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LIQUID PHASE METHANOL LAPORTE PROCESS DEVELOPMENT UNIT:
MODIFICATION, OPERATION, AND SUPPORT STUDIES

DOE/PC/90005-T33

DOE/PC/90005--T33

Quarterly Technical Progress Report No. 12

DE91 007397

For The Period 1 April - 30 June 1990

Contractor

AIR PRODUCTS AND CHEMICALS, INC.
Allentown, PA 18195

and

Subcontractor to Air Products

CHEM SYSTEMS INC.
Tarrytown, NY 10591

D. M. Brown - Air Products Program Manager
M. E. Frank - Chem Systems Program Manager

23 October 1990

Prepared for the United States Department of Energy
Under Contract No. DE-AC22-87PC90005
Contract Period 9 April 1987 - 30 September 1990

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LIQUID PHASE METHANOL PROCESS DEVELOPMENT UNIT:
MODIFICATION, OPERATION, AND SUPPORT STUDIES
Quarterly Technical Progress Report
April-June 1990

CONTRACT OBJECTIVES:

The objectives of this program are to implement and test the process improvements identified through the engineering studies of the current program (Contract DE-AC22-85PC80007), to demonstrate the capability of long-term catalyst activity maintenance, and to perform process and design engineering work that can be applied to a scaled-up Liquid Phase Methanol (LPMEOH) facility. An optional series of PDU runs is offered to extend the testing of the process improvements. A parallel research program will be performed to enhance the LPMEOH technical data base to improve the likelihood of commercialization of the LPMEOH process.

QUARTERLY SUMMARY:

- Flow sheet development for LaPorte PDU modifications continues. A preliminary P&ID review was completed - flow sheet modifications were identified and are being incorporated. A preliminary hazards review was completed on 22 May. Some minor flow sheet modifications resulted and a number of action items were identified. The most significant action item is to develop a materials reactivity and compatibility grid for the different alcohols, ethers, and esters which will be produced at the PDU.
- Heat and material balances were completed for the maximum production cases of the mixed DME/MEOH synthesis campaign. The updated balances reflect reactor productivity and selectivity as currently observed in the laboratory. Preliminary heat and material balances were also developed for the mixed alcohols campaign. At this time, productivity and selectivity are not well known for slurry reactors, so two "representative" product specifications were chosen. Productivity was assumed to be on the order of DME synthesis. The results of work-to-date has led to additional flow sheet modifications - primarily in the area of piping and valves.
- An improved rate expression was developed which fits the BASF S3-86 data base quite well. The incorporation of methanol in the adsorption terms improves the description of the space velocity effect. The average prediction error for the model is 15%. The Modeling task (Subtask 3.5) is now concluded, and the topical report is under preparation.
- The flow of draft topical reports from Process and Research on LPIII activities continues. Chem Systems' draft report on LPMEOH economics was, after some revision, accepted by DOE. The topical report on the tracer study tests done at the LaPorte PDU in spring 1989, was released to DOE. A topical report was completed on the coal-gas clean-up study (Task 3.8). It includes tests at Iron Run with Coolwater gas as well as the two field tests at Great Plains. The report is being reviewed and will be issued shortly to DOE.

- The DOE Quarterly Review was held in Allentown on 15 May. Flow sheet modifications for the LaPorte PDU, which had been developed since the last review meeting, were accepted by DOE PETC. SWRI's fuel testing results generated a lot of questions. We will invite their personnel to the next Quarterly Meeting.
- A paper entitled "LPMEOH: Beyond LaPorte - The Next Steps to Commercialization" was presented by D. M. Brown at the 15th Annual EPRI Conference on Fuel Science and Conversion in June.

FUTURE PLANS:

- Complete fuel tests at SWRI. SWRI will present results at next Quarterly Meeting.
- Continue with process design studies for LaPorte operations in Alternative Fuels I.
- Continue with preparation of topical reports.

RESULTS AND DISCUSSION:

Task 1 - LaPorte PDU Engineering and Modification

The development of the CO₂/fuels recovery/purification section design was completed. The current design incorporates four distillation columns (two for CO₂ recovery and removal; two for product separation), a Freon 22 refrigeration skid, and associated heat exchangers, vessels and pumps.

A preliminary P&ID review was then conducted on the resultant flow sheet. The purpose of this exercise was for process engineering, start-up, and operations to review the flow sheet and determine if adequate instrumentation and piping flexibility were incorporated to provide for start-up and shutdown, as well as normal operations. Some flow sheet modifications and instrument/control additions were identified and incorporated into the design.

Next, the preliminary Hazards Review was held on 22 and 23 May. Some minor flow sheet modifications resulted and a number of action items were identified and documented (this document is attached as an appendix). The most significant action item was to develop a materials reactivity and compatibility grid for the different alcohols, ethers, and esters which may be produced at the AFDU.

Also contained in the hazards review documentation is a description of the AFDU as it will exist when the proposed flow sheet is implemented. Flow sheets for the AFDU have also been attached.

Once the flow sheet had reached a fairly stable state, heat and material balances were completed for the maximum production cases of the mixed methanol/dimethyl ether synthesis campaign. The updated balances reflect reactor productivity and selectivity as currently observed in the laboratory. Preliminary heat and material balances were also developed for the mixed alcohol campaign. At this time, the productivity and selectivity are not well known for slurry reactors so two "representative" product specifications were

chosen; productivity was assumed to be on the order of the DME synthesis. The results of this work lead to additional flow sheet modifications - primarily in the area of piping and valves. These balances will form the basis for sizing the new equipment.

The objectives for the fourth quarter are as follows:

- Develop heat and material balances for the mixed ether campaign.
- Develop heat and material balances for the enhanced syngas conversion campaign.
- Create a Rev. 0 P&ID and issue for project.
- Begin detailed equipment design.

Task 2 - LaPorte PDU Shakedown, Operations, Deactivation, and Disposal

The PDU remains in a deactivation state. A large number of topical reports are under preparation. Drawings for the new shelter at LaPorte are being circulated for comment.

Task 3 - Research Program

Subtask 3.5 - Modeling

A. Development of Rate Model for S3-86 Catalyst:

A significant improvement was made in a rate expression to fit the S3-86 data base. This rate expression yields an improved description of the effect of GHSV by incorporating terms for the adsorption of product methanol. The rate expression, model XX14, was derived assuming CO and CO₂ hydrogenation occur on separate adsorptive sites:

$$\text{rate}_{\text{CH}_3\text{OH}} = \frac{b_0(f_{\text{CO}} f_{\text{H}_2})^{1/2} - \frac{f_{\text{CH}_3\text{OH}}}{K f_{\text{H}_2}^{3/2}}}{(1 + b_2 f_{\text{CH}_3\text{OH}} + b_3 \left(\frac{f_{\text{CO}_2} f_{\text{H}_2}}{f_{\text{CO}}}\right)^2} + \frac{b_1(f_{\text{CO}_2} f_{\text{H}_2})^2 - \frac{f_{\text{CH}_3\text{OH}} f_{\text{CO}_2}}{K f_{\text{CO}}}}{(1 + b_4 f_{\text{CO}_2} + b_5 f_{\text{CH}_3\text{OH}})^2}$$

where b₀ and b₅ are the best fit parameters and K is the equilibrium constant for methanol synthesis from CO. The best-fit values for b₀ through b₅ are:

<u>Parameter</u>	<u>Value</u>
b ₀	0.5891 gmol/(kg-hr-atm ^{3/2})
b ₁	0.1566 gmol/(kg-hr-atm ³)
b ₂	0.0519 atm ⁻¹
b ₃	0.0386 atm ⁻¹
b ₄	0.2276 atm ⁻¹
b ₅	0.1909 atm ⁻¹

Figure 1 shows a parity plot, measured values vs. corresponding predicted values, for model XX14. The average prediction error per observation for this model is 15%. The model still tends to predict higher than observed rates at low GHSV and lower than observed rates at high GHSV, but the overall fit is significantly better than that for previous rate expressions.

B. Process Variable Scans on S3-86 Catalyst:

This activity was completed last quarter.

Task 4 - Chem Systems Engineering and PDU Support Program

All work is now complete. The draft topical report on LPMEOH economics was accepted by DOE and issued.

Task 5 - Air Products Program Management Activities

Subtasks 5.1/5.2 - Reports

Monthly reports for April and May 1990, and a draft Quarterly Report for the period 1 January to 31 March 1990 were prepared and sent to DOE for comment. A large number of topical reports have issued or are close to issue.

Subtask 5.3/5.4 - Management Activities

DOE has requested that we complete a short demonstration of alternative fuels technology at the LaPorte AFUD by April 1991 (the proposal which had been submitted to DOE called for shake-down and operations to begin in early 1992). In response to DOE's request, a revised operating scope-of-work was developed and included in an amended proposal. At this time the plan is to be in the field in early 1991 to begin shake-down and start-up. A brief, two-week operating period will begin in mid-March; the synthesis of dimethyl-ether/methanol mixtures will be demonstrated. Following this demonstration, the plant will be temporarily deactivated; restart of the facility will take place in mid 1992.

Results are now available from SWRI on the side-by-side testing of LaPorte methanol with M85 from BP Oil. As expected, both RVP and flashpoint are lower for LPMEOH than for M85. Octane numbers and fuel lubricity look encouraging. Power and torque measurements look comparable, and emissions data (per EPA protocol) for LaPorte methanol look superior to M85. The data was presented at the May quarterly meeting and generated a lot of questions which can only be answered by SWRI personnel. We intend to have them attend the next quarterly meeting in September.

A paper entitled "LPMEOH: Beyond LaPorte - The Next Steps to Commercialization," coauthored by Process Engineering, was presented by D. M. Brown at the 15th Annual EPRI Conference on Fuel Science and Conversion.

FIGURE 1

PARITY PLOT

Catalyst F21/OE75-43, 250°C

A no-cost 6-month extension of the present LPIII contract is being sought so that adequate time may be given to topical and final reports.

OPEN ITEMS

None

SUMMARY STATUS ASSESSMENT AND FORECAST

The cost summary prepared for the May Quarterly Meeting is attached. We expect to meet the budget exactly.

ATTACHMENTS

A Milestone Schedule Status Report and Milestone Log for the period 1 April to 30 June 1990 are submitted herewith. Also included is the May budget/cost forecast. An internal memorandum on the Hazards Review for continued operations at LaPorte is also attached.

R. L. Williams to Distribution, 8 June 1990, "Alternate Fuels, LaPorte, TX: Preliminary Process Hazards Review Report."

(\$000)

14 MAY 1990

LIQUID PHASE METHANOL PART IIIPROGRAM COSTS

SUBTASK	1 FEB 90 FORECAST	30 APR 90 ACTUAL	TO COMPLETE	1 MAY 90 FORECAST	VARIANCE	
					NEW FORECAST	OLD FORECAST
1.1 PDU ENGINEERING	\$864	\$707	\$121	828	(\$36)	
1.2 PDU MODIFICATIONS	568	568	0	568	0	
2.1 PDU SHUTDOWN	1,029	1,029	0	1,029	0	
2.2 PDU OPERATIONS	2,429	2,429	0	2,429	0	
2.4 PDU DEACTIVATION/DISP	406	148	263	411	5	
3.1 ALTERNATIVE LIQUIDS	112	112	0	112	0	
3.2 EFFECTS OF CO ₂	201	201	0	201	0	
3.3 IN-SITU REDUCTION	143	143	0	143	0	
3.4 CATALYST POISONS	363	363	0	363	0	
3.5 FUNDAMENTAL MODELLING	335	337	0	337	2	
3.6 ALTERNATIVE CATALYSTS	143	143	0	143	0	
3.7 LIFE TEST - ALT CAT	62	82	0	82	0	
3.8 CAT POISONS FLD TEST	1,256	1,254	10	1,284	8	
4.1 OSI PROC DESIGN/REVAL	584	591	0	591	7	
4.3 CSI LAPORTE SUPPORT	239	232	0	232	(7)	
4.5 CSI PROGRAM MGMT	260	260	0	260	0	
5.1 APC PROJ MGMT	378	368	24	382	16	
5.3 ARG MGMT ACTIVITIES	850	684	171	855	5	
TOTAL	\$10,220	\$9,631	\$589	\$10,220		\$0

(\$000)

14 MAY 1990

LIQUID PHASE METHANOL PART III

PROGRAM COSTS

<u>SUBTASK</u>	<u>1 MAY 90 FORECAST</u>	<u>30 APR 90 ACTUAL</u>	(1)	
			<u>PERCENT SPENT</u>	<u>PERCENT COMPLETE</u>
1.1 PDU ENGINEERING	\$828	\$707	90.0%	90.0%
1.2 PDU MODIFICATIONS	568	568	100.0%	100.0%
2.1 PDU SHUTDOWN	1,029	1,029	100.0%	100.0%
2.2 PDU OPERATIONS	2,429	2,429	100.0%	100.0%
2.4 PDU DEACTIVATION/DISP	411	148	40.0%	40.0%
3.1 ALTERNATIVE LIQUIDS	112	112	100.0%	100.0%
3.2 EFFECT OF CO ₂	201	201	100.0%	100.0%
3.3 SIN-SITU REDUCTION	143	143	100.0%	100.0%
3.4 CATALYST POISONS	363	363	100.0%	100.0%
3.5 FUNDAMENTAL MODELLING	337	337	100.0%	100.0%
3.6 ALTERNATIVE CATALYSTS	143	143	100.0%	100.0%
3.7 LIFE TEST ALT CAT	62	62	100.0%	100.0%
3.8 CAT POISONS FLD TEST	1,264	1,254	100.0%	100.0%
4.1 CSI PROC DESIGN/EVAL	591	591	100.0%	100.0%
4.3 CSI LAPORTE SUPPORT	232	232	100.0%	100.0%
4.5 CSI PROGRAM MGMT	260	260	100.0%	100.0%
5.1 APCI PROGRAM MGMT	392	368	90.0%	90.0%
5.3 APCI MGMT ACTIVITIES	855	684	80.0%	80.0%
TOTAL	\$10,220	\$9,631	90.0%	90.0%

NOTE: (1) ACTUALS DIVIDED BY FORECAST

M I L E S T O N E L O G

Report Date: 30 June 1990

Contract No. DE-AC22-87PC90005

<u>Ident. No.</u>	<u>Description</u>	<u>Planned Completion Date</u>	<u>Actual Completion Date</u>	<u>Comments</u>
1.1	LaPorte PDU Engineering	30 Sept 90		
1.2	LaPorte PDU Modification	3 Jun 88	15 Jun 88	Work Completed
2.1	LaPorte PDU Shakedown	15 Aug 88	13 Jul 88	Work Completed
2.2/2.3	LaPorte PDU Operations	3 Mar 89	28 Jul 88 1 Sept 88 9 Jan 89 28 Feb 89 31 Mar 89	Run E-5 Completed * Run E-6 Completed * Run E-7 Completed * Run E-8 Completed * Run E-9 Completed *
2.4	LaPorte PDU Deactivation & Disposal	30 Apr 89 30 Sept 90	31 May 89	Deactivation Only
3.1	Alternate Liquid Media Studies	18 Mar 88	25 Mar 88	Work Completed *
3.2	Effects of CO ₂ in CO-Rich Syngas	30 Sept 88	30 Sept 88	Work Completed *
3.3	In-Situ Reduction, Simp- lification, Optimiza- tion & Slurry Storage	2 Oct 87 28 Oct 88 1 Mar 89	15 Mar 89	Work Completed *
3.4	Catalyst Poisons Studies	16 Sept 88	19 Aug 88	Work Completed *
3.5	Fundamental Modeling	30 Apr 90	30 Jun 90	Work Completed *
3.6	Testing Alternate Comm'l. Catalyst	15 Jan 88	29 Jan 88	Work Completed *

M I L E S T O N E L O G

Report Date: 30 June 1990

Contract No. DE-AC22-87PC90005

<u>Ident.</u> <u>No.</u>	<u>Description</u>	<u>Planned</u> <u>Completion</u> <u>Date</u>	<u>Actual</u> <u>Completion</u> <u>Date</u>	<u>Comments</u>
3.7	Autoclave Life Test for Alternate Commercial Catalyst	16 Sept 88	19 Aug 88	Work Completed *
3.8	Catalyst Poisons Field Demonstration	28 Feb 90	28 Feb 90	Work Completed *
4.1/4.2	Chem Systems Process Design/Evaluation Studies	30 Sept 89	30 Sept 89	Work Completed
4.3/4.4	Chem Systems LaPorte Support	31 Mar 89	31 Mar 89	Work Completed
4.5/4.6	Chem Systems Program Management	30 Sept 89	30 Sept 89	Work Completed
5.1/5.2	Air Products Planning & Reports	30 Sept 90		
5.3/5.4	Air Products Program Management	30 Sept 90		

* Preparation of reports is still outstanding.

U.S. DEPARTMENT OF ENERGY
MILESTONE SCHEDULE ☐ PLAN ☒ STATUS REPORTFORM APPROVED
OMB NO. 1901-1400

1. TITLE Liquid Phase Methanol LaPorte PDU: Modification, Operation, and Support Studies		2. REPORTING PERIOD 1 APRIL - 30 JUNE '90		3. IDENTIFICATION NUMBER DE-AC22-87PC90005																			
4. PARTICIPANT NAME AND ADDRESS Air Products and Chemicals, Inc. P. O. Box 538 Allentown, PA 18105		5. START DATE 9 April 1987		6. COMPLETION DATE 30 SEPTEMBER 1990																			
7. ELEMENT CODE	8. REPORTING ELEMENT	9. DURATION												FY 89	FY 90	10. PER-CENT COMPLETE							
		A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	--	--	Plan	Actual
1.0	LaPorte PDU Eng. & Mod.																						
1.1	Detailed Engineering																						
1.2	LaPorte PDU Mod.																						
2.0	LaPorte PDU Shakedown, Operation, Deactivation & Disposal																						
2.1	LaPorte PDU Shakedown																						
2.2/2.3	LaPorte PDU Operations																						
2.4	LaPorte PDU Deactivation & Disposal																						
3.0	Research Program																						
3.1	Alternate Liquid Media Studies																						
3.2	Effects of CO ₂ in CO-Rich Syngas																						
3.3	In-Situ Reduction, Simplification, Optimization & Slurry Storage																						
3.4	Catalyst Poisons Studies																						
3.5	Fundamental Modelling																						
3.6	Testing Alternate Commercial Catalyst																						
3.7	Autoclave Life Test for Alternate Commercial Catalyst																						
3.8	Catalyst Poisons Field Demonstration																						
4.0	CSI Engineering & PDU Support Program																						
4.1/4.2	Process Design/Evaluation Studies																						
4.3/4.4	CSI LaPorte Support																						
4.5/4.6	CSI Program Management																						
5.0	Air Products Program Management																						
5.1/5.2	Planning & Reports																						
5.3/5.4	Air Products Management Activities																						

Kingman
Program Manager
12/1/90

Memorandum

AIR
PRODUCTS

To: Distribution Dept./Loc.:
From: R. L. Williams Dept./Ext.: PSG - Project Engineering/7323
Date: 25 June 1990
Subject: Alternate Fuels, LaPorte, TX Preliminary Process Hazards Review Report

Distribution:

D. M. Brown - PSG Comm'l. Dev.
D. A. Fritz - Operations, La Porte - MC#83
J. Henderson - Operations
D. M. Herron - Proc. Eng.
R. M. Howard - Proj. Eng.
T. Hsuing - PSG Res. - Iron Run
L. Hvizdos - Econ. Eval.
B. Y. Johnston - PSG Start-up Eng.
G. A. Peters - PSG Eng. Safety

Please find attached a copy of the Preliminary Process Hazards Review for the Alternative Fuels Development Unit (AFDU) for LaPorte, TX. The review was conducted on 22 May 1990 in accordance with Engineering Procedure R-4.

No significant changes from the original estimate were identified during the hazards review.

Please contact me if you have any questions or comments.

R. L. Williams

RLW:pjk
Attachment
7270s

RECEIVED

JUN 26 1990

PROCESS ENGINEERING

PRELIMINARY PROCESS HAZARDS REVIEW

Alternative Fuels Development Unit (AFDU)

LaPorte, TX

22 May 1990

REVIEW TEAM

J. Henderson	Operations
D. M. Herron	Process Engineering
B. K. Johnston	Start-Up Engineering
G. A. Peters	PSG Engineering Safety
R. L. Williams (Chairman/Secretary)	Project Engineering

(D R A F T)

Preliminary Process Hazards Review
Alternative Fuels Development Unit (AFDU)
LaPorte, TX
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Appendices

- I. Process Flow Diagram
- II. Heat and Material Balance
- III. Plant Liquid Inventory List
- VI. Equipment Arrangement

Preliminary Process Hazards Review
Alternative Fuels Development Unit (AFDU)
LaPorte, TX

A. INTRODUCTION

A preliminary Process Hazards Review (PrHR) was conducted on the proposed Alternative Fuels Development Unit (AFDU) for LaPorte, TX. The AFDU is the proposed expansion of the existing Liquid Phase Methanol (LPM_{OH}) Process Development Unit (PDU) that has been operated by APCI under various Department of Energy contracts for the last ten (10) years. Under the anticipated new contract from the DOE, the existing PDU will be modified and new equipment added in order produce alternative fuel products.

In addition to Methanol, Dimethyl Ether (DME) has been identified as one of the alternative fuel products because of its potential as a precursor in commercial syngas-to-gasoline processes. Other fuel development will be the result of current and future lab development and in anticipation of these future fuels, the plant design must be able to accommodate these fuels with minimal changes.

The purpose of the PrHR which was conducted in accordance with Engineering Procedure R-4 is to highlight any major hazards and to define any areas of further study.

Since the existing plant has been operated for various periods of time for the last ten (10) years with the required hazards reviews conducted at the appropriate time, a complete review of the existing plant will not be conducted, only a review of the modifications to the existing plant as well as new equipment and processes was done.

B. PROCESS DESCRIPTION

The AFDU will be comprised of four (4) major plant areas:

- Reactor Train
- Distillation Area
- Refrigeration Area
- Storage Area

Minor modifications and tie-ins will be made to the existing reactor area to support the expansion. (Refer to PFD 4.1-1, Appendix I)

The distillation and refrigeration areas are new. These two areas are required because in the synthesis of oxygenated fuels (alcohols, ethers, esters) CO₂ and water are byproducts of reaction and need to be removed. In addition, the distillation area will be used to separate the fuel product streams into "light" and "heavy" products. (Refer to PFD 4.1-2, Appendix I)

The storage area is new (the existing methanol storage tank will be moved from in-ground) and will consist of three storage tanks and associated transfer/loading pumps and facilities. The expanded storage capacity and flexibility is required to handle the storage of multiple products as well as reaction intermediates. (Refer to PFD 4.1-3, Appendix I)

REACTOR TRAIN -

Fresh Feed (containing hydrogen, carbon monoxide, and carbon dioxide) is compressed from 150 psig to the reactor pressure (500 to 900 psig) in the feed compressor, 01.10. The compressed feed is combined with recycle gas to form the reactor feed - a simulated synthesis gas.

The feed is preheated (in the 21.10) against reactor effluent, mixed with a reinjection stream (if appropriate), and sparged into the bottom of the 27.10 slurry reactor. The 27.10 currently functions as a slurry reactor with small (10 micron) catalyst particles suspended in a white mineral oil. Within the reactor, H₂ and CO are partially converted to products and byproducts.

The heat of reaction is first absorbed by the slurry oil then transferred via convective heat transfer to a circulating, closed loop utility oil system. The heat exchanger which facilitates this energy transfer is located internal to the 27.10 reactor. The utility oil system, which consists of an expansion tank (28.53), a circulating pump (10.53), oil cooler (21.40), and oil heaters (15.40 and 02.83), is designed to maintain a specified reactor temperature by providing the necessary heating or cooling duty.

The reactor effluent is passed to the 27.11 cyclone separator to remove any slurry which has been carried-over. The resultant vapor is then cooled in the 21.10 exchanger to approximately 250°F and sent to the

27.14 separator where condensed slurry oil is further removed. The liquids from the 27.11 and 27.14 are pumped (in the 10.52 pumps) and returned to the 27.10 reactor.

The vapor from the 27.14 is cooled against water (in the 21.30) and introduced to the 22.10 separator where the some of the reaction products are recovered as liquid. The liquid and vapor from the 22.10 are processed further in the downstream distillation section. The downstream processing scheme is dependent on the type of products and byproducts which are formed in the 27.10 reactor.

DISTILLATION AREA -

Four distillation columns are provided to separate products and byproducts.

The first two columns, 07.05 and 07.10, are devoted to byproduct CO₂ removal. CO₂ is absorbed from the reactor effluent vapor in the 07.05 scrub column; CO₂ is rejected from the absorbant fluid in the 07.10 stripper column. The absorbant is comprised of reactor products, such as methanol, and some byproduct water.

The second two columns, 07.15 and 07.20, are designed to split the desirable products into fractions, as well as remove byproduct water.

Flows and compositions within the distillation section are dependent upon the operating mode. A brief discussion of some of the expected operating modes is presented below:

Straight Methanol Synthesis -

The principle reaction taking place in the reactor is

The reaction products include methanol and quantities of ethanol and water (as well as other byproducts). In addition, a small quantity of dissolved CO₂ (which originates in the reactor feed gas) is also recovered with the methanol in the 22.10

The vapor from the 22.10 is split into two streams. A small flow is purged to flare; the major portion (the recycle) is recompressed (in the 01.20) and combined with fresh feed.

The liquid from the 22.10 separator is reduced in pressure and sent to the 07.15 fractionator. A small degree of reboil is provided in the 15.60 to drive the dissolved CO₂ out of the liquid phase; a small condenser duty is supplied to the 21.55 exchanger to minimize methanol losses overhead. The overhead CO₂ stream is directed to flare.

The bottoms product, which contains methanol and water, is directed to the 07.20 fractionator where a water-rich stream is withdrawn as bottoms and a purified methanol stream is withdrawn as liquid overheads. The water-rich stream is sent off to be burnt in the flare; the methanol-rich stream is let down through a number of vessels (22.11, 22.15, 22.16), where any dissolved CO₂ is further degassed, then delivered to storage (28.10).

Methanol Synthesis with Steam Injection -

Demineralized water is pumped to reactor pressure (in 10.85), heated and vaporized in 15.70, and combined with the reactor feed (downstream of the 21.10).

In addition to the methanol reaction, the water-gas shift reaction proceeds,

Thus the reaction products not only include methanol and small quantities of ethanol and water, but also carbon dioxide (in excess of that which had entered the reactor).

The vapor from the 22.10 is cooled in the 21.25 exchanger and introduced to the bottom of the 07.05 CO₂ scrub column. The CO₂ produced in the reactor is absorbed into the downwardly flowing, refrigerated reflux and exits with the bottoms.

The vapor from the 07.05 is rewarmed (in the 21.25) and split into two streams. A small flow is purged to flare; the major portion (the recycle) is recompressed (in the 01.20) and combined with fresh feed.

The bottoms from the 07.05 is reduced in pressure, heated in the 21.65, and sent to the 07.10 stripper column. Within this column, the CO₂ is driven from the liquid by the action of the 15.55 reboiler; the 21.50 condenser duty is applied to minimize solvent losses. The vapor overheads from the 07.05 contain the rejected CO₂ and is directed to the flare.

The liquid bottoms is split into two streams. The major flow, which constitutes the refrigerated solvent, is first cooled in the 21.65, chilled to -25°F in the 21.80 low pressure Freon 22 evaporator, pumped to elevated pressure in the 10.80 pump, and returned to the 07.05 as reflux.

The second portion of the 07.10 bottoms is combined with the liquid from the 22.10 separator to form the feed to the 07.15/07.20 fractionators. The two major components in this stream are methanol and water; small quantities of CO₂ are also present.

Within the 07.15/07.20 fractionators, the methanol is purified by rejecting CO₂ and water (see "Straight Methanol Synthesis").

Mixed Methanol/Dimethyl Ether Synthesis -

Dimethyl ether (DME) is produced from methanol by the following reaction,

This reaction readily occurs when a second catalyst (alumina) is added to the slurry. The water which is formed in this reaction is substantially converted in the water-gas shift reaction. It follows that the major products/byproducts are MeOH, DME, CO₂, and H₂O. Note that DME is much more volatile than MeOH (it has a vapor pressure slightly lower than propane).

The vapor from the 22.10 is cooled in the 21.25 and introduced to the 07.05 scrub column where CO₂ and DME are absorbed.

The vapor from the 07.05 is rewarmed (in the 21.25) and split into two streams. A small flow is purged to flare; the major portion (the recycle) is recompressed (in the 01.20) and combined with fresh feed.

The bottoms from the 07.05 is reduced in pressure, heated in the 21.65, and sent to the 07.10 stripper column. Within this column, the CO₂ and DME are recovered as overhead vapor; the methanol and water are recovered as bottoms.

The liquid bottoms are split into two streams. The major flow, which constitutes the refrigerated solvent, is cooled, chilled, purged, and returned to the 07.05 as reflux.

The second portion of the 07.10 bottoms is combined with the liquid from the 22.10 separator to form the feed to the 07.20 fractionator. This stream is separated into a purified methanol liquid overhead and a water-rich bottoms. The methanol is directed to storage; the water-rich stream is sent to the flare.

The vapor product from the 07.10 is chilled to 50°F in the 21.75 medium pressure Freon 22 evaporator then sent to the 07.15 column. Within this fractionator, CO₂ is rejected as overheads and sent to flare; DME is recovered as bottoms and sent to storage. The 21.55 condenser duty is provided by boiling low pressure Freon 22.

Mixed Alcohol Synthesis -

Mixed alcohols are produced from synthesis gas according to the reaction,

where n is one for methanol, two for ethanol, and so on. The water which is formed in this reaction is substantially converted in the water-gas shift reaction. The major products/byproducts are C1 through C5 alcohols, CO₂, and H₂O.

The vapor from the 22.10 is cooled in the 21.25, introduced to the 07.05 scrub column where CO₂ is absorbed, rewarmed (in the 21.25) and split into two streams - one to flare, and one to recycle.

The bottoms from the 07.05 is reduced in pressure, heated in the 21.65, and sent to the 07.10 stripper column where CO₂ is rejected as overhead vapor and sent to flare. The liquid bottoms is split into two streams. The major flow is cooled, chilled, pump, and returned to the 07.05 as reflux.

The second portion of the 07.10 bottoms is combined with the liquid from the 22.10 separator to form the feed to the 07.15 fractionator. Within the 07.15, methanol, ethanol, propanol and water are recovered as liquid overheads and butanol+ is recovered as bottoms (and sent to storage).

The overhead from the 07.15 is subsequently sent to the 07.20 column where methanol and ethanol are recovered as overheads (and sent to storage) and a mixed blend (plus water) is recovered as bottoms (and sent to storage).

The methanol-rich stream may be recycled to the front-end. In such an event, it would be pumped to reactor pressure (in 10.85), heated and vaporized in (15.70), and combined with the reactor feed (downstream of the 21.10).

Other Synthesis Schemes -

Other schemes may lead to different oxygenated fuel products, such as mixed ethers or methyl acetate. In general, all schemes will produce water and CO₂ as byproducts and will utilize the 07.05/07.10 for CO₂ absorption/rejection and use the 07.15/07.20 for product isolation and water concentration.

REFRIGERATION AREA -

A Freon 22 refrigeration unit will be used. Two temperature levels of refrigeration will be supplied (-35°F and +40°F). Low pressure (low level) refrigeration is supplied by the evaporation of Freon 22 in the 21.80 and 21.55 exchangers. Medium pressure refrigeration is supplied to the 21.75 exchanger.

The vapors from the low level evaporators are combined and compressed to an intermediate pressure in the 01.50-1 compressor. The compressor discharge gas is mixed with the returning flow from the 21.75, then compressed further in the 01.50-2. The compressor discharge gas is desuperheated and condensed (against cooling water) in the 21.70 exchanger, then sent to the 28.60 accumulation tank.

Refrigerant is drawn from the 28.60 to supply the various refrigeration demands. All the circulating, high pressure liquid is first flashed to the intermediated pressure level (21.75) to conserve power. Low level refrigerant circulation is then drawn from the 21.75 to supply the 21.80 and 21.55.

C. Hazards Review

The following are the hazards identified during the Preliminary Hazards Review Meeting and the recommended follow-up action.

<u>Hazard</u>	<u>Recommendation/Follow-up</u>
(The first four (4) items listed below pertain to all areas of operation.)	
1. Improper selection of materials could result in hazard due to premature corrosion. Methanol and higher alcohols are known to be corrosive. DME may be corrosive.	1. Consult with Corporate Engineering to determine proper material selection. PROJECT ENGINEERING to initiate.
2. There are several distinct areas within the process with different pressure ratings and the possibility of adding a higher pressure (3,000 psig) reactor in the future. Although the 3000 psig overpressurization case cannot occur without the addition of a new compressor, some of the plant components will be designed for 3000 psig in anticipation of a plant expansion.	2. Review the various overpressurization scenarios for both new and existing equipment. Each case will be reviewed during the Design Hazards Review upon completion of the Safety Valve Sizing by PROCESS ENGINEERING.
3. Reactions amongst the various chemicals used and produced in the process could result in a potentially dangerous situation. There are other unknown handling steps at this time. For example, the MSDS for DME cautions against purging with CO ₂ .	3. Prepare a reactivity grid for all products used or produced on site. PROCESS ENGINEERING to initiate.
4. Overpressurization of the cooling water circuit could occur where the process side of coolers is at a higher pressure than the cooling water.	4. Install burst discs on the cooling water piping.

Items 5 through 7 pertain to existing plant equipment)

5. Item 21.41 CO ₂ Warming Coils, consisting of a p.enum and coils, will be added above the existing 21.40 Utility Oil Cooler to	5. Review the surface area of the 21.41 to ensure that it is adequate to maintain at least -20°F in the CS piping if the fan on the 21.41 shuts down. An ambient temperature operating criteria may need to be developed for this situation. PROCESS ENGINEERING.

Hazard

provide warming of the CO₂ stream to flare from -25°F to ambient. The low temperature of the stream presents a potential hazard due the existing CS piping to the flare.

6. CO₂ is let down from approximately 250 psig to ambient pressure to the flare stack.
7. Liquid carryover from 21.55 CO₂/DME column condenser could return to the 01.10 compressor feed.
8. Liquid carryover from 21.25 HP Effluent/Recycle Cooler could return to the 01.20 feed.
9. Liquid carryover from the 21.25 HP Effluent/Recycle Cooler could result in low temperatures at the 22.12 Demister.
10. The 07.05 CO₂ Absorber Column, 21.25 Recycle Cooler and associated piping will be designed for a future high pressure case, probably 3000 psig. The higher pressure can only occur if the plant is expanded through the addition of a new compressor and reactor train so overpressurization cannot occur with the current equipment. The 07.05 and 21.25 will be designed for 3000 psig to minimize changeover problems later.
11. Liquid from 22.10 (H&M Point 161) provides the potential for relieving flammable liquids. Liquid feeding the 07.10 bottoms is let down from 900 psig (future: 3000 psig) to 350 psig.

Recommendation/Follow-up

6. Review process to ensure dry ice is not formed. PROCESS ENGINEERING.
7. Install an LSH on 21.55 to close FIC-107, recycle feed to the 01.10. As an alternative, look at the economics of eliminating the CO₂ recycle and use CO₂ from storage. ECONOMIC EVALUATION.
8. Add an LSH on the 22.12 demister on the 01.20 suction.
9. Install a TSL on the vapor return from the 21.25 to the 01.20.
10. Review overall system and components and pressure breaks. Install spectacle blinds where appropriate. (Note: This item ties in closely with the overall pressure situation described in Item 2 above.)
11. Proper selection of pressure rating of materials up to isolation valves on 07.10 bottoms should avoid the need for this. In general, the system should be designed to avoid the need for pressure relieving devices that could release flammable liquids. PROCESS ENGINEERING

Hazard

12. For each catalyst used in the 27.10 Reactor, the potential for an exotherm exists. There will be different catalysts used throughout each campaign depending upon the desired product.
13. A possible operating scenario consists of reinjecting a product (pure or mixture) from storage through the 15.70 Product Heater to the 27.10 Reactor to study sequential reactions.
14. The existing plant controls will be converted to a DCS system and the new plant will be designed with a DCS. Critical shutdowns on the existing plant and new plant must be separate from the computer control.
15. Review sizing of existing relief devices to ensure adequacy based on tie-ins to new equipment.
16. The 10.80 LP Absorber Fluid Pump is used to recirculate a refrigerant currently consisting primarily of methanol. A seal leak could potentially dump the plant inventory of flammables.

(Note: A complete listing of the plant liquid inventories can be found in Appendix III. As can be noted in this table, there is a nominal increase in the volume of flammable liquid over the existing inventory of 339 gallons. This information will be provided to IRI, however no additional fire proofing is anticipated.)

17. There is a possibility of a polymerization type reaction occurring on the steam coils in the 07.10 Stripper column which could lead to plugging of lines and isolation from the safety relief devices.

Recommendation/Follow-up

12. For each catalyst, calculate the potential hazard due to a runaway reaction. Determine if additional safety devices are required for the reactor. PROCESS ENGINEERING/R&D
13. Complete a reactivity grid for possible reactions. Consider the pressure differences between the reactor and storage tanks (900 psig vs. 250 psig). Look at the need for isolation valves to avoid hydrogen leakage. HAZARDS REVIEW TEAM
14. Make sure all cross-hatched areas on the existing flowsheet are separate from the computer and new critical shutdowns are also separate. START-UP ENGINEERING
15. PROCESS ENGINEERING/START-UP
16. Review and select seals to minimize leakage. Install CO monitors and LEL detectors in the area of the 10.80 and 07.05. HAZARDS REVIEW TEAM
17. The possibility of this type of reaction recurring is not clear and further follow-up and research is required before making any recommendations on the design. PROCESS ENGINEERING/R&D

<u>Hazard</u>	<u>Recommendation/Follow-up</u>
18. Excess steam flow as well as loss of steam flow to all column reboilers will result on a process upset.	18. Safety hazard associated with this plant upset is unknown at this time. At a minimum, install high temperature alarms on all column sumps to alert the operator of a pending problem. Further work is required to determine if a hazard exists. HAZARDS REVIEW TEAM
19. There are several operating options associated with the 07.15 and 07.20 columns depending upon the mode of operation. The main hazard associated with these columns is ensuring that the proper valve positions are maintained.	19. Scenarios for improper valve position and the potential for hazards must be defined. The addition of spectacle blinds may be required. Operating procedures must address these issues. HAZARDS REVIEW TEAM
20. The existing 22.11, 22.15, and 22.16 vessels are all of carbon steel construction. An upset in the refrigeration area could result in low temperature feed (-35°F) to the vessels.	20. Install a TSL on the feed to the 22.11.
21. <u>Storage Tanks</u> - All storage tanks must be designed to be purged with nitrogen before filling with a flammable liquid.	21. Design tanks with purge connections and source of nitrogen.
22. <u>Plant Layout</u> - The new plant layout was reviewed with regard to the new equipment, as well as relocation of the existing Methanol Storage (and installation aboveground) and the control room and administrative shelter. Refer to the equipment arrangement in Appendix IV. Location of all the control shelter and storage tanks will be in accordance with NFPA 30 and APCI Design Standard S01.03 governing distance criteria for plant layouts.	22. No major hazards were identified during the review. There is an existing oxygen pipeline valve station running along the south property line. The storage tanks must be located a minimum of 50 feet from this valve. The trailer loading must be reviewed with respect to trailer access, pull away protection, LEL detectors, and spill containment. DESIGN HAZARDS REVIEW

[illegible]

EQUIPMENT LIST		PLANT EQUIPMENT INVENTORY	
8109	WATER COMPRESSOR	2126	WATER COMPRESSOR
8110	WATER PUMP	2127	WATER COMPRESSOR
8111	EXPANSION VALVE	2128	WATER COMPRESSOR
8112	EXPANSION VALVE	2129	WATER COMPRESSOR
8113	EXPANSION VALVE	2130	WATER COMPRESSOR
8114	EXPANSION VALVE	2131	WATER COMPRESSOR
8115	EXPANSION VALVE	2132	WATER COMPRESSOR
8116	EXPANSION VALVE	2133	WATER COMPRESSOR
8117	EXPANSION VALVE	2134	WATER COMPRESSOR
8118	EXPANSION VALVE	2135	WATER COMPRESSOR
8119	EXPANSION VALVE	2136	WATER COMPRESSOR
8120	EXPANSION VALVE	2137	WATER COMPRESSOR
8121	EXPANSION VALVE	2138	WATER COMPRESSOR
8122	EXPANSION VALVE	2139	WATER COMPRESSOR
8123	EXPANSION VALVE	2140	WATER COMPRESSOR
8124	EXPANSION VALVE	2141	WATER COMPRESSOR
8125	EXPANSION VALVE	2142	WATER COMPRESSOR
8126	EXPANSION VALVE	2143	WATER COMPRESSOR
8127	EXPANSION VALVE	2144	WATER COMPRESSOR
8128	EXPANSION VALVE	2145	WATER COMPRESSOR
8129	EXPANSION VALVE	2146	WATER COMPRESSOR
8130	EXPANSION VALVE	2147	WATER COMPRESSOR
8131	EXPANSION VALVE	2148	WATER COMPRESSOR
8132	EXPANSION VALVE	2149	WATER COMPRESSOR
8133	EXPANSION VALVE	2150	WATER COMPRESSOR
8134	EXPANSION VALVE	2151	WATER COMPRESSOR
8135	EXPANSION VALVE	2152	WATER COMPRESSOR
8136	EXPANSION VALVE	2153	WATER COMPRESSOR
8137	EXPANSION VALVE	2154	WATER COMPRESSOR
8138	EXPANSION VALVE	2155	WATER COMPRESSOR
8139	EXPANSION VALVE	2156	WATER COMPRESSOR
8140	EXPANSION VALVE	2157	WATER COMPRESSOR
8141	EXPANSION VALVE	2158	WATER COMPRESSOR
8142	EXPANSION VALVE	2159	WATER COMPRESSOR
8143	EXPANSION VALVE	2160	WATER COMPRESSOR
8144	EXPANSION VALVE	2161	WATER COMPRESSOR
8145	EXPANSION VALVE	2162	WATER COMPRESSOR
8146	EXPANSION VALVE	2163	WATER COMPRESSOR
8147	EXPANSION VALVE	2164	WATER COMPRESSOR
8148	EXPANSION VALVE	2165	WATER COMPRESSOR
8149	EXPANSION VALVE	2166	WATER COMPRESSOR
8150	EXPANSION VALVE	2167	WATER COMPRESSOR
8151	EXPANSION VALVE	2168	WATER COMPRESSOR
8152	EXPANSION VALVE	2169	WATER COMPRESSOR
8153	EXPANSION VALVE	2170	WATER COMPRESSOR
8154	EXPANSION VALVE	2171	WATER COMPRESSOR
8155	EXPANSION VALVE	2172	WATER COMPRESSOR
8156	EXPANSION VALVE	2173	WATER COMPRESSOR
8157	EXPANSION VALVE	2174	WATER COMPRESSOR
8158	EXPANSION VALVE	2175	WATER COMPRESSOR
8159	EXPANSION VALVE	2176	WATER COMPRESSOR
8160	EXPANSION VALVE	2177	WATER COMPRESSOR
8161	EXPANSION VALVE	2178	WATER COMPRESSOR
8162	EXPANSION VALVE	2179	WATER COMPRESSOR
8163	EXPANSION VALVE	2180	WATER COMPRESSOR
8164	EXPANSION VALVE	2181	WATER COMPRESSOR
8165	EXPANSION VALVE	2182	WATER COMPRESSOR
8166	EXPANSION VALVE	2183	WATER COMPRESSOR
8167	EXPANSION VALVE	2184	WATER COMPRESSOR
8168	EXPANSION VALVE	2185	WATER COMPRESSOR
8169	EXPANSION VALVE	2186	WATER COMPRESSOR
8170	EXPANSION VALVE	2187	WATER COMPRESSOR
8171	EXPANSION VALVE	2188	WATER COMPRESSOR
8172	EXPANSION VALVE	2189	WATER COMPRESSOR
8173	EXPANSION VALVE	2190	WATER COMPRESSOR
8174	EXPANSION VALVE	2191	WATER COMPRESSOR
8175	EXPANSION VALVE	2192	WATER COMPRESSOR
8176	EXPANSION VALVE	2193	WATER COMPRESSOR
8177	EXPANSION VALVE	2194	WATER COMPRESSOR
8178	EXPANSION VALVE	2195	WATER COMPRESSOR
8179	EXPANSION VALVE	2196	WATER COMPRESSOR
8180	EXPANSION VALVE	2197	WATER COMPRESSOR
8181	EXPANSION VALVE	2198	WATER COMPRESSOR
8182	EXPANSION VALVE	2199	WATER COMPRESSOR
8183	EXPANSION VALVE	2200	WATER COMPRESSOR
8184	EXPANSION VALVE	2201	WATER COMPRESSOR
8185	EXPANSION VALVE	2202	WATER COMPRESSOR
8186	EXPANSION VALVE	2203	WATER COMPRESSOR
8187	EXPANSION VALVE	2204	WATER COMPRESSOR
8188	EXPANSION VALVE	2205	WATER COMPRESSOR
8189	EXPANSION VALVE	2206	WATER COMPRESSOR
8190	EXPANSION VALVE	2207	WATER COMPRESSOR
8191	EXPANSION VALVE	22	

APPENDIX I

EQUIPMENT LIST

01.50	FROM 22 COMPRESSOR	15.65	ALCOHOL COLUMN REBOLTER	21.70	FROM 22 CONDENSER
07.05	CO2 STRIPPER COLUMN	21.75	HP EFFLUENT/RECYCLE EXCHANGER	21.75	HP FROM 22 EVAPORATOR
07.10	CO2 STRIPPER COLUMN	21.80	PRODUCT OILER	21.80	LP FROM 22 EVAPORATOR
07.15	CO2 STRIPPER COLUMN	21.85	CO2 STRIPPER COLUMN	21.85	WASH DECASSER
07.20	CO2/ETHER SEPARATION COLUMN	21.90	CO2 STRIPPER COLUMN	21.90	LP LIQUID-LOADER
10.80	ALCOHOL FRACTIONATION COLUMN	21.95	CO2 STRIPPER COLUMN	21.95	PROD. COLUMN
13.53	CO2 STRIPPER COLUMN	22.00	ALCOHOL COLUMN EXCHANGER	22.00	FROM 22 STORAGE TANK
15.65	CO2 STRIPPER COLUMN	22.05	ALCOHOL COLUMN EXCHANGER	22.05	
21.70	FROM 22 CONDENSER	22.10	FROM 22 CONDENSER	22.10	
21.75	HP FROM 22 EVAPORATOR	22.15	FROM 22 CONDENSER	22.15	
21.80	LP FROM 22 EVAPORATOR	22.20	FROM 22 CONDENSER	22.20	
21.85	WASH DECASSER	22.25	FROM 22 CONDENSER	22.25	
21.90	LP LIQUID-LOADER	22.30	FROM 22 CONDENSER	22.30	
21.95	PROD. COLUMN	22.35	FROM 22 CONDENSER	22.35	
22.00	FROM 22 STORAGE TANK	22.40	FROM 22 CONDENSER	22.40	
22.05		22.45	FROM 22 CONDENSER	22.45	
22.10		22.50	FROM 22 CONDENSER	22.50	
22.15		22.55	FROM 22 CONDENSER	22.55	
22.20		22.60	FROM 22 CONDENSER	22.60	
22.25		22.65	FROM 22 CONDENSER	22.65	
22.30		22.70	FROM 22 CONDENSER	22.70	
22.35		22.75	FROM 22 CONDENSER	22.75	
22.40		22.80	FROM 22 CONDENSER	22.80	
22.45		22.85	FROM 22 CONDENSER	22.85	
22.50		22.90	FROM 22 CONDENSER	22.90	
22.55		22.95	FROM 22 CONDENSER	22.95	
22.60		23.00	FROM 22 CONDENSER	23.00	

AIR PRODUCTS

LAPORTE ALTERNATIVE FUELS DEVELOPMENT UNIT
CO2 REMOVAL, PRODUCT FRACTIONATION

DATE 15 MAY 1990
JOB NO. 87-7-1555
DWG. BY DWH
CHKD BY
APPRO. BY

NO. LET
REVISION
DATE BY CKD

DATE 15 MAY 1990
JOB NO. 87-7-1555
DWG. BY DWH
CHKD BY
APPRO. BY

The diagram illustrates a steam boiler system with the following components and flow details:

- Flue Header:** Receives input from the boiler (15.90) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- Steam Header:** Receives input from the boiler (15.80) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- Cooling Water Header:** Receives input from the boiler (15.80) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- MeOH/ROH Separator:** Receives input from the boiler (15.80) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- ROH/ROR Separator:** Receives input from the boiler (15.80) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- SCR Control System:** Receives input from the boiler (15.80) and has a steam output (15.75) and a flare output (15.90). A flow rate of 07.20 is indicated for the steam output.
- Flow Rates and Temperatures:**
 - FR 07.15: Input to the boiler.
 - FR 22.18: Input to the MeOH/ROH separator.
 - FR 21.45/07.20: Input to the ROH/ROR separator.
 - FR 07.20: Steam output from the boiler.
 - FR 07.20: Steam output from the MeOH/ROH separator.
 - FR 07.20: Steam output from the ROH/ROR separator.
 - FR 07.20: Steam output from the SCR control system.
- Control Points:**
 - IC (Interlock Control) at the boiler.
 - IC (Interlock Control) at the MeOH/ROH separator.
 - IC (Interlock Control) at the ROH/ROR separator.
 - IC (Interlock Control) at the SCR control system.

EQUIPMENT LIST		NO.	LET	REVISION	DATE	BY	CK'D
10.70	ALCOHOL LOADING PUMP						
10.75	ETHER LOADING PUMP						
10.83	INJECTION PUMP						
10.84	INJ PUMP PRESSURON BOTTLE						
15.70	PRODUCT REINJECTION HEATER						
15.75	FLARE POT HEATER						
15.80	CONDENSATE CHILLER						
15.90	FLARE						
28.10	METHANOL STORAGE TANK						
28.40	ETHER STORAGE TANK						
28.50	ALCOHOL STORAGE TANK

LAPORTE ALTERNATIVE FUELS DEVELOPMENT UNIT
 STORAGE, LOADING, REINJECTION, UTILITY SUMMARY

APPENDIX II

HEAT AND MATERIAL BALANCE

MIXED DIMETHYL-ETHER

AND

METHANOL

STREAM SUMMARY
VERSION 90.7

AIR PRODUCTS & CHEMICALS, INC. -- CYCLE SYNTHESIS
DME FROM SHELL GAS - SV-11000, 70% MECH CAT

HERRON
87-7-1565

25MAY 90 PAGE 64
8:59:09

STREAM SUMMARY - THID - DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						F2 L1 L5	CM ME WA	N2 L3 F22	
62	VAP	157.53	20.00	-9389.43	0.108338	3.47757E-05 0.094302 0.000000	1.71988E-04 0.010437 0.001387	2.28054E-06 0.000000 0.000000	0.002002 0.000000
65	L10	157.53	20.00	-482503.31	4.739288	4.29766E-07 4.562995 0.000000	4.69080E-06 0.017693 0.157985	1.40394E-07 0.000000 0.000000	6.10560E-04 0.000000
100	VAP	100.00	165.00	-2049427.00	90.487228	47.804047 0.039116 0.000000	42.129211 0.085402 7.38552E-04	0.136696 0.000000 0.000000	0.292030 0.000000
101	VAP	322.00	815.00	-1908186.00	90.487198	47.804031 0.039116 0.000000	42.129196 0.085402 7.38551E-04	0.136696 0.000000 0.000000	0.292030 0.000000
110	VAP	165.00	815.00	-15864474.00	449.999756	142.039001 0.133161 0.000000	288.516602 1.553552 0.002663	4.438719 0.000000 0.000000	13.316158 0.000000
115	VAP	386.96	815.00	-15127009.00	449.999756	142.039001 0.133161 0.000000	288.516602 1.553552 0.002663	4.438719 0.000000 0.000000	13.316158 0.000000
125	VAP	482.00	750.00	-16142599.00	398.066895	97.318954 5.037943 0.000000	255.337219 12.084405 3.320605	4.438719 0.000000 0.000000	20.529068 0.000000
130	VAP	250.00	740.00	-16880064.00	398.066895	97.318954 5.037943 0.000000	255.337219 12.084405 3.320605	4.438719 0.000000 0.000000	20.529068 0.000000
135	TOTAL	110.00	750.00	-17405632.00	398.066895	97.318954 5.037943 0.000000	255.337219 12.084405 3.320605	4.438719 0.000000 0.000000	20.529068 0.000000
	VAP			-16832208.00	393.009521	97.314560 2.775026 0.000000	255.327087 12.062692 0.579916	4.438657 0.000000 0.000000	20.511703 0.000000
	L10			-573415.81	5.057240	0.004392 2.262916 0.000000	0.010118 0.021712 2.740689	6.16424E-05 0.000000 0.000000	0.017351 0.000000
140	VAP	110.00	750.00	-16832208.00	393.008789	97.314560 2.775026 0.000000	255.327087 12.062692 0.579916	4.438657 0.000000 0.000000	20.511703 0.000000

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
141	TOTAL	40.00	720.00	-17094624.00	193.009521	97.314560 2.775026 0.000000	255.327087 12.062692 0.579916	4.438657 0.000000 0.000000	20.511703 0.000000
	VAP			-16779936.00	190.074707	97.310181 0.626918 0.000000	255.307236 11.900287 0.031081	4.438489 0.000000 0.000000	20.460617 0.000000
	L10			-314699.44	2.934806	0.004378 2.148108 0.000000	0.019840 0.162404 0.548835	1.67238E-04 0.000000 0.000000	0.051074 0.000000
142	L10	19.67	720.00	-33801968.00	313.496826	0.458394 237.740875 0.000000	2.086378 13.780388 52.285889	0.016971 0.000000 0.000000	7.128181 0.000000
143	TOTAL	21.46	280.00	-33801952.00	313.497070	0.458394 237.740875 0.000000	2.085378 13.780388 52.285889	0.016971 0.000000 0.000000	7.128181 0.000000
	VAP			-102150.87	1.863643	0.334112 0.002699 0.000000	1.226398 0.067218 1.21365E-04	0.012710 0.000000 0.000000	0.220184 0.000000
	L10			-33699808.00	311.633301	0.124282 237.737976 0.000000	0.859979 13.713169 52.285767	0.004260 0.000000 0.000000	6.907995 0.000000
144	TOTAL	276.47	270.00	-31801936.00	313.497070	0.458394 237.740875 0.000000	2.086378 13.780388 52.285889	0.016971 0.000000 0.000000	7.128181 0.000000
	VAP			-1853452.00	19.305542	0.421189 8.558181 0.000000	1.802545 3.431052 1.084345	0.013914 0.000000 0.000000	3.994314 0.000000
	L10			-29948496.00	294.191406	0.037205 229.182693 0.000000	0.283833 10.349335 51.201538	0.003056 0.000000 0.000000	3.133865 0.000000
145	L10	47.73	165.00	-31043392.00	290.000000	1.98327E-10 235.075806 0.000000	3.00822E-08 3.226697 51.696274	3.51253E-09 0.000000 0.000000	0.001272 0.000000
146	L10	-25.00	250.00	-31476048.00	290.000000	0.000000 235.062531 0.000000	0.000000 3.226697 51.707977	0.000000 0.000000 0.000000	0.002900 0.000000

STREAM SUMMARY
VERSION 90.7AIR PRODUCTS & CHEMICALS, INC -- CYCLE SYNTHESIS
CME FROM SHELL GAS - SV=11000, 70% MECH CATHERRON
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STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
147	L10	-22.12	720.00	-31447664.00	290.000000	0.000000 235.062531 0.000000	0.000000 3.226697 51.707977	0.000000 0.000000 0.000000	0.002900 0.000000
148	VAP	-14.75	720.00	-14740314.00	369.511963	96.856155 0.096662 0.000000	253.240784 1.508986 0.001978	4.421686 0.000000 0.000000	13.386401 0.000000
149	VAP	77.83	710.00	-14477898.00	369.512451	96.856155 0.096662 0.000000	253.240784 1.508986 0.001978	4.421686 0.000000 0.000000	13.386401 0.000000
150	VAP	77.83	710.00	-391810.75	9.999998	2.621187 0.002616 0.000000	6.853374 0.040837 5.35358E-05	0.119663 0.000000 0.000000	0.362272 0.000000
151	VAP	77.83	710.00	-14086086.00	359.512207	94.234955 0.094046 0.000000	246.387390 1.468149 0.001925	4.302023 0.000000 0.000000	13.024128 0.000000
152	VAP	113.02	815.00	-13995774.00	359.512451	94.234940 0.094046 0.000000	246.387360 1.468148 0.001925	4.302022 0.000000 0.000000	13.024128 0.000000
155	TOTAL	80.28	20.00	-2111344.00	23.294250	3.083971 0.336219 0.000000	8.949865 0.172262 3.161930	0.136695 0.000000 0.000000	7.453323 0.000000
	VAP			-1772192.00	20.519394	3.083961 0.213421 0.000000	8.949832 0.172261 0.510800	0.136694 0.000000 0.000000	7.452430 0.000000
	L10			-339151.94	2.774865	9.82584E-06 0.122798 0.000000	3.29337E-05 9.24630E-07 2.651130	2.23126E-07 0.000000 0.000000	8.92963E-04 0.000000
156	VAP	137.36	20.00	-2048266.00	23.294250	3.083971 0.336219 0.000000	8.949865 0.172262 3.161930	0.136695 0.000000 0.000000	7.453323 0.000000
160	L10	110.00	750.00	-573415.81	5.057240	0.004392 2.262516 0.000000	0.010118 0.021772 2.740689	6.16424E-05 0.000000 0.000000	0.017351 0.000000
163	L10	327.58	270.00	-29368768.00	293.249023	2.00549E-10 237.709503 0.000000	3.04192E-08 3.262848 52.275467	3.57210E-09 0.000000 0.000000	0.001276 0.000000

STREAM SUMMARY - THID = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD
						H2 L1 L5	CM ME WA	N2 L3 F22	
164	L10	327.58	270.00	-29043376.00	289.999756	1.98327E-10 235.075808 0.000000	3.00822E-08 3.226697 51.696274	3.53253E-09 0.000000 0.000000	0.001272 0.000000
168	L10	327.58	270.00	-325388.19	3.249022	2.22196E-12 2.633677 0.000000	3.37027E-10 0.036150 0.579181	3.95767E-11 0.000000 0.000000	1.42536E-15 0.000000
170	VAP	150.18	270.00	-9818799.00	106.271637	0.484041 1.598145 0.000000	2.462538 94.345734 0.264278	0.019411 0.000000 0.000000	17.097504 0.000000
171	TOTAL	110.00	270.00	-10479578.00	106.271637	0.484042 1.598145 0.000000	2.462539 84.345712 0.264272	0.019411 0.000000 0.000000	17.097519 0.000000
	VAP			-2145082.00	20.248016	0.458394 0.031450 0.000000	2.086378 10.517530 0.010409	0.016970 0.000000 0.000000	7.126902 0.000000
	L10			-8334496.00	86.023621	0.025648 1.566696 0.000000	0.376161 73.828201 0.253869	0.002441 0.000000 0.000000	9.970624 0.000000
172	VAP	110.00	270.00	-2145083.00	20.248016	0.458394 0.031450 0.000000	2.086378 10.517530 0.010409	0.016970 0.000000 0.000000	7.126902 0.000000
175	TOTAL	50.00	230.00	-2241527.00	20.248032	0.458394 0.031450 0.000000	2.086378 10.517530 0.010409	0.016970 0.000000 0.000000	7.126902 0.000000
	VAP			-1008739.75	8.886717	0.453865 5.72045E-04 0.000000	2.003209 1.967546 4.74876E-04	0.016412 0.000000 0.000000	4.444636 0.000000
	L10			-1232788.00	11.361316	0.004529 0.030878 0.000000	0.083169 8.549983 0.009934	5.58315E-04 0.000000 0.000000	2.682264 0.000000
180	VAP	17.16	230.00	-2851603.00	19.598282	0.461554 2.96586E-08 0.000000	2.157672 1.553014 1.04697E-06	0.017468 0.000000 0.000000	15.408587 0.000000

STREAM SUMMARY
VERSION 90.7AIR PRODUCTS & CHEMICALS, INC -- CYCLE SYNTHESIS
CME FROM SHELL GAS - SV=11000, 70% MECH CATHERRON
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STREAM SUMMARY - THID = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD
						H2 L1 L5	CM ME WA	N2 L3 F22	
181	TOTAL	-25.00	230.00	-2921249.00	19.598282	0.461554 2.96603E-08 0.000000	2.157672 1.553014 1.04697E-06	0.017468 0.000000 0.000000	15.408587 0.000000
	VAP			-1315238.00	9.727293	0.458394 1.36875E-10 0.000000	2.086378 0.091254 1.91269E-08	0.016970 0.000000 0.000000	7.074298 0.000000
	L10			-1506011.00	9.871000	0.003160 2.95231E-08 0.000000	0.071294 1.461760 1.02784E-06	4.97440E-04 0.000000 0.000000	8.334289 0.000000
182	VAP	-25.00	230.00	-1315239.00	9.727293	0.458394 1.36875E-10 0.000000	2.086378 0.091254 1.91269E-08	0.016970 0.000000 0.000000	7.074298 0.000000
183	VAP	90.00	225.00	-1304944.00	9.727294	0.458394 1.36875E-10 0.000000	2.086378 0.091254 1.91269E-08	0.016970 0.000000 0.000000	7.074298 0.000000
186	TOTAL	183.89	30.00	-898804.00	8.306261	0.004392 4.896593 0.000000	0.010118 0.057863 3.319869	6.16424E-05 0.000000 0.000000	0.017365 0.000000
	VAP			-31909.01	0.359674	0.004369 0.231666 0.000000	0.010049 0.043846 0.053623	6.13803E-05 0.000000 0.000000	0.016060 0.000000
	L10			-866894.94	7.946588	2.31351E-05 4.864927 0.000000	6.88191E-05 0.014017 3.266245	2.62087E-07 0.000000 0.000000	0.001306 0.000000
188	L10	144.89	230.00	-906029.81	10.520729	3.85623E-11 0.031450 0.000000	1.63296E-07 10.426268 0.010409	4.67165E-10 0.000000 0.000000	0.052604 0.000000
190	VAP	184.55	30.00	-1364124.00	15.848055	0.004470 15.174371 0.000000	0.010509 0.120133 0.515357	6.70015E-05 0.000000 0.000000	0.023150 0.000000

STREAM SUMMARY - THID - DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
191	TOTAL	171.27	30.00	-1604124.00	15.848055	0.004470 15.174371 0.000000	0.010509 0.120133 0.515357	6.70015E-05 0.000000 0.000000	0.023150 0.000000
	VAP			-23350.11	0.269441	0.004357 0.207409 0.000000	0.009941 0.029733 0.003190	5.92215E-05 0.000000 0.000000	0.014752 0.000000
	L10			-1580774.00	15.578613	1.13138E-04 14.966962 0.000000	5.67786E-04 0.090400 0.512167	7.78005E-06 0.000000 0.000000	0.008397 0.000000
192	VAP	171.27	30.00	-23350.12	0.269441	0.004357 0.207409 0.000000	0.009941 0.029733 0.003190	5.92215E-05 0.000000 0.000000	0.014752 0.000000
195	L10	171.27	30.00	-491892.75	4.847625	3.52054E-05 4.657297 0.000000	1.76679E-04 0.028130 0.159372	2.42093E-06 0.000000 0.000000	0.002613 0.000000
198	L10	246.22	30.00	-381851.37	3.189193	0.000000 0.031892 0.000000	0.000000 0.000000 3.157301	0.000000 0.000000 0.000000	0.000000 0.000000
206	L10	120.00	274.66	-25775072.00	120.807144	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 120.807144	0.000000 0.000000
207	TOTAL	40.00	82.65	-25775056.00	120.807144	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 120.807144	0.000000 0.000000
	VAP			-7342517.00	35.305618	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 35.305618	0.000000 0.000000
	L10			-18432544.00	85.501511	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 85.501511	0.000000 0.000000
209	VAP	40.00	82.65	-9977326.00	47.974792	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 47.974792	0.000000 0.000000
211	L10	40.00	82.65	-15701312.00	72.832352	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 72.832352	0.000000 0.000000

STREAM SUMMARY
VERSION 90.7

AIR PRODUCTS & CHEMICALS, INC -- CYCLE SYNTHESIS
DME FROM SHELL GAS - SV=11000, 70% MECH CAT

HERRON
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STREAM SUMMARY - THID - DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
212	L10	40.00	82.65	-2177043.00	10.098470	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 10.098470	0.000000 0.000000
213	TOTAL	-35.00	17.19	-2177042.00	10.098470	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 10.098470	0.000000 0.000000
	VAP			-431267.56	2.066596	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 2.066596	0.000000 0.000000
	L10			-1745775.00	8.031873	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 8.031873	0.000000 0.000000
219	VAP	-35.00	17.19	-2107397.00	10.098470	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 10.098470	0.000000 0.000000
220	VAP	-35.00	17.19	-15199010.00	72.832352	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 72.832352	0.000000 0.000000
221	VAP	131.54	82.65	-15049834.00	72.832352	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 72.832352	0.000000 0.000000
224	VAP	95.86	82.65	-25027152.00	120.807144	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 120.807144	0.000000 0.000000
225	VAP	245.42	279.66	-24799664.00	120.807144	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 120.807144	0.000000 0.000000
230	L10	40.00	82.65	-13524268.00	62.733871	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 62.733871	0.000000 0.000000

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
231	TOTAL	-35.00	17.19	-13524267.00	62.733871	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 62.733871	0.000000 0.000000
	VAP			-2678947.00	12.837284	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 12.837284	0.000000 0.000000
	L10			-10845320.00	49.896576	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 49.896576	0.000000 0.000000
235	VAP	-35.00	17.19	-13091672.00	62.733871	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	0.000000 0.000000 62.733871	0.000000 0.000000
285	L10	321.38	270.00	-36795200.00	368.632812	4.69319E-09 299.784424 0.000000	6.26673E-07 8.191406 60.649170	4.76078E-08 0.000000 0.000000	0.007855 0.000000
286	TOTAL	327.58	270.00	-35846320.00	368.632812	3.96109E-09 299.784668 0.000000	6.26673E-07 8.191405 60.649170	4.76078E-08 0.000000 0.000000	0.007855 0.000000
	VAP			-6477579.00	75.384094	3.76054E-09 62.075287 0.000000	5.96254E-07 4.928557 8.373709	4.40357E-08 0.000000 0.000000	0.006569 0.000000
	L10			-29368752.00	293.249023	2.00549E-10 237.709503 0.000000	3.04192E-08 3.262848 52.275467	3.57210E-09 0.000000 0.000000	0.001286 0.000000
290	L10	141.67	220.00	-2048741.00	23.567459	3.24912E-09 0.038777 0.000000	4.95693E-06 23.193237 0.014944	1.67232E-08 0.000000 0.000000	0.320510 0.000000
291	TOTAL	144.89	220.00	-1958837.00	23.567459	3.24912E-09 0.038777 0.000000	4.95693E-06 23.193237 0.014944	1.67232E-08 0.000000 0.000000	0.320510 0.000000
	VAP			-1052808.00	13.046748	3.21056E-09 0.007327 0.000000	4.79364E-06 12.766975 0.004536	1.62560E-08 0.000000 0.000000	0.267906 0.000000
	L10			-906029.75	10.520729	3.85623E-11 3.031450 0.000000	1.63296E-07 10.426268 0.010409	4.67165E-10 0.000000 0.000000	0.052604 0.000000

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
295	L10	233.29	30.00	-2037474.00	17.126190	1.02948E-14 1.021254 0.000000	1.64110E-15 5.29380E-14 16.104950	0.000000 0.000000 0.000000	0.000000 0.000000
296	TOTAL	246.22	30.00	-1795766.00	17.126205	1.02947E-14 1.021254 0.000000	1.64110E-15 5.29361E-14 16.104965	0.000000 0.000000 0.000000	0.000000 0.000000
	VAP			-1413915.00	13.937037	1.02947E-14 0.989362 0.000000	1.64110E-15 5.29361E-14 12.947675	0.000000 0.000000 0.000000	0.000000 0.000000
	L10			-381851.12	3.189193	0.000000 0.031892 0.000000	0.000000 0.000000 3.157301	0.000000 0.000000 0.000000	0.000000 0.000000
300	L10	100.00	30.00	-993634304.00	8103.312500	0.000000 0.000000 0.000000	0.000000 0.000000 8103.312500	0.000000 0.000000 0.000000	0.000000 0.000000
301	L10	120.00	25.00	-990534240.00	8103.312500	0.000000 0.000000 0.000000	0.000000 0.000000 8103.312500	0.000000 0.000000 0.000000	0.000000 0.000000
305	L10	100.00	30.00	-42633904.00	347.689209	0.000000 0.000000 0.000000	0.000000 0.000000 347.689209	0.000000 0.000000 0.000000	0.000000 0.000000
306	L10	120.00	25.00	-42505168.00	347.689209	0.000000 0.000000 0.000000	0.000000 0.000000 347.689209	0.000000 0.000000 0.000000	0.000000 0.000000
310	L10	100.00	30.00	-1435925.00	11.710299	0.000000 0.000000 0.000000	0.000000 0.000000 11.710299	0.000000 0.000000 0.000000	0.000000 0.000000
311	L10	120.00	25.00	-1431589.00	11.710299	0.000000 0.000000 0.000000	0.000000 0.000000 11.710299	0.000000 0.000000 0.000000	0.000000 0.000000
315	L10	100.00	30.00	-185793.94	1.515192	0.000000 0.000000 0.000000	0.000000 0.000000 1.515192	0.000000 0.000000 0.000000	0.000000 0.000000
316	L10	120.00	25.00	-185232.94	1.515192	0.000000 0.000000 0.000000	0.000000 0.000000 1.515192	0.000000 0.000000 0.000000	0.000000 0.000000

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	H2 L1 L5	COMPONENT FLOW RATES, LBMOL/HR			CD L4
							CH3 ME WA	N2 L3 F22		
320	L10	100.00	30.00	-153954032.00	1255.530030	0.000000 0.000000 0.000000	0.000000 0.000000 1255.530030	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
321	L10	120.00	25.00	-153489168.00	1255.530030	0.000000 0.000000 0.000000	0.000000 0.000000 1255.530030	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
325	L10	100.00	30.00	-174059520.00	1419.494870	0.000000 0.000000 0.000000	0.000000 0.000000 1419.494870	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
326	L10	120.00	25.00	-173533952.00	1419.494870	0.000000 0.000000 0.000000	0.000000 0.000000 1419.494870	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
335	L10	100.00	30.00	-218842496.00	1784.710210	0.000000 0.000000 0.000000	0.000000 0.000000 1784.710210	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
336	L10	120.00	25.00	-218181712.00	1784.710210	0.000000 0.000000 0.000000	0.000000 0.000000 1784.710210	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
340	L10	100.00	30.00	-79484048.00	648.210449	0.000000 0.000000 0.000000	0.000000 0.000000 648.210449	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
341	L10	120.00	25.00	-79244048.00	648.210449	0.000000 0.000000 0.000000	0.000000 0.000000 648.210449	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
345	L10	100.00	30.00	-323038976.00	2634.457760	0.000000 0.000000 0.000000	0.000000 0.000000 2634.457760	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
346	L10	120.00	25.00	-322063616.00	2634.457760	0.000000 0.000000 0.000000	0.000000 0.000000 2634.457760	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
400	VAP	421.66	315.00	-3198526.00	90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	
401	L10	421.66	315.00	-10542095.00	90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000	

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	COMPONENT FLOW RATES, LBMOL/HR			CD L4
						H2 L1 L5	CM ME WA	N2 L3 F22	
402	L10	150.00	305.00	-11006956.00	90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 90.453598	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
410	VAP	421.66	315.00	-6496349.00	63.881775	0.000000 0.000000 0.000000	0.000000 0.000000 63.881775	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
411	L10	421.66	315.00	-7445229.00	63.881775	0.000000 0.000000 0.000000	0.000000 0.000000 63.881775	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
415	VAP	421.66	315.00	-615512.81	6.052638	0.000000 0.000000 0.000000	0.000000 0.000000 6.052638	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
416	L10	421.66	315.00	-705416.75	6.052638	0.000000 0.000000 0.000000	0.000000 0.000000 6.052638	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
420	VAP	421.66	315.00	-1554812.00	16.272583	0.000000 0.000000 0.000000	0.000000 0.000000 16.272583	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
421	L10	421.66	315.00	-1896520.00	16.272583	0.000000 0.000000 0.000000	0.000000 0.000000 16.272583	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
430	VAP	421.66	315.00	-431853.06	4.246622	0.000000 0.000000 0.000000	0.000000 0.000000 4.246622	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
431	L10	421.66	315.00	-494931.06	4.246622	0.000000 0.000000 0.000000	0.000000 0.000000 4.246622	0.000000 0.000000 0.000000	0.000000 0.000000 0.000000
500	VAP	100.31	165.00	-2115095.00	93.395630	49.340546 0.040373 0.000000	43.483307 0.088147 7.62290E-04	0.141089 0.000000 0.000000	0.301417 0.000000 0.000000
501	VAP	304.59	366.71	-1981027.00	93.395630	49.340546 0.040373 0.000000	43.483307 0.088147 7.62290E-04	0.141089 0.000000 0.000000	0.301417 0.000000 0.000000
502	VAP	110.00	361.71	-2109759.00	93.395630	49.340546 0.040373 0.000000	43.483307 0.088147 7.62290E-04	0.141089 0.000000 0.000000	0.301417 0.000000 0.000000

STREAM SUMMARY - THIS = DEFAULT

STREAM LABEL	PHASE	TEMP DEG F	PRES PSIA	ENTHALPY BTU/HR	TOTAL FLOW LBMOL/HR	H2 L1 L5	COMPONENT FLOW RATES, CM ME WA	LBMOL/HR N2 L3 F22	CD L4
503	VAP	322.00	815.00	-1969519.00	93.395630	49.340546 0.040373 0.000000	43.483307 0.088147 7.62290E-04	0.141089 0.000000 0.000000	0.301417 0.000000
504	VAP	322.00	815.00	-61332.51	2.908421	1.536508 0.001257 0.000000	1.354108 0.002745 2.37384E-05	0.004394 0.000000 0.000000	0.009386 0.000000
505	VAP	110.00	165.00	-65368.25	2.908422	1.536508 0.001257 0.000000	1.354108 0.002745 2.37384E-05	0.004394 0.000000 0.000000	0.009386 0.000000
510	VAP	82.48	710.00	-16458188.00	420.430664	110.202774 0.109981 0.000000	288.136963 1.716922 0.002251	5.030988 0.000000 0.000000	15.231027 0.000000
511	VAP	113.02	815.00	-16367315.00	420.430664	110.202774 0.109981 0.000000	288.136963 1.716922 0.002251	5.030988 0.000000 0.000000	15.231027 0.000000
512	VAP	113.02	815.00	-2371541.00	60.918320	15.967831 0.015936 0.000000	41.749603 0.248773 3.26131E-04	0.728965 0.000000 0.000000	2.206899 0.000000
513	VAP	110.00	710.00	-2372102.00	60.918304	15.967831 0.015936 0.000000	41.749603 0.248773 3.26131E-04	0.728965 0.000000 0.000000	2.206899 0.000000
990	L10	100.00	30.00	-122620.75	1.000000	0.000000 0.000000 0.000000	0.000000 0.000000 1.000000	0.000000 0.000000 0.000000	0.000000 0.000000
991	L10	120.00	25.00	-122250.50	1.000000	0.000000 0.000000 0.000000	0.000000 0.000000 1.000000	0.000000 0.000000 0.000000	0.000000 0.000000
995	VAP	421.66	815.00	-101693.31	1.000000	0.000000 0.000000 0.000000	0.000000 0.000000 1.000000	0.000000 0.000000 0.000000	0.000000 0.000000
996	L10	421.66	815.00	-116547.00	1.000000	0.000000 0.000000 0.000000	0.000000 0.000000 1.000000	0.000000 0.000000 0.000000	0.000000 0.000000

CYCLE SYNTHESIS RUN TIME : 69.17 CPU SECONDS

**** END OF INPUT DATA ENCOUNTERED. CYCSYN PROCESSING TERMINATED

APPENDIX III

[illegible]

APPENDIX III

[illegible]

[illegible]

APPENDIX III

[illegible]

END

DATE FILMED

03 / 19 / 91