSHA Process Safety Management documentation.

1. Site Selection Risk Assessment

A Site Selection Risk Assessment will be completed to identify safety and environmental risks to the project based on the site location for the LPMEOH. ECC will retain ownership of the land and the plant ownership will revert to ECC after the demonstration period. The location of the LPMEOH plant is an available area adjacent to part of their existing Methyl Acetate plant.

2. Safety Reviews

The LPMEOH plant involves new technology and hazardous materials and is therefore considered a High Risk Facility according to PSG Engineering Safety Work Instruction ES09011. The following safety reviews will be required. The groups with required attendance at these reviews are noted.

Safety Review	Required Attendance By
Site Selection Risk Assessment	Project, Safety
Preliminary Hazards Review (PrHR)	Safety, ECC, Process, Project, Engineering Technology, Systems, Operations (LaPorte AFDU)
Flowsheet (P&ID) Reviews	Safety, ECC, Process, Systems, Machinery (for machinery items)
Plot Plan/Facility Arrangement Review	Safety, ECC, Process, Project, Design Coordinator for PSG Engineering
Design Hazards Review (DHR)	Safety, ECC, Process, Project, Engineering Technology, Systems, Operations (Part-Time)
Design Verification Review (DVR)	Safety, Process, Project, Systems, ECC

KINGSPORT LIQUID PHASE METHANOL PROJECT

SAFETY PLAN

Safety Review	Required Attendance By
Operation Readiness Inspection (ORI)	Safety, ECC, Process, Project, Construction, Systems, Operations (LaPorte AFDU)

Project Engineering will initiate and coordinate the setting of these safety reviews.

A "Hazop" or "Hazop/What If" combination analysis will be used to analyze hazards in the DHR.

3. **Fire Protection System**

The existing firewater system will be extended for the new LPMEOH plant. The scope of the additions will be reviewed as part of the DHR.

4. **Vent System Review**

Process Engineering will define the release rates and composition of vents. PSG Engineering Safety will assist defining any design features and procedures needed to insure safe operation.

5. **Electrical Area Classification Plan**

The Electrical Area Classification Plan will be reviewed by PSG Engineering Safety, Process, Operations, ECC, Project and PSG Electrical Engineering.

6. **OSHA Process Safety Management Compliance**

Since this plant will be above the threshold for flammable material (10,000 lbs.), the plant owner is required as part of OSHA promulgated regulation for Process Safety Management (PSM) to provide the information to document the safety of the facility operations. APCI and ECC will agree on the scope of information to be provided by APCI to ECC for this project. A list of the "typical" PSM deliverables is attached. The responsibility column will need to be modified for this project.

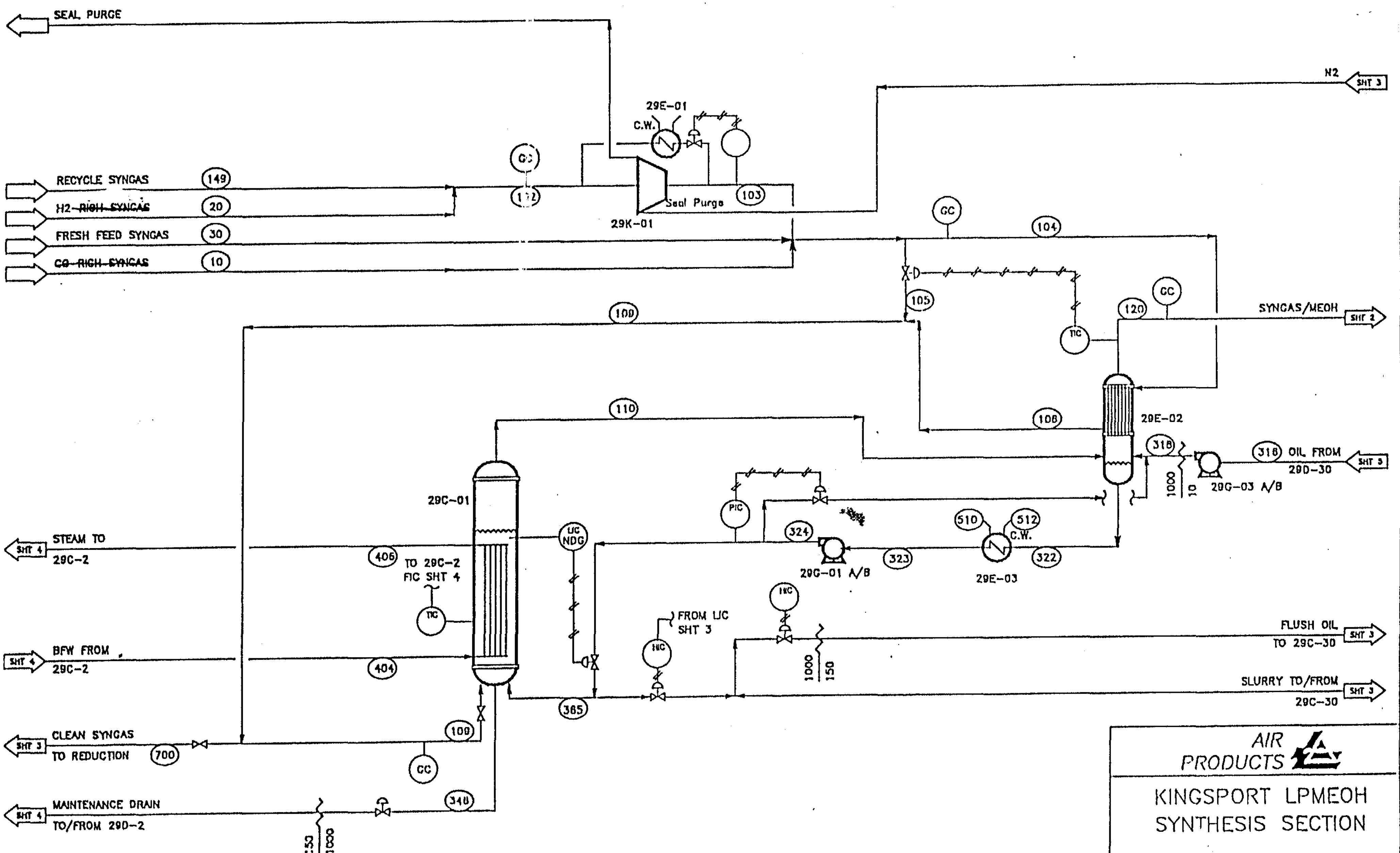
A Preliminary Hazards Review will be performed with the PFD and the plot plan as the basis for the review.

7. Eastman Chemical Company Safety Standards

APCI and ECC will agree on a set of safety standards to apply to the design and construction of this plant. The construction contractors will have to comply with the contractor requirements of the OSHA PSM regulations unless adequate segregation of the construction area from the existing ECC plants can be achieved.

8. Changes to the Safety Plan

The APCI Project Engineer will document and communicate to the appropriate personnel any safety review plan changes that occur during project execution.

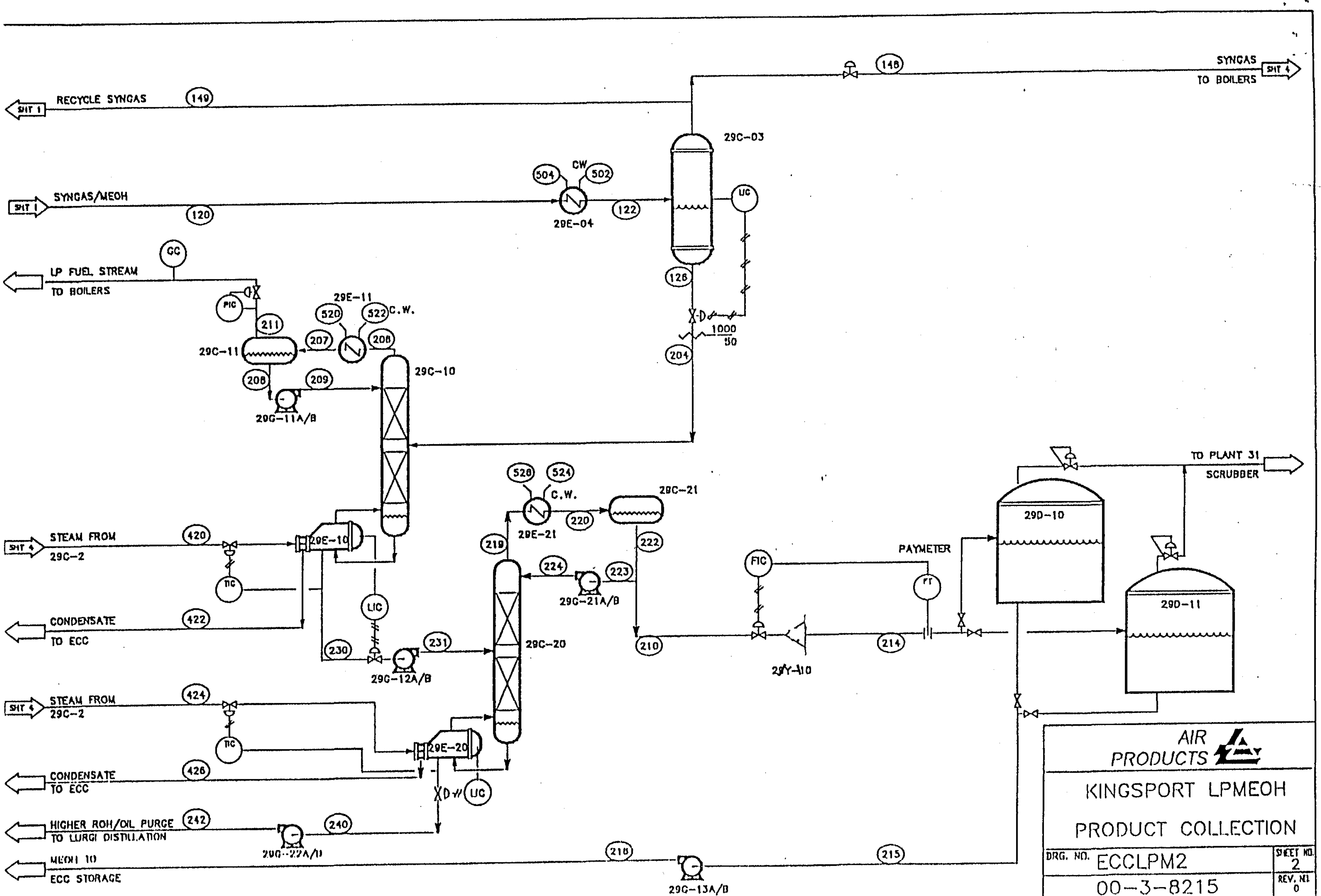


AIR PRODUCTS

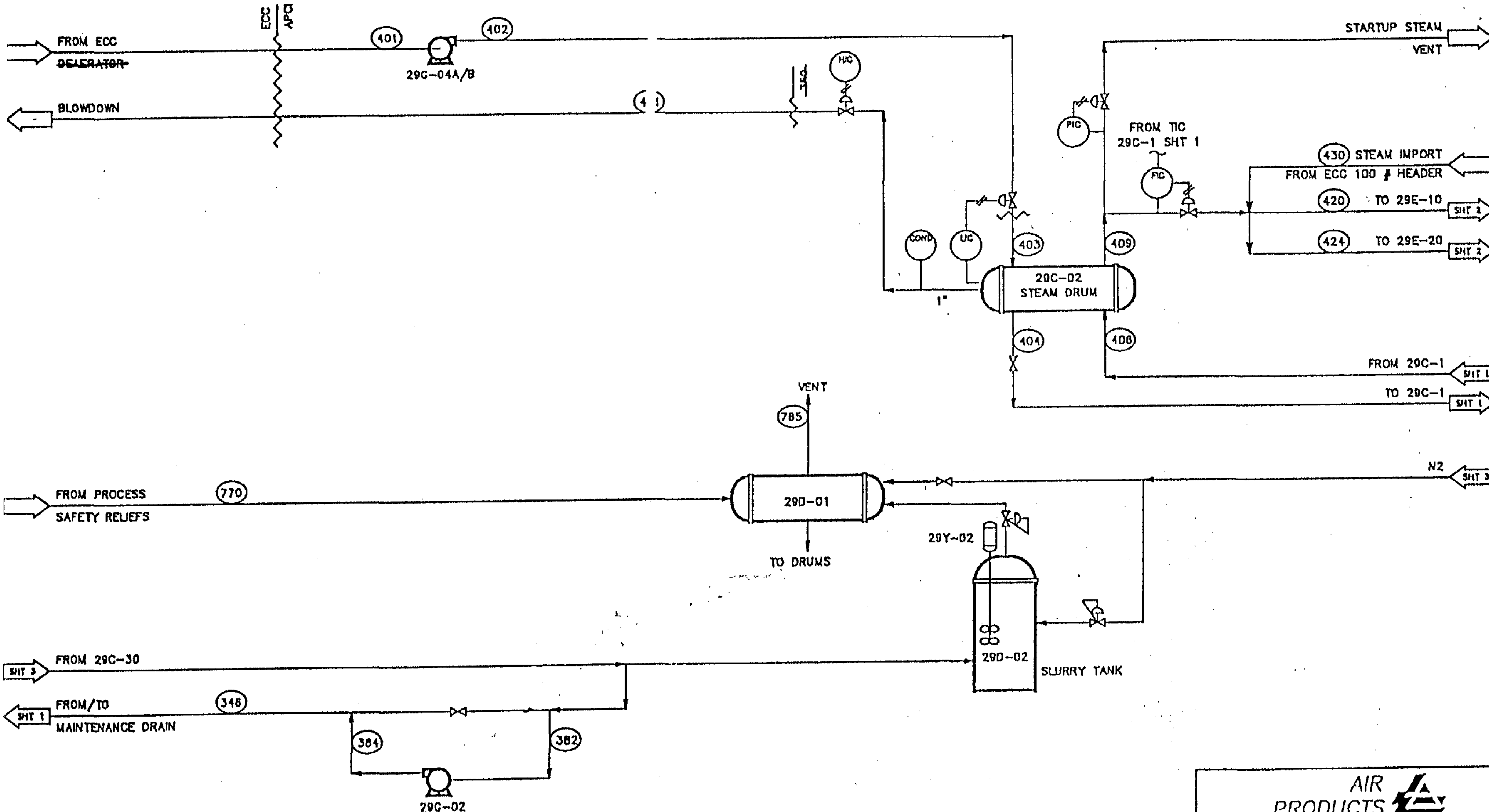
KINGSPORT LPMEOH
SYNTHESIS SECTION

DRG. NO.	SHEET NO.
ECC LPM1	1
00-3-8215	REV NO. 0

APPENDIX 3



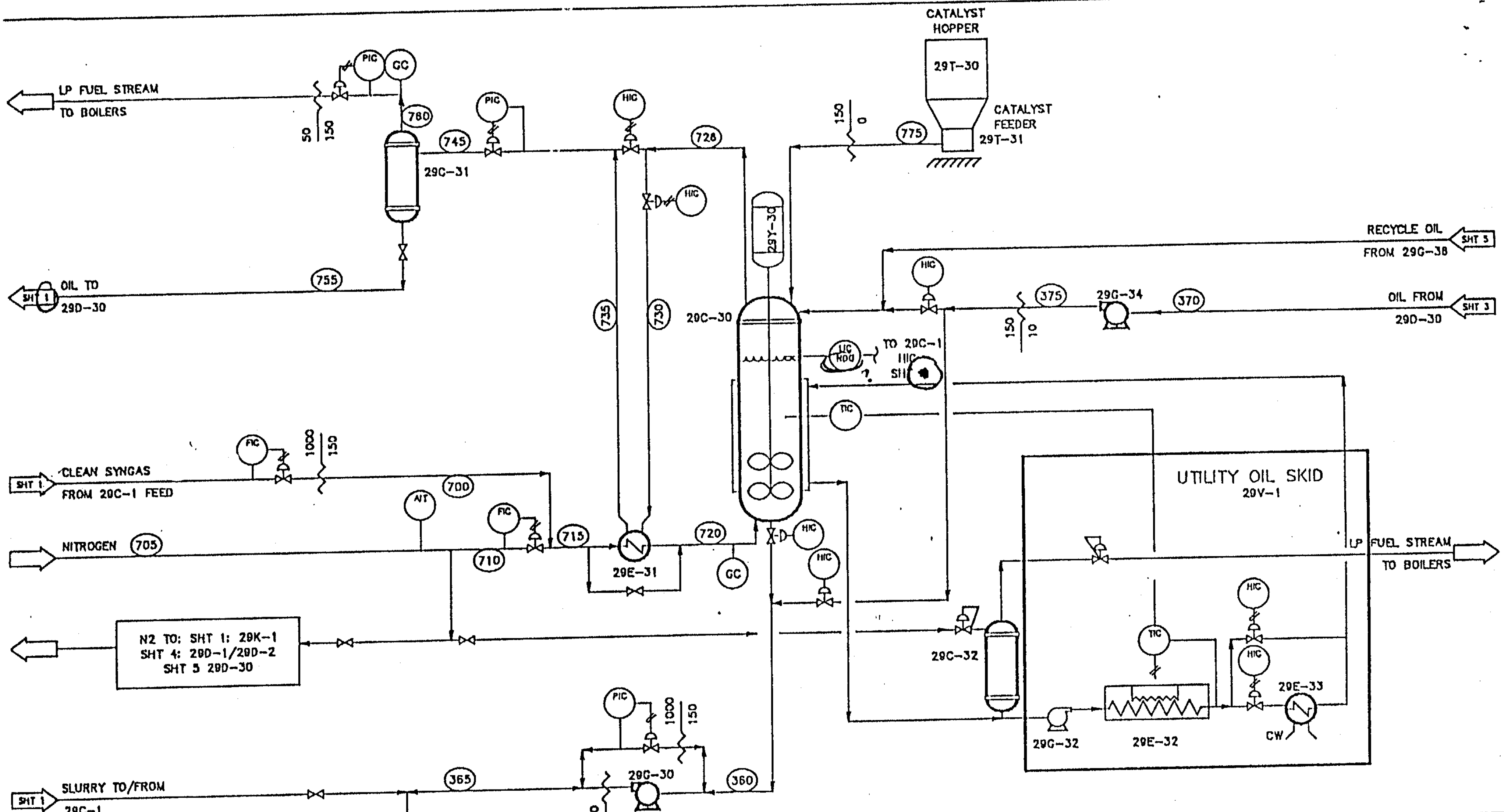
RECYCLE SYNGAS
SHT 1
149
SYNGAS
TO BOILERS
SHT 4
148
SYNGAS/MEOH
120
504
CW
502
29E-04
122
29C-03
LIC
126
1000
50
204
LP FUEL STREAM
TO BOILERS
GC
PIC
211
29E-11
520
522
C.W.
207
208
29C-11
209
29C-10
29G-11A/B
STEAM FROM
29C-2
420
TIC
29E-10
CONDENSATE
TO ECC
422
230
231
29G-12A/B
528
524
C.W.
29E-21
220
29C-21
219
224
223
222
29G-21A/B
29C-20
210
FIC
PAYMETER
FT
214
29Y-110
29D-10
29D-11
TO PLANT 31
SCRUBBER
424
29E-20
426
HIGHER ROH/OIL PURGE
TO LURGI DISTILLATION
242
240
29G-22A/B
MEOH TO
ECC STORAGE
218
29G-13A/B
215
AIR PRODUCTS
KINGSPORT LPMEOH
PRODUCT COLLECTION
DRG. NO. ECCLPM2
00-3-8215
SHEET NO. 2
REV. NO. 0



AIR PRODUCTS

KINGSPORT LPMEOH
GENERAL UTILITIES
SECTION

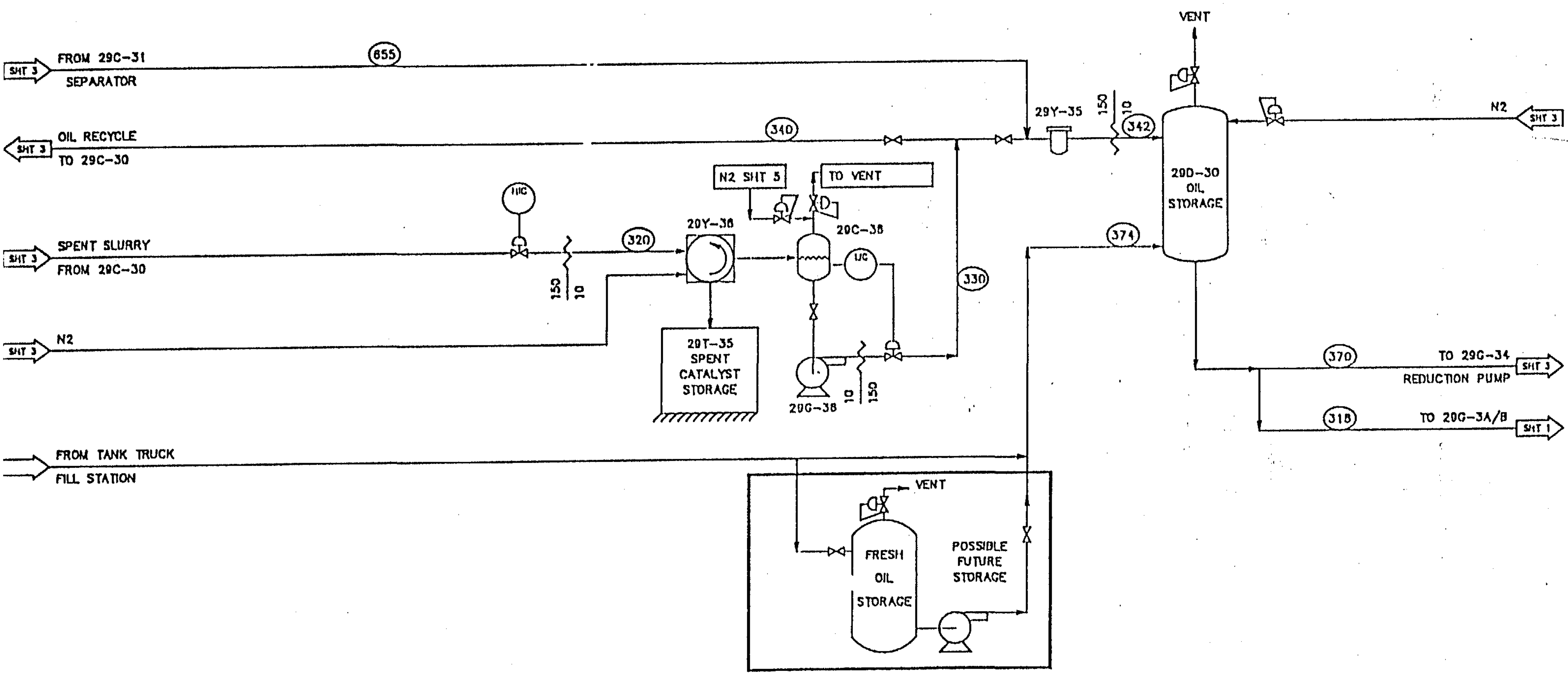
DRG. NO.	ECCLPM4	SHEET NO. 4
	00-3-8215	REV. NO. 0



AIR PRODUCTS

KINGSPORT LPMEOH
SLURRY REDUCTION
SECTION

DRG. NO.	ECCLPM3	SHEET NO. 3
	00-3-8215	REV. NO. 0



AIR PRODUCTS

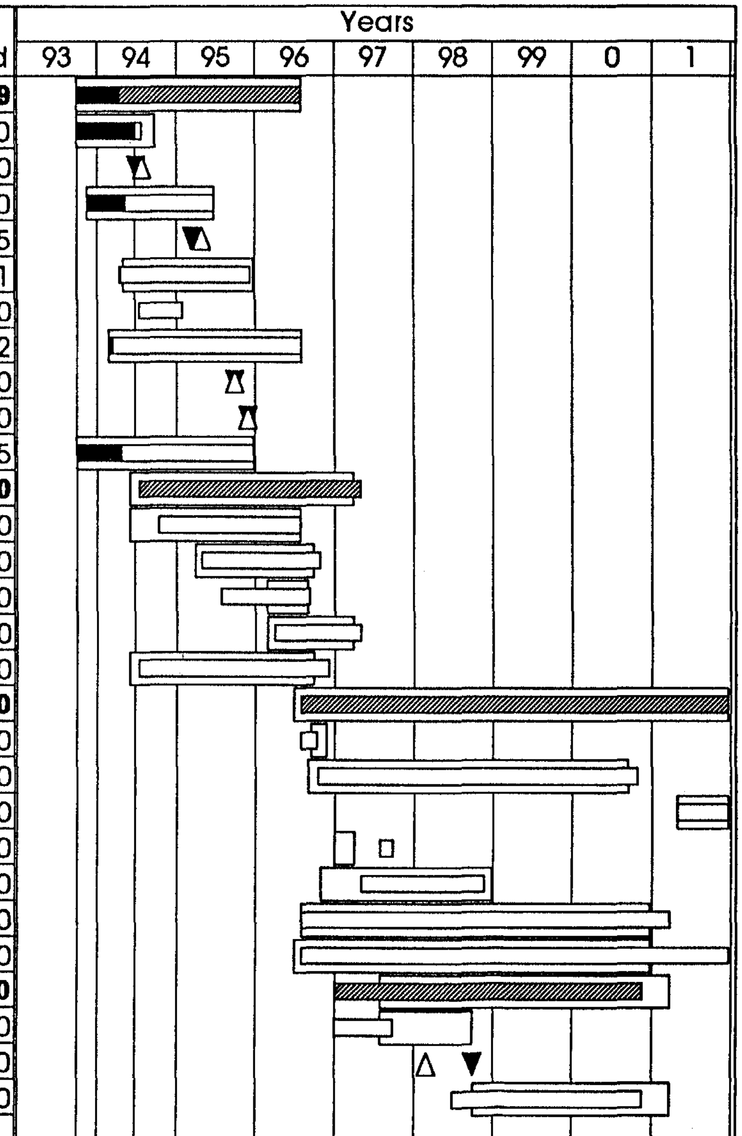
KINGSPORT LPMEOH
CATALYST RECOVERY
SECTION

DRG. NO.	ECCLPM5	SHEET NO. 5
	00-3-8215	REV. NO. 0

APPENDIX C MILESTONE SCHEDULE 6/24/94 1Page

MILESTONE SCHEDULE STATUS REPORT
LIQUID PHASE METHANOL DEMONSTRATION
DE-FC22-92PC90543

Task Name	Duration	Start	End	% Comp	% Sched
PHASE 1: DESIGN	**33.15 m**	**Oct/01/93**	**Aug/08/96**	**30**	**19**
PROJECT DEFINITION(TASK1)	9.66 m	Oct/01/93	Aug/01/94	90	90
CONTINUATION APPLICATION	0.00 d	Jul/29/94	Jul/29/94	0	0
PERMITTING(TASK 2)	18.90 m	Nov/17/93	Jun/30/95	80	30
NEPA FONSI APPROVAL	0.00 d	May/01/95	May/01/95	15	15
DESIGN ENGINEERING(TASK 3)	19.36 m	Apr/15/94	Dec/13/95	1	1
VENDOR ENGINEERING	6.39 m	Jul/15/94	Feb/01/95	0	0
OFF-SITE TESTING(TASK 4)	28.55 m	Feb/25/94	Aug/08/96	2	2
FUEL TEST PLAN DECISION	0.00 d	Oct/01/95	Oct/01/95	0	0
DECISION TO CONTINUE DME TESTING	0.00 d	Dec/01/95	Dec/01/95	0	0
PLANNING, ADMIN & DME DVT(TASK 5)	26.07 m	Oct/01/93	Dec/29/95	30	25
PHASE 2: CONSTRUCTION	**32.51 m**	**Jul/15/94**	**May/05/97**	**0**	**0**
PROCUREMENT(TASK1)	20.87 m	Oct/17/94	Aug/01/96	0	0
CONSTRUCTION(TASK2)	17.47 m	May/01/95	Oct/30/96	0	0
TRAINING & COMMISSIONING(TASK 3)	13.06 m	Aug/01/95	Sep/13/96	0	0
OFF-SITE DEMONSTRATIONS(TASK 4)	12.69 m	Apr/01/96	May/05/97	0	0
PLANNING & ADMINISTRATION(TASK 5)	28.00 m	Jul/15/94	Dec/12/96	0	0
PHASE 3: OPERATION	**62.71 m**	**Aug/01/96**	**Dec/28/01**	**0**	**0**
START-UP(TASK 1)	2.39 m	Aug/01/96	Oct/15/96	0	0
OPERATION(TASK 2.1)	47.00 m	Oct/16/96	Nov/03/00	0	0
DISMANTLE PLANT(TASK 2.3)	7.72 m	May/01/01	Dec/28/01	0	0
ON-SITE PRODUCT DEMO(TASK 3)	2.00 m	Aug/01/97	Oct/02/97	0	0
OFF-SITE PRODUCT DEMO(TASK 4)	18.02 m	May/06/97	Nov/24/98	0	0
DATA COLLECTION/MONITOR(TASK 5)	54.02 m	Aug/01/96	Mar/30/01	0	0
PLANNING & ADMINISTRATIVE(TASK 6)	62.71 m	Aug/01/96	Dec/28/01	0	0
PROVISIONAL DME IMPLEMENTATION	**45.29 m**	**Jan/02/97**	**Nov/24/00**	**0**	**0**
DME DVT(PDU TESTS)(TASK 6)	8.69 m	Jan/02/97	Sep/30/97	0	0
DECISION TO IMPLEMENT	0.00 d	Mar/01/98	Mar/01/98	0	0
DESIGN, MODIFY & OPERATE(TASK 2.2)	28.00 m	Jul/01/98	Nov/24/00	0	0



Printed: Jun/24/94
Page 1

Milestone Δ Summary

APPENDIX D COST MANAGEMENT REPORT 6/94 1Page

DOE F 1332.9
(11-84)

U.S. DEPARTM F ENERGY

COST MANAGEMENT REPORT

FORM APPROVED
OMB 1910-1400

1. TITLE
Liquid Phase Methanol Demonstration

2. REPORTING PERIOD
June 01, 1994 through June 30, 1994

3. IDENTIFICATION NUMBER
DE-FC22-92PC90543

2. PARTICIPANT NAME AND ADDRESS
Air Products and Chemicals, Inc.
7201 Hamilton Boulevard
Allentown, PA 18195-4911

5. COST PLAN DATE
February 23, 1994

6. START DATE
January 1, 1990

7. COMPLETION DATE
December 30, 2001

8. ELEMENT	9. REPORTING ELEMENT	10. ACCRUED COSTS Reporting Period a. Actual **	b. Plan	Cumulative to Date c. Actual	d. Plan	11. ESTIMATED ACCRUED COSTS a. Subsequent Reporting Period	b. Balance of Fiscal Year	c. (1)	(2)	(3)	d. Fiscal Years to Completion	e. Total	12. Total Contract Value	13. Variance
	Prior to Mod 2			15,906	15,906							15,906	15,906	0
1.1.1	Project Definition	138	223	617	1,529	169	108					1,806	1,806	0
1.1.2	Design-Engr.	14	140	63 19	220	165	670	6,960	1,769			9,784	9,784	0
1.1.3	Permitting	5	22	9 54	214	20	40	49				323	323	0
1.1.4	Proj. Mgmt.	26	45	156	316	40	72	468	158			1,054	1,054	0
1.2.1	Procurement	0	150	0	150	150	790	8,188	5,800			15,078	15,078	0
1.2.2	Construction	0	0	0	0	0	0	4,909	9,819			14,728	14,728	0
1.2.3	Proj. Mgmt.	0	5	0	5	5	30	298	297			635	635	0
1.3.1	Startup	0	0	0	0	0	0		922	264		1,186	1,186	0
1.3.2	Operations	0	0	0	0	0	0		5,110	36,309	100,790	142,209	142,209	0
1.3.3	On-Site Demo.	0	0	0	0	0	0			98		98	98	0
1.3.4	Off-Site Demo.	0	0	0	0	0	0			1,533	2,090	3,623	3,623	0
1.3.5	Data Collection	0	0	0	0	0	0		56	336	1,094	1,486	1,486	0
1.3.6	Proj. Mgmt.	0	0	0	0	0	0		321	1,285	4,178	5,784	5,784	0
														0
14. TOTAL		183	585	16,751	18,340	549	1,710	20,872	24,252	39,825	108,152	213,700	213,700	0

15. DOLLARS EXPRESSED IN:
Thousands

16. SIGNATURE OF PARTICIPANT'S PROJECT MANAGER AND DATE
D. P. Drown
7/15/94
DATE

17. SIGNATURE OF PARTICIPANTS AUTHORIZED FINANCIAL REPRESENTATIVE AND DATE
J. R. HIPPS
7/13/94
DATE

** NOTE: Excludes spending by Eastman Chemical and Acurex not yet invoiced.