### ENGINEERING FEASIBILITY AND ECONOMICS OF CO<sub>2</sub> CAPTURE ON AN EXISTING COAL-FIRED POWER PLANT

### FINAL REPORT

### <u>VOLUME I</u> AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5 CO<sub>2</sub> CAPTURE RETROFIT STUDY

VOLUME II BENCH-SCALE TESTING AND COMPUTATIONAL FLUID DYNAMICS (CFD) EVALUATION

SUBMITTED BY

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OHIO DEPARTMENT OF DEVELOPMENT OHIO COAL DEVELOPMENT OFFICE COLUMBUS, OHIO 43266 (CONTRACT NO. CDO/D-98-8)

AND

### US DEPARTMENT OF ENERGY NATIONAL ENERGY TECHNOLOGY LABORATORY PITTSBURGH, PENNSYLVANIA 15236 (CONTRACT NO. DE-FC26-99FT40576)

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# VOLUME I

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# PUBLIC ABSTRACT

ALSTOM Power Inc.'s Power Plant Laboratories (ALSTOM) has teamed with American Electric Power (AEP), ABB Lummus Global Inc. (ABB), the US Department of Energy National Energy Technology Laboratory (DOE NETL), and the Ohio Coal Development Office (OCDO) to conduct a comprehensive study evaluating the technical feasibility and economics of alternate  $CO_2$  capture and sequestration technologies applied to an existing US coal-fired electric generation power plant.

The motivation for this study was to provide input to potential US electric utility actions concerning GHG emissions reduction. If the US decides to reduce  $CO_2$  emissions, action would need to be taken to address existing power plants. Although fuel switching from coal to natural gas may be one scenario, it will not necessarily be a sufficient measure and some form of  $CO_2$  capture for use or disposal may also be required. The output of this  $CO_2$  capture study will enhance the public's understanding of control options and influence decisions and actions by government, regulators, and power plant owners in considering the costs of reducing greenhouse gas  $CO_2$  emissions.

The total work breakdown structure is encompassed within three major reports, namely: (1) Literature Survey, (2) AEP's Conesville Unit #5 Retrofit Study, and (3) Bench-Scale Testing and CFD Evaluation. The report on the literature survey results was issued earlier by Bozzuto, et al. (2000). Reports entitled "AEP's Conesville Unit #5 Retrofit Study" and "Bench-Scale Testing and CFD Evaluation" are provided as companion volumes, denoted Volumes I and II, respectively, of the final report. The work performed, results obtained, and conclusions and recommendations derived therefrom are summarized below.

### Volume I

The Volume I report discusses three retrofit technology concepts, which were evaluated in conjunction with AEP's Conesville Unit #5, namely:

- **Concept A:** Coal combustion in air, followed by CO<sub>2</sub> separation with Kerr-McGee/ABB Lummus Global's commercial MEA-based absorption/stripping process
- **Concept B:** Coal combustion with O<sub>2</sub> firing and flue gas recycle (oxy-fuel firing)
- **Concept C:** Coal Combustion in air with oxygen removal and CO<sub>2</sub> separation by a mixture of primary and tertiary amines, i.e., monoethanolamine (MEA)/methyldiethanolamine (MDEA).

Each of these technologies was evaluated against a baseline case, the existing design without  $CO_2$  capture, from the standpoints of performance, impacts on power generating cost, and  $CO_2$  emissions. AEP's 450 MW Conesville Unit No. 5, located in Conesville, Ohio, was used for the power plant case study. All technical performance and cost results associated with the available options were evaluated in a comparative manner.

### **Major conclusions:**

- No major technical barriers exist for retrofitting AEP's Conesville Unit #5 to capture CO<sub>2</sub> for any of the three concepts considered under this study.
- Concept B (oxygen firing with flue gas recycle) appears clearly to be the best alternative of the three concepts studied from both an efficiency and incremental COE viewpoint for systems designed for very high CO<sub>2</sub> capture (i.e. > 90%). If lower CO<sub>2</sub> capture fractions are considered, it appears that Concept A would likely be the best alternative for capture fractions below some as yet undetermined value. Concept C would also improve considerably with lower capture fractions.
- This study has confirmed two important issues related to firing coal in a CO<sub>2</sub>-rich flue gas / O<sub>2</sub> mixture:
  - Modifications to the existing steam generator unit pressure arts are not required, and as such will also allow the unit to continue to operate in the conventional air- fired mode.
  - CO<sub>2</sub>-rich flue gas can be cleaned and compressed with a relatively simple system to provide high purity CO<sub>2</sub> for usage or sequestration.

- Energy requirements and power consumption are high for all three concepts, resulting in significant decreases in overall power plant efficiencies (HHV basis), ranging from efficiencies of 20.5 to 22.5%, as compared to 35.0% for the Base case (air firing without CO<sub>2</sub> capture), which is equivalent to an energy penalty ranging from 36% to 41%. That is, the net power plant output was reduced to 77% 59%.
- The MEA/MDEA mixture of Concept C requires about 28% less energy per pound of CO<sub>2</sub> captured to regenerate the solvent as compared to the MEA used in Concept A.
- Specific investment costs are high, ranging from about 800 to1800 \$/kW and from 1000 to 2200 \$/kW, corresponding to scenarios with and without replacement power, respectively.
- All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base case (air firing without CO<sub>2</sub> capture) ranges from 3.4 to 8.4 ¢/kWh. Similarly CO<sub>2</sub> mitigation costs range from about 42-98 \$/ton of CO<sub>2</sub> avoided for the range of cases studied.
- Specific carbon dioxide emissions were reduced from about 2 lbm/kWh for the Base case to 0.13 0.27 lbm/kWh for the study cases. Recovery or capture of CO<sub>2</sub> ranged from 91 to 96%.
- Nominally, 5-8 acres of new equipment space is needed for Unit #5 alone on the existing 200-acre power plant site, which accommodates a total of 6 units with a total power generating capacity of 2,080 MW.

### Major recommendations:

- A sensitivity study, for Concepts A and C, showing the impact of reducing CO<sub>2</sub> capture percentage on plant efficiency, investment cost, emissions, and cost of electricity. The current work utilized 90% CO<sub>2</sub> capture (nominal). The sensitivity study would investigate nominal CO<sub>2</sub> capture percentages of 70% and 50%.
- Detailed analysis of the existing steam turbine for Concept A: In Concept A about 79% of the steam leaving the intermediate-pressure (IP) turbine is extracted from the IP/LP crossover pipe for solvent regeneration. The capability of the existing low-pressure (LP) turbine to operate under these conditions of very low steam flow o ver the load range should be investigated in detail, preferably by the original equipment manufacturer (OEM).
- Optimization of the amine system reboiler steam pressure for Concepts A and C.
- Concept B detailed boiler system analysis: A startup/shutdown procedure and system design, particularly the transition from air to oxygen firing (including transient conditions) should be developed. Detailed metal temperature analysis for all heat exchanger sections, including operation at part loads should be analyzed. This should also include furnace wall metal temperatures and analysis of the circulation system. The existing fans should be checked (preferably by the OEM's) for operation under the new conditions. The feasibility of operating the boiler under a slight positive pressure to eliminate air infiltration should also be investigated.
- Investigation of Improved oxygen production systems for Concept B, in line with the membrane-based air separation research being conducted by various research groups (e.g., Praxair, Air Products, Norsk Hydro). Also optimization of an integrated boiler and oxygen production system.
- Measurement of furnace heat transfer in CO<sub>2</sub>/O<sub>2</sub> environments in a proof of concept boiler simulation facility.
- Improved solvents, which require lower regeneration energy requirements and/or can be regenerated at a lower temperature level, similar to MHI's KS1 system, but for coal-firing application.
- Hybrid process using oxygen-enriched combustion and amine based CO<sub>2</sub> absorption, to accrue, simultaneously, both CO<sub>2</sub> capture and drastic NOx emissions reduction.
- Investigation of a new novel high risk CO<sub>2</sub> capture process that would reduce efficiency penalty and retrofit investment cost. This would likely not utilize the existing boiler.

### Volume II

The bench-scale testing consisted primarily of drop-tube (DTFS-1) and thermo-gravimetric analyses (TGA). Three cases were investigated: (1) an air-fired case (Base case); (2) a case in which the  $N_2$  was replaced by an equal mass of CO<sub>2</sub> (Constant Mass case); and (3) a case in which the  $N_2$  volume was replaced by an equal volume of CO<sub>2</sub> (Constant Volume case). The Constant Mass case represents the appropriate retrofit scenario in a commercial pulverized coal firing application, albeit without flue gas recycling.

### **Major conclusions:**

### (a) Based on TGA results

• Both the Conesville Unit #5 and Pittsburgh Seam #8 coals have, for air (Base case) and O<sub>2</sub>/CO<sub>2</sub> environments (Constant Mass/Volume cases), similar burning characteristics, as they both go to completion within the same temperature range (550-575 oC). Burning either of the coals in air or any of the O<sub>2</sub>/CO<sub>2</sub> mixture ratios used here would produce virtually identical results; and (2) both coals have similar reactivity characteristics.

### (b) Based on DTFS-1 results

- Residence time, as expected, has a significant impact on the overall coal combustion efficiency, and hence, on the unburned carbon emission in the fly ash for both coals under consideration. That is, while the combustion efficiency for both coals is only about 80% (dry-ash-free coal basis) at 0.2 sec., it is more than 98% at greater than 0.5 sec. Correspondingly, unburned carbon emissions range from about 65% to about 2% (dry fly ash basis).
- The impact of reaction medium is also significant. While the overall combustion efficiencies do not seem to exhibit significant differences between the baseline and Constant Mass firing, the more sensitive parameter, unburned carbon (UBC) in the fly ash, on the other hand, clearly shows better performance for the Constant Mass case. That is, the UBC at the furnace outlet was about a factor of 4.5 lower for the Constant Mass case (~2% vs. 9%). This is believed to be due to higher reactant gas temperature, and yet longer residence (0.77 sec. vs. 0.57 sec.). It appears, from the shape of the UBC profiles, that, if given enough residence time, these differences would narrow down considerably, implying that the ultimate performance in both mediums would be similar.
- The coal sample from Conesville Unit #5 appears to perform better than the sample from Pittsburgh seam #8 coal (e.g., 9% vs. 12.5% UBC for the air firing case). However, based on the shape of the UBC profiles, it can be seen that if given additional residence time, they would both be expected to perform similarly.
- NOx emission from oxy-fuel firing is about a factor of 3 (0.73 vs. 2.25 lb/MMBtu) lower than that of the Base Case. Correspondingly, sulfur dioxide is lower by about 19% (3.6 vs. 4.3 lb/MMBtu), and CO is significantly lower (0.09 lb/MMBtu vs. a negligible amount).

### (c) Based on CFD results

- The baseline case exhibits higher carbon-in-ash (by 1.6 percentage points), higher outlet NOx emissions (by a factor of 2), and higher outlet CO (by a factor of 2) than the Concept-B case. These same computational trends are also qualitatively exhibited by the bench-scale testing.
- The baseline case exhibits a slightly higher peak gas temperature (maximum difference of about 200 °F), and a correspondingly higher average (cross-sectional) gas temperature (difference of 90 °F at the HFOT), than that of the Concept-B case.
- The net wall absorption in the furnace region for the baseline case is larger (by less than 1%) than that of the Concept-B case. However, A significant variation in both calculated and experimental irradiation to the wall between baseline and oxy-firing scenarios was also found in the literature (e.g., +6 to -18%). Differences may be partially attributed to the sensitivity of the irradiation and local emissivities to the aerodynamic and flame patterns, which are, in turn, a function of the furnace and firing system. It is suggested that radiatively absorbing gas species can either enhance or inhibit the irradiation in the vicinity of the wall, depending upon their local temperature and their relative spatial placement.

### Major recommendations:

- Carry out a systematic coal fundamentals study concerning this field of endeavor. This study should be geared toward the creation of a database of information depicting the impact of coal nature (using coals of various rank coming from both domestic and international sources) when fired in an oxy-fuel environment on:
  - > Coal devolatilization and char oxidation kinetics, and unburned carbon emissions in the fly ash
  - Acid rain-related gaseous (NOx, SO<sub>2</sub>, and CO) emissions
  - Air toxics, particularly, mercury (Hg), volatile organic compounds (VOC's), and particulate emissions.
- Derive furnace heat transfer data from natural gas and coal firing in an oxy-fired pilot-scale furnace, which simulates the temperature/time history of a boiler. Use first the data from natural gas firing to validate the CFD code, without the complication of burning particles transiting the boiler. Apply the experience learned from modeling a natural gas fired boiler to model the coal-fired boiler.

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# **EXECUTIVE SUMMARY**

### Background

International discussions continue to debate the need for reductions in emission levels of greenhouse gases (GHG). Because fossil fuel fired power plants are among the largest and most concentrated producers of  $CO_2$  emissions, it stands to reason that recovery of  $CO_2$  from the flue gas of such plants has been identified as one of the primary means for reducing  $CO_2$  emissions.

ALSTOM Power Inc.'s Power Plant Laboratories (referred to herein as ALSTOM) teamed with American Electric Power (AEP), ABB Lummus Global Inc. (referred to herein as ABB), the US Department of Energy National Energy Technology Laboratory (DOE NETL), and the Ohio Coal Development Office (OCDO) to conduct a comprehensive study evaluating the technical and economic feasibility of three alternate  $CO_2$  capture technologies applied to an existing US coal-fired electric generation power plant. The steam generator analyzed in this study is the Conesville No. 5 unit, operated by American Electric Power (AEP) of Columbus, Ohio. This steam generator is a nominal 450 MW, coal-fired, subcritical pressure, controlled circulation unit. It has a single cell furnace that employs corner-fired, tilting, tangential burners and which fires bituminous coal from the state of Ohio. The flue gas leaving the boiler system is cleaned of particulate matter in an electrostatic precipitator (ESP) and of  $SO_2$  in a lime-based flue gas desulfurization (FGD) system before being discharged to the atmosphere.

ALSTOM is managing and performing the subject study from its Power Plant Laboratories office in Windsor, CT. ABB, from its offices in Houston, Texas, is participating as a sub-contractor. AEP is participating by offering their Conesville Generating Station as the case study and cost sharing consultation, along with relevant technical and cost data. AEP is one of the largest US utilities, and as the largest consumer of Ohio coal, is bringing considerable value to the project. Similarly, ALSTOM and ABB are well established as global leaders in the design and manufacturing of steam generating equipment, petrochemical, and  $CO_2$  separation technology. The DOE National Energy Technology Laboratory and the Ohio Coal Development Office provided consultation and funding. All participants contributed to the cost share of this project.

### **Objectives**

The motivation for this study was to provide input to potential US electric utility actions concerning GHG emissions reduction. If the US decides to reduce  $CO_2$  emissions, action would need to be taken to address existing power plants. Although fuel switching from coal to natural gas may be one scenario, it will not necessarily be a sufficient measure and some form of  $CO_2$  capture for use or disposal may also be required. The output of this  $CO_2$  capture study will enhance the public's understanding of control options and influence decisions and actions by government, regulators, and power plant owners in considering the costs of reducing greenhouse gas  $CO_2$  emissions.

The key goals of the study were to evaluate the impacts on the plant output, efficiency, and  $CO_2$  emissions, resulting from the addition of the  $CO_2$ -capture systems. Cost estimates were developed for the systems required to produce, extract, clean and compress the  $CO_2$ , which could then be available for use in enhanced oil or gas recovery or sequestration. Additionally, the impact of  $CO_2$  capture on the cost of electricity (COE) and on the mitigation cost for  $CO_2$  (\$/ton of  $CO_2$  avoided) was also evaluated.

### Work Scope

The total work breakdown structure is encompassed within three major reports, namely: (1) Literature Survey, (2) AEP's Conesville Unit #5 Retrofit Study, and (3) Bench-Scale Testing and CFD Evaluation. The report on the literature survey results was issued earlier by Bozzuto, et al. (2000). The report entitled "Bench-Scale Testing and CFD Evaluation" constitutes Volume II of the final report.

Work on AEP's Conesville Unit #5 Retrofit Study is presented here as <u>Volume I</u> report. The work performed, results obtained, and conclusions and recommendations derived therefrom are summarized below.

### System Descriptions

The three retrofit  $CO_2$  capture technology concepts evaluated in this study are listed below:

- **Concept A**: Coal combustion in air, followed by CO<sub>2</sub> separation with Kerr-McGee/ABB Lummus Global's commercial MEA-based absorption/stripping process
- **Concept B**: Coal combustion with O<sub>2</sub> firing and flue gas recycle (oxy-fuel firing)
- **Concept C**: Coal combustion in air with oxygen removal and CO<sub>2</sub> separation by a mixture of primary and tertiary amines

The results from each of these three evaluations were compared to the Base Case, which represents the "business as usual" operating scenario for the existing plant without  $CO_2$  capture.

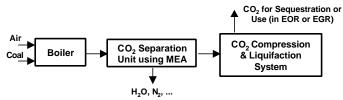
The CO<sub>2</sub> capture systems were designed for a minimum of 90% CO<sub>2</sub> capture. The Dakota Gasification Company's CO<sub>2</sub> specification (DGC WebPages, 2001) for EOR, given in the following table, was used as the basis for the CO<sub>2</sub> capture system design. A very low concentration of oxygen, in particular, is specified for meeting current pipeline operating practices, due to the corrosive nature of the oxygen. Hence, for Concept B, whereby the final CO<sub>2</sub> liquid product was found to contain about 9300 vppm of O<sub>2</sub>, the design of the transport pipe to an EOR site for example would have to take this characteristic under consideration.

Component	Unit	Concentration	
CO2	Vol.%	96.0	
H₂S	Vol.%	0.9	
CH4	Vol.%	0.7	
C2+HCs	Vol.%	2.3	
со	Vol.%	0.1	
N <sub>2</sub>	vppm	< 300	
H <sub>2</sub> O	vppm	< 20	
0 <sub>2</sub>	vppm	< 50	

## Dakota Gasification Project's CO2 Specification for EOR

Concepts A and C are both low temperature  $CO_2$  absorption systems located downstream of the FGD system and as such do not impact the operation of the boiler.

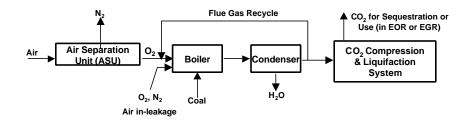
In **Concept A** Coal is burned conventionally in air as schematically depicted below. The flue gases leaving the modified FGD system (a secondary absorber is added to reduce the  $SO_2$  concentration for MEA system) are cooled with a direct contact cooler and ducted to the MEA system where more than 96% of the  $CO_2$  is removed, compressed, and liquefied for usage or sequestration. The remaining flue gases leaving the new MEA system, consisting of primarily oxygen, nitrogen, water vapor and a relatively small amount of sulfur dioxide and carbon dioxide, are discharged to the atmosphere.



Although boiler performance is identical to the Base Case in Concept A, there is a major impact to the steam cycle system where low-pressure steam is extracted to provide the energy for solvent regeneration. About 79% of the

intermediate pressure (IP) turbine exhaust is extracted from the IP/LP crossover pipe. This steam is expanded from 200 psia to 65 psia through a new steam turbine. The exhaust from the new turbine provides the heat requirement for solvent regeneration in the reboiler's of the MEA  $CO_2$  recovery system. Solvent regeneration requires about  $4.7 \times 10^6$  Btu/Ton  $CO_2$ . The condensate from the reboilers is pumped to the existing deaerator. The remaining 21% of the IP turbine exhaust is expanded in the existing low-pressure turbine before being exhausted to the existing condenser. The total output from both the existing and new generators is 331,422 kW. This represents a gross output reduction of 132,056 kW (about 28%) as compared to the Base Case.

The basic concept of the overall system for **Concept B** is to replace air with oxygen for combustion in the furnace, thus directly producing a high  $CO_2$  content flue gas. In designing the Concept B system, emphasis was placed on utilizing as much as possible of the existing equipment, minimizing boiler modifications required, and providing operational flexibility to permit switching to the conventional mode of operation if desired. This process is depicted schematically below.



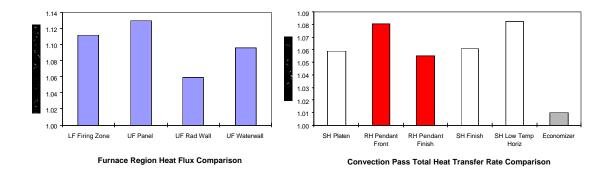
The proposed combustion system uses a mixture of nearly pure oxygen with recycled flue gas. A conventional cryogenic Air Separation Unit (ASU) supplies the oxygen. The recycle flow rate is established by the need to maintain a thermal balance between the radiant and convective heat transfer surfaces of the existing steam generator. The quantity of the recirculated gas is approximately equal to the quantity of nitrogen contained in the combustion air that would have been supplied to the steam generator as part of the oxidant. Inherent in the flue gas recirculation process is the build-up of carbon dioxide and water vapor content in the flue gas. This increased concentration produces significant changes in the thermal and mechanical properties of the flue gas. These gas property differences cause significant differences in the heat transfer processes, which occur within the steam generator unit. Analyses were made to determine the impact of the heat transfer differences on boiler behavior.

Heat transfer in the lower and upper furnace regions is compared in the figure to the left below. The figure on the left compares heat fluxes (Btu/hr-ft<sup>2</sup>) in the lower and upper furnace region between air firing and oxygen firing. Lower furnace results show firing zone heat flux to be about 11% higher with oxygen firing. Upper furnace region results show the reheat radiant wall is about 6% higher and the superheat panels are about 13% higher with oxygen firing. Similarly, the upper furnace waterwall region is about 10% higher.

Convective heat transfer in utility steam generator units is dependent upon many of the transport properties of the flue gas (viscosity, thermal conductivity, density, specific heat and others). Additionally, convection depends strongly on gas velocity. With this system, there are significant changes in the flue gas analysis as compared with air firing. These gas analysis changes cause both transport property and gas velocity changes throughout the unit. Significant differences in non-luminous radiant heat transfer are also expected. Of the gases produced by the complete combustion of a fuel, only carbon dioxide, water vapor and sulfur dioxide emit radiation over a sufficiently wide band of wavelengths to warrant consideration. With this system the primary change in the flue gas as compared to air firing is the large increase in the  $CO_2$  content and decrease in  $N_2$  content. The total heat transfer rates (convective + non-luminous radiation) for the convection pass are shown in the figure on the right, below. Increases are calculated to be in the range of 1 to 8% for oxygen firing over the values with air firing.

# Steam Generator Heat Transfer Comparison

(Oxygen and Air Firing)

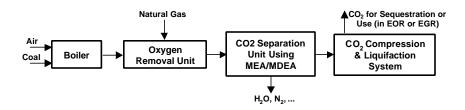


Despite these heat transfer changes, boiler performance is achieved with the existing steam temperature control system that includes burner tilts and desuperheating sprays. Although more detailed analysis are needed, no boiler pressure parts modifications appear to be required.

The products of combustion that exit the furnace are cooled in a series of heat exchangers. Two of these heat exchangers, located downstream of the existing air heater, are new. The first heat exchanger is provided to preheat the oxygen required for combustion. The second heat exchanger recovers additional heat from the flue gas in a low temperature economizer installed in parallel with the low-pressure extraction feedwater heaters. This heat exchanger was necessary as a result of reduced air heater performance with oxygen firing.

The steam cycle system for Concept B is very similar to the Base Case. The only modification was the addition of a low-pressure feedwater heater arrangement in parallel with two low-pressure extraction feedwater heaters. The modified steam cycle system produces almost exactly the same output as the Base Case.

In **Concept C**, coal is burned conventionally in air. A process comprising an optimized mixture of monoethanolamine (MEA) and methydiethanolamine (MDEA), installed downstream of the flue gas desulfurization unit, is integrated into the power plant to strip  $CO_2$  from the effluent gas stream. The mixture of MEA and MDEA cannot be made to be oxygen-resistant. Therefore, while this process potentially offers an improved system from the standpoint of solvent regeneration energy requirement, it is necessary that the excess oxygen in the flue gas be converted to  $CO_2$  by combustion with natural gas over a De-Oxy catalyst upstream of the solvent contactor. Solvent regeneration requires about  $3.4 \times 10^6$  Btu/Ton  $CO_2$  (about 72% of that required for Concept A). High temperature heat recovery is provided in the De-Oxy system by the generation of high pressure superheated steam for power generation and solvent regeneration. Concept C is depicted schematically below.



Boiler performance for Concept C is again identical to the Base Case. There is a major impact to the steam cycle system, similar to Concept A, where low-pressure steam is extracted from the existing steam turbine to provide energy for solvent regeneration. In this case, about 45% of the IP turbine exhaust is extracted from the IP/LP crossover pipe. This steam is expanded from 200 psia to about 65 psia through a new low-pressure steam turbine. The exhaust from

4

the new turbine provides most of the heat requirements for solvent regeneration in the reboiler's of the MEA/MDEA  $CO_2$  capture system. The high-pressure steam generated in the De-Oxy heat recovery system is expanded through a new high-pressure steam turbine for additional power generation. The exhaust from this turbine provides about 20% of the energy requirement for the reboilers. Low temperature heat recovery is provided in the De-Oxy system with a low-pressure feedwater heater which is located in a feedwater stream which is in parallel with the three existing low pressure extraction feedwater heaters. The total output from the modified steam cycle is 431,290 kW. This represents a gross output reduction of 32,188 kW, which represents about 7% of the Base Case output.

### **Performance Analysis Results**

The table shown below summarizes the performance differences between the cases. The primary design constraint among all cases was the supply of an equivalent main steam flow to the existing steam turbine.

	(units)	Original Plant (Base)	Concept A MEA	Concept B O2 Fired	Concept C MEA-MDEA
Fuel Paramaters					
Coal Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4228.7	4140.0	4228.7
Natural Gas Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		17.7	11.4	885.9
Total Fuel Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4246.4	4151.5	5114.6
Steam Cycle Paramaters					
Existing Steam Turbine Generator Output	(kW)	463478	269341	463056	357196
CO2 Removal System Turbine Generator Output	(kW)	0	62081	0	36343
De-Oxy System Turbine Generator Output (Concept C)	(kW)	0	0	0	37751
Total Turbine Generator Output	(kW)	463478	331422	463056	431290
Total Auxiliary Power	(kW)	29700	76007	189709	95317
Net Plant Output	(kW)	433778	255414	273347	335973
Overall Plant Performance Paramaters					
Net Plant Efficiency (HHV)	(fraction)	0.3501	0.2053	0.2247	0.2242
Net Plant Efficiency (LHV)	(fraction)	0.3666	0.2150	0.2354	0.2371
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000	0.5864	0.6419	0.6404
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749	16626	15188	15223
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309	15872	14500	14395

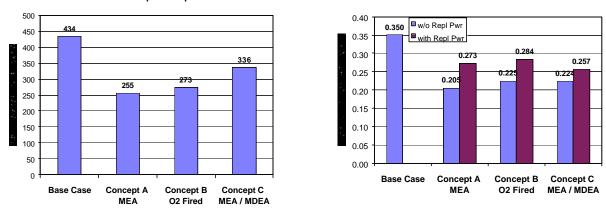
As described above, significant reductions in Net Plant Output are incurred as a result of the  $CO_2$  capture systems (refer to the figure to the left below). Therefore, each case was also analyzed with replacement power to make up this difference. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant was analyzed without capturing the  $CO_2$  from its flue gas. The NGCC plant was assumed to generate power with an efficiency of 57.1 percent (LHV basis). The additional  $CO_2$  emitted from the NGCC was 0.762 lbm/kWh.

Net plant efficiency is reduced from about 35% (HHV basis) for the Base Case to about 20.5% for Concept A and about 22.5% for Concepts B and C (without replacement power) as shown in the figure on the right below. These efficiencies represent energy penalties of 41% and 36%, respectively. The efficiency reductions for Concepts A and C are due to large reductions in the existing steam turbine output and significant auxiliary power requirement increases. Concept C additionally utilizes a large quantity of natural gas in the de-oxy system increasing the total fuel heat input by about 21%. The steam turbine output reductions for Concepts A and C result from solvent regeneration energy requirements, which are provided by low-pressure steam extraction. The auxiliary power increases are due to the  $CO_2$  compression and liquefaction system. Concept B, with a gross output essentially the same as the Base Case, suffers from high auxiliary power primarily from the ASU and the  $CO_2$  compression and liquefaction system.

The efficiencies for these cases including replacement power are also shown on this figure and range from about 26% to 28% (HHV basis) with Concept B being the most efficient.

Net Plant Output Comparison

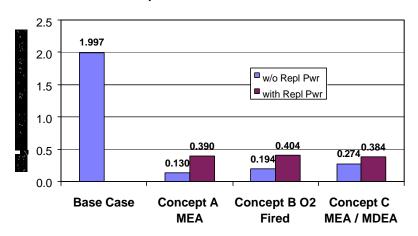
Plant Thermal Efficiency Comparison (HHV Basis)



#### Plant CO<sub>2</sub> Emissions

Specific carbon dioxide emissions were reduced from about 2 lbm/kWh for the Base Case to between 0.13 - 0.27 lbm/kWh for the study cases as shown in the following table and figure (without replacement power). Recovery of CO<sub>2</sub> ranged from 91 to 96%. The CO<sub>2</sub> emissions with replacement power are also indicated on the figure below.

		Original Plant (Base)	Concept A MEA	Concept B O2 Fired	Concept C MEA-MDEA
	(units)				
Plant CO <sub>2</sub> Emissions					
Carbon Dioxide Produced	(lbm/hr)	866102	868137	849255	967806
Carbon Dioxide Recovered	(lbm/hr)	0	835053	796238	875653
Carbon Dioxide Emissions	(lbm/hr)	866102	33084	53016	92153
Fraction of Carbon Dioxide Recovered	(fraction)	0	0.962	0.938	0.905
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997	0.130	0.194	0.274
Normalized Specific CO <sub>2</sub> Emissions (Relative to Base Case)	(fraction)	1.00	0.065	0.097	0.137
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)		1.867	1.803	1.722



### Specific CO<sub>2</sub> Emissions

# **Project Costs**

The project capital cost estimates, including construction, are shown in the following table and figure. These costs include all required equipment such as the amine based  $CO_2$  scrubbing systems of Concepts A and C, the modified FGD system of Concept A, the de-Oxy system of Concept C, the  $CO_2$  compression and liquefaction systems for all three concepts, steam cycle modifications for all concepts, the air separation unit and the boiler island modifications of Concept B. Boiler island modifications for Concept B are relatively small and include costs for such items as air and gas ducts and dampers, booster fans, parallel feedwater heaters and piping,  $O_2$  heater, and controls and instrumentation.

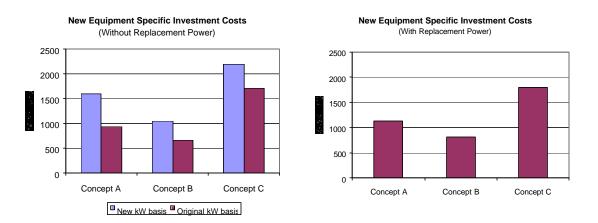
All these  $CO_2$  capture options produce less net plant output than the original plant (Base Case). Therefore, each case was also analyzed with replacement power to make up this difference. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant was analyzed without capturing the  $CO_2$  from its flue gas. The NGCC plant was assumed to cost \$450/kW, installed and its efficiency (LHV basis) was 57.1 percent. The additional  $CO_2$  emitted from the NGCC was 0.762 lbm/kWh.

Two sets of costs are shown for each Concept in the table, one without replacement power and one including replacement power. The figure on the left shows new equipment specific investment costs (\$/kW net) for the three concepts, without replacement power, based on both the original and modified net output. The figure on the right shows new equipment specific investment costs (\$/kW net) for the three concepts, with replacement power, and therefore based on the original net output.

CO <sub>2</sub> Capture Concept	Units	w/o Repl Pwr	with Repl Pwr
Concept A	10 <sup>6</sup> US\$	409	489
	\$/kW	1602	1128
Concept B	10 <sup>6</sup> US\$	285	357
	\$/kW	1042	823
Concept C	10 <sup>6</sup> US\$	738	782
	\$/kW	2197	1803

<b>Total Retrofit Investme</b>	ent Capital Costs
--------------------------------	-------------------

**Note:** The specific costs (\$/kW) shown above for cases without replacement power are based on the new net kW output.



Operating and maintenance (O&M) costs were calculated for all systems. The O&M costs for the Base Case were provided by AEP. The fixed O&M costs (FOM) for the existing plant were about \$16/kW (0.27 Cents/kWh using the base parameter assumptions) and the variable O&M costs (VOM) were about 0.45 Cents/kWh. The VOM costs are

comprised exclusively of the lime cost required for the FGD system and the costs for fly ash, bottom ash and FGD system waste disposal.

For the retrofit  $CO_2$  capture system evaluations, additional O&M costs were calculated for the new equipment. The VOM costs for the new equipment included such categories as chemicals and desiccants, waste handling, maintenance material and labor, and contracted services. The FOM costs for the new equipment includes operating labor only.

For the variable ranges considered in the economic sensitivity study, total FOM costs for the retrofit systems, including existing and new equipment, ranged from about 0.4 to 0.6 Cents/kWh and VOM costs ranged from about 0.9 to 2.3 Cents/kWh.

### **Economic Evaluation**

A total of 66 CO<sub>2</sub> capture cases were compared in the reported sensitivity studies. All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base Case (air firing without CO<sub>2</sub> capture) ranges from 1.5 to 9.8 Cents/kWh. Similarly CO<sub>2</sub> mitigation costs range from about 17-113 \$/Ton of CO<sub>2</sub> avoided for the range of cases studied. The following table and figures summarize the economic analysis results for the six primary cases using base parameter values (i.e.; Coal Cost = 1.32\$/10<sup>6</sup> Btu, Natural Gas Cost = 4.0\$/10<sup>6</sup> Btu, Capacity Factor = 67%, CO<sub>2</sub> Byproduct Sell Price = 0.0\$/Ton, Investment Cost = As Estimated).

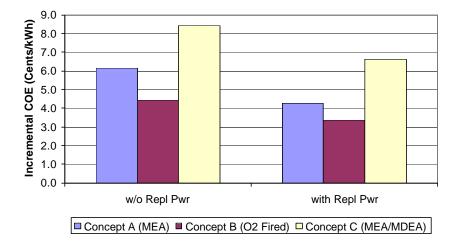
### Summary of Economic Analysis Results

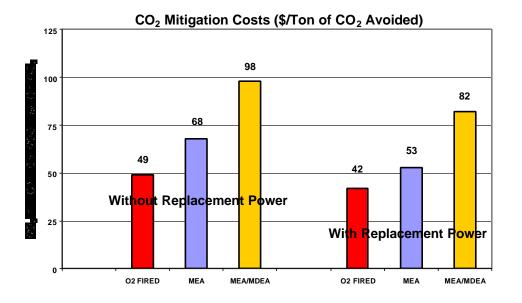
(Using base parameter values)

Parameter	Units	Concept A		Concept B		Concept C	
		w/o Repl Pwr	with Repl Pwr	w/o Repl Pwr	with Repl Pwr	w/o Repl Pwr	with Repl Pwr
Incremental COE	Cents/kWh	6.2	4.3	4.4	3.4	8.4	6.6
CO2 Mitigation Cost	\$/Ton	68	53	49	42	98	82

## **Incremental Cost of Electricity**

(Using base parameter values)





Concept B (oxygen firing with flue gas recycle) appears to clearly be the best alternative of the three concepts studied based on incremental COE or mitigation cost evaluation criteria. Using the base parameters of the sensitivity study for Concept B yields incremental COE values of 3.4 and 4.6 Cents/kWh for cases with and without replacement power respectively. The actual COE values for Concept B are 19% and 12% lower than the corresponding values for Concept C for cases with and without replacement power respectively. Similar results are also obtained when comparing mitigation costs.

If  $CO_2$  byproduct were sold for \$20/ton, incremental COE values would be reduced to 1.59 and 1.64 Cents/kWh respectively. Additional reductions would be possible with capacity factor increases, investment cost decreases or system efficiency increases as quantified in the sensitivity studies. Significant investment cost decreases and efficiency increases may be possible as oxygen transport membrane technology develops. Previous studies, Liljedahl, et al. (1999), have shown membrane technology to provide specific investment cost (\$/kW) reductions of about 30% and net plant heat rate improvements greater than 20%.

## **Conclusions and Recommendations**

No major technical barriers exist for retrofitting AEP's Conesville Unit #5 to capture  $CO_2$  with any of the three concepts considered under this study. Nominally, 5-8 acres of new equipment plan area is needed. For this site, new equipment is located approximately 1500 feet north of the Unit #5 stack on the existing ~200 acre power plant site which accommodates a total of 6 units with a total power generating capability of 2,080 MW.

Energy requirements and power consumption are high, resulting in significant decreases in overall power plant efficiencies (HHV basis), ranging from about 21 to 23% as compared to 35% for the Base Case. The MEA/MDEA mixture of Concept C requires about 28% less energy per pound of  $CO_2$  captured to regenerate the solvent as compared to the MEA used for Concept A.

Specific investment costs are also high ranging from about 1000 to 2200 k without replacement power, and from about 800 to 1800 k with replacement power. All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base case (air firing without CO<sub>2</sub> capture) ranges from 3.4 to 8.4 k wh. Similarly CO<sub>2</sub> mitigation costs range from about 42-98 f of CO<sub>2</sub> avoided for the range of cases studied.

Specific carbon dioxide emissions were reduced from about 2.0 lbm/kWh for the Base Case to 0.13, 0.19, and 0.27 lbm/kWh for study cases A, B, and C, respectively. Recovery of CO<sub>2</sub> ranged from 91 to 96%.

Concept B (oxygen firing with flue gas recycle) appears to clearly be the best alternative of the three concepts studied from both an efficiency and incremental COE viewpoint for systems designed for very high CO<sub>2</sub> capture (i.e. > 90%). If lower CO<sub>2</sub> capture fractions are considered, it appears that Concept A would likely be the best alternative for capture fractions below some as yet undetermined value. Concept C would also improve considerably with lower capture fractions. This study has confirmed two important issues related to firing coal in a CO<sub>2</sub> rich flue gas /O<sub>2</sub> mixture:

- Modifications to the existing steam generator unit pressure parts may not be required, and as such will also allow the unit to continue to operate in the conventional air fired mode. This is an important consideration as it is unlikely that much new coal-fired capacity can be built in the short term.
- CO<sub>2</sub> rich flue gas can be cleaned and compressed with a relatively simple system to provide high purity CO<sub>2</sub> for usage or sequestration.

While overall plant performance penalty and costs are high, the integration of power generation, air separation, and  $CO_2$  separation, compression and liquifaction systems may significantly improve the overall system efficiency and economics. The major cost item in Concept B is in the air separation plant, both from a capital and an operating cost point of view. While in recent years advances have been made in air separation technology which have steadily improved the costs, new membrane based technologies are being researched which promise to provide greatly reduced auxiliary power requirements and investment costs which will significantly improve the overall system efficiency and economics. Previous studies, Liljedahl, et al. (1999), have shown membrane technology to provide specific investment cost (kW) reductions of about 30% and net plant heat rate improvements greater than 20%.

Barring governmental mandates, it is clear that none of these three retrofit concepts will be acceptable to the electric utility industry from the standpoint of cost competitiveness.

Recommendations for Future Work are listed below:

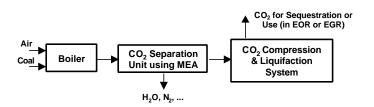
- A sensitivity study, for Concepts A and C, showing the impact of reducing CO<sub>2</sub> capture percentage on plant efficiency, investment cost, emissions, and cost of electricity. The current work utilized 90% CO<sub>2</sub> capture (nominal). The sensitivity study would investigate nominal CO<sub>2</sub> capture percentages of 70% and 50%.
- Detailed analysis of the existing steam turbine for Concept A: In Concept A about 79% of the steam leaving the intermediate-pressure (IP) turbine is extracted from the IP/LP crossover pipe for solvent regeneration. The capability of the existing low-pressure (LP) turbine to operate under these conditions of very low steam flow should be investigated in detail, preferably by the original equipment manufacturer (OEM).
- Optimization of the amine system reboiler steam pressure for Concepts A and C.
- Concept B detailed boiler system analysis: A startup/shutdown procedure and system design, particularly the transition from air to oxygen firing (including transient conditions) should be developed. Detailed metal temperature analysis for all heat exchanger sections, including operation at part loads should be analyzed. This should also include furnace wall metal temperatures and analysis of the circulation system. The existing fans should be checked (preferably by the OEM's) for operation under the new conditions. The feasibility of operating the boiler under a slight positive pressure to eliminate air infiltration should also be investigated.
- Investigation of Improved oxygen production systems for Concept B, in line with the membrane-based air separation work being conducted by various research groups (e.g., Praxair, Air Products, Norsk Hydro). Also optimization of an integrated boiler and oxygen production system.
- Measurement of furnace heat transfer in CO<sub>2</sub>/O<sub>2</sub> environments in a proof of concept boiler simulation facility.

- Improved solvents, which require lower regeneration energy requirements and/or can be regenerated at a lower temperature level, similar to MHI's KS-1 and KS-2 solvents (Iijima, et al., Feb. 1998), but for coal-firing application.
- Hybrid process using oxygen-enriched combustion and amine based CO<sub>2</sub> absorption, to accrue, simultaneously, both CO<sub>2</sub> capture and drastic NOx emissions reduction.
- Investigation of a new novel high risk CO<sub>2</sub> capture process that would reduce efficiency penalty and retrofit investment cost. This would likely not utilize the existing boiler.

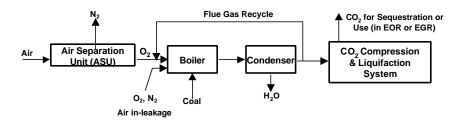
# 1.0 INTRODUCTION

ALSTOM Power Inc. teamed with American Electric Power, ABB Lummus Global Inc., the US DOE NETL, and the Ohio Coal Development Office to conduct a comprehensive study evaluating the technical feasibility and economics of alternate  $CO_2$  capture and sequestration technologies applied to an existing US coal-fired electric generation power plant. The three retrofit technology concepts being evaluated are shown below.

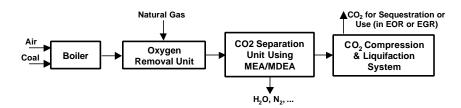
• Concept A: Coal combustion in air, followed by CO<sub>2</sub> separation from flue gas with Kerr-McGee/ABB Lummus Global's commercial MEA-based absorption/stripping process.



• Concept B: Coal combustion with O<sub>2</sub> firing and flue gas recycle.



• Concept C: Coal combustion in air with oxygen removal and CO<sub>2</sub> separation from flue gas by a mixture of primary and tertiary Amines



Each of these technologies was evaluated against a Base Case from the standpoints of performance and impacts on power generating cost. The Base Case represents the "business as usual" operation scenario for the plant without  $CO_2$  capture. A typical existing US domestic pulverized coal-fired power plant is being used in this evaluation. Specifically, American Electric Power's (AEP's) 450 MW Conesville Unit No. 5, located in Conesville, Ohio is the power plant case study. All technical performance and cost results associated with these options are being evaluated in comparative manner.

ALSTOM Power Inc. is managing and performing the subject study from its US Power Plant Laboratories office in Windsor, CT. ABB Lummus Global, from its offices in Houston, Texas, is participating as a sub-contractor. American Electric Power is participating by offering their Conesville Generating Station as the case study and cost sharing consultation, and relevant technical and cost data. AEP is one of the largest US utilities and is the largest consumer of Ohio coal, and as such, is bringing considerable value to the project. Similarly, ALSTOM Power and ABB Lummus Global are well established as global leaders in the design and manufacture of power generation equipment, petrochemical and  $CO_2$  separation technology. ALSTOM Power Performance Projects and Environmental Business Units are world leaders in providing equipment and services for boilers and power plant environmental control, respectively, and are providing their expertise to this project. The US Department of Energy (US DOE) National Energy Technology Laboratory (NETL) and the Ohio Coal Development Office (OCDO) provided consultation and funding. All participants provided cost share to this project.

The motivation for this study was to provide input to potential US electric utility actions to meet Kyoto protocol targets. If the US decides to reduce  $CO_2$  emissions consistent with the Kyoto protocol, action would need to be taken to address existing power plants. Although fuel switching from coal to gas is a likely scenario, it will not be a sufficient measure and some form of  $CO_2$  capture for use or disposal may also be required. The output of this  $CO_2$  capture study will enhance the public's understanding of control options and influence decisions and actions by government, regulators, and power plant owners to reduce their greenhouse gas  $CO_2$  emissions.

The key objectives of the study were to evaluate the impacts on the plant output, efficiency,  $CO_2$  emissions, investment costs, and the cost of generating electricity resulting from the addition of the  $CO_2$  capture systems. All technical performance and cost results associated with these options are being evaluated in comparative manner. Technical and economic issues being evaluated include:

- Boiler performance and plant efficiency
- Purity of O<sub>2</sub> produced and flue gas recycled
- Heat transfer into the radiant and convective sections of the boiler
- NO<sub>X</sub>, SO<sub>2</sub>, CO and unburned carbon emissions
- Heat transfer surface materials
- Steam temperature control
- Boiler and Steam Cycle modifications
- Electrostatic Precipitator system performance
- Flue Gas Desulfurization system performance
- Plant systems integration and control
- Retrofit investment cost and cost of electricity (COE)
- CO<sub>2</sub> Mitigation Costs

Each of the  $CO_2$  capture systems are designed for a minimum of 90%  $CO_2$  capture. Cost estimates were developed for all the systems required to produce, extract, clean, compress and liquefy the  $CO_2$ , to a product quality acceptable for pipeline transport. The Dakota Gasification Company's  $CO_2$  specification (2) for EOR, given in the following table, was used as the basis for the  $CO_2$  capture system design.

Component	Unit	Concentration
CO <sub>2</sub>	Vol.%	96.0
H₂S	Vol.%	0.9
CH4	Vol.%	0.7
C2+HCs	Vol.%	2.3
со	Vol.%	0.1
N <sub>2</sub>	vppm	< 300
H₂O	vppm	< 20
O <sub>2</sub>	vppm	< 50

## Dakota Gasification Project's CO<sub>2</sub> Specification for EOR

The  $CO_2$  product could then be available for usage in enhanced oil or gas recovery or sequestration. Additionally, an economic evaluation, showing the impact of  $CO_2$  capture on the cost of electricity (COE), was developed for each concept. Included in the economic evaluation was a sensitivity study showing the effects of coal cost, natural gas cost, plant capacity factor,  $CO_2$  byproduct sell price, investment cost, and replacement power, on the incremental cost of electricity and on the mitigation cost for the  $CO_2$  (\$/ton of  $CO_2$  avoided).

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# 2.0 STUDY UNIT SELECTION, DESCRIPTION AND PERFORMANCE

This section includes the criteria used for selection of the study unit, and provides a brief description of the selected unit. Additionally, the Base Case is defined as the unmodified existing unit firing coal at full load, utilizing air as the oxidant, without capture of  $CO_2$  from the flue gas. This represents the "business as usual" operating scenario and is used as the basis of comparison for the three  $CO_2$  removal options investigated in this study. The overall performance of the Base Case is presented in Section 2.3.

### 2.1 Study Unit Selection

A decision was required at the end of Task 2 (Site Selection/Plant Evaluation) regarding the selection of either unit #5 or #6 of AEP's Conesville, Ohio, Power Generating Station, as the study unit for our retrofit evaluations.

To provide the necessary background to facilitate this selection, a trip was made to the Conesville site on April 20, 2000. This visit provided the opportunity to gather operating data for unit #5, overall site information for both units #5 and 6, and additionally, to make arrangements for collecting a raw coal sample for Bench-Scale Testing (Task 4a).

It was learned from the operators and plant maintenance personnel that both twin units #5 and #6 operate nearly identically, and that no renovations had been made to either unit aside from replacement in kind. AEP, OCDO and Alstom personnel conducted a walk down of both units. Site drawings were provided and photographs were taken to document the footprints of both units. This information was used to evaluate space availability for the various new equipment that would be required for the three  $CO_2$  capture systems being evaluated in this study. Figure 2.1.1 shows several potential areas for new equipment placement in the neighborhood of units #5 and #6. A large amount of additional land area (about 10 acres) is available in a location about 1,500 feet northeast of the common stack used for units #5 and #6 (upper right corner of Figure 2.1.1).

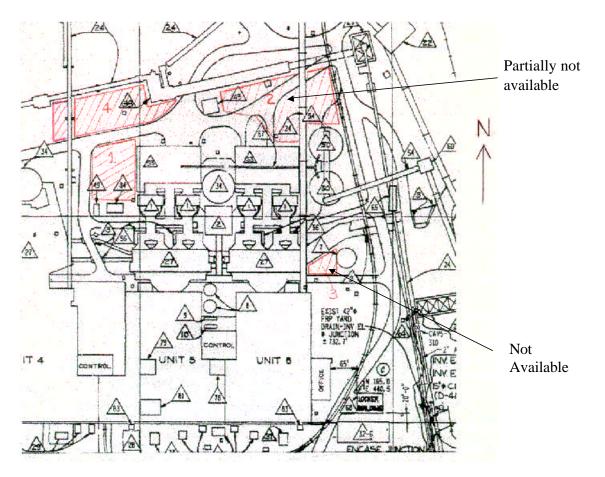
The approximate size of the four areas in the immediate vicinity of units #5 and #6 for locating some of the new equipment on the ground are listed below:

<u>Area #</u>	Approximate Size (square feet)	
1	13,000 (Available)	
2	29,000 (Partially available)	
3	2,600 (Not available)	
4	25,000 (Available)	

Additionally, consideration was given for hanging some of the equipment, where appropriate, in the space between the far end of the ESP and the boiler: fifth floor and up.

The major new equipment envisioned for the three retrofit concepts for this study include:

- An Air Separation Unit of about 9,000 tons of O<sub>2</sub> per day (Concept B),
- An MEA system for removal of about 10,000 tons of CO<sub>2</sub> per day from the flue gas (Concept A),
- An MEA/MDEA system for removal of about than 10,500 tons of CO<sub>2</sub> per day from the flue gas (Concept C),
- A flue gas oxygen removal system upstream of the MEA/MDEA system (Concept C),
- A CO<sub>2</sub> Compression and Liquefaction system (required for all 3 concepts),
- Various other ancillary equipment



### Figure 2.1. 1: Plan View of AEP's Conesville, Ohio, Power Generating Station Site Showing Area Occupied by Units #5 and #6

The four areas identified previously and shown in Figure 2.1.1 indicate the following:

- These areas, even combined, are not large enough to locate all the equipment required for any one of these CO<sub>2</sub> removal concepts. They may however be useful for location of various ancillary equipment.
- Areas 1 and 4, which are in the vicinity of unit #5 total to ~38,000 square feet
- Areas 2 and 3, which are in the vicinity of unit #6, total ~31,000 square feet, of which less than 28,000 square feet are available.
- Furthermore, conveniently we already had performance data from unit #5.
- Although we could have obtained data from unit #6, this step could be eliminated with the selection of unit #5. Hence, it made more sense to use unit #5 in this initial evaluation. If there is in the future a desire to evaluate unit #6, then a further re-examination of areas #2 and #3 would be warranted and performance data from unit #6 could be obtained.

In summary, the preceding information indicated that:

• Unit #5 offers more "on-the-ground" area near the unit for erecting new equipment than does unit #6.

- Both units #5 and #6 are equally accessible for erecting new equipment in the space between the boiler and the far end of the ESP, fifth floor and up.
- Both units #5 and #6 are equally accessible to the large area available about 1,500 feet northeast of the unit #5/#6 stack.
- Both units #5 and #6 perform similarly with respect to power generation.

Considering the totality of the information given above, we concluded that unit #5 offered a relatively more costeffective scenario for our retrofit evaluation. Cognizant personnel of the Conesville Power Generating Station were in complete agreement with these findings and Conesville Unit #5 was selected as the study unit.

### 2.2 Study Unit Description

The steam generator unit analyzed in this study was American Electric Power's Conesville Unit #5. A sectional side elevation drawing of the study unit is shown in Figure 2.2.1. This unit can be described as a nominal 450 MW-gross, tangentially coal fired, subcritical pressure, controlled circulation, radiant reheat wall unit. The furnace is a single cell design utilizing five elevations of tilting tangential coal burners. The unit fires mid-western bituminous coal. The coal is supplied to the five elevations with five RP-903 coal pulverizers. The unit is configured in a "Conventional Arch" type design and is representative in many ways of a large number of coal fired units in use today. The unit is designed to generate about  $3.1 \times 10^6$  lbm/hr of steam at 2400 psi and 1005 F with reheat also to 1005 F. These represent the most common steam cycle operating conditions for existing utility scale power generation systems. Outlet steam temperature control is provided with de-superheating spray and burner tilt.

The furnace is tangentially fired and is of the single cell design. It is about 51.67 ft wide, 44.33 ft deep and 171.67 ft high. The superheater is divided into four major sections. Saturated steam leaving the steam drum first cools the roof and rear pass walls before supplying the low temperature superheater section. The low temperature superheater section is located in the rear pass of the unit and is a horizontal section with the outlet tubes in a vertical orientation adjacent to the finishing superheater section. Steam leaving the low temperature superheater section. The division panels are located in the upper furnace directly above the combustion zone of the lower furnace. Steam leaving the panels flows to the superheater platen section, which is a more closely spaced vertical section located between the panels and the finishing pendant reheater. Steam leaving the platens flows into the finishing superheater section in the rear pass of the unit. Steam leaving the finishing superheater is piped to the high-pressure turbine where it is expanded to reheat pressure and then returned to the reheat de-superheater is piped to the high-pressure turbine where it is expanded to reheat pressure and then returned to the reheat de-superheating spray station.

The reheater is divided into two sections, a low temperature radiant wall section followed by a spaced finishing pendent section. Steam is supplied to the reheater radiant wall from the de-superheating spray station, which is fed from the high-pressure turbine exhaust. The reheater radiant wall section is located in the upper furnace and covers the entire front wall and most of the two sidewalls of the upper furnace. The pendant finishing reheat section is located above the arch between the superheat platen and superheat finishing sections. Steam leaving the finishing reheater is returned to the intermediate pressure turbine where it continues its expansion through the intermediate and low-pressure turbines before being exhausted to the condenser.

The gases leaving the low temperature superheater section are then further cooled in an economizer section. The economizer is comprised of four banks of spiral finned tubes (2 fins/inch) which heats high-pressure boiler feedwater before it is supplied to the steam drum. The feedwater supplying the economizer comes from the final extraction feedwater heater.

Finally, a Lungstrom trisector regenerative air heater is used to heat both the primary and secondary air streams prior to combustion in the lower furnace. Particulate matter is removed from the cooled flue gas leaving the air heater in an electrostatic precipitator and sulfur dioxide is removed in a lime based flue gas de-sulfurization system. The flue gas

is then exhausted to the atmosphere through the stack. The induced draft and forced draft fans are controlled to operate the unit in a balanced draft mode with the furnace maintained at a slightly negative pressure (typically -0.5 inwg).

The high pressure superheated steam leaving the finishing superheater is expanded through the high pressure steam turbine, reheated in the two stage reheater and returned to the intermediate pressure turbine. The steam continues its expansion through the low-pressure turbine sections where it expands to condenser pressure. The generator produces about 463 MW of electric power at Maximum Continuous Rating (MCR). The steam cycle utilizes seven feedwater heaters (three low-pressure heaters, a deaerator, and three high-pressure heaters) where the feedwater is preheated to about 493 F before entering the economizer of the steam generator unit. The boiler feed pump is steam turbine driven with steam provided from the intermediate pressure turbine exhaust and expanded to condenser pressure.

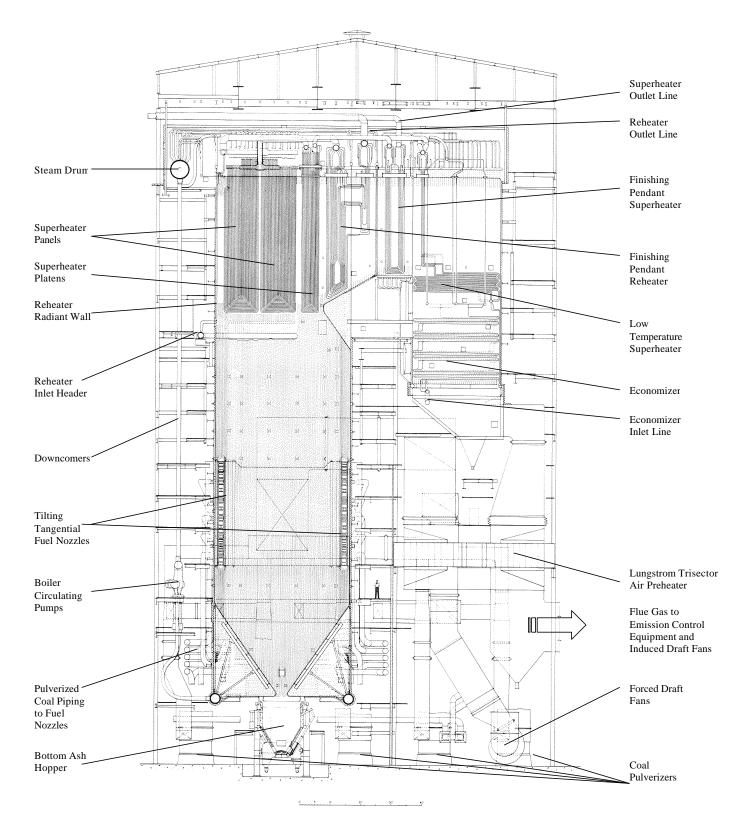


Figure 2.1. 2: Study Unit (Existing Conesville Unit #5 Steam Genertor)

### 2.3 Base Case Performance Analysis

The Base Case can be described as the unmodified existing unit firing coal at full load and utilizing air as the oxidant without capture of  $CO_2$  from the flue gas. This represents the "business as usual" operating scenario and is used as the basis of comparison for the three the  $CO_2$  removal options investigated in this study. The first step in the development of a Base Case was to set up a computer model of the boiler. Using test data from the existing unit, the computer model was then calibrated. The calibrated boiler model was then used for analysis of the Base Case and the three  $CO_2$  removal concepts.

### 2.3.1 Calibration of Boiler Computer Model

The first step in the calculation of a Base Case was to set up a steady state performance computer model of the Conesville #5 steam generator unit. This involves calculating or obtaining all the geometric information for the unit as required by the proprietary Reheat Boiler Program (RHBP). The RHBP provides an integrated, steady state performance model of the Boiler Island including, in addition to the steam generator unit, pulverizers, air heater, and steam temperature control logic. The RHBP is used to size components and/or predict performance of existing components. In this study, since the boiler island component sizes are known, the RHBP was used exclusively for calculating unit performance.

The next step in the heat transfer analysis of the Base Case was to calibrate the RHBP model of the unit. This involves obtaining test data (with air firing) for the existing unit and "adjusting" the performance model to match the test data. The required test data includes steam temperatures entering and leaving each major heat exchanger section in the unit, steam pressures, coal analysis, flue gas oxygen content, etc. The "adjustments or calibration factors" for the model are in the form of "surface effectiveness factors" and "fouling factors" for the various heat exchanger sections throughout the unit. Unfortunately, the test data used for calibration of this model was not totally complete and several assumptions were required in the calibration process. Although all the required data was not available, primarily due to existing instrumentation limitations, a satisfactory calibrated model was obtained.

Using the calibrated boiler model and providing it with new steam side inputs (mass flows, temperatures, and pressures) from the agreed upon MCR steam turbine material and energy balance, the model was run and performance was calculated for the Base Case. The performance for the overall power plant system is described in Section 2.3.2 with the boiler performance shown in Section 2.3.3 and the steam turbine performance in Section 2.3.4.

### 2.3.2 Overall System Description and Material and Energy Balance

The simplified gas side process flow diagram for the Base Case is shown in Figure 2.3.1 and the associated material and energy balance for this case is shown in Table 2.3.1. Overall plant performance is summarized in Table 2.3.2. This system is described previously in Section 2.2. Boiler efficiency is calculated to be 88.13 percent. The net plant heat rate is calculated to be 9,749 Btu/kwhr for this case as shown in Table 2.3.2. Auxiliary power is 29,700 kw and the net plant output is 433,778 kw. Carbon dioxide emissions are 866,156 lbm/hr or about 2.00 lbm/kwhr.

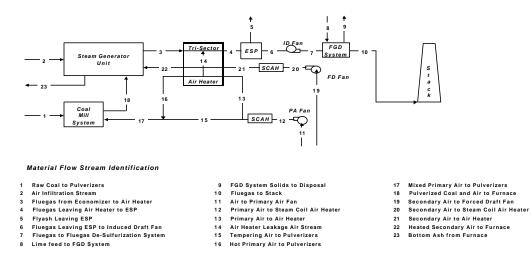


Figure 2.3. 1:Simplified Gas Side Process Flow Diagram (Base Case)

Table 2.3.1:	Base Case Gas Side Material and Energy Balance
--------------	------------------------------------------------

Constituent	(Units)	1	2	3	4	5	6	7	8	9	10	11	12	13
02	(Lbm/hr)	26586	42147	101097	144817		144817	144817	5355		144578	203237	203237	112918
N2	` " ´	4868	139626	2797385	2942220		2942220	2942220			2942220	673283	673283	374075
H2O		37820	2357	228849	231294		231294	231294	250709	45979	436024	11365	11365	6314
CO2				867210	867210		867210	867210			866156			
SO2				20202	20202		20202	20202			1063			
H2		16102												
Carbon		236655												
Sulfur		10110												
Ca									12452					
Mg									584					
MgO										484				
MgSO3										1293				
MgSO4										94				
CaSO3										35179				
CaSO4										2468				
CaCO3										2398				
Ash / Inerts		42313		33851	33851	33851			968	968				
		Raw Coal	Leakage Air	Fluegas to AH	Fluegas to ESP	Flyash	Fluegas to ID Fan	Fluegas to FGD	Lime Slurry	FGD Disposal	Fgas to CO2 Sep	Pri Air to PA Fan	PA from PA Fan	Pri Air to AH
Total Gas	(Lbm/hr)		184130	4014743	4205743		4205743	4205743			4390042	887885	887885	493308
Total Solids		374455		33851	33851	33851			14003	42884				
Total Flow		374455	184130	4048594	4239594	33851	4205743	4205743	270067	88863	4390042	887885	887885	493308
Temperature	(Deg F)	80	80	706	311	311	311	325	80	136	136	80	92	92
Pressure	(Psia)	14.7	14.7	14.6	14.3	14.7	14.2	15.0	14.7	14.7	14.7	14.7	15.6	15.6
hsensible	(Btu/lbm)	0.000	0.000	161.831	57.924	57.750	57.924	61.384	0.000	14.116	14.543	0.000	2.899	2.899
	106 Btu/hi													
	106 Btu/hi	0.000	0.000	655.007	245.567	1.955	243.612	258.166	0.000	3.314	63.916	0.000	2.574	1.430
	106 Btu/hi	0.000	2.475	240.291	242.858	0.000	242.858	242.858	0.000	0.000	464.020	11.933	11.933	6.630
Total Energy(1)	106 Btu/hi	4228.715	2.475	895.298	488.425	1.955	486.470	501.024	0.000	3.314	527.936	11.933	14.507	8.060

Constituent	(Units)	14	15	16	17	18	19	20	21	22	23
02	(Lbm/hr)	43720	90319	66680	156999	183585	641283	641283	641283	643801	
N2		144835	299208	220899	520107	524975	2124443	2124443	2124443	2132785	
H2O		2445	5051	3729	8779	46599	35860	35860	35860	36001	
CO2											
SO2											
H2						16102					
Carbon						236655					
Sulfur						10110					
Ca											
Mg											
MgO											
MgSO3											
MgSO4											
CaSO3											
CaSO4											
CaCO3											
Ash / Inerts						42313					8463
		Air Htr Lkg Air	Tempering Air	Hot Pri Air	Mixed Pri Air	Coal-Pri Air Mix	Sec Air to FD	Sec Air to SCAH	Sec Air to AH	Hot Sec Air	Bottom Ash
Total Gas	(Lbm/hr)	191000	394577	291308	685885		2801587	2801587	2801587	2812587	
Total Solids	"										8463
Total Flow		191000	394577	291308	685885	1060340	2801587	2801587	2801587	2812587	8463
Temperature	(Deg F)	92	92	666	339		80	86.4	86.4	616	2000
Pressure	(Psia)	15.6	15.6	15.6	15.6	15.0	14.7	15.2	15.1	14.9	14.7
hsensible	(Btu/lbm)	2.899	2.899	145.249	63.358		0.000	1.549	1.549	132.582	480.000
	I										
	106 Btu/hr)					4228.715					
	106 Btu/hr		1.144	42.312	43.456		0.000	4.341	4.341	372.898	4.062
	106 Btu/hr	2.567	5.303	3.915	9.218		37.653	37.653	37.653	37.801	0.000
Total Energy(1)	106 Btu/hr	3.121	6.447	46.227	52.674	4281.389	37.653	41.994	41.994	410.699	4.062

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	(	Original Plant (Base)
Euel Paramaters	(units)	Fidili (Dase)
	(40 <sup>6</sup> Dtu/ba)	4228.7
Coal Heat Input (HHV)		4220.7
Natural Gas Heat Input (HHV)	$(10^6 \text{ Btu/hr})$	4228.7
Total Fuel Heat Input (HHV)	(10 Dlu/11)	4220.7
Steam Cycle Paramaters		
Existing Steam Turbine Generator Output	(kW)	463478
CO2 Removal System Turbine Generator Output	(kW)	0
Total Turbine Generator Output	(kW)	463478
Total Auxiliary Power	(kW)	29700
Net Plant Output	(kW)	433778
Overall Plant Performance Paramaters		
Net Plant Efficiency (HHV)	(fraction)	0.3501
Net Plant Efficiency (LHV)	(fraction)	0.3666
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309
Overall Plant CO 2 Emissions		
Carbon Dioxide Emissions	(lbm/hr)	866102
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997
Normalized Specific CO2 Emissions (Relative to Base Case)	(fraction)	1.000
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)	
Specific Carbon Dioxide Emissions	(kg/kwhr)	0.906
Avoided Carbon Dioxide Emissions (as compared to Base)	(kg/kwhr)	

# Table 2.3.2: Overall Plant Performance Summary (Base Case)

#### 2.3.3 Boiler Analysis Results

The main steam flow for this case and all other cases in this study is 3,131,619 lbm/hr. The cold reheat flow leaving the high-pressure turbine for this case and all other cases in this study is 2,766,780 lbm/hr. The hot reheat flow (including de-superheating spray) returning to the intermediate pressure turbine for this case is 2,853,590 lbm/hr. The overall steam conditions produced by the existing Conesville #5 steam generator unit are shown in Table 2.3.3 below. To produce these conditions, the superheat circuit requires about 3.6 percent spray and the reheat circuit requires about 3.1 percent spray to maintain required steam outlet temperatures. The burner tilts are -10 degrees (the minimum value the customer uses). The boiler was fired with 15 percent excess air and the resulting boiler efficiency calculated for this case was 88.13 percent with an air heater exit gas temperature of 311 F.

Table 2.3. 3:	<b>Base Case Boiler/Turbine Steam Flows and Conditions</b>
---------------	------------------------------------------------------------

		SHO	FWI	ECO	RHO	RHI
Mass Flow	(lbm/hr)	3131619	3131619	3017507	2853590	2853590
Pressure	(psia)	2535	3165	3070	590.8	656.5
Temperature	(Deg F)	1005	492.6	630	1005	607.7
Enthalpy	(Btu/lbm)	1459.7	479.2	652.8	1520.4	1290.4

Notes:

SHO = Superheater Outlet; FWI = Feedwater Inlet; ECO = Economizer Outlet; RHO = Reheater Outlet; RHI = Reheater Inlet

#### 2.3.4 Steam Cycle Performance

The steam cycle for the Base Case is shown schematically in Figure 2.3.2. Figure 2.3.3 shows the associated Mollier diagram which illustrates the process on enthalpy - entropy coordinates. The high pressure turbine expands about 3.1 x  $10^6$  lbm/hr of steam at 2535 psia and 1005 F. Reheat steam is returned to the intermediate pressure turbine at 591 psia and 1005 F. These conditions (temperatures, pressures) represent the most common steam cycle operating conditions for existing utility scale power generation systems in use today. The condenser pressure used for the Base Case and all other cases in this study was 2.5 in Hga. The steam turbine performance analysis results show the generator produces 463,478 kw output and the steam turbine heat rate is about 7999 Btu/kwhr.

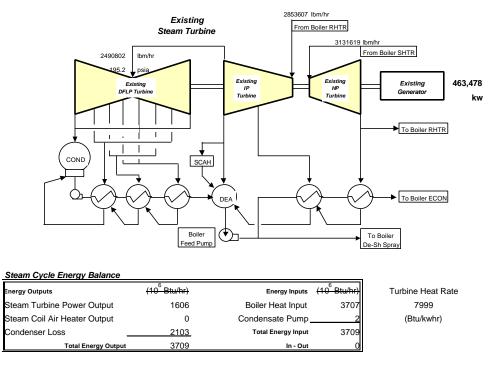


Figure 2.3. 2: Base Case Steam Cycle Diagram and Performance

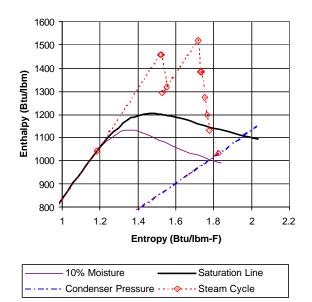


Figure 2.3. 3: Base Case Steam Cycle Mollier Diagram

#### 2.3.5 Flue Gas Desulfurization System Analysis

Figure 2.3.4 shows the process flow diagram for the existing Flue Gas Desulfurization System. The stream numbers in Figure 2.3.4 also correspond to stream numbers shown in Figure 2.3.1 and Table 2.3.1. The flue gas leaving the ID fan (Stream 7) is delivered to the Absorber, which consists of a tray followed by a two-stage spray system. The incoming gas is saturated as it passes through the scrubbing slurry contained on the tray and through the two spray levels. The active component of the scrubbing slurry is calcium oxide (Stream 8a), which reacts with sulfur dioxide to form calcium bisulfite (Stream 9). The scrubbing slurry is circulated from the reagent feed tank that forms the base of the scrubber to the spray levels. The solids loading in the scrubbing slurry controls the blowdown from the reaction tank to byproduct disposal. The flue gas passes through chevron type mist eliminators that remove entrained liquid before exiting the scrubber (Stream 10). The water utilized in spray washing the mist eliminators also serves as make-up (Stream 8b).

Table 2.3.4 identifies the assumptions that were made in predicting the FGD performance. Table 2.3.5 shows the gas constituents at the existing Absorber inlet and outlet locations. Results show a  $CO_2/SO_2$  mole ratio of 63 and an  $SO_2$  removal efficiency of 94.8%, corresponding to a value of 104 vppm at the outlet of the absorber.

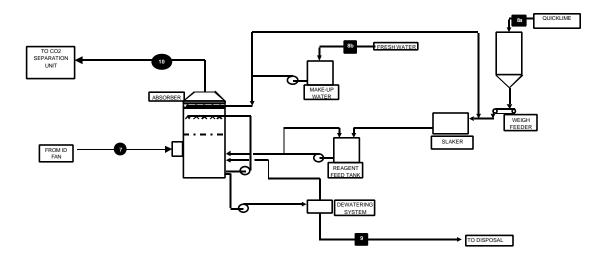


Figure 2.3. 4: Base Case Flue Gas Desulfurization System Process Flow Diagram

Base Case					
Quantity	Unit	Existing Absorber			
Ca/S)	Mol Ratio	1.04			
Solids	Wt.%	20			
CaO	Wt.%	90			
MgO	Wt.%	5			
Inerts	Wt.%	5			
Bypass Leakage	Wt.%	2.5			
Liquid/Gas (L/G) Ratio	gpm/1000 acfm	55			
SO <sub>2</sub> Removal Efficiency					
APC	%	94.8			
Absorber	%	97.2			

Table 2.3.4:FGD Assumptions

	Base Case									
	Exi	stina Absorb	er Inlet	Existing	Absorber O	utlet				
Species	Mol/hr	Vol.%	Unit	Mol/hr	Vol.%	Unit				
O <sub>2</sub>	4,469	3.14	Vol.%	4,461	2.91	Vol.%				
N <sub>2</sub>	105,018	73.74	Vol.%	105,018	68.44	Vol.%				
H <sub>2</sub> O	12,863	9.03	Vol.%	24,228	15.79	Vol.%				
CO <sub>2</sub>	19,743	13.86	Vol.%	19,720	12.85	Vol.%				
SO <sub>2</sub>	315	2,212	vppm	16	104	vppm				
SO₂ Removal Efficiency, %					94.9					
CO <sub>2</sub> /SO <sub>2</sub> Mole Ratio		63								

# Table 2.3.5:FGD Performance

# 3.0 CO<sub>2</sub> REMOVAL SYSTEMS

The following three basic process options were studied:

- **Concept A**: Coal combustion in air, followed by CO<sub>2</sub> separation with Kerr-McGee/ABB Lummus Global's commercial MEA-based absorption/stripping process
- **Concept B**: Coal combustion with O<sub>2</sub> firing and flue gas recycle (oxy-fuel firing)
- **Concept C**: Coal combustion in air with oxygen removal and CO<sub>2</sub> separation

The Capture of  $CO_2$  from the flue gas for Concept A is accomplished using the Kerr-McGeee / ABB Lummus Global oxygen inhibited MEA technology. Only Kerr-McGee/ ABB Lummus oxygen inhibited amine was studied. It is the most commercially proven process evaluated in this study.

Concept B utilizes oxygen firing with the recycle of flue gas to bring the firing and heat transfer characteristics of the boiler back close to original design. The oxygen firing is used to produce a flue gas stream with high enough  $CO_2$  content such that simple compression, refrigeration, and rectification can produce a suitable  $CO_2$  liquid product. Optimizations in various areas such as oxygen purity, air leakage into the boiler and associated equipment operating below atmospheric pressure, and flue gas recycle ratio have been made. On the liquefaction side, an optimization of the flow scheme to remove the inerts while maintaining  $CO_2$  recovery at the lowest energy consumption was made.

For Concept C,  $CO_2$  recovery from the flue gas is accomplished by using generic amines (i.e. MEA, MDEA). However, if more efficient and cost effective, proprietary amines may be used. The difference between the amines used in this case and in Concept A is that the amines are not oxygen resistant. Hence, the oxygen is converted to  $CO_2$ by combustion with methane over a de-oxy catalyst upstream of the amine contactor.

Although triethanolamine (TEA) was first proposed for use for Concept C, due to its relatively low energy requirement for solvent regeneration, the literature survey conducted earlier in the present study, Bozzuto, et al. (2000), revealed that the TEA had a very low recovery of CO<sub>2</sub> when operating at near atmospheric pressure. Operating at higher pressures to improve recoveries is not economically feasible as the carbon dioxide concentration in the flue gas is less than 13% and compressing the entire flue gas stream to 200 psig would require approximately 250,000 hp. Therefore, only generic amines and proprietary amines that absorb efficiently at atmospheric pressure were evaluated for this case. Specifically, the amines evaluated were monoethanolamine/ methyldiethanolamime (MEA /MDEA) blend, BASF activated MDEA, and Mitsubishi Heavy Industries amines (Iijima, et al., 1998; Iijima, 1998). Since these amines are required to be oxygen resistant, de-oxygenation via catalytic combustion is required upstream of the amine unit. Neither the de-oxy catalyst nor any of these amines have been tested in coal fired power plant flue gas streams.

# 3.1 CO<sub>2</sub> Removal Systems Design Basis

# 3.1.1 Site Data

Listed below is the summary of the bases used for this design:

- Plant is located in Connesville, Ohio, elevation 744 feet.
- Atmospheric pressure is 29.92 inches of Hg.
- Ambient temperature for air cooler design is 80 °F.
- Wet bulb temperature for cooling tower design is 75 °F.
- Electric power may be available from the existing facilities. Auxiliary power, 7-8% of the gross, is provided through auxiliary transformers at 4160-volt bus and is reduced down to 480 volts.

- Flue gas is high in halides (chlorides and fluorides) as well as SO<sub>3</sub> so that stainless steel 316L can be used as the material of construction for the flue gas cooling system.
- Pressure of liquid product CO<sub>2</sub> is 2000 psig.

# 3.1.2 Battery Limit Definition

The  $CO_2$  recovery and liquefaction sections are located approximately 1200 feet north of the Unit #5 stack (Figure 3.1.1). The new cooling tower is at a different location, which is about 1900 feet southwest of the  $CO_2$  recovery and liquefaction equipment. The  $CO_2$  recovery and liquefaction equipment, for Concepts A and C, actually receives cooling water from both the existing plants cooling system and the new cooling tower. This is due to the fact that the existing plant cooling water capacity will be partially available as a result of the amine system reboiler's consumption of steam for solvent regeneration. This steam was previously exhausted from the existing low-pressure turbine and condensed in the existing power plant surface condensers.

The new cooling tower section receives frequent deliveries of sodium hypochlorite. It is also periodically attended by cooling tower chemical service such as Betz or Nalco. They bring with them the required dispersant, pH control, and corrosion inhibitors. However, their visits do not totally relieve the power plant personnel from taking samples themselves at least once per shift. The blowdown from the cooling tower must be treated with sodium bisulfite to dechlorinate it. Sodium bisulfite will be unloaded from drums into the injection package. Concept A, which makes use of an existing cooling water make-up stream must have its blowdown filtered to reduce the suspended solids to within acceptable limits. Backwash from the sand filters will go back to the existing cooling tower blowdown disposal system. Concepts B and C require significant amounts of cooling tower make up water. Thus, river water taken from existing pumps will be sent to a new clarifier. It is expected that this clarifier will eliminate suspended solids to the extent that there will be no need for sand filters on the cooling tower blowdown. Blowdown from the clarifier will be sent to an existing clarifier blow down system.

The new  $CO_2$  recovery and liquefaction section comprises another section of the power plant. It has its own control room and motor control center (MCC). In addition to the flue gas, which serves as the feed to the unit, it must also receive the required utilities and chemicals. Caustic, if available from existing facilities, can be used to maintain levels in this facilities day tanks. Otherwise it can be offloaded from trucks into the day tanks. Diatomaceous earth will be off loaded on skids. The spent diatomaceous earth leaves the plant in drums. Reclaimer effluent will be collected in a tank truck parked at one end of the unit. Potable water for eyewashes and cooling tower make-up water for hose down will be routed along side the feed gas duct and 180 psig steam. Corrosion inhibitor to provide oxygen resistance to the amine in Concept A will be directly from drums into an injection package.

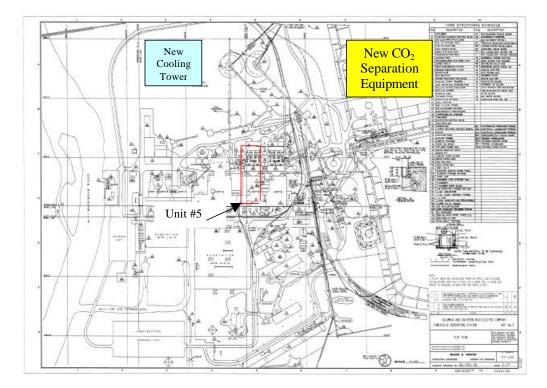


Figure 3.1. 1: AEP Conesville, Ohio, Electric Power Generating Station Site

The design of the  $CO_2$  recovery and liquefaction sections has been based on the flue gas data leaving the Flue Gas Desulfurization System, shown in Table 3.1.1.

Commonant	Concept A	Concept D	Concept C
Component	Concept A	Concept B	Concept C
	Mole %	Mole %	Mole %
O2	2.94	2.91	2.94
N2	68.45	5.03	68.45
H2O	15.77	19.01	15.77
$CO_2$	12.83	73.04	12.83
SO2	<10 ppmv	0.01	106 ppmv
MW	28.61	37.92	28.61
T (°F)	136	144	136
P (psig)	1	0	1

# 3.1.3 CO<sub>2</sub> Product Specification

The product specification for sequeststration (Orr, 2001) is shown in Table 3.1.2. This composition is what can be obtained from the liquefaction scheme for Concept B. Its hydrate locus was verified to be sufficiently close to that of pure  $CO_2$  which is the criterion used by one of the world's foremost  $CO_2$  sequestration experts, Lynn Orr of Stanford University.

Product
Mole %
1.32
1.23
0
97.29
.16
43.68
82
2015

# Table 3.1.2:Specification for Sequestration

Table 3.1.3 represents the specification required for Enhanced Oil Recovery (EOR). It was compiled by comparing the Dakota Gas specification supplied by AEP and contracts signed through Kinder Morgan  $CO_2$  company and taking the strictest specification of the two.

Table 3.1. 3:	Specification for EOR

Component	Specification
0	10 might and marine of the CO
$O_2$	10 weight ppm maximum of the $CO_2$
$N_2$	300 ppmv maximum
$H_2O$	20 ppmv maximum
$CO_2$	96% minimum
$H_2S$	20 weight ppm of the $CO_2$
CO	0.1% maximum
C <sub>2</sub> + Hydrocarbons	2.3 mole % max
Methane	0.7 % maximum
T (°F)	120 F max

A product pressure of 2000 psig was used in the designs that follow.

# 3.1.4 Chemicals

This section provides data for the chemicals available on site and used by the  $CO_2$  Recovery systems. Conditions for liquid chemicals are specified at grade level.

	Pressure at B.L. psig	Temperature °F
Minimum	• •	
Normal	15	ambient
Maximum		
Mechanical	50	125
Design		

Table 3.1.4:	Caustic (NaOH)
--------------	----------------

- Available for reclaiming MEA (Concept A)
- The import and dilution facilities will be used to keep a day tank in the process area at desirable levels.

# 3.1.5 Utilities

The data below applies to both Concepts A and C except where noted. For cooling water, new utility systems will have to be provided and are included in the cost estimate. For steam, obviously the export of 195 psia steam to an external process represents a change from the current operation. It was decided to use extraction steam from the turbine rather than build additional facilities. The reason for this decision comes from plant efficiency, investment cost, and plot considerations. Conditions for all liquid utilities are given at grade level.

#### Steam:

#### Low Pressure Steam (LP) (Concepts A and C) Used mainly for process heating

	Pressure at B.L.	Temperature
	psig	°F
Minimum (for process design)		700
Normal	180	716
Maximum	200	
Mechanical Design	250 /FV	775

#### Water:

#### Cooling Water (Concepts A, B, and C) Source: New Cooling Tower

Source. New Cooling	TOWEI	
CW Supply:	Pressure at B.L.	Temperature
	psig	°F
Minimum		
Normal	50	85
Maximum		
Mechanical Design	100	150
CW Return:	Pressure at B.L.	Temperature
	psig	°F
Minimum		
Normal	30	103
Maximum		
Mechanical Design	100	175

# Surface Condensate (Concept C process cooling, Concept A and C amine make-up)

	Pressure at B.L. psig	Temperature °F
Minimum		
Normal	300	109
Maximum		
Mechanical Design	350	200

#### Raw Water (Fresh Water)

Distributed for general use at hose stations (Concepts A and C). The source of this is a clarifier for cooling tower make-up. The capacity of this clarifier is sufficient for make up for Concept A, but not B or C. Its quality is as follows:

Components	Unit	Specifications
Si	ppm.	22
Iron (as Fe)	ppm.	0.18
Copper (as Cu)	ppm	0.05

Suspended Solids	ppm	15
Chlorine	11	100-180
	ppm	
Alkalinity	ppm	100
Na	ppm	100

For Concepts B and C water from the Muskingum River must be sent to a new clarifier. The specifications for this water are as follows:

	Unit	Specification
Suspended Solids	ppm	10 to many hundreds
Turbidity	ppm	5 to 300

# Potable Water (Concepts A and C)

	Pressure at B.L.	Temperature
	Psig	°F
Minimum (for process design)		
Normal	100	ambient
Maximum		
Mechanical Design	150	150

• Comes from public network

• For safety showers (Concepts A and C)

#### Air:

#### Plant Air (Concepts A, B, C)

	Pressure at B.L.	Temperature
	ps1g	F
Minimum (for process design)		
Normal	115	100
Maximum		
Mechanical Design	175	150
Derry maint (at manneal arranter analy	40°C)	

Dew point (at normal supply pressure -  $40^{\circ}$ C)

# Instrument Air (Concepts A, B, C)

	Pressure at B.L. psig	Temperature °F
Minimum (for process design) Normal	115	100
Maximum		
Mechanical Design	175	150
	115	150

Dew point (at normal supply pressure -  $40^{\circ}$ C) Dust, oil and grease free

# Fuel Gas:

# LP Fuel Gas (Concepts A, B, C)

	Pressure at OSBL psig	Temperature °F
Minimum	1 0	
Normal	50	Ambient
Maximum		
Mechanical Design	100	150

# **Power Supply:**

All of the required power (100%) for the  $CO_2$  Recovery Unit will be provided by AEP either from the local supply or from the Ohio Grid.

(Concepts A, B, C)

Service	Voltage	Phase
Auxiliary plant power system	4160	3-phase
Large Motors	4160	3-phase
Small Motors	480	3-phase
Instruments, Lighting etc	480 / 230	3/1-phase

# 3.1.6 Equipment Design

**Equipment Numbering:** 

Equipment numbering will be based on Lummus standards.

Sparing Philosophy:

A sparing philosophy was employed to reduce investment. Therefore, spares were spread out upon multiple trains or provide 50% or 33% sized spares when possible. Small pumps (e.g. metering pumps) and equipment related to protection of major equipment (e.g. lube oil pumps) may be spared.

Mechanical Design Conditions:

ABBLGI practices will be followed (page 24, T3.1.TP07.402 in "Relief and Flare Systems" manual).

# **3.2** Concept A: CO<sub>2</sub> Separation with Monoethanolamine Absorption

Concept A is defined as a system designed for the removal and recovery of  $CO_2$  from the boiler flue gas using an amine scrubbing system. The amine system selected was the Kerr-McGeee / ABB Lummus Global oxygen inhibited MEA technology.

# 3.2.1 Overall System Description and Material and Energy Balance

A simplified process flow diagram for the modified unit is shown in Figure 3.2.1. The operation and performance of the existing Boiler and ESP systems are identical to the Base Case and are not affected by the addition of the MEA based  $CO_2$  removal system. The FGD system is modified with the addition of a secondary absorber to reduce the  $SO_2$  content to about 10 ppmv (See Section 3.2.4). The overall material and energy balance for the system shown in Figure 3.2.1 is shown in Table 3.2.1. The flue gases leaving the modified FGD system are ducted to the new MEA system where ~94 percent of the  $CO_2$  is removed, compressed, and liquefied for usage or sequestration. The remaining flue gases leaving the new MEA system, consisting of primarily oxygen, nitrogen, water vapor and a relatively small amount of sulfur dioxide and carbon dioxide, is discharged to the atmosphere.

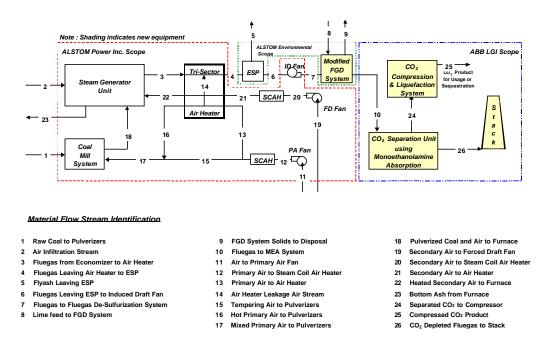


Figure 3.2. 1: Simplified Gas Side Process Flow Diagram for CO<sub>2</sub> Separation by Monoethanolamine Absorption (Concept A)

Constituent	(Units)	1	2	3	4	5	6	7	8	9	10	11	12	13
<b>O</b> 2	(Lbm/hr)	26586	42147	101097	144817		144817	144817	5628		144566	203237	203237	112918
N2		4868	139626	2797385	2942220		2942220	2942220			2942220	673283	673283	374075
H2O		37820	2357	228849	231294		231294	231294	258954	48324	441924	11365	11365	6314
CO2				867210	867210		867210	867210			866102			
SO <sub>2</sub>				20202	20202		20202	20202			87			
H <sub>2</sub>		16102												
CH4														
Carbon		236655												
Sulfur		10110												
Ca									13087					
Mg									613					
MgO										509				
MgSO₃										1251				
MgSO4										76				
CaSO <sub>3</sub>										34395				
CaSO4										2051				
CaCO₃										2520				
Ash / Inerts	"	42313		33851	33851	33851			1017	1017				
		Raw Coal	Leakage Air	Fluegas to AH	Fluegas to ESP	Flyash	Fluegas to ID Fan	Fluegas to FGD	Lime Slurry	FGD Disposal	Fgas to CO2 Sep	Pri Air to PA Fan	PA from PA Fan	Pri Air to AH
Total Gas	(Lbm/hr)		184130	4014743	4205743		4205743	4205743			4394900	887885	887885	493308
Total Solids		374455		33851	33851	33851			14717	41819				
Total Flow		374455	184130	4048594	4239594	33851	4205743	4205743	279300	90143	4394900	887885	887885	493308
Temperature	(Deg F)	80	80	706	311	311	311	325	80	136	136	80	92	92
Pressure	(Psia)	14.7	14.7	14.6	14.3	14.7	14.2	15.0	14.7	14.7	14.7	14.7	15.6	15.6
hsensible	(Btu/Ibm)	0.000	0.000	161.831	57.924	57.750	57.924	61.384	0.000	14.116	14.543	0.000	2.899	2.899
	(													
Chemical	(10 <sup>6</sup> Btu/hr)	4228.715												
	(10 <sup>6</sup> Btu/hr)	0.000	0.000	655.007	245.567	1.955	243.612	258,166	0.000	3.314	63.916	0.000	2.574	1.430
	(10 <sup>6</sup> Btu/hr)	0.000	2.475	240.291	242.858	0.000	242,858	242.858	0.000	0.000	464.020	11.933	11.933	6.630
Total Energy <sup>(1)</sup>	(10 <sup>6</sup> Btu/hr)	4228,715	2.475	895.298	488.425	1.955	486.470	501.024	0.000	3.314	527.936	11.933	14.507	8.060
														2.200
Constituent	(Units)	14	15	16	17	18	19	20	21	22	23	24	25	26
O2	(Lbm/hr)	43720	90319	66680	156999	183585	641283	641283	641283	643801				

Constituent	(Units)	14	15	16	17	18	19	20	21	22	23	24	25	26
<b>O</b> <sub>2</sub>	(Lbm/hr)	43720	90319	66680	156999	183585	641283	641283	641283	643801				
N2		144835	299208	220899	520107	524975	2124443	2124443	2124443	2132785				
H2O		2445	5051	3729	8779	46599	35860	35860	35860	36001				
CO <sub>2</sub>														
SO <sub>2</sub>														
H2						16102								
CH₄														
Carbon						236655								
Sulfur						10110								
Ca														
Mg														
MgO														
MgSO₃														
MgSO₄														
CaSO <sub>3</sub>														
CaSO4														
CaCO <sub>3</sub>														
Ash / Inerts						42313					8463			
Total Gas	(Lbm/hr)	Air Htr Lkg Air 191000	394577	Hot Pri Air 291308	Mixed Pri Air 685885	Coal-Pri Air Mix	Sec Air to FD 2801587	Sec Air to SCAH 2801587	Sec Air to AH 2801587	Hot Sec Air 2812587	Bottom Ash	CO2 to Comp	CO2 Product	Vent Stream
Total Solids	(LDIII/III)	191000	334377	291300	000000		2001307	2001307	2001307	2012307	8463			
Total Flow		191000	394577	291308	685885	1060340	2801587	2801587	2801587	2812587	8463			
Temperature	(Deg F)	92	92	666	339		80	86.4	86.4	616	2000			
Pressure	(Psia)	15.6	15.6	15.6	15.6	15.0	14.7	15.2	15.1	14.9	14.7			
hsensible	(Btu/lbm)	2.899	2.899	145.249	63.358		0.000	1.549	1.549	132.582	480.000			
Chemical	(10 <sup>6</sup> Btu/hr)					4228.715								
	(10 <sup>6</sup> Btu/hr)	0.554	1.144	42.312	43.456	4220.710	0.000	4.341	4.341	372.898	4.062			
	(10 <sup>6</sup> Btu/hr)										4.062			
	(10 <sup>6</sup> Btu/hr)	2.567	5.303 6.447	3.915 46.227	9.218	4281.389	37.653	37.653	37.653 41.994	37.801 410.699	4.062			
i utai Energy	(TO Blu/III)	3.121	b.447	46.227	52.674	4281.389	37.653	41.994	41.994	410.699	4.062			

Boiler efficiency is calculated to be 88.13 percent (HHV Basis), the same as for the Base Case. The net plant heat rate is increased significantly to 16,626 Btu/kwhr (HHV Basis) for this option as shown in Table 3.2.2 which also includes the Base Case for comparison. The plant thermal efficiency for Concept A (20.53%, HHV basis) is about 59 percent of the Base Case value (35.01%), indicating an energy penalty of ~41%. Auxiliary power is increased to 76,007 kw and the net plant output is reduced to 254,414 kw. Carbon dioxide emissions are 33,084 lbm/hr or about 0.13 lbm/kwhr.

# Table 3.2. 2: Overall Plant Performance Summary (Concept A)

	(units)	Original Plant (Base)	Concept A MEA
Fuel Paramaters	_		
Coal Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		4228.7
Natural Gas Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		17.7
Total Fuel Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4246.4
Steam Cycle Paramaters			
Existing Steam Turbine Generator Output	(kW)	463478	269341
CO2 Removal System Turbine Generator Output	(kW)	0	62081
Total Turbine Generator Output	(kW)	463478	331422
Total Auxiliary Power	(kW)	29700	76007
Net Plant Output	(kW)	433778	255414
Overall Plant Performance Paramaters			
Net Plant Efficiency (HHV)	(fraction)	0.3501	0.2053
Net Plant Efficiency (LHV)	(fraction)	0.3666	0.2150
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000	0.5864
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749	16626
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309	15872
Overall Plant CO <sub>2</sub> Emissions			
Carbon Dioxide Emissions	(lbm/hr)	866102	33084
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997	0.130
Normalized Specific CO2 Emissions (Relative to Base Case)	(fraction)	1.000	0.065
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)		1.867

# 3.2.2 Boiler Analysis

The boiler performance in Concept A is identical to that of the Base Case described previously in Section 2.3 and will not be repeated here.

# 3.2.3 Steam Cycle Modifications and Performance

The steam cycle system for Concept A is modified as shown in Figure 3.2.2 while Figure 3.2.3 shows the associated Mollier diagram. About 79 percent of the IP turbine exhaust is extracted from the IP/LP crossover pipe. This steam is expanded to about 65 psia through a new steam turbine generating 62,081 kw. The exhaust from the new turbine, at about 478 F, is de-superheated and then provides the energy requirement for the solvent regeneration done in the reboiler's of the MEA  $CO_2$  removal system. The condensate from the reboiler's is pumped to the Deaerator. The modified existing steam cycle system produces 269,341 kw. The total output from both generators is 331,422 kw. This represents a gross output reduction of 132,056 kw (about 28.5%) as compared to the Base Case. A yet unsolved uncertainty is whether the existing low-pressure turbine can be operated over the required load range with the such a small fraction of the original design steam mass flow rate. The answer to this question was beyond the scope of the current project.

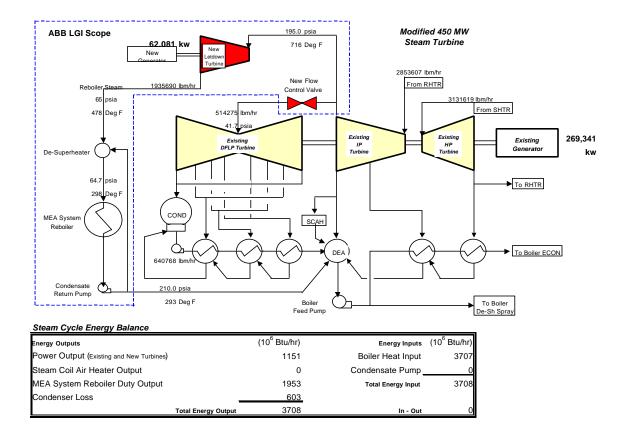


Figure 3.2. 2: Modified Steam Cycle Diagram and Performance (Concept A)

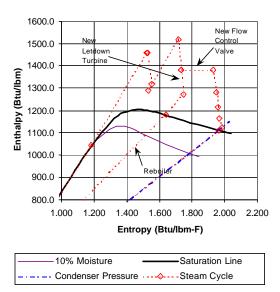


Figure 3.2. 3: Modified Steam Cycle Mollier Diagram (Concept A)

# 3.2.4 Flue Gas Desulfurization System Analysis

The FGD system for Concept A is modified with the addition of a secondary absorber to reduce the  $SO_2$  content to 10 vppm or less as required by the amine system downstream. The principle of operation is as briefly described previously in Section 2.3.5. In this case, however, the flue gas leaving the existing FGD system's absorber is supplied to the new secondary absorber and the flue gas leaving the secondary absorber provides the feed stream for the amine  $CO_2$  absorption system, as discussed later in Section 3.2.5. Additional piping and ductwork is required as is shown in Figure 3.2.4 process flow diagram.

Table 3.2.3 identifies the assumptions that were made in predicting the FGD performance.

Table 3.2.4 shows the gas constituents at the existing Absorber inlet and secondary Absorber outlet. Results show a  $CO_2/SO_2$  mole ratio of 63 and an  $SO_2$  removal efficiency of 99.7%, corresponding to a value of 6.5 vppm at the outlet of the secondary absorber.

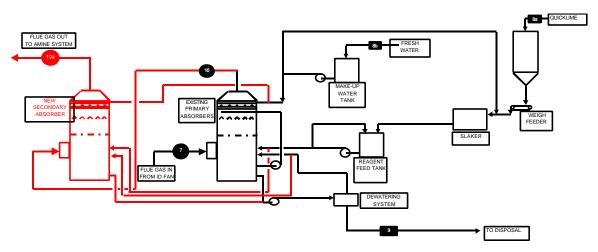


Figure 3.2. 4: Modified FGD System Process Flow Diagram (Concept A)

	Concept A	(MEA)	
Quantity	Unit	Existing Absorber	Secondary Absorber
Ca/S)	Mol Ratio	1.04	1.04
Solids	Wt.%	20	20
CaO	Wt.%	90	90
MgO	Wt.%	5	5
Inerts	Wt.%	5	5
By-pass Leakage	Wt.%	2.5	0
Liquid/Gas (L/G) Ratio	gpm/1000 acfm	75	45
SO <sub>2</sub> Removal Efficiency			
APC	%	94.8	93.0
Absorber	%	97.2	93.0

Table 3.2. 3:FGD Assumptions

	Concept A (MEA)											
	Exi	sting Absorb	er Inlet	Secondary Absorber Outlet								
Species	Mol/hr	Vol.%	Unit	Mol/hr	Vol.%	Unit						
O <sub>2</sub>	4,469	3.14	Vol.%	4,461	2.90	Vol.%						
N <sub>2</sub>	105,018	73.74	Vol.%	105,018	68.30	Vol.%						
H <sub>2</sub> O	12,863	9.03	Vol.%	24,555	15.97	Vol.%						
CO <sub>2</sub>	19,743	13.86	Vol.%	19,718	12.82	Vol.%						
SO <sub>2</sub>	315	2,212	vppm	1	6.50	vppm						
SO <sub>2</sub> Removal Efficiency, %					99.7							
CO <sub>2</sub> /SO <sub>2</sub> Mole Ratio		63										

# Table 3.2.4:FGD Performance

# 3.2.5 Carbon Dioxide Separation and Compression System

The Kerr-McGee/ABB Lummus amine technology is used for the Concept A  $CO_2$  removal system. This system is the most proven of the three processes analyzed in this study. An important feature of this  $CO_2$  recovery technology is its flexibility to operate with boilers or co-generation systems that fire fuels ranging from natural gas to high-sulfur coal and coke. The process tolerates oxygen in the flue gas as well as limited amount of sulfur dioxide. Low corrosion rates and minimal loss of the circulating solvent used to absorb  $CO_2$  ensure economical and reliable operation.

Kerr-McGee started up their 800 TPD  $CO_2$  recovery unit in 1978. The Trona unit has been fed flue gases from boilers fired with natural gas, coal and coke. During its first several years of operation, the installation was improved in terms of reliability and cost effectiveness. As of January 1992, three units have been licensed using this technology. They are:

1.) Applied Energy Systems, Poteau, Oklahoma. This 300 MW coal-fired co-generation plant incorporates a 200 TPD food-grade liquid  $CO_2$  unit as the steam host. Startup was completed in January 1991. Lummus Crest was responsible for engineering, procurement, and construction of the entire facility, including the power plant. Lummus Crest made several design improvements to the AES facility.

2.) Soda Ash Botswana, Pty. Ltd., Sue Pan, Botswana. This soda ash facility, incorporating a 300 TPD  $CO_2$  unit, started up in March 1991.

3.) AES Corporation is building a second food grade  $CO_2$  plant in Warrior run, Pennsylvania using the Kerr-McGee / Lummus technology. This is a 150 short tons/day liquid  $CO_2$  plant, using flue gas from coal fired circulating fluidized bed (CFB) boilers, was commissioned in 1999.

In late 1990, Kerr-McGee and Lummus Global concluded a joint licensing agreement whereby Lummus gained worldwide exclusive marketing rights to Kerr-McGee's  $CO_2$  recovery technology and became responsible for marketing and basic engineering. Kerr-McGee maintains a continuing role in technology transfer, process improvement, quality control of new designs, operator training, and licensing. In addition to providing an experience list for the amine part of the process, these plants also contain  $CO_2$  compression and liquefaction facilities. These plants compress the  $CO_2$  to a slightly higher pressure and utilize ammonia refrigeration. Many of these plants make food grade  $CO_2$ .

# 3.2.5.1 Introduction

The CO<sub>2</sub> Recovery Unit for Concept A is comprised of the following sections:

- Flue Gas Pretreatment
- Absorption
- Stripping
- CO<sub>2</sub> Compression and Liquefaction
- Drying

The flue gas pretreatment section cools and conditions the flue gas, which is then fed to the  $CO_2$  Absorber (or  $CO_2$  contactor as it is often called). In the Absorber,  $CO_2$  is removed from the gas by contacting it, in countercurrent fashion, with monoethanolamine (MEA). The recovered  $CO_2$  is then stripped off in the Stripper (or Regenerator) from where the lean solvent is recycled back to the Absorber. Solvent regeneration for Concept A requires about  $4.7 \times 10^6$  Btu/Ton  $CO_2$ . The overhead vapor from the Stripper is cooled to condense most of the water vapor. The condensate is used as reflux in the Stripper and the wet  $CO_2$  stream is fed forward to the  $CO_2$  Compression and Liquefaction System. Here the  $CO_2$  product is compressed and dried so it can be pumped to its final destination. No specific destination has been chosen for the product pipeline. It has been assumed to end at the battery limit for costing purposes.

A brief description of the processing scheme for Concept A is given in the following paragraphs. Description of the package units is indicative only and may vary for the chosen supplier of the package unit

# 3.2.5.2 Process Description

This section refers to the following process flow diagrams, which are shown in Section 3.2.5.3:

# PROCESS FLOW DIAGRAMS - CONCEPT A:

- Figure 3.2.5:Drawing D 09484-01001R-0: Flue Gas Cooling and CO<sub>2</sub> Absorption
- Figure 3.2.6:Drawing D 09484-01002R-0: Solvent Stripping
- Figure 3.2.7:Drawing D 09484-01003R-0: CO<sub>2</sub> Compression and Liquefaction

The designs include several process trains. Only one train is shown. The note section of the PFD tells how many trains are included in the complete system. To avoid confusion, suffixes have been used to indicate parallel equipment. These are mainly for spared pumps and drier vessels in parallel. Even if there are several trains, only one drawing (typical) has been prepared to represent all of the trains. On these drawings, flow splits to the other parallel trains have been shown. Similarly, flows coming from other parallel trains and converging to a single common stream have also been shown.

A note about stream numbering convention is also necessary. The stream numbers have not been tagged with "A", "B", etc. to indicate which train they belong to. Instead, the flow rate given in the material balance for each stream is the actual flow rate for the stream within the train. The combined flow from all of the trains leaving a process step shows the total flow going to the next process step. As an example, stream 8 (Drawing D 09484-01001R-0) is the Rich Amine stream leaving one train of the absorber process step, and comprises 1/5 of the total rich amine. Stream 9A is the total rich amine going to the Solvent Stripping process step. Stream 9A appears on both the absorber and solvent stripper PFD's. After the rich amine flow sheet continuation block, the stream splits 9 ways for the 9 stripping trains. Then stream 9 continues for processing on the solvent stripper PFD (Drawing D 09484-01002R-0), with 1/9 of the flow entering the rich-lean solvent exchanger (EA-2205). The numbering practice for Concept C is the same as for Concept A.

# Flue Gas Pretreatment:

The pressure profile of the  $CO_2$  capture equipment is contained in the material balance. Since the flue gas pretreatment equipment flow scheme includes a blower, the pressure profile of the existing power generation equipment does not change from today's operation. To force the flue gas from the secondary FGD through the  $CO_2$ 

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Absorber, the pressure of the flue gas after sulfur removal is boosted to 1.5 psig by a motor driven fan. As the power consumption of the fan is considerable, the duct size must be chosen not to add excessive pressure drop for the 1200 feet it takes to get to the absorbers. The blower will run at constant speed. Each blower, provided as part of the boiler flue gas conditioning equipment, is equipped with its own suction and a discharge damper operated pneumatically. The suction damper controls the suction pressure to adjust for the flow variation resulting from the power plant performance. The suction pressure control will avoid any surges to blower. The discharge damper is an isolation damper.

# Direct Contact Cooling (Refer to Drawing No. D 09484-01001R-0):

The Direct Contact flue gas Cooler (DCC) is a packed column where the hot flue gas flowing up is brought into an intimate contact with cold water which is fed to the top of the bed and flows down the tower. Physically, DA-2101 and DA-2102 have been combined into a single, albeit compartmentalized tower. DA-2101 is the lower one and is designed to support DA-2102 so that the top head of DA-2101 is the bottom head of DA-102. Effectively, this dividing head acts as a chimney tray with a number of upward extending chimneys which provide passages for the flue gas to flow directly from the DCC into the Absorber.

Theoretically, a direct contact cooler is capable of cooling the gas to a very close approach in a short bed. When the hot gas enters the DCC, the gas contains water but is highly superheated. At the bottom end of the bed, the gas is quickly cooled to a temperature known as the "Adiabatic Saturation Temperature" (AST). This is the temperature the gas reaches when some of its own heat content has been used to vaporize just the exact amount of water to saturate the gas.

Up to the point when the AST is reached, the mass flow of the gas stream increases due to evaporation of water. At the AST, water vapor contained in the gas begins to condense. And, as the gas travels up the column and cools further, more and more water is condensed. This internal refluxing increases the V/L traffic at the bottom end of the bed significantly beyond the external flows and must be considered in the hydraulic design.

The water stream that leaves the bottom of the DCC contains the water fed to the top as well as any water that has condensed out of the flue gas. The condensed water may be somewhat corrosive due to sulfur and nitrogen oxides that may be present in the flue gas. Therefore, instead of using the condensate in the process, it will be blown down from the system. For the DCC to be effective, the temperature of the leaving water must always be lower than the AST.

Most of the water leaving the bottom of the DCC is circulated back to the top of the direct contact cooler by DCC Water Pump GA-2102 A/B. However, before sending it back to the column the water stream is first filtered in DCC Water Filter FD-2101 and then cooled in DCC Water Cooler EA-2101 against the water from the new cooling tower. Temperature of the cooled water is controlled by a cascade loop which maintains a constant flue gas exit temperature (Absorber feed temperature). Because of the relatively low cooling water temperature at the plant, the circulating water is cooled down to 95 °F which, in turn, easily cools the gas down to 115 °F.

Filtration is necessary to remove any particulate matter that may enter the DCC in the flue gas. The blowdown is taken out after the filter but before the cooler and mixed into the return water of cooler EA-2101. This way the cooler does not have to handle the extra duty that would otherwise be imposed by the blowdown stream.

# Absorption:

# CO<sub>2</sub> Absorber DA-2102 (Refer to Drawing No. D 09484-01001R-0):

From the DCC the cooled flue gas enters the bottom of the  $CO_2$  Absorber and flows up the tower countercurrent to a stream of 20-wt.% monoethanolamine (MEA) solution. The lean MEA solution (LAM) enters the top of the column and heats up gradually as more and more  $CO_2$  is absorbed. By the time the stream leaves the bottom of the tower it has gained approximately 28 °F. The tower has been designed to remove 94% of the  $CO_2$  in the incoming gas. The  $CO_2$  loading in LAM is 0.215 mol  $CO_2$  / mol MEA while the loading of the rich amine leaving the bottom is 0.44 mol  $CO_2$  / mol MEA. These values are consistent with the values reported by Rochelle (2000).

To maintain water balance in the process, it is imperative that the temperature of the LAM feed be very close to that of the feed gas stream. Thus, with feed gas temperature fixed at 115 °F, the temperature of the LAM stream must also be

close to 115 °F, preferably within 10 °F. If the feed gas comes in at a higher temperature than the LAM, it brings in excess moisture, which condenses in the Absorber and becomes excess water. Unless this water is purged from the system, the concentration of MEA will decrease and the performance of the system will suffer. If, on the other hand, the gas feed is colder than the LAM, it heats up in the tower and picks up extra moisture that is then carried out of the system by the vent gas. The result is a water deficiency situation because more water is removed than what comes into the system.

For the reasons explained above, it is essential that both the temperature of the flue gas and that of the LAM be accurately controlled. In fact, it is best to control one temperature and adjust the temperature of the other to maintain a fixed temperature difference. The design difference is approximately 10 °F. The LAM temperature was chosen to be the "master" and the gas temperature to be the "slave".

The rich MEA solvent solution from the bottom of the absorber at 133 °F is heated to 204 °F by heat exchange with lean MEA solvent solution returning from the stripping column. The rich MEA solvent is then fed to the top of the stripping column. The lean MEA solvent solution thus partially cooled to 143 °F is further cooled to 105 °F by exchange with cooling water and fed back to the absorber to complete the circuit.

 $CO_2$  Absorber DA-2102 is a packed tower which contains two beds of structured packing and a third bed, the so called "Wash Zone", at the very top of the column. There is also a liquid distributor at the top of each of bed. The distributors for the main beds are of high-quality design. There are several reasons for selecting structured packing for this service:

- Very low pressure drop which minimizes fan horsepower
- High contact efficiency / low packing height
- Good tolerance for maldistribution in a large tower
- Smallest possible tower diameter
- Light weight

At the bottom of the tower, there is the equivalent of a chimney tray, which serves as the bottom sump for the Absorber. Instead of being flat like a typical chimney tray, it is a standard dished head with chimneys. The hold-up volume of the bottom sump is sufficient to accept all the liquid held up in the packing both in the  $CO_2$  Absorber and in the Wash Zone. Rich Solvent Pump GA-2103 A/D takes suction from the chimney tray.

# Absorber Wash Zone (Refer to Drawing. No. D 09484-01001R-0):

The purpose of the Wash Zone at the top of the tower is to minimize MEA losses both due to mechanical entrainment and also due to evaporation. This is achieved by circulating wash water in this section to scrub most of the MEA from the lean gas exiting the Absorber. The key to minimizing MEA carryover is a mist separator pad between the wash section and the Absorber. But, the demister can not stop losses of gaseous MEA carried in the flue gas. This is accomplished by scrubbing the gas with countercurrent flow of water. Wash Water Pump GA-2101 takes water from the bottom of the wash zone and circulates it back to the top of the bed. Circulation rate has been chosen to irrigate the packing sufficiently for efficient operation.

The key to successful scrubbing is to maintain a low concentration of MEA in the circulating water. The higher the concentration, the higher the vapor pressure of MEA and, consequently, the higher the MEA losses. Therefore, relatively clean water must be fed to the wash zone as make-up while an equal amount of MEA laden water is drawn out. A simple gooseneck seal accomplishes this and maintains a level on the chimney tray at the bottom of the wash section. Overflow goes to the main absorber. Make-up water comes from the overhead system of the Solvent Stripper.

The lean flue gas leaving the wash zone is released to atmosphere. The top of the tower has been designed as stack which is made high enough to ensure proper dispersion of the exiting gas.

# Rich/Lean Solvent Exchanger EA-2205 (Refer to Drawing No. D 09484-01002R-0):

The Rich/Lean Solvent Exchanger is a plate type exchanger with rich solution on one side and lean solution on the other. The purpose of the exchanger is to recover as much heat as possible from the hot lean solvent from the bottom

of the Solvent Stripper by heating the rich solvent feeding the Solvent Stripper. This reduces the duty of the Solvent Stripper Reboiler. This exchanger is the single most important item in the energy economy of the entire  $CO_2$  Recovery Unit. For this study, 10°F approach was chosen to maximize the heat recovery. An air cooler (EC-2201) was added on the lean amine stream leaving the Solvent Stripper. This was to reduce the plot space requirement (compared to placing the air cooler downstream of the rich/ lean exchanger) and overall cost of the project. A study was performed to determine that heat transfer via the plate frame type lean/ rich exchanger is relatively cheap which justifies tight temperature approaches with this type of exchanger.

# Stripping:

Solvent Stripper DA-2201 (Refer to Drawing No. D 09484-01002R-0):

The solvent Stripper is a packed tower which contains two beds of structured packing and a third bed, so called the "wash zone" at the very top of the column. The purpose of the Solvent Stripper is to separate the  $CO_2$  (contained in the rich solvent) from the bottom stream of the  $CO_2$  Absorber that is feeding the stripper. As the solvent flows down, the bottom hot vapor from the reboiler continues to strip the  $CO_2$  from the solution. The final stripping action occurs in the reboiler. The hot wet vapors from the top of the stripper contain the  $CO_2$ , along with water vapor, and solvent vapor. The overhead vapors are cooled by Solvent Stripper CW Condenser (EA-2206) where most of the water and solvent vapors condense. The  $CO_2$  does not condense. The condensed overhead liquid and gaseous  $CO_2$  are separated in a reflux drum (FA-2201).  $CO_2$  flows to the  $CO_2$  purification section on pressure control and the liquid (called reflux) is returned via Solvent Stripper Reflux Pump (GA-2202A/B) to the top bed in the stripper. The top bed of the stripper is a water wash zone designed to limit the amount of solvent (MEA) vapors entering the stripper overhead system.

# Solvent Stripper Reboiler EA-2201 (Refer to Drawing No. D 09484-01002R-0):

The steam-heated reboiler is a vertical shell and tube thermosyphon type exchanger using inside coated high flux tubing proprietary of UOP. Circulation of the solvent solution through the reboiler is natural and is driven by gravity and density differences. The reboiler tube side handles the solvent solution and the shell side handles the steam. The energy requirement for the removal of  $CO_2$  is about 2.6 tons of steam per ton of  $CO_2$  for Concept A.

# Solvent Reclaimer EA-2203 (Refer to Drawing No. D 09484-01002R-0):

The Solvent Stripper Reclaimer is a horizontal heat exchanger. Certain acidic gases, present in the flue gas feeding the  $CO_2$  absorber, form compounds with the MEA in the solvent solution that cannot be regenerated by application of heat in the solvent stripper reboiler. These materials are referred to as "Heat Stable Salts" (HSS). A small slipstream of the lean solvent from the discharge of the Solvent Stripper Bottoms Pump (GA-2201A/B/C) is fed to the Solvent Reclaimer. The reclaimer restores the MEA usefulness by removing the high boiling and nonvolatile impurities, such as HSS, suspended solids, acids and iron products from the circulating solvent solution. Caustic is added into the reclaimer to free MEA up from its bond with sulfur oxides by its stronger basic attribute. This allows the MEA to be vaporized back into the circulating mixture, minimizing MEA loss. This process is important in reducing corrosion, and fouling in the solvent system. The reclaimer bottoms are cooled (EA-2204) and are supplied to a tank truck without any interim storage.

# Solvent Stripper Condenser EA-2206 (Refer to Drawing No. D 09484-01002R-0):

EA-2206 is a water-cooled shell and tube exchanger. The purpose of the condenser is to completely condense all components contained in the overhead vapor stream that can condense under the operating conditions, with the use of cooling water as the condensing medium. Components that do not condense include nitrogen, carbon dioxide, oxygen, nitrogen oxides and carbon monoxide. The water vapor and MEA solvent vapor will condense and the condensed water will dissolve some carbon dioxide. This exchanger uses cooling water capacity freed up due to the reduced load on the existing surface condensers of the power plant. The same is true for the lean solvent cooler (EA-2202).

# Solvent Stripper Reflux Drum, FA-2201 (Refer to Drawing No. D 09484-01002R-0):

The purpose of the reflux drum is to provide space and time for the separation of liquid and gases and also provide liquid hold-up volume for suction to the reflux pumps and also provides surge for pre-coat filter. The separation is not perfect, as a small amount of carbon dioxide is left in the liquid being returned to the stripper and the  $CO_2$ , saturated with water, is routed to the  $CO_2$  compression and liquefaction system.

Solvent Stripper Reflux Pump, GA-2202 (Refer to Drawing No. D 09484-01002R-0): This pump takes suction from the reflux drum and discharges on flow control to the stripper top tray as reflux.

Solvent Filtration Package, PA-2251 (Refer to Drawing No. D 09484-01002R-0):

Precoat Filter PA-2251 is no ordinary filter; it is a small system. The main component is a pressure vessel that has a number of so called "leaves" through which MEA flows. The leaves have a thin (1/8 inch) coating of silica powder which acts to filter off any solids. For the purposes of such application the powder is called "filter aid".

To cover the leaves with the filter aid, the filter must be "precoated" before putting it into service. This is accomplished by mixing filter aid in water in a predetermined ratio (typically 10-wt %) to prepare a slurry. This takes place in an agitated tank. A pump, which takes its suction from this tank, is then operated to pump the slurry into the filter. Provided the flow rate is high enough, the filter aid is deposited on the leaves while water passes through and can be recycled back to the tank. This is continued until the water in the tank becomes clear indicating that all the filter aid has been transferred.

The volume of a single batch in the tank is typically 125% of the filter volume because there must be enough to fill the vessel and have some excess left over so level in the tank is maintained and circulation can continue. In this design, water from the Stripper overhead will be used as make-up water to fill the tank. This way the water balance of the plant is not affected.

During normal operation, it is often beneficial to add so-called "body" which is the same material as the precoat but may be of different particle size. The body is also slurried in water but is continually added to the filter during operation. This keeps the filter coating porous and prevents rapid plugging and loss of capacity. As the description suggests, an agitated tank is needed to prepare the batch. A metering pump is then used to add the body at preset rate to the filter.

When the filter is exhausted (as indicated by pressure drop), it is taken off line so the dirty filter aid can be removed and replaced with fresh material. To accomplish this, the filter must be drained. This is accomplished by pressurizing the filter vessel with nitrogen and pushing the MEA solution out of the filter. After this step, the filter is depressurized. Then, a motor is started to rotate the leaves so a set of scrapers will wipe the filter cake off the leaves. The loosened cake then falls off into a conveyor trough in the bottom of the vessel. This motor operated conveyor then pushes the used cake out of the vessel and into a disposal container (oil drum or similar). The rejected cake has the consistency of toothpaste. This design is called "dry cake" filter and minimizes the amount of waste produced.

For this application, some 2% of the circulating MEA will be forced to flow through the filter. In fact, Filter Circulating Pump GA-2203 draws the liquid through the filter as it has been installed downstream of the filter. The advantage of placing the pump on the outlet side of the filter is reduced design pressure of the filter vessel and associated piping. In spite of the restriction on its suction side, ample NPSH is still available for the pump. Flow is controlled on the downstream side of the pump.

# Corrosion Inhibitor (Refer to Drawing No. D 09484-01002R-0):

Corrosion inhibitor chemical is injected into the process constantly to help control the rate of corrosion throughout the  $CO_2$  recovery plant system. Since rates of corrosion increase with high MEA concentrations and elevated temperatures, the inhibitor is injected at appropriate points to minimize the corrosion potential. The inhibitor is stored in a tank (Part of the Package, not shown) and is injected into the system via injection pump (Part of the Package, not shown). The pump is a diaphragm-metering pump.

The selection of metallurgy in different parts of the plant is based on the performance feedback obtained from our similar commercial units in operation over a long period of time.

# CO<sub>2</sub> Compression and Liquefaction:

# (Refer to Drawing. No. D 09484-01003R-0):

 $CO_2$  from the solvent stripper reflux drum, GA-2201, saturated with water, is compressed in a three stage centrifugal compressor using the air and cooling water from the new cooling tower for interstage and after compression cooling.

The interstage coolers for first and second stage are designed to supply 95 °F  $CO_2$  to the compressor to minimize the compression power requirements.

Most of the water in the wet  $CO_2$  stream is knocked out during compression and is removed from intermediate suction drums. A  $CO_2$  drier is located after the third stage to meet the water specifications for the  $CO_2$  product. The water-free  $CO_2$  is liquefied after the third stage of compression at about 194 psig pressure and is further pumped with a  $CO_2$  pump (GA-2301) to the required battery limit pressure of 2000 psig.

# Drying:

CO<sub>2</sub> DRIER, FF-2351 (Refer to Drawing No. D 09484-01003R-0):

The purpose of the  $CO_2$  drier is to reduce the moisture content of the  $CO_2$  product to less than 20 vppm to meet pipeline transport specifications. The drier package, FF-2351, includes four drier vessels, three of which are in service while one is being regenerated or is on standby. The package also includes a natural gas fired regeneration heater and a cooled regeneration cooler. The exchanger will have a knock out cooler downstream for separating the condensed water. The drier size used as a basis for cost estimate is good for 10 hour run length based on 3A molecular sieve.

The drier is located on the discharge side of the 3rd Stage of the  $CO_2$  Compressor. Considering the cost of the vessel and the performance of the desiccant, this is the location favored by vendors. The temperature of the  $CO_2$  stream entering the drier is 90 °F.

Once a bed is exhausted, it is taken off line and a slipstream of effluent from the on line beds is directed into this drier after being boosted in pressure by a compressor. Before the slipstream enters the bed that is to be regenerated, it is heated to a high temperature. Under this high temperature, moisture is released from the bed and carried away in the  $CO_2$  stream. The regeneration gas is then cooled to the feed gas temperature to condense any excess moisture. After this, the regeneration gas stream is mixed with the feed gas upstream of the third stage knockout drum.

All the regeneration operations are controlled by a PLC that switches the position of several valves to direct the flow to the proper drier. It also controls the regeneration compressor, heater, and cooler. Because the regeneration gas has the same composition as the feed gas, it also contains some moisture. Thus, it is primarily the heat ("temperature swing") that regenerates the bed.

# 3.2.5.3 Process Flow Diagrams

The processes described above are illustrated in the following process flow diagrams:

- Figure 3.2.5: Drawing D 09484-01001R-0: Flue Gas Cooling and CO<sub>2</sub> Absorption
- Figure 3.2.6: Drawing D 09484-01002R-0: Solvent Stripping
- Figure 3.2.7: Drawing D 09484-01003R-0: CO<sub>2</sub> Compression and Liquefaction

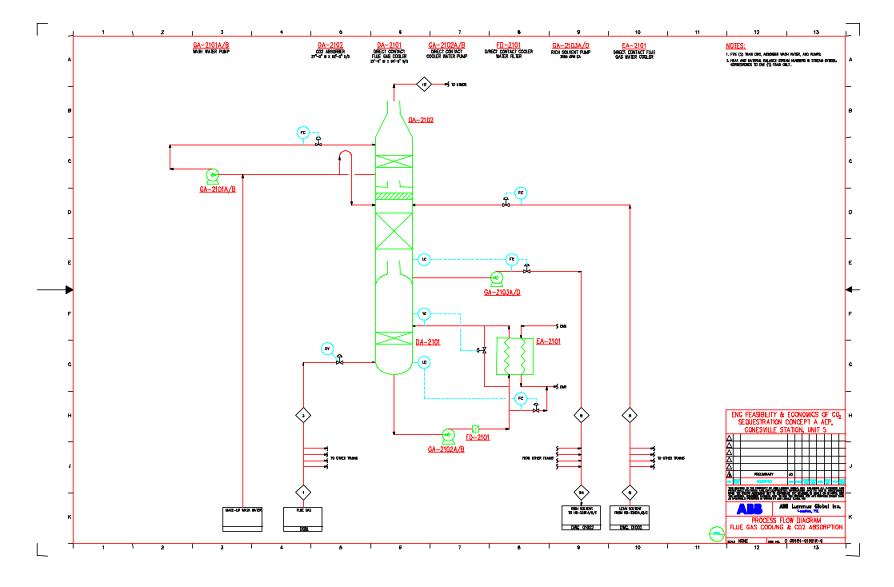


Figure 3.2. 5: Process Flow Diagram for Concept A: Flue Gas Cooling and CO<sub>2</sub> Absorption

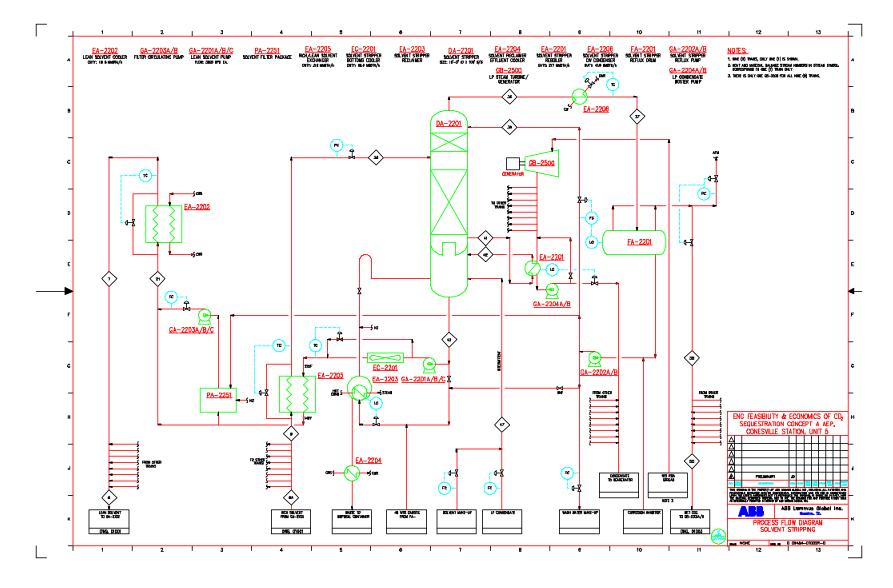


Figure 3.2. 6: Process Flow Diagram for Concept A: Solvent Stripping

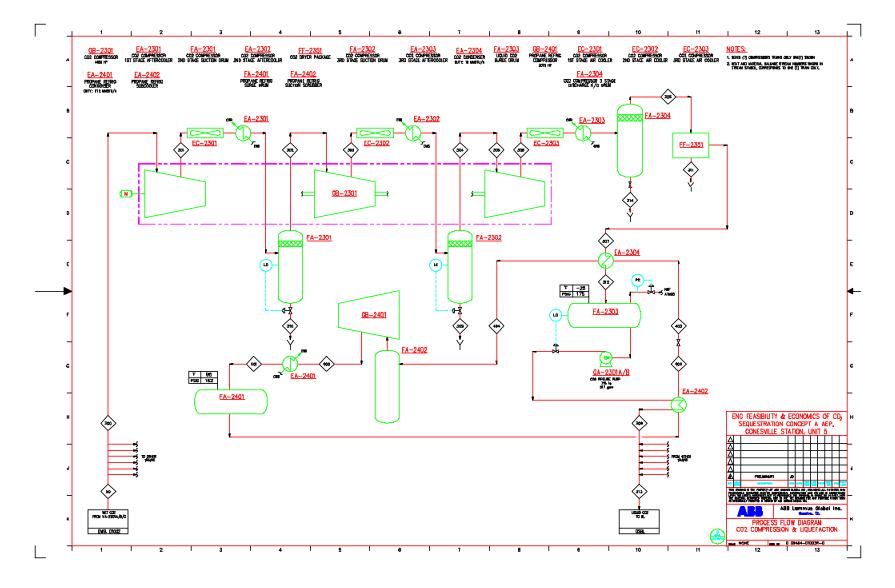


Figure 3.2. 7: Process Flow Diagram for Concept A: CO<sub>2</sub> Compression and Liquefaction

# 3.2.5.4 Overall Material and Energy Balance

The material balances (Tables 3.2.5 and 3.2.6) were run on two process simulators: Hysim and Amsim. Amsim was used for the Absorption/Stripping systems while Hysim was used for the conventional systems as follows:

•	Flue Gas feed	Hysim
-		11,01111

- SO<sub>2</sub> scrubber ALSTOM Power Program
- Absorber and Stripper Amsim
- Compression Hysim
- Heat Pumps Hysim

The two simulators use a different reference enthalpy. They also use slightly different calculation methods for determining water saturation quantities. There is no simple way to normalize the enthalpies to the same reference. Thus, the enthalpies given in the balance are the values copied directly from the simulation. This creates a discontinuity at the interface between Hysim and Amsim simulations. Take for example the wet  $CO_2$  flow to the  $CO_2$  compressor. The stream comes from the Stripper overhead system, which was simulated with Amsim and enters the  $CO_2$  compressor, which was simulated using Hysim. For this particular stream, the enthalpy value given in the balance comes from Hysim. Lastly, convergence algorithms allow the programs to slightly alter input streams. Thus some leniency and care should be exercised when using such interface streams for heat balance checks.

This section contains heat and material balances for Concept A. See the comments under "Process Flow Diagrams" (Section 3.2.5.3) for comments about stream numbering philosophies.

Table 3.2. 5:	Material and Energy Balance for Concept A Amine System
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·			1				Delever		-			Disk Assistants	Rich Amine from
STREAM NAME		Total Sour Gas Feed	Sour Gas Feedto Precontactor	PrecontactorGas Outlet	Gas Feed to Absorber A	Absorber A Inlet Separator Liquid	Primary LeanAmine Feed to Absorber A	Rich Amine from Absorber A	Absorber A Total Treated Gas	Total Rich Amine	Rich Amine Feed to Flash Tank	Rich Amine to Lean/Rich Heat Exchanger	Lean/Rich Heat Exchanger
STREAM NO.		1	3				5	8	12	9a	9	9	12
LIQUID FRACTION		0.000	0.000	0.000	0.000	1.000	1.000	1.000	0.000	1.000	1.000	1.000	0.995
TEMPERATURE	F	150	115	115	115	115	105	133	106	133	133	133	204
PRESSURE	PSIA	16.5	16.5	16.5	16.5	16.5	14.9	16.5	14.9	16.5	16.5	16.5	16.5
COMPONENTS													
(	hMol/Hr	19,684.00	3,936.80	3,936.80	3,936.23	0.14	3,585.44	7,380.58	141 10	36,902.89	4,100.32	4,100.32	4,100.32
	bMol/Hr	0.00	0.00	0.00	0.00	0.00	16.765.89	16.763.07	2.82	83.815.36	9.312.82	9.312.82	9.312.82
· ,	bMol/Hr bMol/Hr	24,551.0	4,910.2	4,910.2	2,544.8	2,365.5	227,379.0	228,257.6	1,666.3	1,141,288.0	126,809.8	126,809.8	126,809.8
	bMol/Hr	105.079.00	21.015.80	21.015.80	21.016.14	0.00	0.00	1.75	21.014.40	0.00	0.00	0.00	0.00
	bMol/Hr	4 518 00	903.60	903.60	903.61	0.02	0.00	0.14	21.014.40	0.70	0.97	0.97	0.08
	bMol/Hr	153.832.0	30,766,4	30,766,4	28,400.8	2.365.6	247,730,4	252,403,2	23,728,1	1.262.016.0	140.224.0	140.224.0	140.224.0
VAPOR													
MASS FLOW RATE	Lb/Hr	446.600.625	3.572.805	3.572.805	3.397.068				2.438.328				
STD. VOL. FLOW RATE M	MSCED	1401.1	280.22	280.22	258.66				216.1				
	MACED	1378	275.6	275.6	254.5				231 72				
MOLECULAR WEIGHT	MW	285.821	57.1642	57.1642	58.9234				55.1246				
	Lb/Et <sup>3</sup>	0 765	0 153	0 153	0 1576				0.1354				
GAS COMPRESSIBILITY VISCOSITY	л.	0	0	0	0				0				
VISCUSITY HEAT CAPACITY E	ar Stu/l h E	0	0	0	0				0				
	u/Hr-ft-F	127,9580	25.5916	25.5916	27.7192				1,1892				
MASS FLOW RATE	l b/Hr					85.263	10.557.848	10.923.302		273.082.551	3.371.390	3.371.390	3.371.390
STD. VOL. FLOW RATE	GPM					85.26	10252.78	10352.54		51762.70	5751.41	5751.41	5751.41
ACTUAL VOL. FLOW RATE	GPM					86.02	10308.54	10467.22		52336.10	5815.12	5815.12	5940.30
MOLECULAR WEIGHT	MW					18.02	21.31	21.64		21.64	21.64	21.64	21.64
STD DENSITY	Lb/Et <sup>3</sup>					62.34	64.19	65.77		65.77	65.77	65.77	65.77
VISCOSITY HEAT CAPACITY E	dP Btu/Lb-F					0.6383	0.8608	0.6868		0.6868	0.6868	0.6868	0.3544
	SIU/LD-F					0.9946	0.9557			0.011		0.011	
THERMAL CONDUCTIVITY Bru	u/Hr-ft-F					0.3979	0.3557	0.3557	Loan Amino from	0.3557	0.3557	0.3557	0.3557
STREAM NAME	u/Hr-ft-F	Rich Amine Feed to Regenerator	RegeneratorOverh ead Vapor	RegeneratorConde nser Outlet	Acid Gas	RegeneratorReflux Liquid	Liquid to Regenerator Reboiler	RegeneratorRebol er Vapor	Lean Amine from RegeneratorReboil er	Lean Amine from Lean/Rich Heat Exchanger	Lean Amine to Cooler	Amine and Water Make-up	Total Add Gas
STREAM NAME	u/Hr-ft-F	to Regenerator 35	ead Vapor 36	nser Outlet	38	RegeneratorReflux Liquid <b>39</b>	Liquid to Regenerator Reboiler <b>41</b>	RegeneratorReboi er Vapor <b>42</b>	RegeneratorReboil	Lean Amine from Lean/Rich Heat Exchanger 21	Lean Amine to Cooler 21	Amine and Water Make-up <b>47</b>	Total Add Gas
STREAM NAME STREAM NO.	u/Hr-ft-F	to Regenerator 35 1 000	ead Vapor 36	nser Outlet 37	<b>38</b> 0.000	RegeneratorReflux Liquid 39 1.000	Liquid to Regenerator Reboiler 41 1.000	RegeneratorReboi er Vapor 42 0.000	RegeneratorReboil er 43 1.000	Lean Amine from Lean/Rich Heat Exchanger 21 1.000	Lean Amine to Cooler 21 1.000	Amine and Water Make-up 47 1.000	Total Acid Gas 24 0.000
STREAM NAME STREAM NO. LIQUID ERACTION TEMPERATURE	F	to Regenerator 35 1 000 209	ead Vapor 36 0.000 209	nser Outlet 37 1.000 105	38 0.000 105	RegeneratorReflux Liquid <b>39</b> 1 000 105	Liquid to Regenerator Reboiler 41 1 000 248	RegeneratorReboi er Vapor 42 0.000 250	RegeneratorReboil er 43 1 000 250	Lean Amine from Lean/Rich Heat Exchanger 21 1 000 173	Lean Amine to Cooler 21 1,000 173	Amine and Water Make-up 47 1 000 68	Total Add Gas 24 0.000 105
STREAM NAME STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE	µ/Hr-ft-F F PSIA	to Regenerator 35 1 000	ead Vapor 36	nser Outlet 37	<b>38</b> 0.000	RegeneratorReflux Liquid 39 1.000	Liquid to Regenerator Reboiler 41 1.000	RegeneratorReboi er Vapor 42 0.000	RegeneratorReboil er 43 1.000	Lean Amine from Lean/Rich Heat Exchanger 21 1.000	Lean Amine to Cooler 21 1.000	Amine and Water Make-up 47 1.000	Total Acid Gas 24 0.000
STREAM NAME STREAM NO. LIQUID EPACTION TEMPERATURE PRESSURE COMPONENTS	F	to Regenerator 35 1 000 209	ead Vapor 36 0.000 209	nser Outlet 37 1.000 105	38 0.000 105	RegeneratorReflux Liquid <b>39</b> 1 000 105	Liquid to Regenerator Reboiler 41 1 000 248	RegeneratorReboi er Vapor 42 0.000 250	RegeneratorReboil er 43 1 000 250	Lean Amine from Lean/Rich Heat Exchanger 21 1 000 173	Lean Amine to Cooler 21 1,000 173	Amine and Water Make-up 47 1 000 68	Total Add Gas 24 0.000 105
STREAM NAME STREAM NO. LIQUID EPACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxide) L	F	to Regenerator 35 1 000 209 28.0	ead Vapor 36 0.000 209 26.0	nser Outlet 37 1.000 105 23.0	38 0 000 105 23.0	RegeneratorReflux Liquid 39 1 000 105 23 0	Liquid to Regenerator Reboiler 41 1.000 248 29.8	Regenerator Reboi er Vapor 42 0.000 250 30.0	RegeneratorReboil er 43 1 000 250 30 0	Lean Amine from Lean/Rich Heat Exchanger 21 1 000 173 30 0	Lean Amine to Cooler 21 1 000 173 30 0	Amine and Water Make-up 47 1 000 68 30 0	Total Add Gas 24 0.000 105 23.0
STREAM NAME STREAM NO. LIQUID ERACTION TEMPERATURE COMPONENTS CO2 (Carbon Dioxide) L MEA L H20 (Water) L	E PSIA bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28.0 4,100.32	ead Vapor 36 0.000 209 26.0 2.081.06 9.92 2.128.7	nser Outlet 37 1,000 105 23,0 2,081,06 9,92 2,128,7	38 0 000 105 23 0 2,079 81 0.01 105 7	RegeneratorReflux Liquid 39 1 000 105 23 0 1 27 9 90 2 023 0	Liquid to Regenerator Reboiler 41 1 000 248 29.8 2.701 12 9,381.40 137,717.9	Regenerator Reboi er Vapor 42 0.000 250 30.0 680.61	RegeneratorReboil er 43 1 000 250 30 0 2,020.51 9,312.81 126,704 0	Lean Amine from Lean/Rich Heat Exchanger <b>21</b> 1 000 173 30 0 2 020 51 9 312 81 126 704 0	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8	Amine and Water Make-up 47 1 000 68 30 0 0 0 0 1.58 (382 3)	Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 951.3
STREAM NAME STREAM NO. LICULD EPACTION TEMPERATURE PEESSURE COMPONENTS C02 (Carbon Dioxide) I MEA L L (1 (Methane) L L	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1.000 209 28.0 4.100.32 9.312.82 126,809.8 0.00	ead Vapor 36 0.000 209 26.0 2.081.06 9.92 2.128.7 0.00	nser Outlet 37 1 000 105 23 0 2,081 06 9,92 2,128 7 0.00	38 0 000 105 23 0 2 079 81 0.01 105 7 0.00	RegeneratorReflux Liquid 39 1 000 105 23 0 1 27 9.90 2.023 0 0.00	Liquid to Regenerator Reboiler 41 1 000 248 29.8 2,701 12 9,381.40 137,717,9 0,00	Regenerator Rebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.013.8 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020.51 9,312.81 126,704.0 0.00	Lean Amine from Lean/Rich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0.00	Lean Amine to Cooler <b>21</b> 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.00	Amine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00	Total Add Gas 24 0.000 105 23.0 18,718.28 0.11 951.3 0.00
STREAM NAME           STREAM NO.           LIQUID ERACTION           TEMPERATURE           PRESSURE           CO2 (Carbon Dioxide)           LIQUED LIARA           LIARA           LIARARA           LIARARARARA </td <td>F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr</td> <td>to Regenerator 35 1 000 209 28.0 4 100.32 9.312.82 126.809.8 0.00 0.97</td> <td>ead Vapor 36 0 000 209 26.0 2.081 06 9.92 2.128 7 0.00 0 97</td> <td>nser Outlet 37 1 000 105 23.0 2.081.06 9.92 2.128.7 0.00 0.97</td> <td>38 0 000 105 23 0 2 079 81 0.01 105 7 0.00 0 97</td> <td>RegeneratorReflux Liquid 39 1 000 105 23 0 1 27 9.90 2,023 0 0.00 0.00</td> <td>Liquid to Regenerator Reboiler 41 1 000 248 29.8 2.701 12 9.381.40 137.717 9 0.00</td> <td>Regenerator Reboi er Vapor 42 0 000 250 30 0 680.61 68.60 11,013.8 0.00 0 0.00</td> <td>RegeneratorReboil er 43 1 000 250 30 0 2.020.51 9.312.81 126.704.0 0.00</td> <td>Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2 020 51 9 312 81 126,704 0 0.00</td> <td>Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.00 0.00</td> <td>Amine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0 0.00</td> <td>Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 9.51.3 0.00 8.76</td>	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28.0 4 100.32 9.312.82 126.809.8 0.00 0.97	ead Vapor 36 0 000 209 26.0 2.081 06 9.92 2.128 7 0.00 0 97	nser Outlet 37 1 000 105 23.0 2.081.06 9.92 2.128.7 0.00 0.97	38 0 000 105 23 0 2 079 81 0.01 105 7 0.00 0 97	RegeneratorReflux Liquid 39 1 000 105 23 0 1 27 9.90 2,023 0 0.00 0.00	Liquid to Regenerator Reboiler 41 1 000 248 29.8 2.701 12 9.381.40 137.717 9 0.00	Regenerator Reboi er Vapor 42 0 000 250 30 0 680.61 68.60 11,013.8 0.00 0 0.00	RegeneratorReboil er 43 1 000 250 30 0 2.020.51 9.312.81 126.704.0 0.00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2 020 51 9 312 81 126,704 0 0.00	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.00 0.00	Amine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0 0.00	Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 9.51.3 0.00 8.76
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PRESSURE           COMPONENTS           CO2 (Carbon Dioxide)           LH20 (Water)           LH20 (Mater)           LY20 (Mater)           LY20 (Mater)           D2 (Oxygen)	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	ead Vapor 36 0,000 209 26.0 2,081.06 9,92 2,128.7 0,00 0,97 0,08	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 0.01 105 7 0.00 0 97 0.08	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorReboi er Vapor 42 0 000 250 30 0 680 61 16 68 60 11 013 8 0 00 0 0 0 00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0 000 105 23 0 18 718 28 0.11 951 3 0.00 8 76 0.70
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PRESSURE           COMPONENTS           CO2 (Cardon Dioxide)           H20 (Water)           LIQUID LADER)           L1QUID VATER)           L1QUID VATER)           L1QUID VATER)           L1QUID VATER)           L1QUID VATER)           L1QUID VATER)           L1           MEA           L102 (Vater)           L1           L1 (Methane)           L1           Q2 (Oxygen)           L102 (Oxygen)	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28.0 4 100.32 9.312.82 126.809.8 0.00 0.97	ead Vapor 36 0 000 209 26.0 2.081 06 9.92 2.128 7 0.00 0 97	nser Outlet 37 1 000 105 23.0 2.081.06 9.92 2.128.7 0.00 0.97	38 0 000 105 23 0 2 079 81 0.01 105 7 0.00 0 97	RegeneratorReflux Liquid 39 1 000 105 23 0 1 27 9.90 2,023 0 0.00 0.00	Liquid to Regenerator Reboiler 41 1 000 248 29.8 2.701 12 9.381.40 137.717 9 0.00	Regenerator Reboi er Vapor 42 0 000 250 30 0 680.61 68.60 11,013.8 0.00 0 0.00	RegeneratorReboil er 43 1 000 250 30 0 2.020.51 9.312.81 126.704.0 0.00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2 020 51 9 312 81 126,704 0 0.00	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.00 0.00	Amine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0 0.00	Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 9.51.3 0.00 8.76
STREAM NAME           STREAM NO.           LIQUID ERACTION           TEMPERATURE           PRESSURE           COMPONENTS           CO2 (Carbon Dioxide)           L 420 (Water)           L 101 (Methane)           L 20 (Water)           L 101 (Methane)	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	ead Vapor 36 0,000 209 26.0 2,081.06 9,92 2,128.7 0,00 0,97 0,08	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 0.01 105 7 0.00 0 97 0.08	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorReboi er Vapor 42 0 000 250 30 0 680 61 16 68 60 11 013 8 0 00 0 0 0 00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0 000 105 23 0 18 718 28 0.11 951 3 0.00 8 76 0.70
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PRESSURF           CO2 (Carbon Dioxide)           LIQUID EPACTION           LIQUID EPACTION           CO2 (Carbon Dioxide)           LIQUID EPACTION           LIQUI	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	ead Vapor 36 0.000 209 26.0 2.081.06 9.92 2.128.7 0.00 0.97 0.08 4.220.7	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0.000 105 2.079.81 0.01 105.7 0.00 0.97 0.08 2.186.6	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 2.50 30.0 6.80.61 11.013.8 0.00 0.00 111.763.0	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2
STREAM NAME           STREAM NO.           LICILID ERACTION           TEMPERATURE           PRESSURE           COMPONENTS           GO2 (Carbon Dinxide)           HEA           HE20 (Water)           I           1101 (Matrogen)           I           122 (Oxygen)           I Total Molar Flow Rate           WASDR           MASS FLOW RATE           STD. VOL ELOW RATE           ACTUAL VOL ELOW RATE	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 001 105 7 0.00 0.037 0.08 2 186 6 166 131 19 91 13 72	Regenerator Refutur Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 360.61 686.60 11.013.8 0.00 0.00 0.00 11.763.0 429.305 107.13 70.62	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0.000 105 23.0 18.718.28 0.111 95.1.3 0.001 8.75 0.700 19.679.2 121.109.333 179.20
STREAM NAME           STREAM NO.           LIGUID EBACTION           TEMPERATURE           PRESSURE           COMPONENTS           CO2 (Carbon Dioxide)           LIA           STD VOL           LIA	E PSIA bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 2 079 81 105 7 0 000 0 97 0 08 2 1866 166 131 19 91 13 72 47 50	Regenerator Refutur Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 0.00 11.763.0 420.305 107.13 70.62 21.97	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0.000 105 23.0 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 121.109.333 179.20 123.50 427.46
STREAM NAME STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE CO2 (Carbon Dioxide) I MEA I L2Q (Water) I 1 C0 (Methane) I 1 C0	F PSIA bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr bMol/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 23.0 2.079.81 0.01 105.7 0.00 0.97 0.08 2.186.6 166.131 19.91 13.72 47.50 0.18	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	Regenerator Rebol er Vapor 42 0.000 250 30.0 680.61 68.60.61 68.60.61 68.60.61 10.13.8 0.00 0.00 11.763.0 11.763.0 429.305 107.13 70.62 21.97 0.09	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Arrine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Acid Gas 24 0.000 105 23.0 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 19.679.2 121.109.333 179.20 123.50 427.46 1.62
STREAM NAME STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE CO2 (Carbon Dioxide) I MEA LQU(Vater) I C1 (Methane) I 20 (Navgen) I C1 (Methane) I C2 (Oxygen) I C2 (Oxygen) I C3 (Oxygen) I C4 (Mass FLOW Rate I VAPOR MASS FLOW RATE MOLECUW RATE MOLECUL AR WEIGHT STD. PONETY CAS COMPRESSIBILITY	E PSIA bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr L	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 0 01 105 7 0 00 0 97 0 08 2 186 6 166 131 19 91 13 72 47 50 0 18 0 00	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 2.500 3.0.0 6.86.060 11.013.8 0.00 0.00 11.763.0 429.305 1.07.13 70.62 21.97 0.09 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Arrine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Acid Gas 24 0.000 105 23.0 18, 718, 28 0.11 951.3 0.00 8, 76 0.70 19, 679.2 121, 109, 333 179, 20 123, 50 427, 46 1, 62 0, 00 1, 71 1, 718, 28 0, 00 0, 00 0, 00 1, 718, 28 0, 00 0, 00 1, 95 1,
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PRESSURE           COMPONENTS           GO2 (Carbon Dioxide)           L1 (Methane)           L1 (Methane)           L1 (Methane)           L0 (More)           L0 (Methane)           L0 (More)           L0 (Methane)           L1 (Methane)           L2 (Oxvgen)           L1 (Methane)           MASS FLOW Rate           MASS FLOW RATE           SID. VOL ELOW RATE           SID. DENSITY           VISCOSITY	E PSIA bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	ad Vapor           36           0.000           209           200           2010           202           202           203           203           204106           9.92           203           000           0.97           0.08           4.220.7           221688           38.44           27.73           34.37           0.00           0.00	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 0 001 105 7 0 008 2 186 6 166 131 19 91 13 72 47 50 0 18 0 00 0 00	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.013.8 0.00 0.00 11.763.0 429.305 107.13 70.62 21.97 0.09 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Acid Gas 24 0.000 105 23.0 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 19.679.2 121.109.333 179.20 123.50 427.46 1.62
STREAM NAME           STREAM NO.           LIGUID EPACTION           TEMPERATURE           PRESSURE           CO2 (Carbon Dioxide)           LIGUID EPACTION           CO2 (Carbon Dioxide)           MEA           LIQUID EPACTION           CO2 (Carbon Dioxide)           MEA           LIQUID EPACTION           DO2 (Oxygen)           LIQUID EFOW RATE           VAPOP           MASS FLOW RATE           STD VOL FLOW RATE           MOL ECULAR WEIGHT           STD DENSITY           GAS COUMPERSUBULITY           WISCOSITY           HEAT CAPACITY	E PSIA bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Acid Gas 24 0.000 105 23.0 18, 718, 28 0.11 951.3 0.00 8, 76 0.70 19, 679.2 121, 109, 333 179, 20 123, 50 427, 46 1, 62 0, 00 1, 71 1, 718, 28 0, 00 0, 00 0, 00 1, 718, 28 0, 00 0, 00 1, 95 1,
STREAM NAME           STREAM NO.           LIGUID EPACTION           TEMPERATURE           PRESSURE           CO2 (Carbon Dioxide)           LIGUID EPACTION           CO2 (Carbon Dioxide)           MEA           LIQUID EPACTION           CO2 (Carbon Dioxide)           MEA           LIQUID EPACTION           DO2 (Oxygen)           LIQUID EFOW RATE           VAPOP           MASS FLOW RATE           STD VOL FLOW RATE           MOL ECULAR WEIGHT           STD DENSITY           GAS COUMPERSUBULITY           WISCOSITY           HEAT CAPACITY	E PSIA bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr bMoi/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr Lb/Hr L	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 230 2 079 81 0 001 105 7 0 008 2 186 6 166 131 19 91 13 72 47 50 0 18 0 00 0 00	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.013.8 0.00 0.00 11.763.0 429.305 107.13 70.62 21.97 0.09 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0.000 105 230 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 121.109.333 179.0 122.50 427.46 1.62 0.00 0.00 0.00 0.00
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PBESSURE           COMPONENTS           CO2 (Carbon Dioxide)           L1 (Methane)           L1 (Methane)           L2 (Water)           L3 (Methane)           L4 (Methane)           L4 (Methane)           L4 (Methane)           L4 (Methane)           L5 (L0W Rate           L4 (Methane)           L5 (L0W Rate           L5 (L0W Rate           STD, VOL ELOW RATE           MOL ECULAR WEIGHT           STD, DENSITY           GAS COMPERSIBILITY           VISCOSITY           HEAT CAPACITY           THERMAL CONDUCTIVITY	E PSIA bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht bMoi/Ht	to Regenerator 35 1 000 209 28 0 4 100 32 9 312.82 126,809.8 0.00 0.97 0.08	**************************************	nser Outlet 37 1 000 105 23.0 2,081.06 9.92 2,128.7 0.00 0.97 0.08	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Refue Liquid 39 106 230 1230 2020 20230 0.000 0.000	Liquid to Regenerator Rebailer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.000 0.000	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorReboil er 43 1 000 250 30 0 2,020 51 9,312 81 126,704 0 0,00 0,00	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2,020 51 9,312 81 126,704 0 0,000 0,000	Lean Amine to Cooler 21 1 000 173 30 0 2.020 51 9.314.38 126.321.8 0.000 0.000	Artine and Water Make-up 47 1 000 68 30 0 0 00 1.58 (382 3) 0.00 0.00 0.00	Total Add Gas 24 0.000 105 230 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 121.109.333 179.0 122.50 427.46 1.62 0.00 0.00 0.00 0.00
STREAM NAME           STREAM NO.           LIQUID EPACTION           TEMPERATURE           PBESSURE           COMPONENTS           CO2 (Carbon Dioxide)           L1 (Methane)           L1 (Methane)           L2 (Water)           L3 (Methane)           L4 (Methane)           L4 (Methane)           L4 (Methane)           L4 (Methane)           L5 (L0W Rate           L4 (Methane)           L5 (L0W Rate           L5 (L0W Rate           STD, VOL ELOW RATE           MOL ECULAR WEIGHT           STD, DENSITY           GAS COMPERSIBILITY           VISCOSITY           HEAT CAPACITY           THERMAL CONDUCTIVITY	E PSIA bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt bMol/Hrt 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138.037.3 30.0 138.037.3 30.0 3.267.542 5709.78	Lean Amine to Cooler 21 1 000 173 30.0 2.020.51 9.314.38 0.200 0.00 0.00 137.656.7	Amine and Water Make-up 47 1 000 68 30 0 1.58 (382 3) 0.00 0 00 0 00 0 00 0 00 0 00 0 00 0 0	Total Add Gas 24 0.000 105 230 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 121.109.333 179.0 122.50 427.46 1.62 0.00 0.00 0.00 0.00
STREAM NAME STREAM NO. LIQUID EPACTION TEMPERATURE PRESSURF CO2 (Carbon Dioxide) I MEA I CO2 (Carbon Dioxide) I MEA I CO2 (Carbon Dioxide) I O(Advater) I O(Advat	F PSIA bMol/Hir bMol/Hir bMol/Hir Lb/Hir Lb/Hir Lb/Hr Lb/Hr Lb/Hr Lb/Hr lb/Fi <sup>3</sup> cP Stu/Lb/E Stu/Lb/Hr CP CP CP CP CP CP CP CP CP CP CP CP CP	to Regenerator 35 1 000 280 280 280 280 4 100 32 9.312 82 126 809 8 0.00 0.97 0.08 140 224 0 140 224 0 140 224 0 3.371,390 5.751 41 5.951.79	**************************************	37           1.000           105           23.0           2.081.06           9.92           2.128.7           0.00           0.97           0.08           4.220.7           1.15.088           2.47.18           2.48.73	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Reflux liquid 39 1 000 105 23 0 1 27 9 90 2 0230 0 000 0 000 2 0341 2 0341	Uquid to Regenerator Reballer 41 1 000 248 29.8 2.701.12 9.381.40 137.717.9 0.00 0.00 0.00 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.3 149.800.300.3 149.800.3 149.800.3 14	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorRetol ef 43 1000 250 30.0 2020 51 9.312.81 126.704.0 0.000 0.000 138.037.3 3.267.542 5.709.78 6011.14	Lean Amine from LeanRich Heat Exchanger 21 1 000 173 30 0 2.020 51 9.312 81 126 704 0 0.00 0.00 0.00 0.00 0.00 0.00 0.00	Lean Amine to Coder 21 1 000 173 30 0 2 020 51 9.314.38 126 321 8 0.010 0.00 137 656 7 3.259.998 5696 63 5825.79	Amine and Water Make-up 47 1 000 68 30 0 0.00 1.58 (382.3) 0.00 0.00 0.00 0.00 (380.7) (380.7) -7.547 -7.547 -13.59 -13.6	Total Add Gas 24 0.000 105 230 18.718.28 0.11 951.3 0.00 8.76 0.70 19.679.2 121.109.333 179.0 122.50 427.46 1.62 0.00 0.00 0.00 0.00
STREAM NAME STREAM NO. LIQUID EPACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxide) I MEA LIQUINGEN CO2 (Carbon Dioxide) I MEA LIQUINGEN L	F PSIA bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit bMol/Hit 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  2.018.7           0.02           9.92           2.128.7           0.00           9.92           2.020           0.03           4.2007           0.08           4.2007           145.088           241.7           30.94	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Reflux Liquid 39 4 0000 105 23.0 2.033.0 0.000 2.033.0 0.000 2.033.1 0.000 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 2.034.1 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000 68 30 0 1 558 (382 3) 0 000 0 000000	Total Acid Gas 24 0.000 105 23.0 23.0 18.718.28 0.11 95.13 0.00 8.76 0.70 19.679.2 121.109.333 179.0 123.50 427.46 1.62 0.00 0.00 0.000
STREAM NAME STREAM NO. LICIUID EPACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxide) L MEA L H20 (Water) L C1 (Methane) L L C1 (Methane) L L L L L L L L L L L L L L L L L L L	E PSIA bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit b bMoi/Hit b bMoi/Hit b bMoi/Hit b b b b/Hit b b b/Hit b b/Hit b b/Hit b b/Hit b b/Hit b/Hit b/Hit b b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/Hit b/H	to Regenerator 35 1,000 28,0 28,0 4,100,32 9,312,82 126,809,8 0,00 0,07 0,08 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,044,0 140,244,044,044,044,044,044,044,044,044,	**************************************	are Outlet           37           1.000           105           23.0           2.081.06           9.92           2.128.7           0.00           9.7           0.08           4.220.7           0.08           4.220.7           1.45.088           247.18           247.18           247.18           247.18           265.86	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Rolluc Liquid 39 1 000 105 23 0 1 27 9 90 2 0330 0 000 0 000000	Liquid Io Regenerator Rebelief 41 1 000 248 29 8 2 701 12 9 381 40 132 771 9 0 000 0 000 149 800 3 149 800 3 3 525 978 6116 13 643 423 21 18 64 69	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorReted ef 43 1 000 250 30 0 2 020 51 9 312 81 126 704 0 0 000 138 037 3 3 267 542 5 709 78 6011.14 2 130 64 21	Lean Amine from LearRich Heat Exchanger 21 1 000 173 30 0 2 020 51 9 312 81 126 704 0 0 000 0 000 138 037 3 3 267 542 5709 78 5839 38 21 30 64 21	Lam Ambe to Coder 21 1 000 173 300 2 020 51 9 314 38 0 000 0 000 0 000 137 656 7 3 259 998 5696 53 5825 79 21 31 64 21	Amine and Water Make-up 47 1 000 68 -30.0 0.00 1.58 (382 3) 0.00 0.00 0.00 (380 7) -7.547 -13.6 -7.547 -13.6 17.84 62.31	Total Acid Gas 24 0.000 105 23.0 23.0 18.718.28 0.11 95.13 0.00 8.76 0.70 19.679.2 121.109.333 179.0 123.50 427.46 1.62 0.00 0.00 0.000
STREAM NAME  STREAM NO.  LIGUID EPACTION  TEMPERATURE  PRESSIURE  CO2 (Carbon Dioxide)  I MEA  LGUID COMPONENTS  CO2 (Carbon Dioxide)  I MEA  LGUID COMPONENTS  CO2 (Carbon Dioxide)  I O2 (Cvygen)  LGUID COMPONENTS  TO LOW RATE  STD VOL FLOW RATE  STD PENSITY  VISCOSITY	E F PSIA bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//Hi bM0//	to Regenerator 35 1 000 280 280 4 100 32 9 312 82 126 809 8 106 809 8 100 00 0 07 0 08 140 224 0 140 5751 41 5551 79 21 64 65 77 0 3401	**************************************	iser Outlet           37           1.000           105           23.0           2.081.06           9.92           2.128.7           0.00           9.92           2.128.7           0.00           9.92           2.128.7           0.00           9.92           2.128.7           0.00           9.92           0.08           4.220.7           0.08           4.220.7           145.068           247.18           248.73           30.94           65.86           0.6888	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Rolluc Uquid 39 4 000 105 23 0 2 023 0 0 00 0 00 2 034 1 2 034 1 2 036 1 2 0 2 0 2 030 1 2 030 1 2 030 1 2 030 1 2 030 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Liquid lo Regenerator Rebolier 41 4000 248 29.8 2.701.12 9.381.40 137.717.9 0.00 0.00 0.00 149.800.3 149.800.3 3.525.578 6.116.13 6.434.23 21.18 6.46.9 0.2592	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorRetol ef 4 3 1000 250 300 2020 51 9.312 81 126.704.0 0.000 0.000 138.037.3 3.267.542 5.709.78 6011.14 21.20 564.21 0.2564	Lean Amine from LearRich Heat Exchanger 21 4 000 173 30 0 2 020 51 9 312 81 126 704 0 0 000 0 000 138 037 3 300 3 207 542 5709 78 5833 38 21 30 64 21 0 4548	Lean Amine to Coder 21 1 000 173 30.0 2.020.51 9.314.38 0.00 0.00 137.656.7 3.259.998 5696.53 5825.79 21.31 5622.79	Amine and Water Make-up 47 1 000 68 30 0 0.00 1.58 (382.3) 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	Total Acid Gas 24 0.000 105 23.0 23.0 18.718.28 0.11 95.13 0.00 8.76 0.70 19.679.2 121.109.333 179.0 123.50 427.46 1.62 0.00 0.00 0.000
STREAM NAME STREAM NO. LIQUID.EBACTION TEMPERATURE PRESSURE GOMPONENTS CO2 (Carbon Dioxide) I MEA LIQUIAtion Lioxide) I CO2 (Carbon Dioxide) I CO2 (Carbon Dioxi	E PSIA bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit bMoi/Hit b bMoi/Hit b bMoi/Hit b bMoi/Hit b b b b b b b b b b b b b b b b b b b	to Regenerator 35 1,000 28,0 28,0 4,100,32 9,312,82 126,809,8 0,00 0,07 0,08 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,224,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,0 140,244,044,0 140,244,044,044,044,044,044,044,044,044,	**************************************	are Outlet           37           1.000           105           23.0           2.081.06           9.92           2.128.7           0.00           9.7           0.08           4.220.7           0.08           4.220.7           1.45.088           247.18           247.18           247.18           247.18           265.86	38 0 000 105 2 079 81 0 001 105 7 0 008 2 106 6 166 131 19 91 13 72 47 50 0 18 0 00 0 18	Regenerator Rolluc Liquid 39 1 000 105 23 0 1 27 9 90 2 0330 0 000 0 000000	Liquid Io Regenerator Rebelief 41 1 000 248 29 8 2 701 12 9 381 40 132 771 9 0 000 0 000 149 800 3 149 800 3 3 525 978 6116 13 643 423 21 18 64 69	RegeneratorRebol er Vapor 42 0.000 250 30.0 680.61 68.60 11.0138 0.00 0.00 11.763.0 11.763.0 11.763.0 11.763.0 21.97.0 0.00 0.00 0.00	RegeneratorReted ef 43 1 000 250 30 0 2 020 51 9 312 81 126 704 0 0 000 138 037 3 3 267 542 5 709 78 6011.14 2 130 64 21	Lean Amine from LearRich Heat Exchanger 21 1 000 173 30 0 2 020 51 9 312 81 126 704 0 0 000 0 000 138 037 3 3 267 542 5709 78 5839 38 21 30 64 21	Lam Ambe to Coder 21 1 000 173 300 2 020 51 9 314 38 0 000 0 000 0 000 137 656 7 3 259 998 5696 53 5825 79 21 31 64 21	Amine and Water Make-up 47 1 000 68 30 0 0 00 1 58 (382 3) 0 00 0 00 0 00 0 00 0 00 0 00 0 00 0	Total Acid Gas 24 0.000 105 23.0 23.0 18.718.28 0.11 95.13 0.00 8.76 0.70 19.679.2 121.109.333 179.0 123.50 427.46 1.62 0.00 0.00 0.000

Table 3.2.6:	Material and Energy Balance for Concept A CO <sub>2</sub> Compression and Liquifaction System
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STREAM NAME	Total Acid gas from strippers	To train A liquefaction	First stage discharge	To second stage	First stage water KO	2nd stage discharge	To 3rd stage	2nd stage water KO	From 3rd stage	To drier	3rd stage water KO
STREAM NO.	300	300	301	302	310	303	304	309	306	305	314
VAPOR FRACTION Molar	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000	1.000	0.000
TEMPERATURE F	105	105	230	95	95	236	95	95	282	90	90
PRESSURE PSIG	4	4	25	19	19	62	56	56	191	185	185
MOLAR FLOW RATE LbMol/Hr	19,679.08	2,811.30	2,811.30	2,743.70	67.60	2,743.70	2,708.50	35.19	2,708.50	2,686.56	21.94
MASS FLOW RATE Lb/Hr	841,192	120,170	120,170	118,951	1,219	118,951	118,315	636	118,315	117,917	398
ENERGY Btu/Hr	8.79E+07	1.26E+07	1.58E+07	1.19E+07	-9.79E+05	1.56E+07	1.17E+07	-5.09E+05	1.64E+07	1.10E+07	-3.18E+05
COMPOSITON Mol %.											
CO2	95.12%	95.12%	95.12%	97.46%	0.09%	97.46%	98.72%	0.18%	98.72%	99.52%	0.54%
H2O	4.83%	4.83%	4.83%	2.49%	99.91%	2.49%	1.23%	99.82%	1.23%	0.42%	99.46%
Nitrogen	0.04%	0.04%	0.04%	0.05%	0.00%	0.05%	0.05%	0.00%	0.05%	0.05%	0.00%
Ammonia	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Propane	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Oxygen	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
VAPOR											
MOLAR FLOW RATE LbMol/Hr	19,679.1	2,811.3	2,811.3	2,743.7	-	2,743.7	2,708.5	-	2,708.5	2,686.6	
MASS FLOW RATE Lb/Hr	841,192	120,170	120,170	118,951	-	118,951	118,315	-	118,315	117,917	
STD VOL. FLOW MMSCED ACTUAL VOL. FLOW ACEM	179.23	25.60 14.843.95	25.60	24.99	-	24.99	24.67		24.67	24.47	<u> </u>
	103,907.68		8,749.53	8,063.83		4,417.63	3,728.32		1.698.44	1,224.03	
MOLECULAR WEIGHT MW DENSITY Lb/Ft <sup>3</sup>	42.75	42.75	42.75	43.35	-	43.35	43.68		43.68	43.89	
DENSITY Lb/Ft <sup>3</sup> VISCOSITY CP	0.13	0.13	0.23	0.25	-	0.45	0.53		1.16 0.0212	1.61	
	0.0149	0.0149	0.0187	0.0149	-	0.0193	0.0152	-	0.0212	0.0154	-
HYDROCARBON LIQUID MOLAR FLOW RATE LbMol/Hr											
	-		-	-	-	-	-				
MASS FLOW RATE Lb/Hr STD VOL, FLOW BPD	-	-	-	-	-	-	-	-	-	-	
	-	-		-	-	-	-	-		-	
ACTUAL VOL. FLOW GPM DENSITY Lb/Ft <sup>3</sup>	-			-	-	-	-				
	-	-	-	-	-	-	-	-	-	-	
MOLECULAR WEIGHT MW	-	-	-	-	-		-	-			
VISCOSITY cP SURFACE TENSION Dyne/Cm			-	-	-	-	-			-	
SURFACE TENSION Dyne/Cm	-	-	-	-	-	-	-	-	-	-	
STREAM NAME	From drier/ To condenser	Water from drier	From condenser	From product pump	From Train A liquefaction	To pipeline	Refrig compressor discharge	From refrig condenser	From subcooler	Refrig to CO2 condenser	Refrig from CO2 condenser
STREAM NAME						To pipeline 313	compressor		From subcooler		
STREAM NO.	condenser	drier	condenser	pump	liquefaction		compressor discharge	condenser		condenser	CO2 condenser
	condenser 307	drier 311	condenser 312	pump 308	liquefaction 309	313	compressor discharge 400	condenser 401	402	condenser 403	CO2 condenser
STREAM NO. VAPOR FRACTION Molar	condenser <b>307</b> 1.000	drier 311 0.726	condenser 312 0.000	90000 308 0.000	liquefaction 309 0.000	<b>313</b> 0.000	compressor discharge 400 1.000	condenser 401 0.000	<b>402</b> 0.000	condenser 403 0.173	CO2 condenser 404 0.996
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F	condenser 307 1.000 90	drier 311 0.726 380	condenser 312 0.000 -26	308 0.000 -12	1iquefaction 309 0.000 82	<b>313</b> 0.000 82	compressor discharge 400 1.000 65	condenser 401 0.000 95	<b>402</b> 0.000 24	condenser 403 0.173 -31	CO2 condenser 404 0.996 -31
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PRESSURE PSIG	condenser 307 1.000 90 180	drier 311 0.726 380 180	condenser 312 0.000 -26 2.003	308 0.000 -12 2.000	liquefaction 309 0.000 82 2,000	313 0.000 82 2,000	compressor discharge 400 1.000 65 55	condenser 401 0.000 95 162	<b>402</b> 0.000 24 159	condenser 403 0.173 -31 5	CO2 condenser 404 0.996 -31 5
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PERSSIBE PSIG MOLAR FLOW RATE LbMoi/Hr	condenser 307 1.000 90 180 2,675.15	drier 311 0.726 380 180 11.41	condenser           312           0.000           -26           2.003           2,675.15	9ump 308 0.000 -12 2,000 2,675.15	Iiquefaction           309           0.000           82           2.000           2,675.15	313 0.000 82 2.000 18,726.05	compressor discharge 400 1.000 65 55 2,928.57	condenser 401 0.000 95 162 2,928.57	<b>402</b> 0.000 24 159 2,928.57	403 0.173 -31 5 2,928.57	<b>404</b> 0.996 -31 5 2,928.57
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PRESSURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr	condenser 307 1.000 90 180 2.675.15 117.711	drier 311 0.726 380 180 11.41 206	condenser           312           0.000           -26           2.003           2,675.15           117.711	308 0.000 -12 2.000 2.675.15 117.711	309           0.000           82           2,000           2,675.15           117.711	313 0.000 82 2,000 18,726.05 823.979	compressor discharge 400 1.000 65 55 2.928.57 129.141	condenser 401 0.000 95 162 2.928.57 129.141	<b>402</b> 0.000 24 159 2,928.57 129.141	403 0.173 -31 5 2,928.57 129.141	CO2 condenser 404 0.996 -31 5 2,928.57 129.141
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PRESSIJRE PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr	condenser 307 1.000 90 180 2.675.15 117.711	drier 311 0.726 380 180 11.41 206	condenser           312           0.000           -26           2.003           2,675.15           117.711	308 0.000 -12 2.000 2.675.15 117.711	309           0.000           82           2,000           2,675.15           117.711	313 0.000 82 2,000 18,726.05 823.979	compressor discharge 400 1.000 65 55 2.928.57 129.141	condenser 401 0.000 95 162 2.928.57 129.141	<b>402</b> 0.000 24 159 2,928.57 129.141	403 0.173 -31 5 2,928.57 129.141	CO2 condenser 404 0.996 -31 5 2,928.57 129.141
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PRESSURE PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btw/Hr COMPOSITON Mol %.	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07	drier 311 0.726 380 180 11.41 206 2.51E+04	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06	308 0.000 -12 2.000 2.675.15 117.711 -7.29E+06	Ilquefaction 309 0.000 82 2.000 2.675.15 117.711 -1.36E+06	313 0.000 82 2,000 18,726.05 823.979 -9.50E+06	compressor discharge 400 1.000 65 55 2,928.57 129,141 1.81E+07	condenser 401 0.000 95 162 2.928.57 129.141 7.63E+05	402 0.000 24 159 2.928.57 129.141 -5.17E+06	condenser 403 0.173 -31 5 2,928.57 129.141 -5.17E+06	CO2 condenser 404 0.996 -31 5 2,928.57 129.141 1.39E+07
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PRESSURF PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %.	condenser 307 1.000 90 180 2.675.15 117 711 1.10E+07 99.95%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117 711 -8.07E+06 99.95%	pump 308 0.000 -12 2.000 2.675.15 117 711 -7.29E+06 99.95%	liquefaction 309 0.000 82 2.000 2.675.15 117.711 -1.36E+06 99.95%	313 0.000 82 2.000 18,726.05 823.979 -9.50E+06 99.95%	compressor discharge 400 1.000 65 55 2.928.57 129.141 1.81E+07 0.00%	condenser 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00%	C02 condenser 404 0.996 -31 5 2.928.57 129.141 1.39E+07 0.00%
STREAM NO.       VAPOR FRACTION     Molar       TEMPERATURE     F       PRESSURF     PSIG       MOLAR FLOW RATE     LbMol/Hr       MASS FLOW RATE     LbMol/Hr       ENERGY     Btu/Hr       COMPOSITON     Mol %       CO2     H2O	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00%	drier 311 0.726 380 11.41 2.51E+04 0.00% 100.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00%	pump 308 0.000 -12 2.000 2.675.15 117 711 -7.29E+06 99.95% 0.00%	liquefaction 309 0.000 82 2.000 2.675.15 117.711 -1.36E+06 99.95% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00%	compressor discharge 400 1.000 65 55 2.928.57 129.141 1.81E+07 0.00% 0.00%	condenser 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00%	C02 condenser 404 0.996 -31 5 2.928.57 1.29.141 1.39E+07 0.00% 0.00%
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F ERESSURE PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol % CO2 H2O Nitrogen	soord           307           1.000           90           180           2.675.15           117.711           1.10E+07           99.95%           0.00%           0.05%	drier 311 0.726 380 180 11.41 2.51E+04 0.00% 100.00% 0.00%	condenser           312           0.000           -26           2.003           2.675.15           117 711           -8.07E+06           99.95%           0.00%           0.05%	9000 308 0.000 -12 2.000 2.675.15 117.711 -7.29E+06 99.95% 0.00% 0.05%	Ilquefaction           309           0.000           82           2.000           2.675.15           117.711           -1.36E+06           99.95%           0.00%           0.05%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05%	compressor discharge 400 1.000 65 55 2.928.57 129.141 1.81E+07 0.00% 0.00%	condenser 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00%	403           0.173           -31           5           2,928.57           129,141           -5.17E+06           0.00%           0.00%           0.00%	404           0.996           -31           5           2,928.57           129.141           1.39E+07           0.00%           0.00%
STREAM NO. VAPOR FRACTION Molar. TEMPERATURE F PRESSIURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %. CO2 H2O Nitrogen Ammonia	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.05% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.05% 0.00%	pump 308 0.000 -12 2.000 2.675.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 -1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor           discharge           400           1.000           65           2.928.57           129.141           1.81E+07           0.00%           0.00%           0.00%           0.00%           0.00%	condenser 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2,928.57 129.141 -5.17E+06 0.00% 0.00% 0.00%	C02 condenser 404 0.996 -31 5 2.928.57 129.141 1.39E+07 0.00% 0.00% 0.00%
STREAM NO. VAPOR FRACTION Molar. TEMPERATURE F PRESSIURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %. CO2 H2O Nitrogen Ammonia Propane	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.05% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor           discharge           400           1.000           65           55           2.928.57           129.141           1.81E+07           0.00%           0.00%           0.00%           100.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00% 100.00%	C02 condenser 404 0.996 -31 5 2.928.57 1.29.141 1.39E+07 0.00% 0.00% 0.00% 100.00%
STREAM NO. VAPOR FRACTION Molar. TEMPERATURE F PRESSIURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %. CO2 H2O Nitrogen Ammonia Propane	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.05% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor           discharge           400           1.000           65           55           2.928.57           129.141           1.81E+07           0.00%           0.00%           0.00%           100.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00% 100.00%	C02 condenser 404 0.996 -31 5 2.928.57 1.29.141 1.39E+07 0.00% 0.00% 0.00% 100.00%
STREAM NO. VAPOR FRACTION Molar. TEMPERATURE F PRESSIURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %. CO2 H2O Nitrogen Ammonia Propane	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.05% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor           discharge           400           1.000           65           55           2.928.57           129.141           1.81E+07           0.00%           0.00%           0.00%           100.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00% 100.00%	C02 condenser 404 0.996 -31 5 2.928.57 1.29.141 1.39E+07 0.00% 0.00% 0.00% 100.00%
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE LbMol/Hr MASS FLOW RATE Ib/Hr ENERGY Btu/Hr COMPOSITON Mol % CO2 H2O Nitrogen Ammonia Propane Oxygen VAPOR MOL AR FL OW RATE LbMol/Hr	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.05% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor           discharge           400           1.000           65           55           2.928.57           129.141           1.81E+07           0.00%           0.00%           0.00%           100.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00% 100.00%	C02 condenser 404 0.996 -31 5 2.928.57 1.29.141 1.39E+07 0.00% 0.00% 0.00% 100.00%
STREAM NO. VAPOR FRACTION Molar. TEMPERATURE F PRESSIURE PSIG. MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE Lb/Hr ENERGY Btu/Hr COMPOSITON Mol %. CO2 H2O Nitrogen Ammonia Propane Oxygen VAPOR	condenser           307           1.000           90           180           2,675.15           117.711           1.10E+07           99.95%           0.00%           0.00%           0.00%           0.00%           0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor discharge 400 1.000 65 55 2.928.57 129.141 1.81E+07 0.00% 0.00% 0.00% 0.00% 100.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2,928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00% 100.00% 0.00%	C02 condenser 404 0.996 -31 5 2.928.57 129.141 1.39E+07 0.00% 0.00% 0.00% 0.00% 100.00% 0.00%
STREAM NO. VAPOR FRACTION Molar TEMPERATURE F PSIG MOLAR FLOW RATE LbMol/Hr MASS FLOW RATE LbMol/Hr MASS FLOW RATE Ib/Hr ENERGY Btu/Hr COMPOSITON Mol % CO2 H2O Nitrogen Ammonia Propane Oxygen VAPOR MOL AR FL OW RATE LbMol/Hr	condenser 307 1.000 90 180 2.675.15 117.711 1.10E+07 99.95% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00%	drier 311 0.726 380 180 11.41 206 2.51E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 2.003 2.675.15 117.711 -8.07E+06 99.95% 0.00% 0.00% 0.00%	pump 308 0.000 -12 2.075.15 117.711 -7.29E+06 99.95% 0.00% 0.05% 0.00%	Iquefaction 309 0.000 82 2.000 2.675.15 117.711 1.36E+06 99.95% 0.00% 0.05% 0.00%	313 0.000 82 2.000 18.726.05 823.979 -9.50E+06 99.95% 0.00% 0.05% 0.00%	compressor discharge 400 1.000 65 55 2.928.57 129.141 1.81E+07 0.00% 0.00% 0.00% 0.00% 100.00% 0.00%	condensor 401 0.000 95 162 2.928.57 129.141 7.63E+05 0.00% 0.00% 0.00% 0.00% 100.00%	402 0.000 24 159 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 0.00%	condenser 403 0.173 -31 5 2.928.57 129.141 -5.17E+06 0.00% 0.00% 0.00% 100.00% 0.00% 100.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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# 3.2.5.5 Equipment List with Data

Equipment data for Concept A, provided in Appendix II, has been presented in the so-called "short spec" format which provides adequate data for a factored cost estimate.

3.2.5.6 Consumption of Utilities

The following utilities from outside boundary limits (OSBL) are required in the CO<sub>2</sub> Recovery Unit.

- Steam
- High Pressure (HP) Steam
- Low Pressure (LP) Steam
- Water
- Demineralized Water
- Raw Water (Fresh Water) (Cooling tower make-up)
- Potable Water (hoses, etc.)
- Air
- Plant Air (maintenance, etc.)
- Instrument Air
- Electric Power
- Natural Gas

Note: The CO<sub>2</sub> Recovery Plant includes cooling water pumps that supply all the cooling water required by this unit.

Concept A utility consumption is presented in Table 3.2.7.

		Utility	Amount Consumed	Units	_	
	N	latural Gas	.42	MMSCFD		
		um (180 psig)	1,950,000	Lb/hr		
	Co	oling water	22,000	Gpm	-	
					Power (ea)	
					including	
				Number	0.95	Total
Number of				Operating	motor eff	all trains
Trains	Tag no.		Description	per train	(kW)	(kW)
5	GA-2101 A/E	3 1	Vash Water Pump	1	19	95
5	GA-2102 A/E	B Direct Co	ontact Cooler Water Pump	) 1	32	162
5	GA-2103 A/B/C	C/D R	ich Solvent Pump	3	146	729
9	GA-2201A/B/	C L	ean Solvent Pump	2	117	1,053
9	GA-2202 A/E	B Solver	t Stripper Reflux Pump	1	3	28
9	GA-2203 A/E	3	Filter Circ. Pump	1	12	107
7	GA-2301 A/E	3 C	O2 Pipeline Pump	1	184	1,288
9	GA-2204 A/E	B LP co	ndensate booster pump	1	74	667
3	GA-2501	Ca	istic metering pump	1	0	0

# Table 3.2.7: Concept A Utility Consumption

7	GB-2301	CO <sub>2</sub> Compressor (Motor driven)	1	3,557	24,901
7	GB-2401	Propane Refrig Compressor	1	2,395	16,765
1	GB-2500	LP steam turbine/ generator	NA	NA	NA
7	EC-2301	CO2 compressor 1st stage air cooler	1	9	66
7	EC-2302	CO2 compressor 2nd stage air cooler	1	10	69
7	EC-2303	CO2 compressor 3rd stage air cooler	1	15	103
9	EC-2201	Solvent stripper bottoms cooler	1	256	2,305
7	PA-2351	CO2 Drier Package	1	151	1054
1	PA-2551	Cooling Tower	1	962	962
		Total			50,355

#### 3.2.5.7 Consumption of Chemicals and Desiccants

The consumption of chemicals and desiccants for Concept A are identified in Table 3.2.8 shown below.

Chemical	Consumption per day (lbs.)
Caustic (100%)	3600
MEA	14000
Corrosion inhibitor	1140
Diatomaceous earth	916
Molecular sieve	257
Sodium hypochlorite	3590
Sodium bisulfite	13.8

 Table 3.2.8:
 Concept A Chemical s and Desiccants Consumption

This total does not include chemicals provided by the cooling tower service people nor disposal of waste. These are handled as a component of operating costs referred to as contracted services and waste handling, respectively.

# 3.2.5.8 Design Considerations

The following parameters were optimized for Concept A with the objective of reducing the overall unit cost and energy requirements.

- Solvent Concentration
- Lean Amine Loading
- Rich Amine Loading
- Absorber Temperature
- Rich /Lean Exchanger approach
- CO<sub>2</sub> Compressor inter-stage temperatures
- CO<sub>2</sub> Refrigeration Pressure and Temperature

A minimum of 90%  $CO_2$  recovery was targeted. The above parameters were adjusted to increase the recovery until a significant increase in equipment size and/ or energy consumption was observed. AES Corporation owns and operates a 200 STPD food grade  $CO_2$  production plant in Oklahoma. This plant was designed and built by ABB Lummus

Global as a part of the larger power station complex using coal fired boilers. This plant was started up in 1990 and has been operating satisfactorily with lower than designed MEA losses. The key process parameters from the present design for Concept A are compared with those from the AES plant (Barchas and Davis, 1992) in Table 3.2.9.

PROCESS PARAMETER	AEP DESIGN (Concept A)	AES DESIGN
	0000	200
PLANT CAPACITY TPD	9888	200
$CO_2$ in Feed, % mol	13.9	14.7
$O_2$ in Feed, % mol	3.2	3.4
$SO_2$ in Feed, % mol	100 ppm	10 PPMV (Max)
SOLVENT	MEA	MEA
SOLVENT CONC. %WT	20	15 (Actual 17-18%Wt)
LEAN LOADING	0.21	0.10
RICH LOADING	0.44	0.41
STRIPPER FEED TEMP , F	210	194
STRIPPER BOTTOM TEMP F	250	245
FEED TEMP TO ABSORBER, F	105	108
CO <sub>2</sub> RECOVERY %	95	90 (ACTUAL 96-97%)
ABSORBER PRESSURE DROP psi	1	1.4
STRIPPER PRESSURE DROP psi	0.6	4.35
R/L EXCHANGER APPROACH,F	10	50
CO <sub>2</sub> COMPRESSOR I/STG TEMP F	105	115
LIQUID CO <sub>2</sub> TEMP F	82	-13
STEM CONSUMPTION (T steam/ T CO2)	2.6	3.45
LIQUID CO <sub>2</sub> PRESSURE psi (A)	2015	247

# Table 3.2.9: Concept A Key Process Parameters Comparison

#### 3.2.5.9 OSBL Systems

# Reclaimer Bottoms (Concept A):

The reclaimer bottoms are generated during the process of recovering MEA from heat stable salts (HSS), which are produced from the reaction of MEA with  $SO_2$  and  $NO_2$ . The HSS accumulate in the reclaimer during the lean amine feed portion of the reclaiming cycle. The volume of reclaimer bottoms generated will depend on the quantity of  $SO_2$  and  $NO_2$  that is not removed in the Flue Gas Scrubber. A typical composition of the waste is presented in Table 3.2.10.

MEA	9.5 wt.%
NH <sub>3</sub>	0.02 wt.%
NaCl	0.6 wt.%
$Na_2SO_4$	6.6 wt.%
Na <sub>2</sub> CO <sub>3</sub>	1.7 wt.%
Insolubles	1.3 wt.%
Total Nitrogen	5.6 wt.%
Total Organic Carbon	15.6 wt.%
РН	10.7
Specific Gravity	1.14

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Table 3.2. 10:	<b>Reclaimer Bottoms</b>	Composition

June 30, 2001

#### Filter Residues:

A pressure leaf filter filters a slipstream of lean amine. Diatomaceous earth is used as a filter-aid for pre-coating the leaves and as a body feed. Filter cycles depend on the rate of flow through the filter, the amount of filter aid applied, and the quantity of contaminants in the solvent. A typical composition of the filter residue is provided in Table 3.2.11 below. These will be disposed of by a contracted service hauling away the drums of spent cake.

MEA	2.6 wt.%
Total Organic Carbon	1.5 wt.%
SiO <sub>2</sub>	0.03 wt.%
Insolubles	0.03 wt.%
РН	10.0
Specific Gravity	1.0

# Table 3.2.11: Filter Residue Composition

# Excess Solvent Stripper Reflux Water:

The  $CO_2$  Recovery Facility has been designed to operate in a manner to avoid accumulation of water in the Absorber / Stripper system. Conversely, no continuous make-up stream of water is required, either. By controlling the temperature of the scrubbed flue gas to the absorber, water balance of the MEA system can be kept in check. Excess water can accumulate in the Stripper Reflux Drum and can be reused once the system is corrected to operate in a balanced manner. Should water need to be discarded, contaminants will include  $CO_2$  and MEA.

#### Secondary FGD Absorber Effluent:

The existing plant uses lime in its flue gas desulfurizer. In the cost estimate of this plant, it has been assumed that the existing plant disposal facilities can include the relatively small additional load of the secondary regenerator.

# Cooling Tower Blowdown:

The composition limits on cooling tower blowdown are shown in Table 3.2.12.

Component	Specification
Suspended Solids	30 ppm monthly, 100 ppm daily
PH	6.5 to 9
Oil and Grease	15 ppm maximum monthly, 20 ppm maximum daily
Free Chlorine	0.035 ppm

# Table 3.2. 12: Cooling Tower Blowdown Composition Limitations

There is a thermal limit specification for the entire river. However, the blowdown volume is too small to affect it significantly.

# Relief Requirements:

The relief valve discharges from the  $CO_2$  Recovery Unit are discharged to atmosphere. No tie-ins to any flare header are necessary.

# 3.2.5.10 Plant Layout

The new equipment required for Concept A covers about 7 acres of plot area. Plant layout drawings prepared for the Concept A  $CO_2$  Recovery System are as follows:

These drawings are shown in Appendix I.

Plot Plan – Overall Site before CO<sub>2</sub> Unit Addition

U01-D-0208 Plot Plan – Concept A: Flue Gas Cooling & CO<sub>2</sub> Absorption U01-D-0214 Plot Plan – Concept A: Solvent Stripping U01-D-0204 Plot Plan – Concept A: CO<sub>2</sub> Compression & Liquefaction U01-D-0211 Plot Plan – Concept A: Overall Layout Conceptual Plan U01-D-0200R Plot Plan – Concept A: Modified Overall Site Plan

Plant layout has been designed in accordance with a spacing chart called "Oil and Chemical Plant Layout and Spacing" Section IM.2.5.2 issued by Industrial Risk Insurers (IRI).

When reviewing the layout, the first thing to observe is that no highly flammable materials are handled within the  $CO_2$ Recovery Unit. The open cup flash point of MEA is 200 °F and, therefore, will not easily ignite. In addition to MEA, the corrosion inhibitor is the only other hydrocarbon liquid within the battery limits. The flash point of this material is higher than that of MEA and is handled in small quantities.

As the chemicals used in the process present no fire hazard, there is an opportunity to reduce the minimum spacing between equipment from that normally considered acceptable in hydrocarbon handling plants. Regardless, for the drawings that follow, standard spacing requirements, as imposed by IRI have been followed.

The plot area available for the installation of the desired equipment is small. Some equipment items are placed on structures to allow other pieces of equipment to be placed underneath them. This way pumps and other equipment associated with the Absorber can be located under the structure. Locating the pumps under the structure has been considered acceptable because the fluids being pumped are not flammable.

Noise is an issue with the flue gas fan as much as it is with compressors. Discussions with vendors suggest that it will be possible to provide insulation on the fan casing to limit noise to acceptable levels. Therefore, it has been assumed that no building needs to be provided for noise reasons.

Having economized on the required plot space as noted above, it was judged not to be practical to divide up the absorbers and strippers that are required into the relatively small plot areas initially offered for this purpose (refer to Section 2.1 and Figure 2.1.1). Eventually it was agreed that the units would be placed in an area about 1200 feet north of the Unit #5 stack (refer to Figure 3.1.1). By locating the units on a single site, the flue gas duct length and MEA piping between the absorber and stripper could be minimized, although the latter impact is not nearly as important as the flue gas routing.

The corrosion inhibitor must be protected against freezing during winter. The caustic solution will not freeze but will become very viscous when it gets cold. Therefore, a heated shed has been provided for housing the Corrosion Inhibitor and the Caustic injection packages.

The plot plan shows a substation in the Stripper area but none for the Absorber area. The assumption is that because the electrical consumption of the Absorber equipment is small (0.23 MW) compared to the Stripper equipment, the equipment can be run directly from the auxiliary power 480 volt power system.

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For the Rich/Lean Solvent Exchanger which is a plate and frame type exchanger, area estimates received from vendors based on similar conditions suggest that five units/ train would be sufficient for the specified service.

# 3.3 Concept B: CO<sub>2</sub> Separation with Oxygen Firing and Flue Gas Recirculation

The basic idea of the overall system for Concept B is to replace air with oxygen for combustion in the furnace in order to produces a high carbon dioxide content flue gas stream leaving the boiler island. A stream of re-circulated flue gas to the furnace is required to maintain thermal balance in the existing boiler between the lower furnace region where evaporation takes place and the convective heat transfer surfaces where steam is superheated and reheated to the required temperature level. This arrangement produces a high carbon dioxide content flue gas that after leaving the boiler system, is processed to provide high-pressure carbon dioxide liquid product for sequestration, enhanced oil recovery (EOR) or other uses.

#### 3.3.1 Overall System Description and Material and Energy Balance

A simplified system diagram for the modified unit is shown in Figure 3.3.1. The system was designed to provide maximum flexibility of operation and to facilitate combustion of coal in either air or oxygen and recirculated flue gas mixture environment.

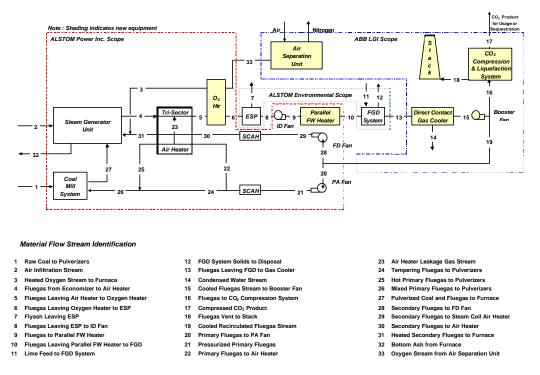


Figure 3.3. 1: Simplified Gas Side Process Flow Diagram for CO<sub>2</sub> Separation with Oxygen Firing

Raw coal (Stream 1) from the coal bunkers is supplied to the existing coal mills where it is pulverized and transported with recycled flue gas (Stream 27) to the furnace. The air separation unit (ASU) supplies the oxidant for the existing boiler. There is no air supply to the boiler except for air infiltration (Stream 2). The oxygen produced, about 8,924 tons per day, (Stream 33) flows through a heat exchanger where it is preheated by cooling the flue gas leaving the existing air heater (Stream 5). The pulverized coal is combusted in the furnace with a mixture of preheated oxygen (Stream 3) and preheated recycled flue gas (Stream 31).

The products of combustion leave the furnace and are cooled in a series of heat exchangers. The gas leaving the furnace first enters the existing convection pass of the unit where steam generated in the existing furnace walls is superheated and reheated in the existing convection pass heat exchangers. The flue gas leaves the convection pass (Stream 4) and is further cooled in the existing air heater of the unit. The air heater, however, is now used to heat recycled flue gas since air is no longer supplied to the unit in this mode of operation. The flue gas stream leaving the air heater (Stream 5) flows through the oxygen heater, electrostatic precipitator, induced draft fan, parallel feedwater

heater, flue gas de-sulfurization unit, gas cooler and booster fan, in series, before it is split into two streams. One stream (Stream 16) represents the exhaust gas stream leaving the boiler island. This stream provides the feed stream for the Carbon Dioxide Separation and Compression System (described in detail in Section 3.3.7). The remaining flue gas (Stream 19), which is roughly twice as large as Stream 16, is recycled back to the unit with the forced draft and primary air fans. Figure 3.3.2 shows the cooling curve for the flue gas leaving the existing boiler.

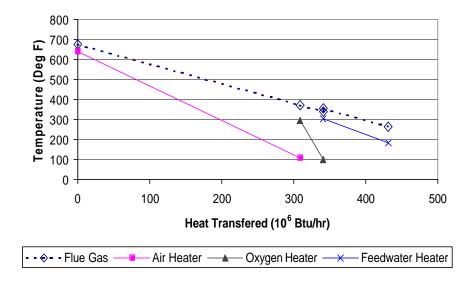


Figure 3.3. 2: Boiler Flue Gas Cooling Curve

The primary reason for the large recycle stream is to maintain the thermal balance between heat transferred in the radiant furnace and the convective heat transfer surfaces, and to generate required boiler performance. In addition, gas temperatures throughout the unit must be low enough to assure the ash, which is contained within the fuel, is maintained in a state where cleanability of the unit is not compromised. Additionally, the integrity of the existing metallurgy in the furnace walls and convective pass heat exchangers must be ensured. The recycled flue gas is supplied to the unit through a combination of new ducts and the existing air ducts. These recycle streams (Streams 29, 30, 31, 21, 22, 24, 25, and 26) provide the primary and secondary "air" streams for the air heater as well as the tempering "air" stream for outlet temperature control of the pulverizers. The modified system was designed to generate approximately  $3.1 \times 10^6$  lbm/hr of steam, which represents the Maximum Continuous Rating (MCR) for the unit.

Table 3.3.1, below, shows constituent mass flows, temperatures, pressures, enthalpies, and energy values (chemical, sensible, latent, and total) for all the points shown in the system diagram of Figure 3.3.1 This table therefore provides the gas side energy and material balance for the system. Two of the key assumptions used in the development of this material and energy balance were an oxygen stream purity of 99 percent by weight, and an air infiltration rate equivalent to one percent of the total oxygen required for the process. For the definition of state points 17 and 18, (not defined in Table 3.3.1) refer to Section 3.3.7.4, which provides the complete material and energy balance for the  $CO_2$  Compression and Liquifaction System.

Constituent	(Units)	- 31 -	2	3	4	6	6	7	8	9	1	0	11	12	13	14	15	16
O <sub>2</sub>	(LDrafty)	2902.0	7612	743840	99996	102588	102588		10258	6. 10258	8 1	02588			102342		102342	34614
Ns .		4788	24384	7512	149030	154515	154515		15451	5 15451	5 1	54515			154515		154515	37161
60		\$7037	420		259301	263120	269129		28312	9 26312	9 2	83129	159352	48955	375528	263965	111683	26855
CO,					3402777	352678D			352678			36780			3525704		3525704	547949
50,					20545	20581	20581		3055			20581			104.5		1045	24.5
au2		15754			200940	20.001	20.201		2000	1 20,49		21.701			1040		1040	54-3
Carbon		231693									-							
Sultur		8898																
CaO		9070									-		17784					
MgD	1.4.												968	494				
CaSO,											-		100	33404				
CaSO,	4													1982				
Mg90,	1.1										-			1215				
											-							
Mg80,											-			74				
CaCO1		200.20												3448				
Ash / Inerta	· · ·	41425			35.141	33141	53141	33141					566	266				1
	Turnerst	RevCed	LodgeAt		Repairedates			fly it is		e Hurgeric IPs			lierlikes (i	CB Remains		Codeware	Repairing for the	
Total Gas	(Lbrafte)	11.2	32816	751151	1830554		4057591		405758	406759	1 40	07591			4159135		3895233	916822
Total Solids		366602	10.00		33141	33141	33141	33141				All and a local second	19750	40515		ALC: NO.		
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Carbon												251693						
Suffar												9696	3					
CeD	- 10 - I												-				-	-
Mg0																		

#### Table 3.3.1: Gas Side Material and Energy Balance for Concept B

Notes: (1) Energy Basis; Chemical based on Higher Heating Value (HHV); Sensible energy above 80F; Latent based on 1050 Btu/Lbm of water vapor

T84502

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784602

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Boiler efficiency for the modified system is calculated to be 90.47 percent (HHV basis). This is increased significantly as compared to the Base Case (88.13 percent) due to Oxygen firing and the addition of the Oxygen Heater and Parallel Feedwater Heaters. The net plant heat rate (HHV basis) is increased significantly to 15,188 Btu/kwhr for this option as shown in Table 3.3.2, which also includes the Base Case for comparison. The plant thermal efficiency (HHV basis) for Concept B (22.47%) is about 64 percent of the Base Case value of 35.01%. This case represents the highest efficiency of the three CO<sub>2</sub> removal cases studied in this project. Auxiliary power is increased to 189,709 kW as a result of the added Air Separation Unit and the CO<sub>2</sub> Compression and Liquefaction System. Net plant output is reduced to 273,347 kW. Carbon dioxide emissions are 53,016 lbm/hr or about 0.194 lbm/kWh which is about 9.7% of the Base Case value of 1.997 lbm/kWh.

4143

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(Dep F)

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0<sup>6</sup> Blute

HIP BOUT

## Table 3.3.2: Overall Plant Performance Summary for Concept B

	(units)	Original Plant (Base)	Concept B O2 Fired
Fuel Paramaters			
Coal Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4140.0
Natural Gas Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		11.4
Total Fuel Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4151.5
Steam Cycle Paramaters			
Existing Steam Turbine Generator Output	(kW)	463478	463056
CO2 Removal System Turbine Generator Output	(kW)	0	0
Total Turbine Generator Output	(kW)	463478	463056
Total Auxiliary Power	(kW)	29700	189709
Net Plant Output	(kW)	433778	273347
Overall Plant Performance Paramaters			
Net Plant Efficiency (HHV)	(fraction)	0.3501	0.2247
Net Plant Efficiency (LHV)	(fraction)	0.3666	0.2354
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000	0.6419
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749	15188
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309	14500
Overall Plant CO 2 Emissions			
Carbon Dioxide Emissions	(lbm/hr)	866102	53016
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997	0.194
Normalized Specific CO2 Emissions (Relative to Base Case)	(fraction)	1.000	0.097
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)		1.803
Specific Carbon Dioxide Emissions	(kg/kwhr)	0.906	0.088
Avoided Carbon Dioxide Emissions (as compared to Base)	(kg/kwhr)		0.818

#### 3.3.2 Air Separation Unit

Concept B uses nearly pure oxygen instead of air for combustion of coal and therefore requires an Air Separation Unit (ASU) to provide the supply of oxygen to the furnace. The ASU selected is a cryogenic type design because of the large capacity required.

#### 3.3.2.1 Background

As stated above in Section 3.3.1, AEP's Conesville Unit #5 requires 8,924 standard tons of 99% purity  $O_2$  per day (T/D) when fired at 100% of the maximum continuous rating (MCR). Hence it was necessary to design an Air Separation Unit (ASU) that would be capable of producing at least this amount of oxygen. Initial discussions between ABB and air separation plant vendors were about using two 3685 T/D of oxygen trains and one 1600 T/D train for a total of 8950 T/D. This is due to the fact that a 3685 T/D is the largest plant, which could be comfortably offered at this time. After factoring in capital cost considerations, it was decided to design an overall plant comprised of two-3930 T/D trains and two-550 T/D trains, for a total capacity of 8,960 T/D. A variety of practical and technical issues are discussed below. A process flow diagram of a typical cryogenic air separation unit (BOC Webpage) showing all its major components is shown in Figure 3.3.3.

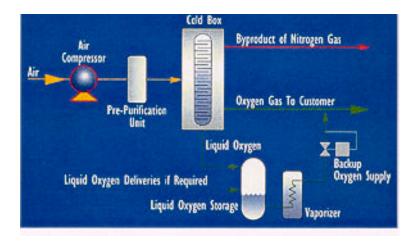


Figure 3.3. 3: Process Flow Diagram of a BOC Improved Air Separation Unit

## 3.3.2.2 Oxygen Purity Considerations

Oxygen purities above 98% have significant impacts on the cryogenic portion of the process.  $O_2$  purities below 95% do not benefit in a cost reduction due to reduction in main air compressor discharge pressure requirements. The purities below 95% often require a frame size increase due to higher inlet volumetric flow rates. It also increases the size of the air adsorber system. The reduced discharge pressure requirements do save on energy of the main air compressor, but other process duties increase due to the higher flow rate of oxygen product. The overall energy consumption could increase if the product is gaseous oxygen with a significant battery limit pressure requirement.

#### 3.3.2.3 Bottlenecks for building plants larger than 3685 ST/D

The current largest single ASU in operation is 3500 ST/D at Rozenburg, The Netherlands. However, sizes up to 4950 ST/D have been designed on paper. Usually, larger size plants are cheaper than smaller plants due to economy of scale. However, it is believed that a break point somewhere near 3685 T/D is where increased plant size will actually cost more for the following reasons:

- The compressor size, driver size, motor sizes, and line voltage drop at start-up are potential hurdles. The largest compressor sizes that ASU manufacturers have experience with are in the 40000-hp range. There may not be any significant aspects of the larger compressors that would create problems over the voltage drop to the compressor if it is motor driven, however, there is no actual experience among the major manufacturers with compressors and drivers exceeding this size.
- Columns larger than 20 feet in diameter create transportation problems for the part of the trip, which is over land. Plants located adjacent to navigable bodies of water would not have any limitation like this. The impact could translate to the need to field fabricate the column.
- Large size pipe and valves become more job specific which create the loss of pricing economies of scale which can be attained when pipe and valve sizes fit many units being built at the same time.

#### 3.3.2.4 Major Vendors Experience

A plant size of 3685 ST/D  $O_2$  production is larger than any vendor had operating as of May 2000. The following list represents the largest operating plant size that the three vendors had running at that time:

Vendor	Largest size operating plant
	(ST/D O <sub>2</sub> )
Air Liquide	3190
Air Products	3500
BOC	2640

## 3.3.2.5 Power Consumption

The Air Separation unit (ASU) includes a cryogenic plant for air separation. Economic considerations for this application favored the selection of oxygen stream purity of 99 percent by weight. As stated above, four trains were required to produce the required oxygen mass flow rate of about 8924 tons per day. This system consumes 95,822 kW of electric power or about 21 percent of the generator output. This energy consumption is equivalent to about 260 kWh/ton of  $O_2$  produced. By contrast, Kobayashi and Prasad (Kobayashi and Prasad, 1999) state that the thermodynamic minimum energy requirement is about 40 kWh/ton of  $O_2$  produced. If this limit could be approached, it would represent a breakthrough technology that would enable Concept B to become nearly cost competitive with "business as usual" (coal-fired in air without  $CO_2$  capture) electricity generation.

## 3.3.2.6 Plot Plan Requirements

The required plot plan areas, supplied by Air Products, are 185 feet by 250 feet and 125 feet by 150 feet for the 3930 T/D and 550 T/D plants, respectively. When the areas for storage and oxygen compressions are included, the required total plot plan amounts to 555 feet by 620 feet. Refer to Appendix I for the plant layout drawings for Concept B.

## 3.3.2.7 Investment and Operation and Maintenance Costs

The investment, and operation and maintenance costs of the Air Separation Unit are presented in Section 5.3.2.

## 3.3.3 Boiler Heat Transfer Analysis

The primary objective of the systems analysis task for Concept B was to develop a system, which would produce high carbon dioxide content flue gas from an existing coal, fired boiler without requiring major pressure part modifications to the boiler. In order to access whether pressure part modifications would be necessary an accurate heat transfer analysis of the existing boiler was required.

The first step was to set up a steady state performance model of the Conesville #5 steam generator unit. This involved calculating or obtaining all the geometric information for the unit as required by the proprietary Reheat Boiler Program (RHBP). The RHBP provides an integrated performance model of the boiler island including, in addition to the steam generator unit, pulverizers, air heater, and steam temperature control logic. The RHBP is used to size components and/or predict performance of existing components. In this study, since the boiler island component sizes are known, the RHBP was used exclusively for calculating unit performance.

The next step in the heat transfer analysis of the system was to calibrate the RHBP model of the unit. This involved obtaining a set of test data (with air firing) for the existing unit and adjusting the performance model to match the test data. The required test data includes steam temperatures entering and leaving each major heat exchanger section in the unit, steam pressures, coal analysis, flue gas oxygen content, etc. The adjustments to the model are in the form of "surface effectiveness factors" and "fouling factors".

After the model was calibrated, additional adjustments were required in order to obtain an accurate heat transfer analysis with the high carbon dioxide content flue gas of the Concept B system. The combustion process occurs in a non-conventional environment, which produces gases of different physical and thermal properties. These gas property differences cause significant differences in the heat transfer processes, which occur within the steam generator unit. Analyses were made to determine the impact of the heat transfer differences on boiler behavior.

The RHBP accounts for three modes of heat transfer in the upper furnace and convective pass of the unit (direct radiation, non-luminous radiation and convection). The direct radiation is emitted from the furnace "fire-ball" and is absorbed in various areas of the unit depending on the geometry of the tube banks and the proximity to the "fire-ball". Since the distribution of direct radiation is only a function of geometry, no formulation modifications were necessary for this component of the heat transfer analysis. Investigation of the non-luminous radiation formulations within the RHBP indicated that current equations (based on the Hottel curves, 1957) would be accurate and formulation modifications would not be required. The convection formulations, however, were not set up with the capability of

accurately analyzing convective heat transfer for flue gases which were this much different than the typical range of boiler flue gases. The appropriate corrections were made to properly model the convection process in the RHBP with oxygen firing.

#### 3.3.3.1 Furnace Analysis

Initially, it was expected that heat fluxes to the furnace walls might be increased or decreased somewhat for Concept B (oxygen firing) due to the higher  $CO_2$  and  $H_2O$  content of the flue gas relative to the air fired Base Case for the following reasons:

- Higher gas emissivity and absorptivity of  $CO_2$  and  $H_2O$  relative to  $N_2$ . For an equivalent local gas temperature, the higher emissivity of  $CO_2$  and  $H_2O$ , relative to the optically transparent  $N_2$ , should serve to increase the absorption coefficient and hence, the radiation to the walls in the recycled flue gas case (Concept-B) relative to the Base Case.
- Higher specific heat of CO<sub>2</sub> and H<sub>2</sub>O relative to N<sub>2</sub>. For an equivalent local heat release and heat transfer, the higher specific heat of carbon dioxide will serve to decrease the overall flame temperatures of the recycled flue gas mixture in the Concept-B case, relative to the baseline case. This would tend to compensate for the higher gas emissivity.

In preparation for the Concept B furnace performance analysis, a review of pertinent literature and CFD furnace analysis results developed for this project (Bozzuto, et al., 2000) were completed. Explanations for the observed trends must rely on physical property differences between nitrogen, which dominates in the Base Case, and carbon dioxide, which largely supplants nitrogen in Concept-B.

## Literature review:

The first step in the furnace analysis was to review applicable results obtained from the literature regarding combustion of coal in an environment where  $CO_2$  displaces the  $N_2$  in the combustion air. Several investigators (Thambimuthu, 1998; Kiga, et al., 1997; and Weller, at al., 1985) have found from pilot-scale testing that when coal is burned in  $O_2/CO_2$  environment whereby  $CO_2$  displaces the  $N_2$  in the combustion air (i.e., in ~30%  $O_2/70\%$   $CO_2$  mixture, by volume), the heat absorption in the lower furnace is not significantly impacted.

To illustrate this point, the results of re-analyses of Thambimuthu's (Thambimuthu, 1998) data concerning the combustion of a subbituminous coal sample from Western Canada are presented in Figure 3.3.4. As can be seen in this figure, the radiative heat fluxes into the lower furnace were, for the three cases studied (air, 28%  $O_2/72\%$   $CO_2$ , and 35%  $O_2/65\%$   $CO_2$ ), roughly similar at gas temperatures greater than 1275 °C.

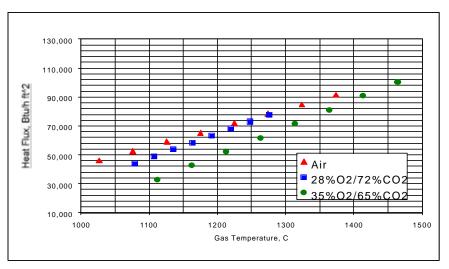


Figure 3.3. 4: Variation of Radiative Heat Flux with Gas Temperature During Combustion in Air and O<sub>2</sub>/CO<sub>2</sub> Mixtures (from Thambimuthu, 1998)

Results from a similar experiment, Chui, et al., (2001), were also investigated, in somewhat more detail, in order to assess the apparent overall change in gas emissive power that would occur in a furnace when switching from air-firing to a high  $CO_2$ - $O_2$  environment. The test facility, the same one used previously by Thambimuthu et.al.(1998), is a pilot-scale, 0.3 MW facility and consists of a cylindrical, down-fired vertical combustor (0.61 m I.D. and 6.7 m in length). The most relevant tests from the literature source are designated as Case-1 (baseline condition with air firing and a burner swirl setting of 11) and Case-2 (dry recycle with burner swirl setting of 10). The dry recycle case is representative of an oxygen fired case similar to Concept B with 28%  $O_2 / 72\%$  CO<sub>2</sub> by volume. The principal conclusion of the work by Chui, et al., based on both experimental and simulated results, was that the dry recycle case demonstrated a distinct decrease in the incident radiant heat flux to the wall (by about 18%) relative to the baseline case (Case-1).

The intent of the present re-analysis of this data was to utilize the incident heat flux measurements and measured centerline gas temperatures for the cases reported by Chui, et al., and then back-calculate the apparent gas emissivity for the furnace as a function of the longitudinal position. The desire was to verify whether the apparent emissivity differences between the baseline and dry recycle cases mirrored the known physical differences in radiative absorption properties between N<sub>2</sub> and CO<sub>2</sub> (corresponding to the baseline and dry recycle cases, respectively). The comparison of Case-1 and Case-2, which have similar swirl settings (and thus similar flow patterns), should isolate the effects of gas emissive properties without introducing the strong effects of flow pattern changes as observed by Chui and reconfirmed by our analysis. Based on the incident heat flux measurements and the measured centerline gas temperatures, apparent gas emissivities for the furnace were calculated. These values are tabulated in Table 3.3.3 and plotted in Figure 3.3.5.

Axial Distance (m)	Case-1 (Air Firing) Gas Emissivity	Case-2 (Oxy-Firing) Gas Emissivity
0.95	0.685	0.782
1.55	0.657	0.737
2.15	0.611	0.796
2.77	0.562	0.829
3.40	0.532	0.766

 Table 3.3.3:
 Apparent Combustor Gas Emissivities

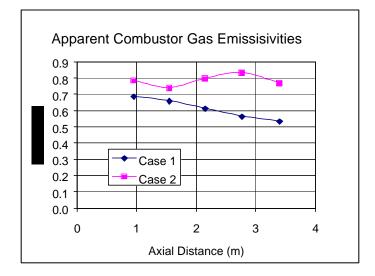


Figure 3.3. 5: Apparent Combustor Gas Emissivities as a Function of Axial Distance

As shown in Figure 3.3.5, the apparent emissivity of the dry recycle case (Case-2) is higher than that of the baseline case (Case-1). Based on the substitution of the radiating gas  $CO_2$  for non-radiating nitrogen in the dry recycle case, the observed shift is what would be expected. It should be understood, however, that these results are only to be expected for cases with identical or similar flow patterns. The other test cases reported in Chui, et al. (2001) with swirl settings and corresponding aerodynamic and flame patterns that were different from those of Case-1 and Case-2, showed that such flow patterns have a dominant influence on the apparent gas radiative properties.

Another interesting aspect of the combustor results are the measured centerline gas temperatures. Table 3.3.4 tabulates the corresponding temperatures measured in the Chui, et al. combustor, along with the Case-1 to Case-2 shift. The temperature shifts are plotted in Figure 3.3.6. The mean gas temperature shift, averaged over all measurement locations, is -214 °F.

Axial Distance (m)	Case-1 Centerline Gas Temperature, °F	Case-2 Centerline Gas Temperature, °F	Temperature Shift, °F (Case 2 - Case 1)
0.95	2664	2419	-245
1.55	2552	2367	-185
2.15	2421	2215	-205
2.77	2284	2041	-243
3.40	2143	1953	-191

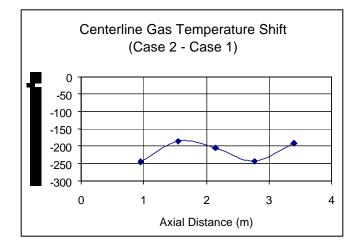


Figure 3.3. 6: Centerline Gas Temperature Shift as a Function of Axial Distance

Calculations of adiabatic flame temperature  $(T_{ad})$  were performed for coal firing in AEP's Conesville Unit #5 at maximum continuous rating (MCR). A number of scenarios were considered, namely: (1) Base Case (i.e., coal firing in air); (2) Constant Mass Case (i.e., the mass of nitrogen in air was replaced by the mass of CO<sub>2</sub> in the flue gas recycle (FGR); and (3) Various CO<sub>2</sub>/O<sub>2</sub> Mole Ratio Cases. Results (Figure 3.3.7) indicated that the  $T_{ad}$  for air firing was approximately 180 °F higher than for the Constant Mass Case. This difference is due to differences in specific heat (Cp) between N<sub>2</sub> and CO<sub>2</sub> (i.e., CO<sub>2</sub> Cp > N<sub>2</sub> Cp at elevated temperatures, Figure 3.3.8). One implication is that the ultimate combustion efficiency difference between air firing and O<sub>2</sub>/FGR firing could be governed by opposing phenomena, i.e., potentially lower reaction rate, but longer residence time in O<sub>2</sub>/FGR than in air. Thermo-gravimetric analysis (TGA) and Drop Tube Furnace System-1 (DTFS-1) results -- obtained from combustion firing of both Conesville Unit #5 and Pittsburgh Seam #8 coals other (See Volume II Report of this work, Bozzuto, et al., 2001) -- indicate that these two phenomena indeed virtually cancel each other.

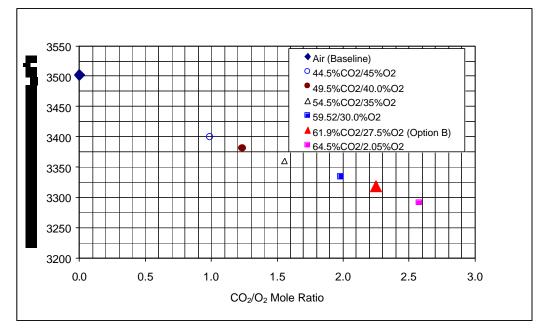


Figure 3.3. 7: Calculated Adiabatic Flame Temperature as a Function of CO2/O2 Mole Ratio for Conevsville Unit #5

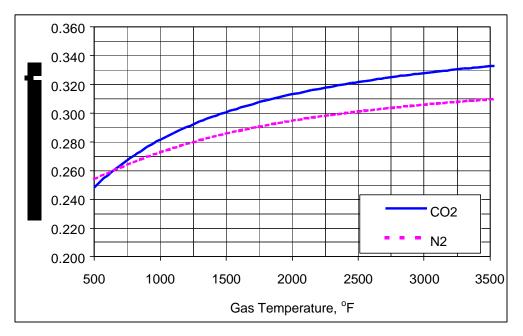


Figure 3.3. 8: Specific Heats (Cp) of Nitrogen and Carbon Dioxide as a Function of Temperature

## **CFD Furnace Model Results and Conclusions:**

Review of the CFD analysis results (Bozzuto, et al., 2001) which were developed for this project indicated the following with respect to furnace heat transfer:

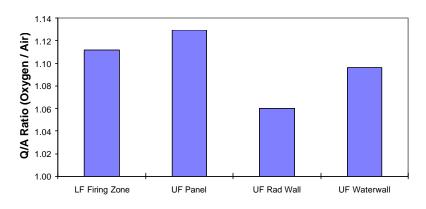
The baseline case (or Base Case) exhibits a slightly higher peak gas temperature (maximum difference of about 200 °F), and a correspondingly higher average (cross-sectional) gas temperature (difference of 90 °F at the HFOT), than that of the Concept-B case. This result compares favorably with the approximate -214 °F shift found by Chui et.al.

Note, however, that this close correspondence may be somewhat fortuitous, particularly since the two furnaces are so different. Nevertheless, the correspondence may indicate that the baseline air case may be expected to exhibit consistently higher peak and averaged post-flame temperatures than an oxy-fired case (with similar flow and flame patterns).

The net wall absorption in the furnace region for the baseline case is larger (by less than 1%) than that of the Concept-B case. Conversely, the net wall absorption for the baseline calculation with the proprietary in house Reheat Boiler Program (RHBP), as described below, was found to be about 6% lower than the Concept-B case calculated by the RHBP. The higher specific heat of the carbon dioxide, and the associated lower gas temperatures in the Concept-B case, will tend to offset somewhat or compensate for the expected increase in the wall absorption (i.e., anticipated due to the enhanced emissivity of the  $CO_2$ .) Furthermore, the spatial distribution of the carbon dioxide across the cross-section may be important; it is hypothesized that high concentrations of  $CO_2$  in the cooler gas mixtures between the wall and the flame may actually act to inhibit the net radiative flux to the walls.

## Performance Model (RHBP) Results:

The present study for Concept B involves coal combustion in a medium with  $\sim 31\%O_2/69\%$  CO<sub>2</sub> volume ratio. Heat transfer in the lower and upper furnace regions as calculated by the RHBP is compared in Figure 3.3.9. This figure compares heat fluxes (Btu/hr-ft2) in selected lower and upper furnace regions for air firing and oxygen firing. Lower furnace region results show firing zone heat flux to be about 11 percent higher with oxygen firing. Upper furnace region results show the reheat radiant wall is about 6 percent higher and the superheat division panels are about 13 percent higher with oxygen firing. Similarly, the upper furnace waterwall area is about 10 percent higher. The overall lower furnace heat absorption for Concept B was about 6% higher than for the air fired Base Case. The horizontal furnace outlet temperature (HFOT) for Concept B was calculated to be 123 °F lower than for the Base Case.





The trend calculated by the CFD code, with respect to the furnace temperature at the HFOP, appears to be qualitatively aligned with the trend calculated by the in-house RHBP code. However, the difference in wall absorption for the Concept-B case relative to the baseline case, calculated by FLUENT (change of -1%), does not fully agree with the results of the RHBP (change of +6%). Computed and/or experimental trends that indicate that oxy-firing may induce either an increase in wall absorption or a decrease in wall absorption, relative to the baseline case, are supported in the literature. It is suggested that the absorptive properties of a local CO<sub>2</sub>-containing gas mixture in the vicinity of the wall may either act to enhance or inhibit the incident radiative flux to the wall, depending upon its relative spatial location and mixture temperature. For example, a low-temperature, CO<sub>2</sub>-rich mixture near the wall would absorb the radiative flux from the interior "fireball" region; a portion of the energy would be re-emitted at the lower gas temperature, and the remainder of the energy would be used to heat up the gas. The result would be a net reduction in the incident radiative flux to the wall. Conversely, a high-temperature, CO<sub>2</sub>-rich mixture near the wall would emit at its local gas temperature, thus enhancing the incident radiative flux to the wall. Therefore, it is suggested that the relative spatial relationships of the cool and hot gas mixtures, the relative composition of the absorbing media, and the proximity of that media to the wall (as induced by the furnace and firing

system aerodynamics), may significantly impact the gas-phase irradiation to the wall. Indeed, the aerodynamic and flame patterns that prevail in a given air-fired or oxy-fired furnace may conceivably have as strong an impact on the net wall absorption as the physical property differences themselves (gas-phase emissivity, specific heat, etc.)

The results of computational tools (such as CFD and the RHBP) should be viewed with some skepticism, particularly when they are asked to produce calculations outside of the experience base for which they have been validated. Certainly, the gas-phase and particle-phase radiation property sub-models could be enhanced in both codes, and the impact of spatial gradients (caused by the interleaving of hot and cool regions of varying CO<sub>2</sub> composition) on radiative wall flux needs to be investigated more fully. CFD computations have been utilized to gain a more in-depth qualitative understanding of aerodynamic and flame patterns in combustion systems, but have not yet been integrated into routine boiler design procedures. At the present time, the ALSTOM design standards are based upon the experience and expertise built into the RHBP and other design protocols, and those standards must be adhered to in any new design project in order to mitigate risk. Therefore, the results of the RHBP, as reported in this work, must be regarded as the current standard, both from an engineering experience viewpoint and from a rules-based design viewpoint. However, additional validation work needs to be done in order to confirm the trends for oxy-firing scenarios.

Although differences in physical properties of the transport gases (e.g., air-firing versus oxy-firing) may initially induce undesirable deviations from the performance goals of an existing field unit, the designer and engineer views such alterations as challenges rather than insurmountable obstacles. Much can be done in the way of operating condition optimization (e.g., spray, nozzle tilt, and amount of gas recirculation), without major modifications to the unit, to realign steam temperatures and wall absorption with their desired, target values. Design parameters are often in conflict, and the intelligent designer must work to balance various parameters and operating conditions to achieve the desired outcome. The CFD work performed here was based on certain constraints to maintain equivalency for comparison purposes, which would not necessarily be the case in the field. For example, a potential decrease in furnace wall absorption of several percentage points could be nullified through manipulation of the various operating parameters available.

## 3.3.3.2 Convection Pass Analysis

Figures 3.3.10, 3.3.11 and 3.3.12 show the comparison of convective, non-luminous, and total heat transfer rates between air firing and oxygen firing for all the major sections contained in the existing convection pass of the unit at full load operating conditions as calculated by the RHBP.

Convective heat transfer in utility steam generator units is dependent upon many of the transport properties of the flue gas (viscosity, thermal conductivity, density, specific heat and others). Additionally, convection depends strongly on gas velocity. With the Concept B system there are significant changes in the flue gas analysis as compared with air firing. These gas analysis changes cause both transport property and gas velocity changes throughout the unit. The resulting convective heat transfer rates, as shown in Figure 3.3.10, ranged from about 80 to 105 percent as compared to air firing.

Significant differences in non-luminous radiant heat transfer are also expected. Of the gases produced by the complete combustion of a fuel, only carbon dioxide, water vapor and sulfur dioxide emit radiation over a sufficiently wide band of wave lengths to warrant consideration. With this system the primary change in the flue gas as compared to air firing is the large increase in the  $CO_2$  content and decrease in  $N_2$  content. The resulting enhancement in non-luminous heat transfer rates range from about 26 to 28 percent greater than air firing as shown in Figure 3.3.11.

Ultimately the convection pass total heat transfer rates, shown in Figure 3.3.12, were increased in the range of 1 to 8 percent over the values with air firing.

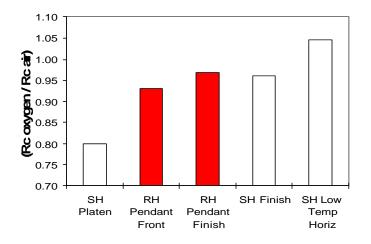


Figure 3.3. 10: Convective Heat Transfer Rate Comparison

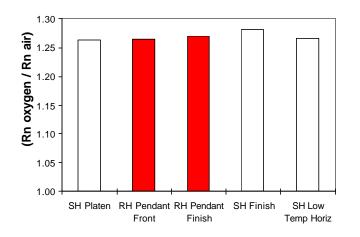


Figure 3.3. 11: Non-luminous Heat Transfer Rate Comparison

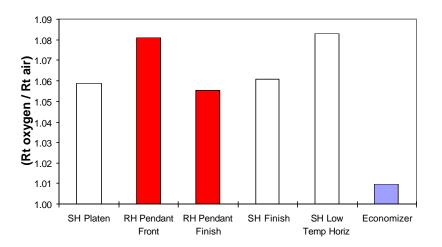


Figure 3.3. 12: Total Heat Transfer Rate Comparison

Steam temperature control was achieved through the use of burner tilt and reheat spray. The performance analysis results indicated the reheater circuit required about 1.45 percent spray to maintain the reheat outlet temperature at the design value. The superheater circuit required about 0.34 percent spray to maintain the superheat outlet temperature at the design value. The burner tilt was set at -10 degrees, the minimum value the customer uses. The overall steam conditions produced are shown in Table 3.3.5 below. Furthermore, with this recycle gas system, flue gas recirculation is also available as an additional steam temperature control variable. In this study however, we did not utilize this as an additional steam temperature control variable. We decided, as a first approximation, to set the flue gas recirculation rate at a value such that the flue gas flow to coal flow ratio was the same as with air firing. As it turned out, this was an acceptable setting for the gas recirculation rate.

	SHO	FWI	ECO	RHO	RHI
Flow (lbm/hr)	3131619	3131619	3131619	2808511	2808511
Pressure (psia)	2535	3165	3070	590.8	656.5
Temperature (F)	1000	493	622	1000	631
Enthalpy (Btu/lbm)	1456.3	479.2	640.8	1517.6	1305.6
		G	amain steam	(10 <sup>6</sup> Btu/hr)	3059.9
			Qreheat	(10 <sup>6</sup> Btu/hr)	595.4
		·	Q Total s/w	(10 <sup>6</sup> Btu/hr)	3655.3

Table 3.3. 5:	Boiler/Turbine Steam Flows and Conditions for Concept B
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Notes:

SHO = Superheater Outlet; FWI = Feedwater Inlet; ECO = Economizer Outlet; RHO = Reheater Outlet; RHI = Reheater Inlet

With the increased heat transfer rates with oxygen firing and similar steam temperature profiles, there was concern regarding metal temperatures throughout the unit. A detailed analysis using the Metal Temperature Program (MTP) was however, beyond the scope of this study. The MTP, using thermal inputs from the RHBP, calculates steam and metal temperatures at any selected point along the length of the tube. All tubes of each heat exchanger bank are modeled. A very brief review of metal temperatures at only a few selected points was done in this study. In general, for the points investigated, the metal temperatures were found to be the same or slightly lower than with air firing. The primary reason for this result was that although the heat transfer rates were slightly higher and the steam temperature profile was similar, the gas temperatures were lower. This combination yields similar heat flux conditions and ultimately similar metal temperatures.

## 3.3.4 Boiler System Modifications

Listed below are the basic modifications required for the Conesville No.5 unit to support firing with oxygen as required in Concept B.

## 3.3.4.1 Boiler

The Boiler Island should be inspected for potential air leaks into the system and should be sealed to minimize any infiltration. Special attention should be given to all penetrations including seal boxes for convective surfaces, sootblowers, wallblowers, expansion joints, ductwork, fuel piping, fans and windbox.

## 3.3.4.2 Ducts and Dampers and Fans

Refer to the Duct and Damper Diagram (Figure 3.3.13) shown below for the required duct arrangement and associated cross-sectional areas for this system. New flue gas ductwork is required for the Oxygen Heater. Part of the existing ductwork from the Air Heater flue gas exit to the Electrostatic Precipitator inlet must be removed and replaced with new ductwork that accommodates the new Oxygen Heater. Additionally, oxygen supply ductwork from the ASU to

the Oxygen Heater is required and hot oxygen supply ductwork from the Oxygen Heater to the existing secondary "air" duct must be provided. Similarly, New flue gas ductwork is required for the Parallel Feedwater Heater. Part of the existing ductwork from the Induced Draft fan outlet to the Scrubber inlet must be removed and replaced with new ductwork that accommodates the new Parallel Feedwater Heater. New ductwork and dampers are also required for the recycle flue gas streams that feed the existing Forced Draft and Primary Air fans.

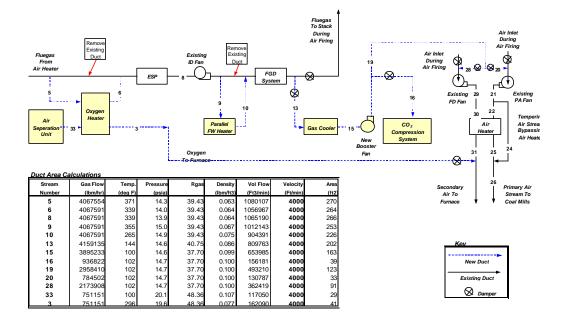


Figure 3.3. 13: Duct and Damper Diagram for Concept B

A new booster fan will be required as a minimum. The booster fan is required to overcome the added draft loss of the various new heat exchanger components shown in Figure 3.3.1 previously. Specifications for the booster fan are shown in Table 3.3.6 below. The existing Induced Draft, Forced Draft and Primary Air fans should eventually be checked with the suppliers to see if they can handle the new conditions (Note: The molecular weight is now 37.7 for the FD and PA fans and 39.4 for the ID fan). For this study we have assumed that both fans are acceptable.

_			
ſ	Booster Fan Specific	ation	
	<del>Gas Analysis</del>		
	Oxygen	(wt percent)	2.63
	Nitrogen	"	3.97
	Water Vapor	"	2.87
	Carbon Dioxide	"	90.51
	Sulfur Dioxide	н	0.03
	Total	"	100.00
	Mass Flow Rate	(lbm/hr)	3895233
	Gas Inlet Temperature	(Deg F)	100.0
	Inlet Pressure	(psia)	14.56
	Outlet Pressure	(psia)	14.70
	Pressure Rise	(in wa)	4.00

Table 3.3.6:Booster Fan Specification

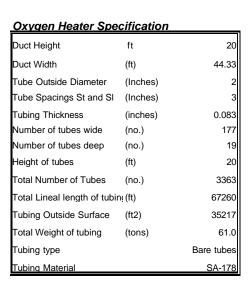
## 3.3.4.3 Oxygen Heater

The flue gas exiting the Air Heater is at 371 °F. A large quantity of sensible heat is still available in this gas stream. The Oxygen heater is used to recover additional sensible heat in the flue gas as a result of reduced air heater performance with oxygen firing. This heat is partially recovered in the Oxygen Heater where cold O2 from the Air

Separation Unit is preheated before being mixed with the gas recirculation stream prior to furnace injection. Part of the existing ductwork connecting the existing Air Heater flue gas exit stream to the Precipitator inlet is removed. New ductwork, which accommodates the addition of the new Oxygen Heater, is installed. Performance requirements and gas analyses for the Oxygen Heater are shown in Table 3.3.7. Table 3.3.8 shows the Oxygen Heater specifications. It should be noted that the flue gas stream, which provides the heat source for this heat exchanger, contains flyash, as the Oxygen Heater is located between the Air Heater and the Electrostatic Precipitator (ESP). A simple sketch of the oxygen heater, which is similar in design to a tubular air heater, is shown in Figure 3.3.14. Refer to Appendix I Concept B Boiler modification drawings for the proposed arrangement of this equipment.

Table 3.3.7:	Oxygen Heater Performance Requirements and Gas Analysis
--------------	---------------------------------------------------------

Oxygen Heater Performance F	Oxygen Heater Performance Requirements					Fluegas
	(units)	Value	Constituant	(units)	Stream	Stream
Flue Gas Mass Flow	(lbm/hr)	4067591	<b>O</b> <sub>2</sub>	(Wt Frac)	0.9900	0.0252
Flue Gas Inlet Temperature	(deg F)	371	N <sub>2</sub>	"	0.0100	0.0380
Flue Gas Outlet Temperature	(deg F)	339	H₂O	"		0.0647
Oxygen Mass Flow	(lbm/hr)	751151	CO₂	"		0.8670
Oxygen Inlet Temperature	(deg F)	100	SO <sub>2</sub>	"		0.0051
Oxygen Outlet Temperature	(deg F)	296	Total		1.0000	1.0000
Oxygen Heater Heat Transfer	(10 <sup>6</sup> Btu/hr)	33.062				
Oxygen Pressure	(psia)	20				
Flue Gas Pressure	(psia)	14.281				



**Table 3.3.8:** 

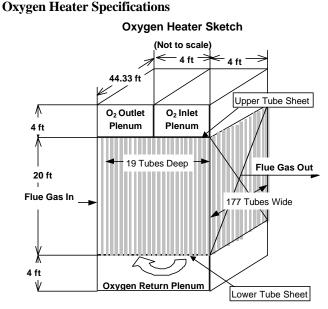


Figure 3.3. 14: Oxygen Heater Sketch

# 3.3.4.4 Parallel Low Pressure Feedwater Heater

A parallel low-pressure feedwater heater (PFWH) is facilitated to remove remaining useful sensible heat in the flue gas. This heater is installed in a parallel feedwater stream with the existing extraction low-pressure feedwater heaters number 52 and 53. The heat source for the PFWH is flue gas leaving the ID fan as shown on the system diagram (Figure 3.3.1). In actuality, there are two ID fans on this unit and therefore two PFWH's are used. The flue gas

temperature leaving the induced draft fans is 355 F. The PFWH cools the flue gases down to 265 F by heating feedwater in a parallel stream with the feedwater being heated in the extraction feedwater heaters No. 52 and 53 as shown in Figure 3.3.15. About 29 percent of the total low-pressure feedwater flow leaving the No. 51 low-pressure feedwater heater is heated in the new PFWH. This heat exchanger is essentially a low temperature economizer section that is designed similar to Heat Recovery Steam Generator (HRSG) tube banks with finned tubing. The fin pitch can be quite high (6 fins/inch) since the flue gas at this point is particulate free.

These new components recover about 26,458 kW [90.3 x 106 Btu/hr]. This causes the steam extractions to heaters No. 52 and No. 53 to be reduced proportionally and the steam flow through the low-pressure section of the existing steam turbine to be increased by approximately two percent. This increases the generator output proportionally. Performance requirements and specifications for the PFWH are shown in Tables 3.3.9 and 3.3.10. Figure 3.3.16 shows a simple sketch of the new component. Refer to Appendix I Concept B Boiler modification drawings for the proposed arrangement of this equipment.

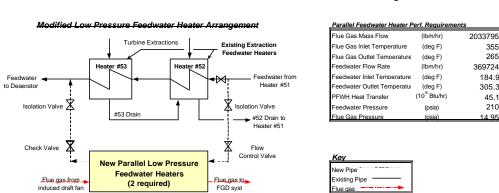




Figure 3.3. 15: Parallel Feedwater Heater Arrangement

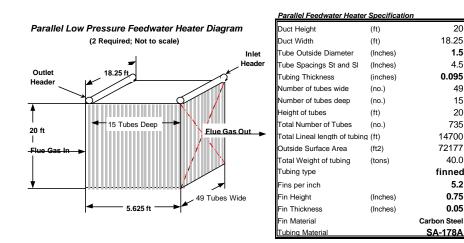


 Table 3.3.10:
 Parallel Feedwater Heater Specification

Figure 3.3. 16: Parallel Feedwater Heater Sketch

Table 3.3.11 shows the specifications for the PFWH headers and piping. The piping runs from the feedwater pipe entering existing feedwater heater #52 to the two PFWH unit inlet headers and returns from the to PFWH outlet headers to the feedwater pipe leaving existing feedwater heater #53.

	Outside Dia.	Nominal ID	Material	Weight	Length	Connections
	(inches)	(inches)		(lbm/ft)	(ft)	(number)
Headers	8.625	6.251	SA-106C	53.41	18.25	49-1.5" ; 1-6.625"
Piping	6.625	SCH 120	ASA B36.1	36.3	375 ea. 2 reqd	

Table 3.3.11:	<b>PFWH Header and Piping Specifications</b>
---------------	----------------------------------------------

## 3.3.4.5 Controls and Instrumentation:

Additional controls and instrumentation will be required for the new components and systems described. The transition between air firing and oxygen firing needs careful consideration.

## 3.3.4.6 Modified Boiler Drawings

Drawings of the modified boiler showing the existing and new equipment are listed below and contained in Appendix I.

U00-E-0551R General Arrangement - Side Elevation for Concept B U00-E-0552R General Arrangement - Plan View "B-B" for Concept B U00-E-0585R General Arrangement - Plan View "A-A" for Concept B

## 3.3.5 Steam Cycle System

The steam cycle system for Concept B is modified slightly with the addition of a low-pressure feedwater heater arrangement in parallel with extraction feedwater heaters # 52 and 53 as described in Section 3.3.4.4. The parallel feedwater heaters are used to recover additional sensible heat in the flue gas as a result of reduced air heater performance with oxygen firing. The modified steam cycle is shown in Figure 3.3.17. The associated Mollier diagram showing the modified steam cycle on enthalpy vs entropy coordinates is shown in Figure 3.3.18. The modified steam cycle system produces 463,056 kw with a steam turbine heat rate of 8089 Btu/kwhr.

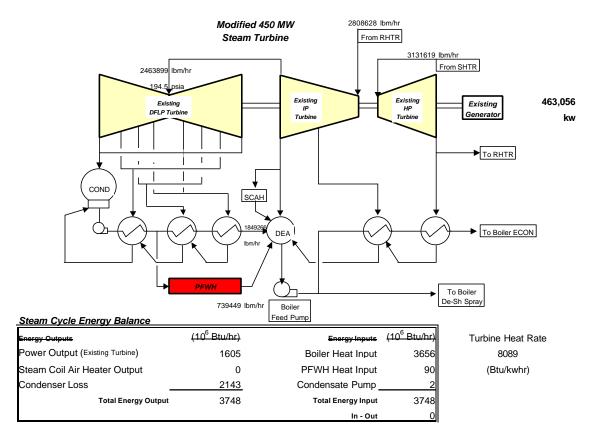


Figure 3.3. 17: Modified Steam Cycle Diagram and Performance for Concept B

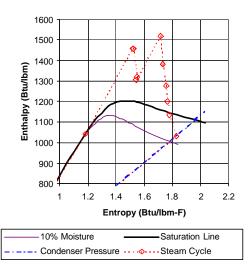


Figure 3.3. 18: Modified Steam Cycle Mollier Diagram for Concept B

#### 3.3.6 Flue Gas Desulfurization and Electrostatic Precipitator Systems Performance Issues

Because the flue gas for Concept B was significantly different in composition from the Base Case due to combustion with oxygen as opposed to air, analysis of the Flue Gas Desulfurization System (FGD) system and the Electrostatic Precipitator (ESP) system performance with these new conditions was investigated. The most noticeable differences regarding the flue gas composition for this case is that it contains significantly more  $CO_2$  and less  $N_2$  than with air firing. The overall mass flow rates for both cases are nearly identical. The effects of operating the Flue Gas Desulfurization System and the ESP with the high  $CO_2$  content flue gas of Concept B are discussed in this section.

#### 3.3.6.1 Flue Gas Desulfurization System Performance Issues

Table 3.3.12 identifies the assumptions that were made in predicting the FGD system performance. Table 3.2.13 shows the gas constituents at the existing Absorber inlet and outlet locations. It should be noted that the  $CO_2/SO_2$  mole ratio is 199, as opposed to the value of 63 encountered previously for the Base Case and Concept A (refer to Section 3.2.4). Hence, it was necessary to assess the impact of high  $CO_2$  content in the flue gas on the performance of FGD System. It is important to note that  $SO_2$  forms a much stronger acid than  $CO_2$  (with a dissociation constant of 7.8E-3 vs. 5.2E-7). Additionally,  $SO_2$  is about 35 times more soluble in water than  $CO_2$ . The absorbed  $SO_2$  will drop the pH of the scrubbing solution to about 4.5. At this level, the  $CO_2$  is basically insoluble in water. ALSTOM Power's Environmental Systems group predicted that, under these circumstances, the flue gas desulfurization systems  $SO_2$  capture efficiency would decrease by approximately 2%.

Conce	ept B (O <sub>2</sub> Fired)					
Quantity	Unit	Existing Absorber				
Ca/S)	Mol Ratio	1.04				
Solids	Wt.%	20				
CaO	Wt.%	90				
MgO	Wt.%	5				
Inerts	Wt.%	5				
By-pass Leakage	Wt.%	2.5				
Liquid/Gas (L/G) Ratio	gpm/1000 acfm	55				
SO <sub>2</sub> Removal Efficiency						
APC	%	94.9				
Absorber	%	97.3				

 Table 3.3.12:
 FGD System Assumptions

	Concept B (O <sub>2</sub> Fired)										
	Exi	sting Absorbe	er Inlet	Existing	Existing Absorber Outlet						
Species	Mol/hr	Vol.%	Unit	Mol/hr	Vol.%	Unit					
O <sub>2</sub>	3,200	3.09	Vol.%	3,190	2.87	Vol.%					
N <sub>2</sub>	5,467	5.27	Vol.%	5,467	4.92	Vol.%					
H <sub>2</sub> O	14,570	14.05	Vol.%	22,400	20.16	Vol.%					
CO <sub>2</sub>	80,031	77.20	Vol.%	80,021	72.03	Vol.%					
SO <sub>2</sub>	403	3,887	vppm	21	189	vppm					
SO <sub>2</sub> Removal Efficiency, %					94.8						
CO <sub>2</sub> /SO <sub>2</sub> Mole Ratio		199									

## Table 3.3. 13:FGD System Performance

#### 3.3.6.2 Electrostatic Precipitator (ESP) System Performance Issues

The effects of operating the Electrostatic Precipitator (ESP) in the high  $CO_2$  content flue gas environment of Concept B are discussed in this section.

The electrostatic precipitation process can be characterized as four stages.

- Corona generation and flue gas ionization
- Particle charging resulting from ionization
- Migration of particles under the influence of the electric field
- Removal of particle cake from collecting electrodes

Background From White, J. "Industrial Electrostatic Precipitation" (1962):

Corona discharge is vital to the electrical separation of particles from the gas stream. The dominant ion production mechanism in the corona is ionization by electron impact, in which free electrons in the gas acquire energy from an applied electric field and collide violently with gas molecules, literally knocking electrons out of the molecules. The net result is free electrons and positively charged gas ions.

The unipolar corona, used in electrical precipitation, is a stable, self-maintaining gas discharge between an emitting electrode and a receiving electrode. The ionization processes are confined to or near the glow region in the strong electric field adjacent to the emitting electrode. Most of the ionization is produced by free electrons that are accelerated to fairly high energies in this region and ionize by collision with molecules.

With negative corona free electrons from the ionization zone, upon entering the low-field region of the corona, combine with molecules of the gas to form negative ions. The ability to form negative ions is a fundamental property of the molecular species. Some gases such as nitrogen, hydrogen, helium, neon and argon, if sufficiently pure, have no affinity for electrons and hence do not form negative ions. Negative corona does not occur in these gases. Instead, when the voltage is raised to a point that would correspond to the corona onset point, spark over occurs. On the other hand, oxygen, chlorine, sulfur dioxide, and many other gases do have strong electron affinities, and, as would be expected, they produce highly stable negative coronas. Negative corona is possible only in gases, or mixtures of gases, that exhibit appreciable electron attachment. Consequently negative corona characteristics are highly sensitive to gas composition and can range from no corona to highly stable corona.

Fortunately practically all industrial furnaces, boilers and process gases as well as air contain electro-negative gases such as oxygen, water vapor, carbon dioxide and frequently sulfur dioxide. Electron attachment is the process by

which electrons combine with neutral molecules to form negative ions. The probability of attachment varies greatly with the gas composition. It is zero for gases such as nitrogen and hydrogen, very small for ammonia, and relatively high for chlorine.

Theory and experiment show that the molecular composition of the gas profoundly influences its negative-corona characteristics (Please refer to Figures 3.3.19, 3.3.20 and 3.3.21 below, extracted from White, 1962). The general conclusion is that gases such as nitrogen that in the pure state have zero electron affinity, are incapable of supporting negative corona, and gases of the  $CO_2$  type that have moderate electron affinity do have considerable negative corona, and gases of the  $SO_2$  type have a very wide range of negative corona.

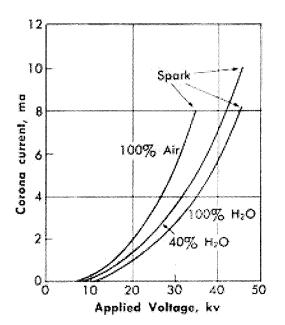


Figure 3.3. 19: Negative Corona Curves for Ai r-water Vapor Mixtures at 400F; Atmospheric Pressure; 3-in. Tube; 0.010-in. Wire

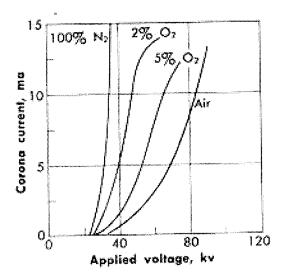


Figure 3.3. 20: Negative Corona Characteristics for Nitrogen-Oxygen Mixtures; 6-in Tube; 0.109-in Wire

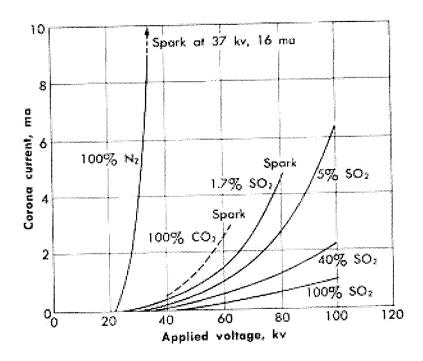


Figure 3.3. 21: Negative Corona Curves for Nitrogen-Sulfur Dioxide Mixtures; 6-in. Tube; 0.019-in. Wire

Conditions with recycled flue gas:

Table 3.3.14 gives a comparison of the flue gas analysis for air firing and  $O_2$ /Recycled flue gas firing. The high nitrogen content, 73.7%, found with the air firing is reduced to 5.3% where as the  $CO_2$  increases from 13.9% to 77.2%. There is also a small increase in the moisture content from 9% to 14.1% and  $SO_2$  content from 2212 vppm to 3887 vppm.

Species	Unit	Air Firing: (ESP Inlet Gas Composition)	O <sub>2</sub> /Recycled Flue Gas Firing: (ESP Inlet Gas Composition)
O <sub>2</sub>	Vol.%	3.1	3.1
$N_2$	Vol.%	73.7	5.27
$H_2O$	Vol.%	9.0	14.1
$\dot{CO}_2$	Vol.%	13.9	77.2
$SO_2$	vppm	2212	3887

 Table 3.3.14:
 Composition of Flue Gases Entering the Electrostatic Precipitator (ESP)

If the gas was 100% Nitrogen, the negative corona precipitation process could not occur. Nitrogen has no affinity for electrons and hence cannot form negative ions. When the voltage is raised to a point that would correspond to the corona onset point, spark over occurs. Figure 3.3.20 shows that the introduction of  $O_2$  allows an increase in voltage to take place creating a stronger electrical field prior to spark over. Figure 3.3.21 shows again the 100% nitrogen gas and the effects of various levels of the electro-negative gas  $SO_2$ . Also a comparison curve is given for 100%  $CO_2$ . It can be seen that  $CO_2$  has electron affinity resulting in a significant increase in voltage, beyond corona onset voltage, before spark break down occurs. The curve tends to the improved characteristic that is obtained with the presence of a small percentage of  $SO_2$ .

Hence with all other gas components remaining constant the replacement of nitrogen by  $CO_2$  will result in a gas that is more beneficial for negative corona precipitation.

In Conclusion, for the gas analysis of Concept B shown above in Table 3.3.14, no ESP performance degradation is expected as a result of firing coal in  $O_2$ /Recycled flue gas environment.

#### 3.3.7 Carbon Dioxide Separation and Compression System

This system processes the flue gas stream leaving the oxygen fired boiler system of Concept B to provide a liquid product  $CO_2$  stream with suitable conditions for sequestration or usage.

#### 3.3.7.1 Introduction:

Traditionally, amine scrubbing has been used on industrial scale to recover  $CO_2$  from boiler flue gases. Monoethanolamine (MEA) is one of the most effective absorbents but reclamation of the absorbed  $CO_2$  from MEA solution consumes large amounts of energy. Therefore, a search is on for more energy efficient methods for recovering  $CO_2$  from flue gas streams. One proposed method is to replace combustion air of a power plant with nearly pure oxygen. Theoretically, the flue gas from such a plant would consist of only  $CO_2$  and water vapor. Because water can be separated from this gas relatively easily (by condensation) this method seems to offer a promising way to recover  $CO_2$  by simply compressing it to a high enough pressure so it can be disposed of or recovered for some useful purpose. Practically however, the stream leaving the Boiler Island contains many other components other than just  $CO_2$  and water vapor, which must be fully considered in the system design for Concept B.

## 3.3.7.2 Process Description:

Figure 3.3.22 (Refer to Section 3.3.7.3) shows the Flue Gas Cooling process flow diagram and Figure 3.3.23 shows the Flue Gas Compression and Liquefaction process flow diagram.

The following describes a  $CO_2$  recovery system that cools and then compresses a  $CO_2$  rich flue gas stream from an oxygen-fired boiler to a pressure high enough so  $CO_2$  can be liquefied. The resulting liquid  $CO_2$  is passed through a  $CO_2$  Stripper to reduce the  $N_2/O_2$  content to an acceptable level. Then the liquid  $CO_2$  is pumped to a high pressure so it can be economically transported for sequestration or usage. Pressure in the transport pipeline will be maintained above the critical pressure of  $CO_2$  to avoid 2-phase flow. The overhead gas from the  $CO_2$  Stripper is vented to atmosphere.

The key process parameters (pressures, temperatures, duties etc.) are shown on the process schematics and will not be repeated here except in selected instances.

Later in this report there is a section titled "Design Considerations" (Section 3.3.7.8). This section covers design issues that are not discussed in the Process Description below.

## Flue Gas Cooling:

Please refer to Figure 3.3.22 (drawing D 09484-01005R-0).

The feed to the  $CO_2$  Recovery System is the flue gas stream that leaves the FGD system of the Boiler Island. At this point, the flue gas is at the dew point of H<sub>2</sub>O. All of the flue gas leaving the boiler is cooled to 100 °F in Gas Cooler DA-101 A/B/C which operates essentially under atmospheric pressure. A significant amount of water condenses out in this cooler. Approximately 2/3 of the gas is then recycled back to the boiler while 1/3 is fed forward to the  $CO_2$  compression area. The recycle stream is required to maintain thermal balance in the existing Conesville #5 steam generator unit in order to avoid major pressure part modifications to the boiler. The Gas Cooler minimizes the volumetric flow rate to, and the resulting power consumption of, the Flue Gas Compression equipment located downstream. Excess condensate is blown down to the cooling water system. Three vessels have been provided for these coolers because a single vessel would be too large.

The Gas Cooler is configured in a packed tower arrangement where the flue gas is contacted with cold water in countercurrent fashion. Warm water from the bottom of the contactor is recycled back to the top of the contactor by

Water Pump GA-101 A/B/C/D after first cooling it in an external water cooled heat exchanger, Water Cooler EB-101 (plate and frame exchanger). The cooling water for this exchanger comes from the new cooling tower.

Because the flue gas may carry a small amount of fly ash, the circulating water is filtered in Water Filter FD-101 to prevent solids build-up in the circulating water. Condensate blowdown is filtered and is taken out downstream of the filter. However, the stream is not cooled and is split off before EB-101. Thus the heat load to the cooling tower is minimized.

From the Gas Cooler, the flue gas stream enters a series of booster blowers that are located adjacent to the Gas Cooler. This design was developed to minimize the length of ducting operating at a slight vacuum and to minimize the temperature of the gas being recycled back to the boiler. This arrangement also minimizes energy consumption, as it does not needlessly over boost the pressure of the stream to be recycled back to the boiler. It is only necessary to boost the pressure of the flue gas flow that proceeds to compression and liquefaction to overcome the pressure drop of the duct which is about 1200 feet long.

#### Three-Stage Gas Compression System:

Please refer to Figure 3.3.23 (drawing D 09484-01004R-0).

The compression section, where  $CO_2$  is compressed to 365 psig by a three-stage centrifugal compressor, includes Flue Gas Compressor GB-101. After the aftercoolers, the stream is then chilled in a propane chiller to a temperature of -21 °F. Note that both the trim cooling water and water for the propane condenser come from the new cooling tower. At this pressure and temperature, about 80 mole % of the stream can be condensed. The flash vapors contain approximately 80 weight % of the inlet oxygen and nitrogen, but also 12 weight % of the  $CO_2$ . Therefore, a rectifier tower has been provided to reduce the loss of  $CO_2$  to an acceptable level (about 6 weight %). Then the pressure of the liquid is boosted to 2000 psig by  $CO_2$  Pipeline Pump GA-103. This stream is now available for sequestration or usage.

The volumetric flow to the compressor inlet is about 80,000 ACFM to each of the two trains and only a single frame is required in each train. The discharge pressures of the stages have been balanced to give reasonable power distribution and discharge temperatures across the various stages. They are:

1st Stage	28 psig
2nd Stage	108 psig
3rd Stage	365 psig

Power consumption for this large compressor has been estimated assuming adiabatic efficiency of 75%.

The hot gas from each stage is first cooled in an air cooler to 120  $^{\circ}$ F (Flue Gas Compressor 1st/ 2nd / 3rd Stage Aftercooler EC-101/2/3) and then further cooled by a water-cooled heat exchanger to 95  $^{\circ}$ F (Flue Gas Compressor 1st/ 2nd Stage Trim Cooler EA-101/2). The flue gas compressor 3rd stage cooler (EA-103) cools the gas down to 90  $^{\circ}$ F to reduce the size of the dryers. Due to their large size, many of these heat exchangers consist of multiple shells. Because of highly corrosive conditions, the process side of the coolers must be stainless steel.

Because the flue gas stream leaving DA-101 is wet, some water condenses out in the three aftercoolers. The sour condensate is separated in knockout drums (FA-101/2/3) equipped with mist eliminator pads. Condensate from these drums is drained to the cooling tower or to waste water treatment. To prevent corrosion, these drums have a stainless steel liner.

Flue gas leaving the 3rd stage discharge knockout drum (FA-103) is fed to Flue Gas Drier FF-101 A/G where additional moisture is removed.

#### Gas Drying:

Please refer to Figure 3.3.23 (drawing D 09484-01004R-0).

It is necessary to dry the  $CO_2$  stream to meet the product specification. A mole sieve drier has been selected.

The performance of a fixed-bed drier improves as pressure increases. This favors locating the drier at the discharge of the compressor. However, as the operating pressure of the drier increases, so does the design pressure of the equipment. This favors low-pressure operation. But, at low pressure the diameter or number of the drier vessels grows, increasing the cost of the vessel. Having to process the recycle gas from the rectifier condenser cooling would also increase the diameter of the vessel. However, this is less than 10% of the forward flow. For this design the drier has been optimally located downstream of the 3rd stage compressor. The CO<sub>2</sub> Drier system consists of six vessels; FF-101 A/G. One vessel is on line while the others are being regenerated. Flow direction is down during operation and up during regeneration.

The drier is regenerated with the non-condensable vent gas from the rectifier after it exits the third stage discharge trim cooler in a simple once through scheme. During regeneration, the gas is heated in Regeneration Heater FH-101 before passing it through the exhausted drier. After regeneration, heating is stopped while the gas flow continues. This cools the bed down to the normal operating range. The regeneration gas and the impurities contained in it are vented to the atmosphere.

Regeneration of a mole sieve bed requires relatively high temperature and, because HP steam pressure may fluctuate, a gas-fired heater has been specified for this service.

Flue Gas Filter FD-102 has been provided at the drier outlet to remove any fines that the gas stream may pick up from the desiccant bed.

## <u>CO<sub>2</sub> Condensation and Stripping:</u>

Please refer to Figure 3.3.23 (drawing D 09484-01004R-0).

From the  $CO_2$  Drier, the gas stream is cooled down further to -21 F with propane refrigeration in  $CO_2$  Condenser EA-104. From EA-104 the partially condensed flue gas stream continues on to  $CO_2$  Rectifier DA-102.

At this pressure and temperature 80 mole % of the stream can be condensed. The flash vapors contain approximately 80 weight % of the inlet oxygen and nitrogen, but also 12 weight % of the  $CO_2$ . Therefore, as mentioned, a rectifier tower has been provided to reduced the loss of  $CO_2$  to an acceptable level. The pressure of the liquid is boosted to 2000 psig by  $CO_2$  Pipeline Pump GA-103 for delivery to a sequestration or usage location.

The vapors in the feed to the rectifier contain the nitrogen and the oxygen that flashed from the liquid  $CO_2$ . To keep the  $CO_2$  loss to the minimum, the rectifier also has an overhead condenser,  $CO_2$  Rectifier Condenser EA-107. This is a floodback type condenser installed on top of the Rectifier. It cools the overhead vapor from the tower down to -48 °F. The condensed  $CO_2$  acts as cold reflux in the  $CO_2$  Rectifier.

Taking a slipstream from the inert-free liquid  $CO_2$  from the Rectifier bottoms and letting it down to the Flue Gas Compressor 3rd stage suction pressure cools EA-107. At this pressure,  $CO_2$  liquid boils at -55 °F thus providing the refrigeration necessary to condense some of the  $CO_2$  from the Stripper overhead gas. The process has been designed to achieve at least 94%  $CO_2$  recovery. The vaporized  $CO_2$  from the cold side of EA-107 is fed to the suction of the Flue Gas Compressor 3rd stage.

Any system containing liquefied gas such as  $CO_2$  is potentially subject to very low temperatures if the system is depressurized to atmospheric pressure while the system contains cryogenic liquid. If the  $CO_2$  Rectifier (and all other associated equipment that may contain liquid  $CO_2$ ) were to be designed for such a contingency, it would have to be made of stainless steel. However, through proper operating procedures and instrumentation such a scenario can be avoided and low temperature carbon steel (LTCS) can be used instead. Our choice here is LTCS. However, the condenser section will be made from stainless steel.

## CO<sub>2</sub> Pumping and CO<sub>2</sub> Pipeline:

Please refer to Figure 3.3.23 (drawing D 09484-01004R-0).

The  $CO_2$  product must be increased in pressure to 2000 psig. A multistage heavy-duty pump (GA-103A/B) is required for this service. This is a highly reliable derivative of an API-class boiler feed-water pump.

It is important that the pipeline pressure be always maintained above the critical pressure of  $CO_2$  such that singlephase (dense-phase) flow is guaranteed. Therefore, pressure in the line should be controlled with a pressure controller and the associated control valve located at the destination end of the line.

## Offgas:

Please refer to Figure 3.3.23 (drawing D 09484-01004R-0).

The vent gas from the  $CO_2$  Rectifier overhead is at high pressure and there is an opportunity for power recovery using turbo-expanders. Because the gas cools down in the expansion process, there is also an opportunity for cold recovery. Heat recovery from the stream after let down via an expander was examined and it was determined that the amount of duty that could be recovered without the carbon dioxide in the stream freezing was small. Thus heat recovery could not be justified. The offgas leaves the Rectifier at -48 °F approximately. The refrigeration recovery to condense  $CO_2$  was the best use for this cold since it also produces a reasonable temperature regeneration gas for the dryers.

3.3.7.3 Process Flow Diagrams

Two process flow diagrams are shown below for these systems:

- Figure 3.3.22 (drawing D 09484-01005R-0) Flue Gas Cooling PFD
- Figure 3.3.23 (drawing D 09484-01004R-0) CO<sub>2</sub> Compression and Liquefaction PFD

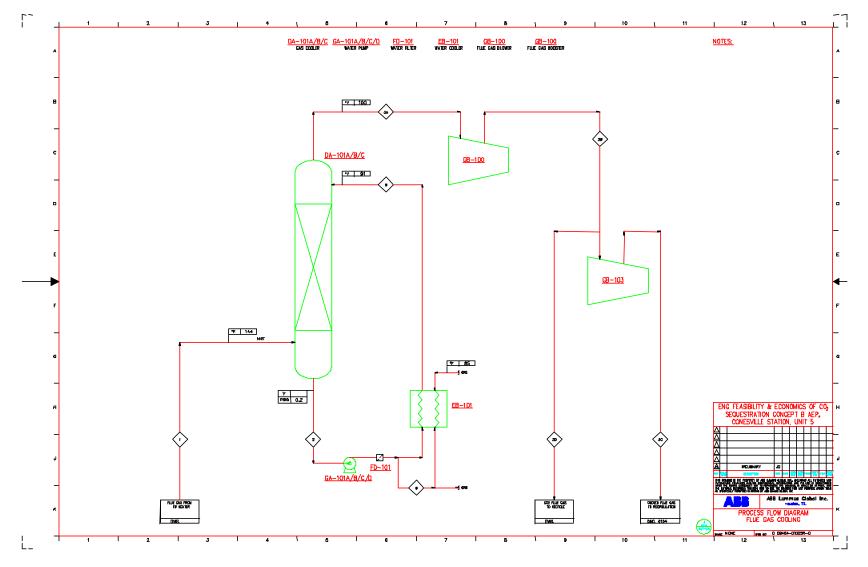


Figure 3.3. 22: Process Flow Diagram for Concept B: Flue Gas Cooling

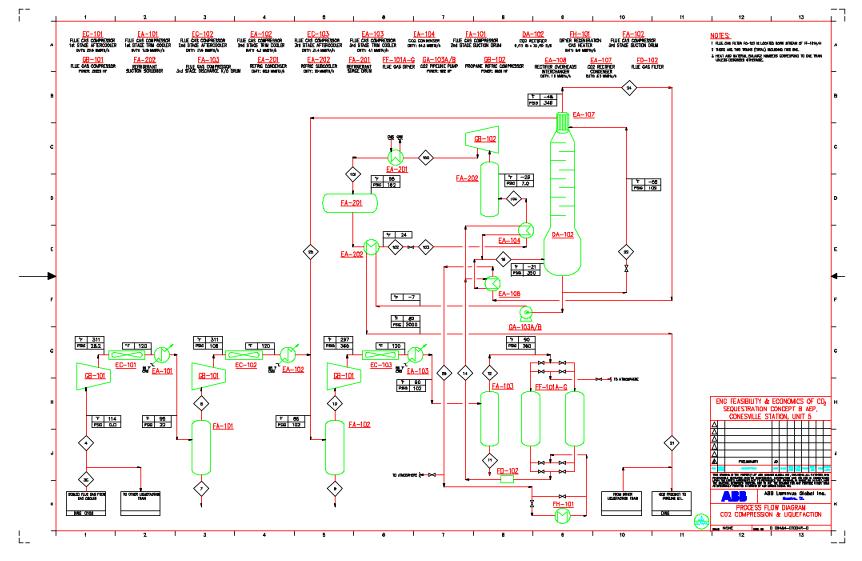


Figure 3.3. 23: Process Flow Diagram for Concept B: CO<sub>2</sub> Compression and Liquefaction

#### 3.3.7.4 Overall Material and Energy Balance

Table 3.3.15 contains the overall material balance for the Flue Gas Cooling System and the  $CO_2$  Compression and Liquefaction System. It is based on 94% recovery of  $CO_2$ .

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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>Nitrogen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>Nitrogen<br>Ammonia<br>Propane                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>Oxyraen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>Oxyraen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H20<br>Nitrogen<br>Ammonia<br>Propane<br>Oxygen<br>SO2<br>VAPOR<br>MOLAR FLOW RATE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | F<br>PSIG<br>LbMol/Hr<br>Bt//Hr<br>Mol %                                                                                                                 | 12<br>1.000<br>90<br>359<br>11.638.67<br>495.913<br>4.50E+07<br>90.54%<br>0.28%<br>5.79%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>11.638.6                                        | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>1,000<br>90<br>354<br>1,606.4<br>495,335<br>4,50E+07<br>90,79%<br>0,00%<br>0,00%<br>0,00%<br>0,00%<br>1,606.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0.200<br>-21<br>349<br>11318.6±07<br>90.79%<br>0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.02%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2Q<br>Nitrogen<br>Ammonia<br>Probane<br>Oxygen<br>SO2<br>VAPOR<br>MOLAR FLOW RATE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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    | 101<br>0.000<br>95<br>162<br>9,750.00<br>429,946<br>2.54E+06<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>GO2<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>MASS FLOW RATE<br>SD VUL FLOW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Mol %<br>LbMol/Hr<br>LbMol/Hr<br>Lb/Hr                                                                                 | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.02%<br>0.00%<br>0.00%<br>0.00%<br>0.02%<br>11.638.6<br>495.913<br>1.06.00                                             | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>1,000<br>90<br>354<br>495,335<br>4,505+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666.6<br>11,666.5<br>3,39%                                                                                                                                                                                                                                                                                                                                                                                      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0.200<br>-21<br>3.49<br>11,318.5<br>483.06<br>11,318.5<br>483.06<br>-1.86E+01<br>-1.86E+01<br>-0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.02%<br>0.02%<br>1.2263<br>8.73(5)<br>8.73(5)<br>2.665<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263<br>1.2263 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                          | 21                                                                                          | 100<br>1.000<br>144<br>169<br>9,750.00<br>429.946<br>7.13E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>9.750.0<br>429.946<br>8.8 A0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            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                                                                                                                                                                                                                                                                                                                                                                                                       | 102<br>0.000<br>24<br>159<br>9,750.00<br>429,946<br>-1.73E+07<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | concenser           103           -26           8           9,750.00           429,946           -1,73E+07           0,00%           0,00%           0,00%           0,00%           0,00%           0,00%           0,00%           0,00%           0,00%           0,00%           100,00%           0,00%           1,539,9           67,905           14,02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.0%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 | 26<br>1.000<br>81<br>341<br>5.0,218<br>5.355+06<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.421.6<br>5.0,218<br>5.355+06<br>1.421.6<br>5.2,95%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2Q<br>Nitrogen<br>Ammonia<br>Propane<br>Oxygen<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>STD YOL FLOW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Btu/Hr<br>Mol %                                                                                                        | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.28%<br>5.79%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>11.638.6<br>495.913<br>106.00<br>2.686.04                         | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>1,000<br>90<br>354<br>11,606.4(<br>495,333<br>4.50E+07<br>90.79%<br>0.00%<br>5.81%<br>0.00%<br>0.00%<br>0.02%<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,606.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11,605.5<br>11, 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0.200<br>-21<br>349<br>11,318.6±07<br>90.79%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00% 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100<br>1.000<br>144<br>169<br>9,750.00<br>429,946<br>7,13E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%     | 101<br>0.000<br>95<br>162<br>9,750.00<br>429,946<br>2.54E+06<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 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                   | concenser           103           0.158           -26           8           9.750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           15.39.9           67.905           14.02           5.11.132                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 104<br>0.993<br>-26<br>8<br>8,750.00<br>429,946<br>4,67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>100.00%<br>0.00%<br>100.00%<br>100.00%                                                                                                                                                                                                                                                               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26<br>1.000<br>81<br>341<br>5.35E+06<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.421.6<br>5.35E+06<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00<br>1.421.61<br>5.35E+06<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>H2O<br>H2O<br>MICOGAN<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>STD VOIL FLOW<br>MASS FLOW RATE<br>STD VOIL FLOW<br>ACTUAL VOIL FLOW<br>MOLECULAR WEIGHT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Mol %<br>LbMol/Hr<br>LbMol/Hr<br>Lb/Hr                                                                                 | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>5.79%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>11.638.6<br>495.913<br>106.00<br>2.868.04<br>42.61                | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>1,000<br>90<br>354<br>4,96,335<br>4,50E+07<br>90,79%<br>90,79%<br>5,81%<br>0,00%<br>3,39%<br>0,02%<br>11,666,54<br>0,00%<br>3,39%<br>0,02%<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,65 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0.200<br>-21<br>3.49<br>111,318.9<br>483.06<br>11,318.9<br>483.06<br>-1.86E+07<br>-1.86E+07<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>-0.00%<br>- 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0,427         -           24.4         0           294.5         -           295.00         -           34.1         -           295.0         -           295.0         -           295.0         -           295.0         0           295.0         0           295.0         0           295.0         0           295.0         0           295.0         0           124.2         -           5.207         -           113         -           37.90         -           11.94         -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 21                                                                                          | 100<br>1.000<br>144<br>169<br>9,750.00<br>429.946<br>7.13E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>9.750.0<br>429.946<br>8.8 A0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 102<br>0.000<br>24<br>159<br>9,750.00<br>429,946<br>-1.73E+07<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | concenter           103           0.158           -26           8           9,750.00           429,946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           1.539.9           67.905           14.02           5.111.32           44.10                                                                                                                                                                                                                                                                                                                                                                                                           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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.0%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 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26<br>1.000<br>81<br>341<br>5.352406<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00<br>1.421.61<br>5.352406<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00% 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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>GO2<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>MASS FLOW RATE<br>STD VOL FLOW<br>RATE<br>STD VOL FLOW<br>RATE<br>STD VOL FLOW                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Btu/Hr<br>Mol %<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>ACEM<br>MWSCFD                                                           | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>5 11.318.94<br>483.06<br>-1.88E-07<br>0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.02%<br>2.263<br>8.7.33<br>2.263<br>5.7.26<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1. 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100<br>1.000<br>144<br>159<br>9,750.00<br>429,945<br>138+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. | 101<br>0.000<br>95<br>162<br>9,750.00<br>429,946<br>2.54E+06<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     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104<br>0.993<br>-26<br>8<br>9,750.00<br>429,946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>100.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00 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| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>H2O<br>H2O<br>MICOGAN<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>STD VOIL FLOW<br>MASS FLOW RATE<br>STD VOIL FLOW<br>ACTUAL VOIL FLOW<br>MOLECULAR WEIGHT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Btu/Hr<br>Mol %<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>ACEM<br>MWSCFD                                                           | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>5.79%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>11.638.6<br>495.913<br>106.00<br>2.868.04<br>42.61                | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>1,000<br>90<br>354<br>4,96,335<br>4,50E+07<br>90,79%<br>90,79%<br>5,81%<br>0,00%<br>3,39%<br>0,02%<br>11,666,54<br>0,00%<br>3,39%<br>0,02%<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,666,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,665,55<br>11,65                                                                                                                                 | 0.200<br>-21<br>349<br>5 11.318.94<br>483.06<br>-1.88E-07<br>0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.02%<br>2.263<br>8.7.33<br>2.263<br>5.7.26<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1. 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100<br>1.000<br>144<br>169<br>9,750.00<br>429,946<br>7,13E-07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00% 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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.0%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 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26<br>1.000<br>81<br>341<br>5.352406<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00<br>1.421.61<br>5.352406<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00% 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| STREAM NO. VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 H2O Nitrogen Ammonia Probane Oxvaen SO2 VAPOR MOLAR FLOW RATE MASS FLOW RATE MASS FLOW RATE MASS FLOW RATE STD YOL FLOW MOLECULAR WEIGHT DENSITY VISCOSITY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Btu/Hr<br>Mol %<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>ACEM<br>MWSCFD                                                           | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>5 11.318.94<br>483.06<br>-1.88E-07<br>0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.02%<br>2.263<br>8.7.33<br>2.263<br>5.7.26<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.36<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.2.263<br>5.7.26<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.38.95<br>1.38.95<br>1.38.95<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.39.55<br>1.                                                                                                                           | 24           1.000           -46           346           346           346           346           346           346           346           346           346           346           346           346           346           3000           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002           0.002      0.003           0.002                                                                                                                             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   5         2           5         2           6         -           75         2           25.00         -           24         -           7%         0           9%         0           9%         0           9%         0           124.2         5           5.207         1           1.28         0           11.94         1.28           0116         - <td>21</td> <td>100<br/>1.000<br/>144<br/>159<br/>9,750.00<br/>429,945<br/>138+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.</td> <td>101<br/>0.000<br/>95<br/>162<br/>9,750.00<br/>429,946<br/>2.54E+06<br/>0.00%<br/>0.00%<br/>0.00%<br/>100.00%</td> <td>102<br/>0.000<br/>24<br/>159<br/>9,750.00<br/>429,946<br/>-1.73E+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>100.00%</td> <td>concenser           103           0.158           -26           8           9.750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           1.539.9           67.905           1.422           5.111.32           44.10           0.22</td>
<td>104<br/>0.993<br/>-26<br/>8<br/>9,750.00<br/>429,946<br/>4.67E+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.0%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0</td> <td>26<br/>1.000<br/>81<br/>341<br/>5.355+06<br/>40.47%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>1.421.6<br/>5.29%<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.355-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8<br/>5.352-06<br/>1.421.8</td> | 21                                                                                          | 100<br>1.000<br>144<br>159<br>9,750.00<br>429,945<br>138+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. | 101<br>0.000<br>95<br>162<br>9,750.00<br>429,946<br>2.54E+06<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 102<br>0.000<br>24<br>159<br>9,750.00<br>429,946<br>-1.73E+07<br>0.00%<br>0.00%<br>0.00%<br>100.00%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | concenser           103           0.158           -26           8           9.750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           1.539.9           67.905           1.422           5.111.32           44.10           0.22                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   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104<br>0.993<br>-26<br>8<br>9,750.00<br>429,946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.0%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 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26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.421.6<br>5.29%<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>STD VOL FLOW<br>MASS FLOW RATE<br>STD VOL FLOW<br>MASS FLOW RATE<br>STD VOL FLOW<br>MOLE CULAR WEIGHT<br>DENSITY<br>VISCOSITY<br>HYOROCARED N LIQUID                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Mol %<br>Lb/Hr<br>Lb/Hr<br>MSCFD<br>ACFM<br>MWSCFD<br>CP<br>CP                                                         | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>3.49<br>111,318.9<br>483.06<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+                                                                                                                                                                                                                 |
24<br>24<br>1,000<br>-466<br>346;<br>166<br>1,44;<br>55<br>56;<br>7<br>3,76E+<br>40,477<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,009<br>0,000<br>0,009<br>0,000<br>0,000 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100<br>1.000<br>144<br>159<br>9,750.00<br>429,945<br>138+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. 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1022001F301<br>102<br>24<br>159<br>9,750.00<br>429,946<br>-1,73E407<br>0,00%<br>0,00%<br>0,00%<br>0,00%<br>-0,00%<br>-1,00%<br>0,00%<br>0,00%<br>-1,73E407<br>-1,00%<br>0,00%<br>-1,73E407<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%<br>-1,00%                                                                         | concenser           103           -26           8           9,750.00           429,946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           100.00%           0.00%           1.539.9           67.905           1.402           5.111.32           44.10           0.22           0.0066                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.421.6<br>5.29%<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>CO2<br>H2O<br>MOLAR FLOW RATE<br>MOLAR FLOW RATE<br>MASS FLOW RATE<br>MASS FLOW RATE<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>STD VOI FLOW<br>MOLECULAR WEIGHT<br>DENSITY<br>HYDROCARBON LIQUID<br>MOLAR FLOW RATE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | F<br>PSIG<br>LbMol/Hr<br>Blu/Hr<br>Blu/Hr<br>Mol %<br>Lb/Hr<br>MMSCFD<br>MMSCFD<br>MMSCFD<br>MMSCFD<br>Lb/Hr<br>CP                                       | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>5 11,318,84,07<br>1.88E+07<br>1.88E+07<br>0.00%<br>5.81%<br>0.00%<br>3.39%<br>0.00%<br>2.263<br>8.73(3,9%<br>0.02%<br>1.252<br>1.38,9%<br>0.00%<br>3.39%<br>0.00%<br>3.39%<br>0.00%<br>3.39%<br>0.00%<br>1.265<br>1.36,07%<br>0.00%<br>1.36,07%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%         | Vent           24           1.000           -46           346           65           47           3764           0.009           0.009           20.99           0.009           0.009           38.51           4.66           57.72           37.72           37.72           37.72           37.72           37.72           32.00           32.12           44                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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2162         -10         0.2           2163         -10         0.2           216         -12.2         0.0           20         0.00         0.0           216         0.00         0.0           212         0.6         0.0           25.32         0.3         3.30           0146         0.0         0.0           -         85.92         -3.5.2           -         3.30         0.0146                                                                                                                                                                                                                                                                                                                                                                               | 17ain         PP           2                                                                                                                                                                                                                             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104<br>0.993<br>-26<br>8<br>9,750.00<br>429,946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. 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26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.421.6<br>5.29%<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.355-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8<br>5.352-06<br>1.421.8 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| STREAM NO. VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 H2CO Nitrogen Ammonia Propana Oxygen SO2 VAPOR MOLAR FLOW RATE MASS FLOW RATE MASS FLOW RATE MOLECULAR WEIGHT DENSITY VISCOSITY HYDROCARBON LIQUD MOLAR FLOW RATE MASS FLOW RATE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Blu/Hr<br>Mol %<br>Hol/Hr<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr/Lb/Hr                                  | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>11,318.9<br>48.3 06<br>1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07<br>-1.96E+07                                                                                                                                                                                                                 | 24           1.000           -46           346           1.5           40           1.000           -46           346           346           346           1.425           40.047           0.002           38.537           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           1.14      <                              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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%0    | 26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>20.9%<br>0.00%<br>0.00%<br>1.421.6<br>5.298%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| STREAM NO. VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 H2Q Nitrogen Ammonia Probane Oxygen SO2 VAPOR MOLAR FLOW RATE STD VOL FLOW MOLECULAR WEIGHT DENSITY VISCOSITY HYDROCARBON LIQUID MOLAR FLOW RATE STD VOL FLOW CATE MASS FLOW RATE STD VOL FLOW COLECULAR WEIGHT DENSITY VISCOSITY HYDROCARBON LIQUID MOLAR FLOW RATE STD VOL FLOW CATE STD VOL | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Blu/Hr<br>Mol %<br>Lb/Mol/Hr<br>Lb/Hr<br>MMSGED<br>ACEM<br>MWY<br>Lb/Ft <sup>2</sup><br>CP<br>CP                       | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>-21<br>-21<br>-349<br>-11,318.9<br>-483.06<br>-1,86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+                                                                                                                                                                                                               | 24           1,000           -46           346           66           35           67           3.76E+           40.047           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009           0.009                                  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100<br>1.000<br>144<br>159<br>9,750.00<br>429,945<br>138+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. 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101<br>0.000<br>95<br>162<br>9.750.00<br>429.946<br>2.54E+06<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 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1022001F301<br>102<br>24<br>159<br>2,750.00<br>429,946<br>-1.73E407<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0 | concenter           103           -26           8           9,750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.                                                                                                                                                                                                                                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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%0 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26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>20.9%<br>0.00%<br>0.00%<br>1.421.6<br>5.298%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| STREAM NO.<br>VAPOR FRACTION<br>TEMPERATURE<br>PRESSURE<br>MOLAR FLOW RATE<br>ENERGY<br>COMPOSITON<br>CO2<br>H2O<br>H2O<br>Nitrogen<br>Ammonia<br>Propane<br>Ovyraen<br>SO2<br>VAPOR<br>MOLAR FLOW RATE<br>STD VOL FLOW RATE<br>STD VOL FLOW RATE<br>STD VOL FLOW<br>MOLECULAR WEIGHT<br>MOLECULAR FLOW RATE<br>MASS FLOW RATE<br>STD VOL FLOW<br>MOLECULAR VEIGHT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Mol %<br>Lb/Hr<br>Lb/Hr<br>MMSCFD<br>ACEM<br>MWC<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr<br>Lb/Hr                                   | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>1.1.638.6<br>495.913<br>11.638.6<br>495.913<br>10.68.04<br>42.61<br>3.3.08 | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>5 11.318.94<br>0.00%<br>5.81%<br>0.00%<br>5.81%<br>0.00%<br>0.00%<br>3.39%<br>0.02%<br>2.263<br>8.7.33<br>2.263<br>8.7.33<br>9.0.72%<br>1.2.263<br>8.7.33<br>9.0.2%<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.39.57<br>1.38.57<br>1.38.57<br>1.39.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.38.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.57<br>1.39.5 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                          | 21 20 20 20 22 247.50 404.163 35+36 24% 00% 24% 00% 22% 24% 00% 22% 24% 00% 92% 02%         | 100<br>1.000<br>144<br>159<br>9,750.00<br>429,945<br>138+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0. 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   | concenser           103           0.158           -26           8           9.750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           1.539.9           362042           48.927           35.57 <t<
td=""><td>104<br/>0.993<br/>-26<br/>8<br/>9,750.00<br/>429,946<br/>4.67E+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.</td><td>26<br/>1.000<br/>81<br/>341<br/>5.355+06<br/>40.47%<br/>0.00%<br/>20.9%<br/>0.00%<br/>0.00%<br/>1.421.6<br/>5.298%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98</td></t<> 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26<br>1.000<br>81<br>341<br>5.355+06<br>40.47%<br>0.00%<br>20.9%<br>0.00%<br>0.00%<br>1.421.6<br>5.298%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>0.00%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98%<br>20.98                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| STREAM NO. VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 H2Q Nitrogen Ammonia Probane Oxygen SO2 VAPOR MOLAR FLOW RATE STD VOL FLOW MOLECULAR WEIGHT DENSITY VISCOSITY HYDROCARBON LIQUID MOLAR FLOW RATE STD VOL FLOW CATE MASS FLOW RATE STD VOL FLOW COLECULAR WEIGHT DENSITY VISCOSITY HYDROCARBON LIQUID MOLAR FLOW RATE STD VOL FLOW CATE STD VOL | F<br>PSIG<br>LbMol/Hr<br>Lb/Hr<br>Mol %<br>Mol %<br>LbMol/Hr<br>Lb/Hr<br>MMSCFD<br>ACEM<br>MW<br>Lb/Ff<br>CP<br>LbMol/Hr<br>Lb/Ff<br>BPD<br>GPM<br>Lb/Ff | 12<br>1.000<br>90<br>359<br>11.638.57<br>495.913<br>4.50E+07<br>90.54%<br>0.26%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.02%<br>11.638.6<br>495.913<br>106.00<br>2.686.04<br>42.61                | 11<br>0.000<br>90<br>359<br>36.62<br>668<br>-5.28E+05<br>0.88%<br>99.11%<br>0.00%<br>0.00% | 14<br>14<br>1,000<br>90<br>354<br>4,55,335<br>4,50E+07<br>90,79%<br>0,00%<br>5,81%<br>0,00%<br>0,00%<br>0,00%<br>11,666,6<br>4,95,335<br>11,666,5,335<br>4,95,335<br>11,666,6<br>4,95,335<br>11,666,6<br>3,39%<br>0,00%<br>11,666,6<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,538<br>10,53 | 0.200<br>-21<br>349<br>111,318.9<br>483.060<br>1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+07<br>-1.86E+0                                                                                                                                                                                                                 | 24           1.000           -466           3465           16           1,42           5           40,47           0,009           20,99           0,009           20,99           0,009           38,53           1,44           1,5           1,6           5,7           3,7           20,99           0,009           20,99           0,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           20,009           21,000           22           24           21           22           24           25           20,000           21,100 <t< td=""><td>botten           22           0           1           22           1           1           21           1           21           1           21           1           22           23           24           406           -2.55           5           0.00%           5           20.00%           120.6           212.16           212.16           122.6           33.50           122.6           33.60           135.52           33.00           -           -           -           -           -           -           -           -</td><td>Train mato         Train PP           2        </td><td>21 0.000 82 0.000 9.247.50 404.163 33E+06 82% 00% 00% 00% 00% 00% 00% 00% 00% 00%
0</td><td>100<br/>1.000<br/>144<br/>159<br/>9,750.00<br/>429,945<br/>138+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.</td><td>101<br/>0.000<br/>95<br/>162<br/>9.750.00<br/>429.946<br/>2.54E+06<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br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001<br/>102<br/>0.000<br/>24<br/>159<br/>9,750.00<br/>429,946<br/>1.73E+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%</td><td>concenser           103           0.158           -26           8           9,750.00           429.946           -1.73E+07           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           0.00%           1.539.9           67.905           14.02           5.111.32           44.10           0.22           0.0066           8.210.14           362042           48.927           1.268.98          
35.57</td><td>104<br/>0.993<br/>-26<br/>8<br/>9.750.00<br/>429.946<br/>4.67E+07<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%<br/>0.00%</td><td>26<br/>1.000<br/>81<br/>341<br/>5.355+06<br/>40.47%<br/>0.00%<br/>20.9%<br/>0.00%<br/>0.00%<br/>1.421.6<br/>5.298%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>0.00%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98%<br/>20.98</td></t<> | botten           22           0           1           22           1           1           21           1           21           1           21           1           22           23           24           406           -2.55           5           0.00%           5           20.00%           120.6           212.16           212.16           122.6           33.50           122.6           33.60           135.52           33.00           -           -           -           -           -           -           -           -                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Train mato         Train PP     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104<br>0.993<br>-26<br>8<br>9.750.00<br>429.946<br>4.67E+07<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00%<br>0.00% 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## Table 3.3.15: Material and Energy Balance for Flue Gas Cooling, CO2 Compression and Liquefaction

## 3.3.7.5 Equipment List with Data

Equipment data for Concept B, summarized in Appendix II, has been tabulated in the so-called "short spec" format which provides adequate data for a factored cost estimate.

#### 3.3.7.6 Consumption of Utilities

In addition to the primary utilities listed below (Table 3.3.16), the plant will also need a supply of other utilities such as instrument air, plant air, process water, nitrogen etc. However, these needs are minor and in many cases are for maintenance purposes only. Consumption of these utilities has not been estimated.

	Utility	Amount Consumed	Units		
	Natural Steam Cooling water	0	MMSCFD Lb/hr Gpm	_	
				Power (ea)	
			Number	including	
Number of	Item		Operating	0.95	Total
Trains	Number	Service	per train	motor eff	all trains
			1	(kW)	(kW)
2	EC-101	Flue Gas Compressor 1st	1	81	163
		Stage Aftercooler			
2	EC-102	Flue Gas Compressor 2nd	1	69	138
		Stage Aftercooler			
2	EC-103	Flue Gas Compressor 3rd	1	68	137
		Stage Aftercooler			
1	PA-101A/B	Large Air Separation Unit	2	40255	80511
1	PA-102	Small Air Separation Unit	1	15311	15311
1	PA-103	Cooling Tower	1	4074	4074
2	GB-101	1 Stage	1	6416	12831
2		2 Stage	1	6675	13349
2		3 Stage	1	6718	13436
2	GB-102	1 stage	1	2362	4724
2		2 stage	1	5204	10408
1	GB-100	Flue Gas Blower	1	2173	2173
1	GB-103	Flue Gas Booster	1	396	396
1		Water	2	104	311
1	GA-101 A/B/C/D	Water pump	3		
2	GA-103A/B	CO2 Pipeline pump	1	1045	2089
		Total			160051

#### Table 3.3.16: Concept B Utility Consumption

#### 3.3.7.7 Consumption of Chemical and Desiccants

The  $CO_2$  compression system does not need any chemicals for its operation. Naturally, there will be a minor demand of lube oil and similar supplies. These have not been estimated.

It has been assumed that the mole sieve desiccant in the  $CO_2$  Drier must be replaced once every 3 years. The estimated consumption of mole sieve and other chemicals can be found Table 3.3.17.

Table 3.3. 17:	<b>Concept B Chemical and Desiccant Consumption</b>
----------------	-----------------------------------------------------

Chemical	Consumption per day (lbs.)
Sodium Hypochlorite	15300
Sodium Bisulfite	86
Mole Sieves	136

The totals shown in Table 3.3.17 do not include chemicals provided by the cooling tower service personnel. This is handled as a component of operating costs referred to as contracted services. It also does not include air separation plant chemicals and lubricants that were presented as monetary value only. They will appear in the operating expense break down.

#### 3.3.7.8 Design Considerations

The process and equipment specifications presented for Concept B were the result of a number of optimizations. The areas of optimizations in the CO<sub>2</sub> Compression and Liquifaction System were:

- O<sub>2</sub> purity
- CO<sub>2</sub> purity
- CO<sub>2</sub> condensation pressure and temperature

#### $O_2$ Purity:

Initial analysis included an Air Separation Unit (ASU) producing oxygen of 95% purity. Additionally, 5% of the total oxygen demand was assumed to be from infiltration of ambient air into the boiler which is typical for a boiler of this type and age. These operating conditions combined with the need for nominally 15% excess oxygen for combustion, resulted in almost 15-wt% of nitrogen and oxygen in the flue gas. This concentration is much higher than typically accepted for EOR applications. The conclusion then was that the bulk of the inerts must be separated from  $CO_2$  before it can be used for EOR. Thus, direct compression to the pipeline is not an option. Instead,  $CO_2$  would have to be condensed so the inerts could be separated.

It soon became obvious that it is impossible to condense  $CO_2$  from such a mixture at pressures below the critical pressure of  $CO_2$  and temperatures achievable with cooling water. This is illustrated by Figure 3.3.24 which shows the achievable  $CO_2$  recovery (the ratio of pure  $CO_2$  product recovered to the  $CO_2$  in the flue gas entering the system) as a function of pressure and temperature. Pressure was limited to 1000 psig, which is just slightly below the critical pressure of  $CO_2$  (1070 psia).

CO2 Recovery - Original Basis (14.69wt% N2 - Dry Basis)

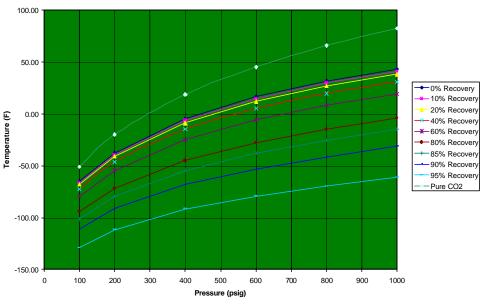


Figure 3.3. 24: CO<sub>2</sub> Recovery from Boiler Flue Gas (Combustion with 95% Pure O<sub>2</sub> and 5% Air Infiltration)

Because the combustion process requires excess oxygen (typically 15-20% with coal firing), the flue gas will always contain at least some oxygen. Furthermore, it is not easy to completely eliminate nitrogen. Some infiltration of air will always occur as long as the combustion chamber of the boiler operates under slight vacuum, as is the current practice with coal firing, thus some  $N_2$  will also be present. Additionally, increasing oxygen purity from the ASU beyond 99% is expensive because the remaining 1% is mainly argon and the separation becomes more difficult.

Because the inert gases have a strong effect on the dew point of the flue gas, the only way to condense a substantial fraction of the  $CO_2$  is by refrigeration. One should keep in mind that the critical temperature of  $CO_2$  is approximately 88 F and condensation of  $CO_2$  without some form of refrigeration may not be feasible in the warmer regions of the world even when inerts are not present in the  $CO_2$  stream.

Figure 3.3.25 shows the achievable  $CO_2$  recovery as a function of pressure and temperature using 99% pure  $O_2$  and 1% air infiltration as combustion process assumptions. One comparison which emphasizes the impact of flue gas purity is that with 95%  $O_2$  purity, the temperature for 95% recovery at 1000 psig is -60°F (Figure 3.3.24) whereas it is 30 °F (Figure 3.3.25) with 99% pure oxygen.

CO2 Recovery - Revised Basis (3.56 wt% N2 - Dry Basis)

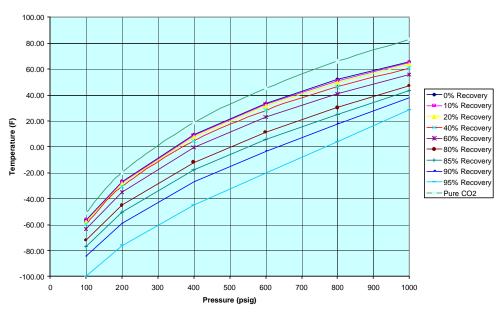


Figure 3.3. 25: CO<sub>2</sub> Recovery Boiler Flue Gas (Combustion with 99% Pure O<sub>2</sub> and 1% Air Infiltration)

#### $CO_2$ purity:

Simulations were made to evaluate modifications to the liquefaction flow scheme presented in Sections 3.3.7.2 & 3.3.7.3 for this concept. The alternate schemes evaluated included total product condensation and having a reboiler on the rectifier (turning it into a complete distillation column). The result was that total condensation, even with the use of 99% pure oxygen, left the product with approximately 11% inerts, which cast doubt according to experts that it could be sequestered in a body of water. The result of having a reboiler on the bottom of the rectifier showed that it improved the CO<sub>2</sub> product purity, but could never be feasibly made to produce a product which contained less than 10 ppm O<sub>2</sub> which would be required for EOR applications. The reason that a reboiler was not presented in the final design was that all of the heat of reboiling was added to the condenser, which required refrigeration at a much lower temperature than the refrigeration which was recovered in the reboiler. The result was a significant work of liquefaction increase.

#### *CO*<sub>2</sub> *condensation pressure and temperature:*

The range of condensation pressures evaluated ranged from 995 psia to 70 psia. The range of condensation temperatures evaluated ranged from 41 °F to -69 °F. The optimum was found to be 350 psig and -22 °F.

#### 3.3.7.9 OSBL Systems

Concept B has equipment associated with the liquefaction of  $CO_2$  in four different areas. The areas include the cooling tower, flue gas cooling section, air separation plant, and the compression and liquefaction equipment.

For this Concept, all of the cooling water must come from a new cooling tower since there is no diversion of steam to supply process heat. The clarifier producing make-up water for the cooling tower produces a blowdown sludge that must be sent to the existing clarifier blowdown handling system. The blowdown from the cooling tower itself can be discharged to the river after the free chlorine is removed by injection of sodium bisulfite.

The air separation plant utilizes the bulk of the cooling water. It also consumes electric power. The original design of the air separation plant involved the consumption of steam for molecular sieve drier regeneration. This duty was converted to an electric load to get the  $CO_2$  recovery process isolated from swings in steam pressures that can occur with changes in throughput. The only other utility it takes in is instrument air.

The  $CO_2$  compression and liquefaction section requires less supplemental utilities and chemicals than its amine counterparts. Only cooling water and electric power are required. Once every three years the molecular sieve in the dryers may need to be replaced.

## 3.3.7.10 Plant Layout

The gas from the flue gas desulfurizer arrives at the nozzles of the flue gas coolers at atmospheric pressure. In order to avoid any additional inflow of oxygen, the flue gas coolers must be placed as close to the power boilers as possible. The coolers are located just west of the existing FGD system.

Initially there were concerns about the piping between the air separation plant and the power boiler. The oxygen is produced at the air separation plant at 5 psig. Therefore it should not be subject to more than 3 psi of frictional pressure loss in the duct connecting it to the power boiler. Calculations reveal that two 36-inch supply lines can carry the oxygen from the ASU to the Boiler, a distance of about 1500 feet. The wall thickness of standard pipe should provide more than enough protection from most incidents that could be envisioned for a pipe spanning this distance. There may be even scope to reduce the wall thickness to less than standard wall if calculations permit. Air Products also had concerns about putting the Air Separation plant too close to the power plant where the inlet air may be high in  $CO_2$ . This  $CO_2$  could affect the drier operation. Due to the fact that this  $CO_2$  liquefaction unit reduces gases going up the stack, there should be no problem.

The layout of the compression and liquefaction unit offers few areas to comment on. At the low-pressure section of the plant, elbows are quite large making spacing allowances on the plot plan difficult without a rigorous design being made.

Plant layout drawings for Concept B (listed below) are included in Appendix I. This new equipment requires about 5.5 acres of plot area.

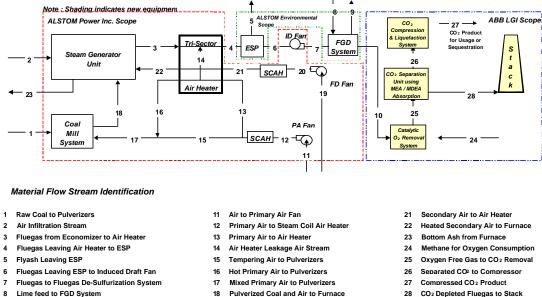
U01-D-0203 Plot Plan – Concept B: Air Separation Plants
U01-D-0209 Plot Plan – Concept B: Flue Gas Cooling
U01-D-0205 Plot Plan – Concept B: CO<sub>2</sub> Compression & Liquefaction
U01-D-0212 Plot Plan – Concept B: Overall Layout Conceptual Plan
U01-D-0201R Plot Plan – Concept B: Modified Overall Site Plan

#### 3.4 Concept C: CO<sub>2</sub> Separation by MEA/MDEA Absorption and De-Oxy Catalyst

Concept C is defined as a system designed for the removal and recovery of CO<sub>2</sub> from the boiler flue gas using MEA/MDEA blended amine technology. The difference between the amines used in this case and in Case A is that the mixture of amines are not oxygen resistant. Therefore, the oxygen in the flue gas is converted to  $CO_2$  by combustion with methane over a de-oxy catalyst upstream of the amine contactor.

#### 3.4.1 Overall System Description and Material and Energy Balance

A simplified process flow diagram for the modified unit is shown in Figure 3.4.1. The operation and performance of the existing Boiler, ESP, and FGD systems are identical to the Base Case and are not affected by the addition of the MEA/MDEA based  $CO_2$  removal system. The gas side material and energy balance for the Boiler Island system is shown in Table 3.4.1 below. The flue gases leaving the existing FGD system are ducted to the new de-oxy system. The de-oxy system converts the remaining oxygen contained in the flue gas to  $CO_2$  using two stages of catalytic combustion with natural gas as the fuel source. High temperature heat recovery is provided in the de-oxy system by generation of high pressure superheated steam, which is expanded through a new steam turbine for additional power generation. The exhaust from this turbine provides part of the feed for solvent regeneration in the re-boilers of the MEA/MDEA system. The de-oxygenated flue gas leaving the de-oxy system is supplied to the MEA/MDEA system where about 91 percent of the  $CO_2$  is removed, compressed, and is available for usage or sequestration. The remaining flue gases leaving the new MEA/MDEA system absorber, consisting of primarily, nitrogen, water vapor, carbon dioxide, and relatively small amounts of sulfur dioxide and methane, is discharged to the atmosphere through stacks above the absorbers.



FGD System Solids to Disposal

Fluegas to O2 Removal System

10

- 18 Pulverized Coal and Air to Furnace
- 19 Air to Forced Draft Fan 20 Secondary Air to Steam Coil Air Heater
- 28 CO<sub>2</sub> Depleted Fluegas to Stack

#### Simplified Gas Side Process Flow Diagram for CO<sub>2</sub> Separation by Figure 3.4. 1: **MEA/MDEA** Absorption for Concept C

Table 3.4.1:	Gas Side Material and Energy Balance for Concept C
--------------	----------------------------------------------------

Constituent	(Units)	1	2	3	4	5	6	7	8	9	10	11	12	13
02	(Lbm/hr)	26586	42147	101097	144817		144817	144817	5355		144578	203237	203237	112918
N2		4868	139626	2797385	2942220		2942220	2942220			2942220	673283	673283	374075
H2O		37820	2357	228849	231294		231294	231294	250709	45979	436024	11365	11365	6314
CO2				867210	867210		867210	867210			866156			
SO2				20202	20202		20202	20202			1063			
H2		16102												
Carbon		236655												
Sulfur		10110												
Ca									12452					
Mg									584					
MgO										484				
MgSO3										1293				
MgSO4										94				
CaSO3										35179				
CaSO4										2468				
CaCO3										2398				
Ash / Inerts		42313		33851	33851	33851			968	968				
		Raw Coal	Leakage Air	Fluegas to AH	Fluegas to ESP	Flyash	Fluegas to ID Fan	Fluegas to FGD	Lime Slurry	FGD Disposal	Fgas to CO2 Sep F	Pri Air to PA Fan	PA from PA Fan	Pri Air to AH
Total Gas	(Lbm/hr)		184130	4014743	4205743		4205743	4205743			4390042	887885	887885	493308
Total Solids	,	374455		33851	33851	33851			14003	42884				
Total Flow		374455	184130	4048594	4239594	33851	4205743	4205743	270067	88863	4390042	887885	887885	493308
Temperature	(Deg F)	80	80	706	311	311	311	325	80	136	136	80	92	92
Pressure	(Psia)	14.7	14.7	14.6	14.3	14.7	14.2	15.0	14.7	14.7	14.7	14.7	15.6	15.6
hsensible	(Btu/lbm)	0.000	0.000	161.831	57.924	57.750	57.924	61.384	0.000	14.116	14.543	0.000	2.899	2.899
Ohamiaal	100 Dtu/h	4000 745												
	106 Btu/hi 106 Btu/hi		0.000	655.007	245.567	1 055	243.612	258,166	0.000	3.314	63.916	0.000	2.574	1.430
						1.955								
	106 Btu/hi 106 Btu/hi		2.475	240.291	242.858	0.000	242.858	242.858	0.000	0.000	464.020	11.933	11.933	6.630
Total Energy(1)	nuo Btu/ni	4778.712	2.475	895.298	488.425	1.955	486.470	501.024	0.000	3.314	527.936	11.933	14.507	8.060
		i												
Constituent	(Units)	14	15	16	17	18	19	20	21	22	23	24	25	26

Constituent	(Units)	14	15	16	17	18	19	20	21	22	23	24	25	26
02	(Lbm/hr)	43720	90319	66680	156999	183585	641283	641283	641283	643801				
N2		144835	299208	220899	520107	524975	2124443	2124443	2124443	2132785				
H2O		2445	5051	3729	8779	46599	35860	35860	35860	36001				
CO2														
SO2														
H2						16102								
Carbon						236655								
Sulfur						10110								
Ca														
Mg														
MgO														
MgSO3														
MgSO4														
CaSO3														
CaSO4														
CaCO3														
Ash / Inerts						42313					8463			
		Air Htr Lkg Air		Hot Pri Air	Mixed Pri Air	Coal-Pri Air Mix		Sec Air to SCAH		Hot Sec Air	Bottom Ash	CO2 to Comp	CO2 Product	Vent Stream
Total Gas	(Lbm/hr)	191000	394577	291308	685885		2801587	2801587	2801587	2812587				
Total Solids											8463			
Total Flow		191000	394577	291308	685885	1060340	2801587	2801587	2801587	2812587	8463			
Temperature	(Deg F)	92	92	666	339		80	86.4	86.4	616	2000			
Pressure	(Psia)	15.6	15.6	15.6	15.6	15.0	14.7	15.2	15.1	14.9	14.7			
hsensible	(Btu/lbm)	2.899	2.899	145.249	63.358		0.000	1.549	1.549	132.582	480.000			
	106 Btu/hr					4228.715								
	106 Btu/hi		1.144	42.312	43.456		0.000	4.341	4.341	372.898	4.062			
	106 Btu/hi	2.567	5.303	3.915	9.218		37.653	37.653	37.653	37.801	0.000			
Total Energy(1)	106 Btu/hi	3.121	6.447	46.227	52.674	4281.389	37.653	41.994	41.994	410.699	4.062			

Notes: (1) Energy Basis; Chemical based on Higher Heating Value (HHV); Sensible energy above 80F; Latent based on 1050 Btu/Lbm of water vapor

Boiler efficiency is calculated to be 88.13 percent, the same as for the Base Case and Case A. The net plant heat rate is increased significantly to 15,223 Btu/kwhr for this case as shown in Table 3.4.2 which also includes the Base Case for comparison. The plant thermal efficiency for Case C (22.42%) is about 64 percent of the Base Case value (35.01%). Auxiliary power is increased to 95,317 kW and the net plant output is reduced to 335,973 kw. Fuel heat input to the overall system is increased by about 21 percent as compared to the Base Case due to the natural gas consumption of the de-oxy system. The fuel heat input to the boiler is the same as in the Base Case and Concept A. Carbon dioxide emissions are 92,153 lbm/hr or about 0.274 lbm/kWh which is about 13.7% of the Base Case value.

# Table 3.4. 2: Overall Plant Performance Summary for Concept C

	(units)	Original Plant (Base)	Concept C MEA-MDEA
Fuel Paramaters	(10 <sup>6</sup> Btu/hr)	4228.7	4228.7
Coal Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		4228.7 885.9
Natural Gas Heat Input (HHV) Total Fuel Heat Input (HHV)	$(10^6 \text{ Btu/hr})$	4228.7	5114.6
Steam Cycle Paramaters			
Existing Steam Turbine Generator Output	(kW)	463478	357196
CO2 Removal System Turbine Generator Output	(kW)	0	36343
Total Turbine Generator Output	(kW)	463478	431290
Total Auxiliary Power	(kW)	29700	95317
Net Plant Output	(kW)	433778	335973
Overall Plant Performance Paramaters			
Net Plant Efficiency (HHV)	(fraction)	0.3501	0.2242
Net Plant Efficiency (LHV)	(fraction)	0.3666	0.2371
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000	0.6404
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749	15223
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309	14395
Overall Plant CO 2 Emissions			
Carbon Dioxide Emissions	(lbm/hr)	866102	92153
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997	0.274
Normalized Specific CO2 Emissions (Relative to Base Case)	(fraction)	1.000	0.137
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)		1.722
Specific Carbon Dioxide Emissions	(kg/kwhr)	0.906	0.125
Avoided Carbon Dioxide Emissions (as compared to Base)	(kg/kwhr)		0.782
· · · ·	/		

#### 3.4.2 Boiler Analysis

The existing boiler system performance in Case C is identical to that of the Base Case described previously in Section 2.3 and will not be repeated here.

#### 3.4.3 Steam Cycle Modifications and Performance

The steam cycle system for Concept C is modified as shown in Figure 3.4.2. Figure 3.4.3 shows the associated Mollier diagram for this system. About 45 percent of the IP turbine exhaust is extracted from the IP/LP crossover pipe. This steam is expanded to about 65 psia through a new letdown steam turbine generating 36,343 kw. The exhaust from the letdown turbine, at about 478 °F, is de-superheated and then provides most of the heat requirement for solvent regeneration in the re-boilers of the MEA/MDEA CO<sub>2</sub> removal system. The condensate leaving the re-boilers is split. About 20 percent of the condensate provides feedwater for the de-oxy system heat recovery steam generator system. The remainder is pumped to the Deaerator of the existing steam cycle. High temperature heat

recovery is provided in the de-oxy by the generation of high pressure superheated steam. This steam is then expanded through a second new steam turbine for additional power generation. This turbine generates 37,751 kw. The exhaust from this turbine provides about 20 percent of the feed for the re-boilers of the MEA/MDEA system. Low temperature heat recovery is provided in the de-oxy system with a low pressure feedwater heater which is located in a feedwater stream which is in parallel with the three existing low pressure extraction feedwater heaters. This heat exchanger is located in the gas stream leaving the gas to gas heat exchanger. About 92 percent of the low-pressure feedwater leaving the main condenser flows through this new heat exchanger with the remainder flowing through the existing extraction feedwater heaters. The modified existing steam cycle system produces 357,196 kw. The total output from the modified steam cycle is 431,290 kw. This represents a gross output reduction of 32,188 kW (about 7%) as compared to the Base Case.

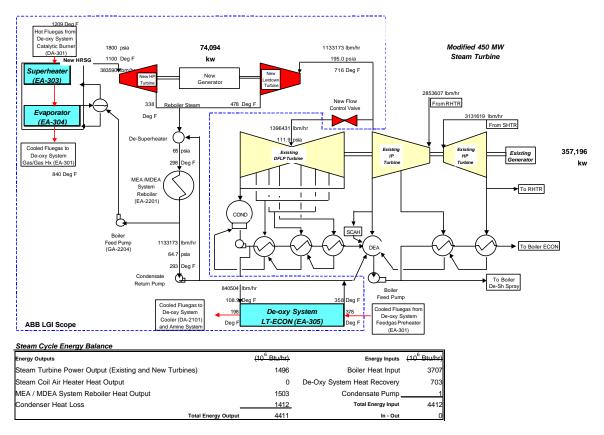


Figure 3.4. 2: Modified Steam Cycle Diagram and Performance for Concept C

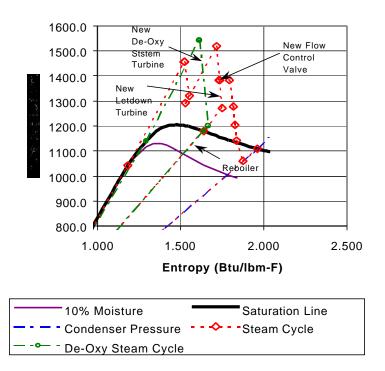


Figure 3.4. 3: Modified Steam Cycle Mollier Diagram for Concept C

3.4.4 Flue Gas Desulfurization System Analysis

The Flue Gas Desulfurization System performance in Case C is identical to that of the Base Case described previously in Section 2.3.5 and will not be repeated here. Table 3.4.3 identifies the assumptions that were made in predicting the FGD performance. Table 3.4.4 shows the gas constituents at the existing Absorber inlet and outlet locations. Results show a  $CO_2/SO_2$  mole ratio of 63 and an  $SO_2$  removal efficiency of 94.8%, corresponding to a value of 104 vppm at the outlet of the absorber.

Conce	pt C (MEA/MDEA)	
Quantity	Unit	Existing Absorber
Ca/S)	Mol Ratio	1.04
Solids	Wt.%	20
CaO	Wt.%	90
MgO	Wt.%	5
Inerts	Wt.%	5
Bypass Leakage	Wt.%	2.5
Liquid/Gas (L/G) Ratio	gpm/1000 acfm	55
SO <sub>2</sub> Removal Efficiency		
APC	%	94.8
Absorber	%	97.2

Table 3.4. 3:	FGD Assumptions
Lable Clinet	1 OD Hostimphons

			Concept C (ME	EA/MDEA)		
	Exi	sting Absorb	er Inlet	Existing	Absorber O	utlet
Species	Mol/hr	Vol.%	Unit	Mol/hr	Vol.%	Unit
O <sub>2</sub>	4,469	3.14	Vol.%	4,461	2.91	Vol.%
N <sub>2</sub>	105,018	73.74	Vol.%	105,018	68.44	Vol.%
H <sub>2</sub> O	12,863	9.03	Vol.%	24,228	15.79	Vol.%
CO <sub>2</sub>	19,743	13.86	Vol.%	19,720	12.85	Vol.%
SO <sub>2</sub>	315	2,212	vppm	16	104	vppm
SO <sub>2</sub> Removal Efficiency, %					94.9	
CO <sub>2</sub> /SO <sub>2</sub> Mole Ratio		63				
		03				-

# Table 3.4.4:FGD Performance

## 3.4.5 Carbon Dioxide Separation and Compression System

One important aspect of this project was to evaluate a new technology to separate the  $CO_2$  with the intent of finding a more cost-effective process. Initially triethanolamine (TEA) was proposed for the solvent due to its low energy requirement to remove the absorbed  $CO_2$ . Preliminary calculations made on TEA showed that it had poor performance removing  $CO_2$  at atmospheric pressure. Calculations made on compressing the flue gas stream in order to use TEA showed that energy requirements were excessive and that a different solvent should be found. The result was that a 10/25-weight % mixture of monoethanolamine (MEA) and methyldiethanolamine (MDEA) was to be employed. This combination has the benefit of the low energy requirement for  $CO_2$  stripping of a tertiary amine with the aggressiveness to capture  $CO_2$  at atmospheric pressure of MEA. The energy requirement for the removal of  $CO_2$  (about 3.4x10<sup>6</sup> Btu per ton of  $CO_2$ ) is about 72% of what was required for Concept A with MEA. However, MDEA lacked both oxygen resistance and  $SO_2$  resistance. Thus a process had to be developed to reduce both of these components to very low levels.

Burner manufacturers, Corporate Development Labs, and Catalyst Vendors were contacted. In the end only one catalyst vendor was willing to put forth the resources to demonstrate that they could meet our process requirements. CRI Catalyst, affiliated with the Shell Oil Company, modified their NOx reduction catalyst to create a low-pressure drop surface to promote the reaction between the excess oxygen present in the flue gas and natural gas added to the mixture. In reality the bench tests were done with ethylene instead of natural gas due to availability at the testing facility. However, identical results for oxygen removal (to below 100 ppmv) with natural gas were promised by CRI. The resulting process, reflected in the following pages, shows the most thermally efficient process to get the flue gas heated above its minimum inlet temperature, 550 °F, by the use of a feed/effluent exchanger.

#### 3.4.5.1 Process Description

The numbering practice for Concept C is the same as for Concept A. The process description for the amine absorption and stripping in Concept C is essentially the same as of Concept A except that Concept C uses a less energy intensive amine than Concept A. Thus the reboiler duty will be less per unit of  $CO_2$  absorption. Also prior to selecting which amine was to be used for Concept C, it was decided to remove essentially all of the oxygen in the flue gas stream. Tertiary amines cannot tolerate oxygen and form oxalic, acetic, propionic, glycolic, and formic acids, which are corrosive. Thus, there will be no chemical injection package for Concept C. Besides the process differences, the oxygen removal steps have an impact on the material balance. The de-oxy catalyst reactor enables the injection of methane to combine with the 2.94% of the flue gas stream that is oxygen. The process of combusting methane creates 11 % more  $CO_2$  than in Concept A and also requires the addition of additional heat recovery equipment. The hydraulics of the equipment sized in Concept A were such that this volume of gas can be tolerated in the same size equipment. The hydraulics in this Concept are also helped by the fact that there is less liquid circulation required due to the higher amine concentration.

Thus the process flow for Concept C proceeds as follows:

# Flue Gas De-Oxygenation and Cooling Systems:

# Please refer to Figures 3.4.4 and 3.4.5 (drawings D 09484-01006R-0; D 09484-01007R-0)

Flue gas supplied from the existing Flue Gas Desulfurizer (FGD) is at 14.7 psia and 136 F. It goes through the Flue Gas Blower, GB-301 where it is boosted by 2.4 psi which increases its temperature to 173 °F. The flue gas is then delivered to the Bottom Direct Contact Cooler DA-2103 to be cooled to 140 °F. The heat from this process stream goes to the new cooling tower. This is done because the flow to one train is at the maximum capacity of the largest skid built by the Flue Gas Scrubber manufacturer with which there is the most experience. The gas then proceeds to Flue Gas Scrubber, D-301X, a two stage scrubbing system. The active component of the scrubbing solution is sodium sulfite, which reacts with sulfur dioxide to form sodium bisulfite. The resulting bisulfite is converted sodium sulfite with make-up caustic prior to recirculation to the scrubber. It is also equipped with a pressure control damper that maintains a constant inlet pressure to the scrubber. The scrubbing liquid used in this stage is fed to a common manifold that feeds the quench and the first stage of scrubbing. Flue gas traverses through the two-stage scrubber. The first stage includes three baffles and a Chevron type mist eliminator. In the second stage, three more baffles are encountered and scrubbing with sodium sulfite is introduced at a constant pH. The liquid level controller is used to control blowdown from the second stage to the first stage. Each section has separate pH controllers for caustic addition. The water spray in spray washing the mist eliminators also serves as make-up. The purpose of this equipment is to reduce the inlet SO<sub>2</sub> level from 108 ppmv down to 1 ppmv.

The gas then flows to a feed/ effluent exchanger, EA-301, where it exchanges heat with the de-oxy catalyst reactor effluent. Next the gas proceeds to a mixing chamber where the stochiometric quantity of natural gas required for the complete combustion of the oxygen is flow ratio controlled into the flue gas stream. A temperature of 628 °F is sufficient to start the reaction with the natural gas. The heat from the exothermic reaction is not available until the reaction has been established, so a start-up heater is also required. This heater, FH-302 is placed in series with the feed/ effluent exchanger, but it is normally turned off. It has 33 % of the duty of the feed/ effluent exchanger and is designed to initially heat the reactors using 33% of the design flow rate. The other 67 % of the flow continues to flow up the stack until the reactors reach operating temperature. However, as the gas leaving the de-oxy catalyst reactor increases in temperature as the reactors absorb the heat from the start-up heater, a larger gas flow can be put through the heater. Note that during the start-up mode natural gas is not mixed in with the flue gas.

All of the piping downstream of the feed/effluent exchanger through the start-up heater and reactor loop back to the other side of the feed effluent exchanger is refractory lined. The De-oxy Catalyst Reactor, DA-301, is refractory lined also. It is actually two reactors in parallel. This reactor is in a vertical orientation and contains two catalyst beds, each 5 feet deep, which create a pressure drop of 0.5 psi for each reactor vessel. The flow goes into the middle of each reactor and is split into to 50% streams by having symmetrical external piping and identical internals in the reactors. Half of the flow goes through the upper bed and half of the flow goes through the lower bed. The catalyst is a hollow cylinder 6-mm OD x 2.5-mm ID x 6-mm long. The de-oxygenated flue gas exits the reactor at 1209 °F. The outlet of the exchanger is cooled back to 840°F in the EA-303 and EA-304, Reactor Effluent/ Steam Superheater & Steam Generator, respectively. These heat exchangers are similar to a Heat Recovery Steam Generator (HRSG) type heat exchanger and only have about 6 inches of water pressure drop. The pressure of the steam generated is 1800 psia due to the desire to generate power. The effluent from the steam turbine, which drives the generator, provides part of the reboiler steam for solvent regeneration in the amine stripper. The flow passes from the steam generating heat exchangers to the Feed/ Effluent Exchanger, EA-301, where it cools by exchanging heat with the flue gas coming from the Flue Gas Scrubber. The effluent outlet temperature from EA-301supplies 42.4 MM-Btu/h heat to preheat the boiler feed water in each of the five trains. This heat is used to preheat low-pressure feedwater before supplying the power plant deaerator. The heat exchange takes place in the Dry Flue Gas Cooler EA-305. The gas is further cooled in Direct Contact Cooler (DCC) Flue Gas Cooler DA-2101. From the DCC cooler the gas then continues on to the CO<sub>2</sub> Absorber.

The DCC Flue Gas Cooler DA-2101 is a packed column where the hot flue gas flowing up is brought into an intimate contact with cold water which is fed to the top of the bed and flows down the tower. Physically, DA-2101, DA-2102,

and DA-2103 have been combined into a single, albeit compartmentalized tower. DA-2103 is the bottom one and will be designed to support the top portion of this column. However, since there is intervening equipment between this equipment and the DCC Flue Gas cooler, DA-2101, the top head must have an outlet nozzle added to it so that the outlet pipe can exist through the section of skirt between these two vessel sections. The top of the DCC Flue Gas Cooler is configured differently. Since the flow from it proceeds directly to the amine absorption section above it, the top head of this section serves as the bottom head for the  $CO_2$  Absorber. Effectively, this dividing head acts as a chimney tray with a number of upward extending chimneys which provide passages so the flue gas may flow directly from the DCC into the Absorber.

Theoretically, a direct contact cooler is capable of cooling the gas to a very close approach in a short bed. When the hot gas enters the DCC, it contains water but is highly superheated. At the bottom end of the bed, the gas quickly cools down to a temperature called the "Adiabatic Saturation Temperature" (AST). The AST is the temperature the gas reaches when some of its own heat content has been used to vaporize just the exact amount of water to saturate the gas.

Up to the point when the AST is reached, the mass flow of the gas stream increases due to evaporation of water. At the AST, water begins to condense. And, as the gas travels up the column and cools down further, more and more water is condensed. This internal refluxing increases the V/L traffic at the bottom end of the bed significantly beyond the external flows and must be considered in the hydraulic design.

The water stream which leaves the bottom of the DCC contains the water fed to the top as well as any water which has condensed out of the flue gas. The condensed water may be somewhat corrosive due to sulfur and nitrogen oxides that may be present in the flue gas. Therefore, instead of using the condensate in the process, it will be blown down from the system. For the DCC to be effective, the temperature of the leaving water must always be lower than the AST.

DCC Water Pump GA-2102A/B circulates most of the water leaving the bottom of the DCC back to the top of the direct contact cooler. However, before sending it back to the column the water stream is first filtered in DCC Water Filter FD-2101 and then cooled in DCC Water Cooler EA-2101. The source of this cooling water is the new cooling tower. Temperature of the cooled water is controlled by a cascade loop which maintains a constant flue gas exit temperature (Absorber feed temperature). The circulating water is cooled to 95 °F, which in turn, easily cools the gas to 115 °F.

Filtration is necessary to remove any particulate matter that may enter the DCC in the flue gas. The blowdown is taken out after the filter but before the cooler and mixed into the return water of cooler EA-2101. This way the cooler does not have to handle the extra duty that would otherwise be imposed by the blowdown.

The process description of all other equipment (CO<sub>2</sub> absorption, solvent stripping, and CO<sub>2</sub> compression and liquefaction) is essentially the same as in Concept A and will not be repeated here. Refer to Section 3.2.5.2 for the process description of this equipment. One small exception to note is a difference in the lean amine cooling. In Concept C the lean amine is cooled in two steps against cooling water downstream of the lean-rich exchanger. The warmest cooling water exchanger (EA-2208) is fed from the new cooling tower. The final cooler (EA-2202) is fed from the existing plant cooling tower. The solvent stripper CW condenser (EA-2206) also gets water from the existing plant cooling tower. Another exception for Concept C is the lean and rich amine loading. For Concept C the loadings are 0.148 mole CO<sub>2</sub>/mole of amine and 0.445 mole CO<sub>2</sub>/mole of amine for the lean and rich streams respectively. Please refer to Figures 3.4.6 and 3.4.7 (drawings D 09484-01008R-0; D 09484-01009R-0) for process flow diagrams of these systems for Concept C.

# 3.4.5.2 Process Flow Diagrams:

The processes described above for Concept C are illustrated in the following Process Flow Diagrams.

Figure 3.4.4: Drawing D 09484-01006R-0: De-Oxy System Figure 3.4.5: Drawing D 09484-01007R-0: Flue Gas Cooling and Absorption Figure 3.4.6: Drawing D 09484-01008R-0: Solvent Stripping Figure 3.4.7: Drawing D 09484-01009R-0: CO<sub>2</sub> Compression and Liquefaction

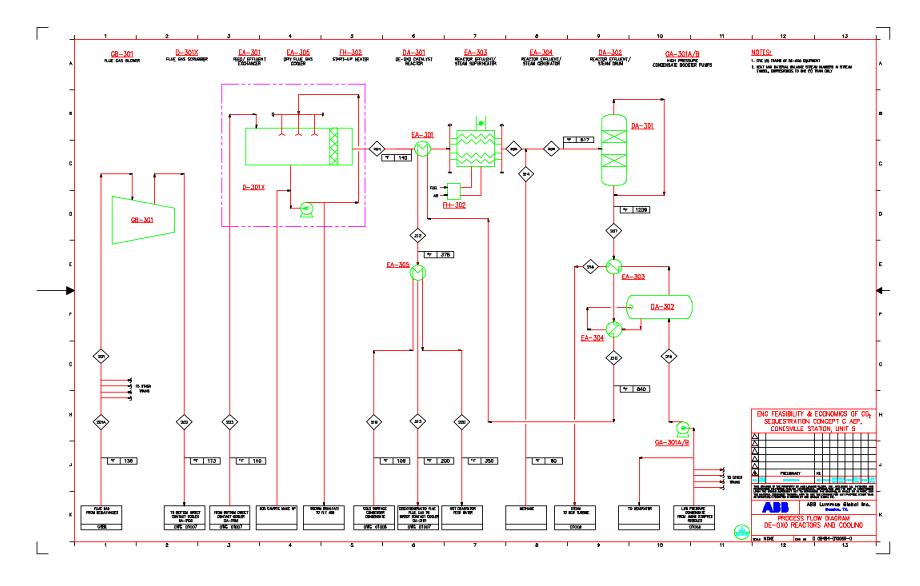


Figure 3.4. 4: De-Oxy System Process Flow Diagram for Concept C

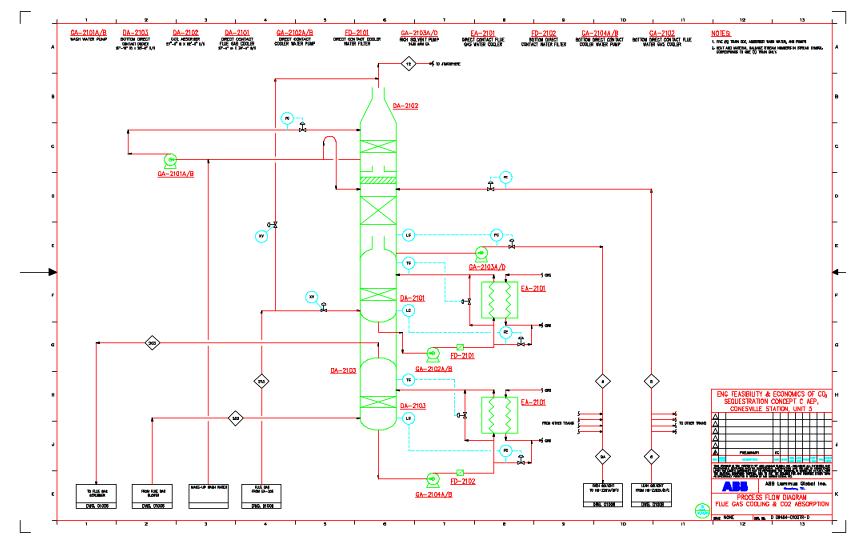


Figure 3.4. 5: Flue Gas Cooling and Absorption System Process Flow Diagram for Concept C

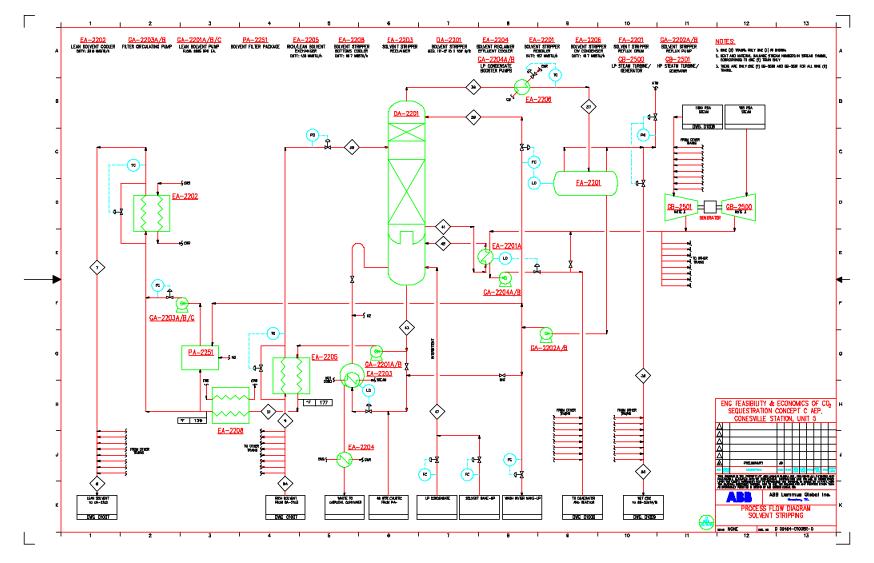


Figure 3.4. 6: Solvent Stripping System Process Flow Diagram for Concept C

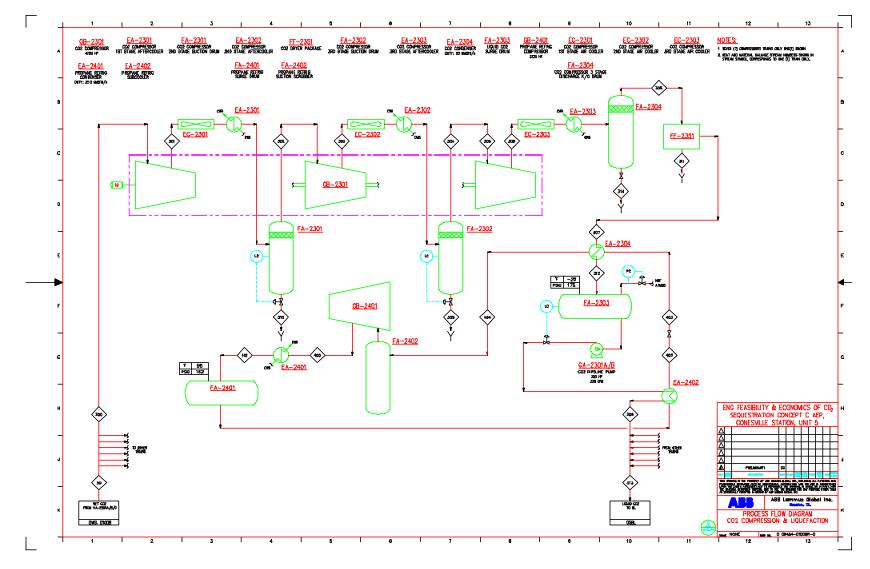


Figure 3.4. 7: CO<sub>2</sub> Compression and Liquefaction System Process Flow Diagram for Concept C

## 3.4.5.3 Overall Material and Energy Balance

This section contains energy and material balances for the CO<sub>2</sub> capture system for Concept C.

· · · · · · · · · · · · · · · · · · ·									-	-		
STREAM NAME		Flue gas from power plant	Flue gas to train A de- oxygenation	Flue gas from booster blowe		Flue gas on desulfuri		Flue gas fr feed/ efflu exchange	ent first deoxo	First de-oxo reactor inlet	First de-oxo reactor outlet	
STREAM NO.		201A	201	202	203	204	4	205	214	206	207	215
VAPOR FRACTION	Molar	1.000	1.000	1.000	1.000	1.00	00	1.000	1.000	1.000	1.000	#N/A
TEMPERATURE	F	136	136	173	140	140	0	628	80	618	1.209	#N/A
PRESSURE	PSIG	0	0	2	2	2		2	2	2	1	#N/A
MOLAR FLOW RATE	LbMol/Hr	153.440.00	30.688.00	30.688.00	30.688.0	0 30.68	6.00	30.686.	00 451.80	31.138.00	31.138.00	#N/A
MASS FLOW RATE	Lb/Hr	4.390.041	878.008	878.008	878.00	8 877	.796	877.7	96 7.248	885.044	885.042	#N/A
ENERGY	Btu/H	6.60E+08	1.32E+08	1 41E+08	1.33E+08	1.33E	+08	2 48E+0	1 96E+06	2.50E+08	4.06E+08	#N/A
COMPOSITON	Mol %											
Methane		0.00%	0.00%	0.00%	0.00%	0.00	%	0.00%	100.00%	1.45%	0.00%	#N/A
Oxygen		2.94%	2.94%	2.94%	2.94%	2.94	%	2.94%	0.00%	2.90%	0.01%	#N/A
Nitrogen		68 45%	68 45%	68 45%	68 45%	68.4	5%	68 45%	0.00%	67 46%	67 46%	#N/A
H2O		15.77%	15.77%	15.77%	15.77%	15.7	7%	15.77%	0.00%	15.55%	18.44%	#N/A
CO2		12.83%	12.83%	12.83%	12.83%	12.8	3%	12.83%	0.00%	12.64%	14.09%	#N/A
SO2		0.01%	0.01%	0.01%	0.01%	0.00	%	0.00%	0.00%	0.00%	0.00%	#N/A
SO3		0.00%	0.00%	0.00%	0.00%	0.00	%	0.00%	0.00%	0.00%	0.00%	#N/A
VAPOR												
MOLAR FLOW RATE	LbMol/Hr	153.440.0	30.688.0	30.688.0	30.688.	0 30.6	86.0	30.686		31.138.0	31.138.0	#N/A
MASS FLOW RATE	l b/Hr	4,390,041	878,008	878,008	878,00	8 877	796	877.7	96 7.248	885,044	885,042	#N/A
STD VOL. FLOW	MMSCFD	1.397.55	279.51	279.51	279.5	1 27	9.48	279.	48 4.11	283.59	283.59	#N/A
ACTUAL VOL. FLOW	ACEM	1,109,800.0	221,960.00	203,080.00	193,174.0	0 196,04	4.00	359,640.	00 2,620.60	361,460.00	577,460.00	#N/A
MOLECULAR WEIGHT	MW	28.61	28.61	28.61	28.6	1 2	8.61	28.	61 16.04	28.42	28.42	#N/A
DENSITY	Lb/Ft <sup>3</sup>	0.07	0.07	0.07	0.0	8	0.07	0.	04 0.05	0.04	0.03	#N/A
VISCOSITY	cP	0.0173	0.0173	0.0184	0.017	5 0.0	0175	0.02	81 0.0113	0.0277	0.0379	#N/A
STREAM NAME			From re effluent c		fee	luent from d/ effluent xchanger	flu	oxygenated ue gas to amine	High pressure BFW to steam generator	Superheated steam from steam superheater	Condensate to Dry Gas Cooler	
STREAM NO.		208	210	0 2	211	212		213	216	218	219	220
VAPOR FRACTION	М	olar #N/A	1.00	00 #	N/A	1.000		1.000	0.000	1.000	0.000	0.000
TEMPERATURE		F #N/A			N/A	378		200	297	1.102	109	350
PRESSURE	Р	SIG #N/A			N/A	1		1	1.785	1.785	195	192
MOLAR FLOW RATE	LbMo					1.138.00	2	1.138.00	4.300.00	4.300.00	9,224.09	9.224.09
MOLAR FLOW RATE						885.046					<u>9.224.09</u> 166.173	
		D/Hr #N/A			N/A			885.046	77.465	77.465		166,173
ENERGY		u/Hr #N/A	3.08E	+08 #	N/A 1.	92E+08	1.3	50E+08	-4.56E+07	5.25E+07	-1.31E+08	-8.87E+07
COMPOSITON	Mo	ol %										
Methane		#N/A	0.01	% #	N/A	0.00%	(	0.00%	0.00%	0.00%	0.00%	0.00%
Oxygen		#N/A	0.01	% #	N/A	0.01%		0.01%	0.00%	0.00%	0.00%	0.00%
Nitrogen		#N/A	67.4	6% #	N/A é	37 46%	6	7 46%	0.00%	0.00%	0.00%	0.00%
H2Q		#N/A	18.4	4% #	N/A ·	8 44%	1	8 44%	100.00%	100.00%	100.00%	100.00%
CO2		#N/A	14.0	9% #	N/A	4 09%	1	4 09%	0.00%	0.00%	0.00%	0.00%
SO2		#N/A	0.00	% #	N/A	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%
503		#N/A	0.00		N/A	0.00%		0.00%	0.00%	0.00%	0.00%	0.00%
VAPOR												
MOLAR FLOW RATE	LbMo	l/Hr #N/A	31.1	38.0 #	N/A	31.138.0		31,138.0		4.300.0		
MASS FLOW RATE		0/Hr #N/A			N/A	885.046		885.046	-	77.465	-	
STD VOL. FLOW	MMSC	1			N/A N/A	283.60	1	283.60	-	39.16	-	
STD VUL. FLUW	IVIIVISU		28	lo.c∪ #	IN/A	283.00		20.1 D()	-	39.16	-	

De-Oxy System Material and Energy Balance for Concept C Table 3.4. 5:

MOLAR FLOW RATE	LbMol/Hr	#N/A	31,138.00	#N/A	31.138.00	31,138.00	4.300.00	4.300.00	9,224.09	9.224.09
MASS FLOW RATE	Lb/Hr	#N/A	885.046	#N/A	885.046	885.046	77,465	77,465	166,173	166,173
ENERGY	Btu/Hr	#N/A	3.08E+08	#N/A	1.92E+08	1.50E+08	-4.56E+07	5.25E+07	-1.31E+08	-8.87E+07
COMPOSITON	Mol %									
Methane		#N/A	0.01%	#N/A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Oxygen		#N/A	0.01%	#N/A	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
Nitrogen		#N/A	67 46%	#N/A	67 46%	67 46%	0.00%	0.00%	0.00%	0.00%
H2Q		#N/A	18 44%	#N/A	18 44%	18 44%	100 00%	100.00%	100.00%	100 00%
CO2		#N/A	14 09%	#N/A	14 09%	14 09%	0.00%	0.00%	0.00%	0.00%
SO2		#N/A	0.00%	#N/A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SO3		#N/A	0.00%	#N/A	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
VAPOR										
MOLAR FLOW RATE	LbMol/Hr	#N/A	31,138.0	#N/A	31,138.0	31.138.0	-	4.300.0		<u> </u>
MASS FLOW RATE	Lb/Hr	#N/A	885.046	#N/A	885.046	885.046	-	77.465		<u> </u>
STD VOL. FLOW	MMSCFD	#N/A	283.60	#N/A	283.60	283.60	-	39.16		<u> </u>
ACTUAL VOL. FLOW	ACFM	#N/A	455.320.00	#N/A	299.000.00	236.160.00		620.17	-	<u> </u>
MOLECULAR WEIGHT	MW	#N/A	28.42	#N/A	28.42	28.42		18.02	-	
DENSITY	Lb/Ft <sup>3</sup>	#N/A	0.03	#N/A	0.05	0.06		2.08	-	
VISCOSITY	сP	#N/A	0.0314	#N/A	0.0229	0.0186	-	0.0335	-	1

Table 3.4.6:         Amine System Material and Energy Balance for Concept C
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STREAM NAME		Gas Feed to Absorber A	Lean Amine from Stripping Section		d Rich Amines fro Absorber A	m Rich Amine fro Absorption Ser			Rich Aminesto Lean/Rich Heat Exchanger	Rich Amine Lean/Rich Exchan	hHeat	RegeneratorOve ead Vapor	h RegeneratorCond enser Outlet
STREAM NO.		213	6	5	8	9A	12		9	35		36	37
LIQUID FRACTION		0.000	1.000	1.000	1.000	1.000	0.00		1.000	0.98		0.000	1.000
TEMPERATURE	F	115	105	105	137	137	109		137	201	1	211	105
PRESSURE	PSIA	15.5	14.9	14.9	15.8	15.8	14.9	9	15.6	15.6	6	26.0	23.0
COMPONENTS													
CO2 (Carbon Dioxi	LbMol/Hr	4.383.84	9.889.26	1.977.8	5.953.08	29.765	42 40	8.61	3.307.27	3.30	7.27	2.207.25	2.207.25
MEA	LbMol/Hr	0.00	29.344.65	5 5.868.93	5.867.05	29.335.	26	1.88	3.259.47	3.25	9.47	6.71	6.71
MDEA	LbMol/Hr	0.00	37,607.29					0.08	4,178.54	4,17		0.41	0.41
H2O (Water)	LbMol/Hr	2.479.20	646.705						72.267.71	72.26		2.345.92	
C1 (Methane)	LbMol/Hr	1.54	0.00			0.0.		1.54	0.00		0.00	0.00	
N2 (Nitrogen)	LbMol/Hr	21,005.66	0.00				81 21,00		0.58		0 58	0.58	
O2 (Oxygen)	LbMol/Hr	3.09	0.00					3.09	0.00		0.00	0.00	0.00
Total Molar Flow	LbMol/Hr	27.873.34	723.546	5 144.709	14942	4 747.1	22 23.15	8.16	83.013.58	83.01	3.58	4.560.86	4.560.86
VAPOR				-			_	-			_		
MASS FLOW RATE	Lb/Hr	3,152,095					2,365.				-	236,573	4 1
STD. VOL. FLOW RATE	MMSCFD	253.86					210.9				_	41.5444444	l.
ACTUAL VOL FLOW RATE	MMACED	265.88					227 4				1	30.066666	<u></u>
	MW	59.28		-		1	55.09				-	34.0783333	5
	Lb/Ft	0.149				1	0.13					0.123	
GAS COMPRESSIBILITY	сР	1 9978 0.035		1		1	1.99	-				<u>1 10211111</u> 0.01822222	
		0.035		1		1							
HEAT CAPACITY THERMAL CONDUCTIVITY	Btu/Lb-F Btu/Hr-ft-F	0.4922		1		1	0.50					0.29622222	
	Blu/HI-II-F	0.0204					0.023	10				0.0157	
MASS FLOW RATE	Lb/Hr		183 618 326	7 344 733	7721129	193 028 2	10		2 383 064	2 383	064		155 429
STD. VOL. FLOW RATE	GPM		35184.1	7036.82	7169.36	35846.8			3982 97778	3982.97			279.655556
ACTUAL VOL. FLOW	GPM		35498.9	7099 78	7296.84	36484.2			4053.8	4152.81			281.522222
			25.3776	25 3776	25,8363	25 8363			25 8363	25.83			30 6705
MOLECULAR WEIGHT	M/\//				1								
MOLECULAR WEIGHT	MW Lb/Et <sup>3</sup>		65 0654	65 0654	67 1353	67 1353			67 1353	67 13	353		
STD. DENSITY	Lb/Ft <sup>3</sup>		65.0654 1443 164	65.0654 1443 164	67.1353 4263 43	67.1353			67.1353 4263 431	67.13 4263.4			62.3637 40525 96
MOLECULAR WEIGHT STD. DENSITY VISCOSITY HEAT. CAPACITY	0		65.0654 1443.164 1.3621	65.0654 1443.164 1.3621	67.1353 4263.43 0.9361	67.1353 4263.43 0.9361			67.1353 4263.431 0.9361	67.13 4263.4 0.523	431		40525.96
STD. DENSITY VISCOSITY	Lb/Ft <sup>3</sup> cP		1443.164	1443.164	4263.43	4263.43			4263.431	4263.4	431 33		40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY	Lb/Ft <sup>3</sup> cP Btu/Lb-F		1443.164 1.3621	1443.164 1.3621	4263.43 0.9361	4263.43 0.9361			4263.431	4263.4	431 33		40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY	Lb/Ft <sup>3</sup> cP Btu/Lb-F		1443.164 1.3621 0.8545	1443.164 1.3621 0.8545	4263.43 0.9361 0.838	4263.43 0.9361 0.838			4263.431 0.9361 0.838	4263.4 0.523 0.855	431 33 54	47	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO.	Lb/Ft <sup>3</sup> cP Btu/Lb-F	38	1443.164 1.3621 0.8545 <b>50</b>	1443.164 1.3621 0.8545 <b>39</b>	4263.43 0.9361 0.838 41	4263 43 0 9361 0.838 42	43		4263.431 0.9361 0.838 21	4263.4 0.523 0.855 47	431 33 54	<b>47</b>	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO.	Lb/Ft <sup>3</sup> cP Btu/Lb-F	0.000	1443.164 1.3621 0.8545 50 0.000	1443.164 1.3621 0.8545 39 1.000	4263.43 0.9361 0.838 41 1.000	4263.43 0.9361 0.838 42 0.000	<b>43</b> 1.000	1.(	4263.431 0.9361 0.838 21 000 1	4263.4 0.523 0.855 <b>47</b> .000	431 33 54 1.1	000	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO.	Lb/Ft <sup>3</sup> cP Btu/Lb-F		1443.164 1.3621 0.8545 <b>50</b>	1443.164 1.3621 0.8545 <b>39</b>	4263.43 0.9361 0.838 41	4263 43 0 9361 0.838 42	43	1.0	4263.431 0.9361 0.838 21 000 1 77	4263.4 0.523 0.855 47	431 33 54 1.1		40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID FRACTION TEMPERATURE PRESSURE	Lb/Ft <sup>3</sup> cP Btu/I b-E Btu/Hr-ft-F	0.000 105	1443.164 1.3621 0.8545 50 0.000 105	1443.164 1 3621 0.8545 39 1.000 105	4263.43 0.9361 0.838 41 1.000 248	4263 43 0 9361 0.838 42 0.000 250	<b>43</b> 1,000 250	1.0	4263.431 0.9361 0.838 21 000 1 77	4263.4 0.523 0.855 <b>47</b> .000 68	431 33 54 1.1	000 05	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID FRACTION TEMPERATURE	Lb/Ft <sup>3</sup> cP Btu/I b-E Btu/Hr-ft-F	0.000 105	1443.164 1.3621 0.8545 50 0.000 105	1443.164 1 3621 0.8545 39 1.000 105	4263.43 0.9361 0.838 41 1.000 248	4263 43 0 9361 0.838 42 0.000 250	<b>43</b> 1,000 250	1.0 1 30	4263.431 0.9361 0.838 21 000 1 77	4263.4 0.523 0.855 <b>47</b> .000 68	431 33 54 1.1 1 1	000 05	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS	Lb/Ft <sup>3</sup> CP Btu/Hr-ft-F Btu/Hr-ft-F	0.000 105 23.0	1443.164 1.3621 0.8545 50 0.000 105 23.0	1443 164 1 3621 0.8545 39 1.000 105 230	4263.43 0.9361 0.838 41 1.000 248 29.8	4263.43 0.9361 0.838 42 0.000 250 30.0	<b>43</b> 1,000 250 30,0	1.0 1 30 1,1	4263 431 0 9361 0.838 21 0000 1 177 0.0 :	4263.4 0.523 0.855 47 .000 68 30.0	431 33 54 1.1 1 1, 1, 1,	000 05 4.9	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dirayi	Lb/Ft <sup>3</sup> cP Btu/Hr-ft-F Btu/Hr-ft-F F PSIA	0.000 105 23.0 2,205.90	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09	1443 164 1 3621 0.8545 39 1.000 105 230 1.40	4263.43 0.9361 0.838 41 1.000 248 29.8 1.852.30	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93	<b>43</b> 1.000 250 30.0	1.0 1 30 1,1 3.2	4263.431 0.9361 0.838 21 000 177 0.0 101.37	4263.4 0.523 0.855 47 .000 68 30.0	431 33 54 1.1 1.1 1.1 1.1 3.2	000	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSIURE COMPONENTS CO2 (Carbon Dioxi MEA	Lb/Ft <sup>3</sup> CP Btu/Hr-ft-F Btu/Hr-ft-F F F PSIA	0.000 105 23.0 2,205.90 0.01	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07	1443 164 1 3621 0.8545 39 1.000 105 23.0 1.40 6.70	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18	<b>43</b> 1.000 250 30.0 1.101 37 3.259.46	1.0 1 30 1,1 3.2 4,1	4263 431 0 9361 0.838 21 000 1 77 0.0 : 101 37 259.46 178 54	4263.4 0.523 0.855 47 .000 68 30.0 0.00 1.05	431 33 54 1.1 1.1 1.1 1.1 3.2 4.1	000 05 4.9 098.81 260.52	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDEA	Lb/Ft <sup>3</sup> CP Btu/Lb-E Btu/Hr-ft-F F F PSIA LbMol/Hr LbMol/Hr	0.000 105 23.0 2,205.90 0.01 0.00	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07 0.00	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41	4263 43 0 9361 0.838 41 1.000 248 29.8 1.852 30 3.291.65 4,180.89	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35	<b>43</b> 1.000 250 30.0 	1.0 1 30 1,1 3.2 4,1	4263 431 0 9361 0.838 21 000 1 77 0.0 : 101 37 259.46 178 54	4263.4 0.523 0.855 47 .000 68 30.0 .000 1.05 0.04	431 33 54 1.1 1.1 1.1 1.1 3.2 4.1	000 05 4.9 098.81 260.52 178.59	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA 420 (Water) C1 (Methane)	Lb/Ft <sup>3</sup> CP Rtu/Lb_E Btu/Hr-ft-F Btu/Hr-ft-F F PSIA LbMol/Hr LbMol/Hr LbMol/Hr	0.000 105 23.0 2,205.90 0.01 0.00 112.29	1443.164 1.3621 0.8545 50 0.000 105 23.0 19,853.09 0.07 0.00 1,010.61	1443 164 1 3621 0.8545 39 1.000 105 23.0 1.40 6.70 0.41 2.233 58	4263 43 0 9361 0.838 41 1.000 248 29.8 1.852 30 3.291.65 4.180.89 80.554.30	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8.398.87	<b>43</b> 1.000 250 30.0 1.101 37 3.259.46 4.178 54 72.155.42	1.0 1 30 1,1 3.2 4,1	4263 431 0 9361 0.838 21 000 1 1.77 0.0 1 101 37 259.46 178 54 155 42	4263.4 0.523 0.855 47 .000 68 .30.0 .000 1.05 0.04 (299.34)	431 33 54 1.1 1.1 1.1 1.1 3.2 4.1	000 05 4.9 208.81 260.52 178.59 356.12	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COP/Carbon Dioxi MEA HDEA H2O (Water) C1 (Methane) N2 (Nitrogen)	LIMFI <sup>3</sup> CP Rtu/LIMFI Btu/Hrft-F F PSIA LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr	0.000 105 23.0 2,205.90 0.01 0.00 112.29 0.00	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07 0.00 1010 61 0.00 5.23 0.00	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1,852 30 3 291,65 4,180 89 80 554 30 0 00	4263 43 0 9361 0.838 42 0000 250 300 750 93 32.18 2 35 8 398.87 0.00	43 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00	1.0 1 30 1,1 3.2 4,1	4263 431 0 9361 0.838 21 0000 1 77 0.0 1 259 46 178 54 155 42 0.00	4263.4 0.5223 0.855 47 0.000 68 30.0 1.05 0.04 (299.34) 0.00	431 33 54 1.1 1.1 1.1 1.1 3.2 4.1	000 05 4.9 260.52 178 59 356 12 0 00	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MIDEA H2O (Water) C1 (Methane) N2 (Nitrogen) C2 (Caygen) Total Molar Flow	LIMFI <sup>3</sup> cP Rtu/Lote Btu/Hrft-F F PSIA LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr	0.000 105 23.0 2,205.90 0.01 0.00 112.29 0.00 0.58	1443 164 1 3621 0.8545 50 0.000 105 23.0 19,853 09 0.07 0.00 1,010.61 0.00 5.23	1443 164 1 3621 0.8545 39 1 000 105 230 1 40 6.70 0.41 2,233 58 0.00 0.00	4263.43 0.9361 0.838 41 1.000 248 29.8 29.8 3.291.65 4.18.69 80.554.30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8,398.87 0.00 0.00	<b>43</b> 1000 250 30.0 1,101.37 3.259.46 4.178.54 72,155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 17 77 000 17 259.46 175.42 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL. CONDUCTIVITY STREAM NO. LIQUID FRACTION TEMPERATURE PRESSURE COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS COMPONENTS CO	LIMFI <sup>3</sup> CP Rtv/l b.E Blu/Hrft-F PSIA PSIA LIMG//Hr LIMG//Hr LIMG//Hr LIMG//Hr	0.000 105 23.0 2,205.90 0.01 0.00 112.29 0.00 0.58 0.00 2,318.78	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 2.0.868.99 2.0.868.99	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.0361 0.838 42 0.000 250 3.0.0 750.03 3.2.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 17 77 000 17 259.46 175.42 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDDA H2O (Water) C1 (Mathane) N2 (Nirtogen) O2 (Oxygen) Total Molar Flow VAPOR	LIMFI <sup>3</sup> cP Btu/LoE Btu/Hr-ft-F PSIA PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr	0.000 105 23.0 0.01 0.01 112.29 0.00 0.58 0.00	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07 0.00 1010 61 0.00 5.23 0.00	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 30.0 32.18 2.25 8.398.87 0.00 0.00 0.00	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 17 77 000 17 259.46 175.42 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDEA H2O (Water) C1 (Methane) V2 (Nitrogen) O2 (Oxygen) Total Molar Flow VABOR MASS FLOW RATE STD. VOL. FLOW RATE	LIDER <sup>3</sup> cP Btu/LibE Btu/Hrsft-F PSIA PSIA LIDMO/Hr LIDMO/Hr LIDMO/Hr LIDMO/Hr LIDMO/Hr LIDMO/Hr LIDMO/Hr	0,000 105 23,0 2,205,90 0,001 0,000 112,29 0,000 0,58 0,000 2,318,78 176236 21,12	1443 164 1 3621 0.8545 50 0.000 105 23.0 19,853 09 0.07 0.00 1,010.61 0.00 5.23 0.00 20.868.99 128475917 190.10	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33 344216 8.364	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 17 77 000 17 259.46 175.42 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MIDEA H2Q (Water) C1 (Methane) N2 (Nitrogen) O2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE ACTUAL VOL. FLOW RATE	LIMFI <sup>3</sup> cP Rtu/LoE Btu/Hr-ft-F PSIA F PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr	0 000 105 230 2 205 90 0 01 0 00 112 29 0 00 0 58 0 00 2 318 78 176236 21 12 14.54	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 20.868 99 128475917 190.10 130.90	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8.398.87 0.00 0.00 0.00 0.00 9.184.33 344216 8.364 55.18	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 17 77 000 17 259.46 175.42 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MDEA H2O (Water) C1 (Methane) V2 (Nirrogen) C2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL. FLOW RATE ACTUAL VOL. FLOW RATE MOLECUI AR WEIGHT	LIMEI <sup>3</sup> Rtu/LoE Rtu/LoE Blu/Hrft-F F PSIA LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/At LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT LIMG/AT	0 000 105 230 2,205 90 0 01 0 00 112 29 0 00 122 9 0 00 0 58 0 00 0 058 0 00 2 318 78 176236 21 12 14 54 47 50	1443 164 1 3621 0.8545 50 0.000 105 23.0 10.853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 20.868 99 128475917 190.10 130.90 427.47	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.0361 0.638 42 0.000 250 32.03 32.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33 344216 83.64 55.18 22.58	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID FRACTION TEMPERATURE PRESSURE CODY (Carbon Dioxi MEA MODEA H2O (Water) C1 (Methane) N2 (Nitrogen) O2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE MOLECULAR WEIGHT STD. DENSITY	LIMFI <sup>3</sup> cP Rtu/LoE Btu/Hr-ft-F PSIA F PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr	0,000 105 2,205,90,001 0,001 112,29 0,00 112,29 0,00 0,58 0,00 2,318,78 176236 21,12 14,54 47,50 0,1802	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 1.010 61 0.00 5.23 0.00 1.010 61 0.00 1.010 61 0.00 1.000 61 1.000 61 1.0000 61 1.0000 61 1.0000 61 1.0000 61 1.0	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.0361 0.838 42 0.000 250 30.0 750.03 32.18 2.95 8.398.87 0.000 0.00 9.184.33 344216 83.64 55.18 25.8 0.0889	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDEA H2O (Water) C1 (Methane) V2 (Nitrogen) C1 (Methane) V2 (Direcut Retrogen) C1 (	LIMFI <sup>3</sup> CP Rtv/ILb.E Btv/Hcft-F PSIA PSIA LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr LIMC/Hr	0 000 105 230 2 205 90 0 01 0 00 12 28 0 00 0 058 0 00 2 318 78 176236 2 112 14 54 47 50 0 1802 1 1026	1443 164 1 3621 0.8545 50 0.000 105 23.0 19,853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 1.010 61 0.00 5.23 0.00 1.010 61 0.00 1.010 61 0.00 0.00 1.010 61 0.00 0.00 1.010 61 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 250 30.0 750.93 32.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33 344216 83.64 55.18 22.58 0.0888 1.0958	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDEA H2O (Water) C1 (Methane) H2C (Nitrogen) O2 (Oxygen) Total Molar Flow WASS FLOW RATE STD. VOL FLOW RATE STD. VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE STD. DENSITY GAS COMPRESSIBILITY VISCOSITY	LIMEI <sup>3</sup> CP Rtu/LoE Btu/Hr-ft-F PSIA PSIA PSIA PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/HR LIMA/H	0,000 105 230 2,205,90 0,01 0,00 112,29 0,000 0,058 0,000 2,318,78 176236 21,12 14,54 47,50 0,150 1,1026 0,0174	1443 164 1 3621 0.8545 50 0.000 105 23.0 19,853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 20.868 39 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33 344216 83.64 55.18 22.58 0.0889 0.0889 0.0885 0.0885 0.0162	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT. CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MIDEA H2O (Water) C1 (Mathane) N2 (Nitrogen) C2 (Caygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE MOLECUI AR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY	LIMFI <sup>3</sup> Rtu/LoE Rtu/LoE Btu/Hr-ft-F PSIA F PSIA F PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr L	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026 0,0174 0,0174 0,0174	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.0361 0.0300 250 32.08 232.08 2.332.08 2.332.08 2.332.08 2.332.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08000000000000000000000000000000000	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MDEA H2O (Water) C1 (Methane) V2 (Nitrogen) C2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE MOLECULI AR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY	LIMFI <sup>3</sup> Rtu/LoE Rtu/LoE Btu/Hr-ft-F PSIA F PSIA F PSIA LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr LIMA/Hr L	0,000 105 230 2,205,90 0,01 0,00 112,29 0,000 0,058 0,000 2,318,78 176236 21,12 14,54 47,50 0,150 1,1026 0,0174	1443 164 1 3621 0.8545 50 0.000 105 23.0 19,853 09 0.07 0.00 1.010 61 0.00 5.23 0.00 20.868 39 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570	1443 164 1 3621 0.8545 39 1.000 105 230 1.40 6.70 0.41 2.23358 0.00 0.00 0.00	4263 43 0 9361 0.838 41 1 000 248 29.8 1.852 30 3.291.65 4.180.89 80.554 30 0.000	4263.43 0.9361 0.838 42 0.000 250 30.0 750.93 32.18 2.35 8.398.87 0.00 0.00 0.00 9.184.33 344216 83.64 55.18 22.58 0.0889 0.0889 0.0885 0.0885 0.0162	<b>43</b> 1.000 250 30.0 1.101.37 3.259.46 4.178.54 72.155.42 0.00 0.000	1.1 30 1.1 3.2 4.1 72,1	4263 431 0 9361 0.838 21 21 000 1 77 000 1 259.46 178.54 0.00 0.00 0.00 0.00	4263.4 0.523 0.855 47 .000 68 30.0 1.05 0.04 (299.34) 0.00 0.00	431 433 44 54 10 11 10 10 10 10 10 10 10 10	000 05 4.9 260.52 178.59 356.12 0.00 0.00	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MODA 420 (Water) C1 (Mathane) V2 (Nitrogen) O2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE ACTUAL VOL FLOW RATE STD OPNSITY STD DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY LIQUID	LIME <sup>3</sup> Rhull b.E Blu/Hrft-F PSIA PSIA LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att LIMG/Att 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STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MDEA H2O (Water) C1 (Methane) V2 (Nitrogen) O2 (Oxygen) Total Molar Flow VAPOR WASS FLOW RATE STD VOL FLOW RATE ACTUAL VOL FLOW RATE MOI ECUI AR WEIGHT STD DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY LIQUID	LIDER <sup>3</sup> RU/ILSE BU/HI-RE BU/HI-RE PSIA PSIA PSIA PSIA LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI LIDMO/HI 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1 72 1 80 6 	4263 431 0 9361 0 838 21 21 27 000 17 77 101 32 259.46 178 54 0 00 178 54 0 00 0 00 00	4263.4.0522 0.855 47 0.000 6.8 30.0 0.00 0.00 0.00 0.00 0.00 0.00 0.		000 05 49 98 81 260.52 178 59 356 12 0.00 0.00 0.00 394.03 	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Dioxi MEA MIDEA H2Q (Water) C1 (Mathane) V2 (Nitrogen) O2 (Oxygen) Total Molar Flow MASS FLOW RATE STD. VOL FLOW RATE ACTUAL VOL. FLOW RATE ACTUAL VOL. FLOW RATE ACTUAL VOL. FLOW RATE ACTUAL CONDUCTIVITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY LIQUID MASS FLOW RATE STD. VOL FLOW RATE	LIMFI <sup>3</sup> CP Rtu/LoE Btu/Hr-ft-F PSIA F PSIA F PSIA CP Rtu/LoHa LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/LoE Rtu/Rtu/LoE Rtu/Rtu/Rtu/LoE Rtu/Rtu/Rtu/Rtu/Rtu/Rtu/Rtu/Rtu/Rtu/Rtu/	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026 0,0174 0,0174 0,0174	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 0 8545 39 1 000 105 230 1 40 6.70 0.41 2,233 58 0.00 0.00 0.00 2.242 09 2.242 09 2.242 09 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 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0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	431 33 54 11 11 11 11 11 11 11 11 11 1	000 05 4.9 108.84 260.52 178.59 556.12 0.00 0.00 0.00 394.03 	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSIJRE COMPONENTS CO2 (Carbon Diovi MEA MIDEA H2O (Water) C1 (Methane) N2 (Nitrogen) C2 (Oxygen) Total Molar Flow VAPOR MASS ELOW RATE STD. VOL ELOW RATE STD. VOL ELOW RATE MOLECUILAR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY LIQUID MASS ELOW RATE STD. VOL ELOW RATE STD. VOL ELOW RATE STD. VOL ELOW RATE	1 b/F1 <sup>3</sup> cP Rtv/l b.E Btu/Hr-ft-F PSIA F PSIA LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr LbMo/Hr RMSCED MWW Lb/F1 Lb/F1 Rtv/Lb/F1 Rtv/Lb/F1 Rtv/Lb/F2 Rtv/Lb/F2 Rtv/Lb/F2	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026 0,0174 0,0174 0,0174	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 1 3621 1 0.00 105 230 1 000 105 230 1 40 6.70 0 41 2,233 58 0 00 0 00 2.242 09 2.242 09 0 00 0 000 0 00 0 00	4263 43 0 9261 0.838 41 1 000 248 29.8 1.852 30 3.29165 4.180 29 80.554 30 0.00 0.00 0.00 89.879 13 89.879 13 80.879 14 80.979 14 80.9791 14 80.9791 14 80.979 14 80.9	4263.43 0.0361 0.0300 250 32.08 232.08 2.332.08 2.332.08 2.332.08 2.332.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08000000000000000000000000000000000	43 1.000 250 30.0 1.101 37 3.259.46 4.178 54 72.155 42 0.00 80.694.80 	1 1 1 1 1 3 3 1 1,1 3 2 4 1,1 7 2,1 80.6 227 3911 405	4263 431 0 9361 0 838 21 0 000 177 0 0 177 101 32 1259 46 155 42 0 00 155 42 0 00 155 42 0 00 155 42 155 42 0 00 155 42 155 42 0 00 155 42 155	4263.4.4 0.522 0.855 47 0.000 68 30.0 0.000 (298.34) 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.0000 0.00000 0.0000 0.000000 0.0000 0.00000 0.	431 33 44 1 1 1 1 1 1 1 1 1 1 1 1 1	000 05 4.9 08.84 260.52 178.50 156.12 0.00 0.00 0.00 394.03 394.03 	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MIDEA H2O (Watar) C1 (Methane) X2 (Nitrogen) C2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE STD. VOL FLOW RATE MOLECULAR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY	LIME <sup>3</sup> Rhull b.E Blu/Hrft-F PSIA PSIA LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026,0,0174 0,0174 0,0174 0,2383	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 0 8545 39 1 000 105 230 1 40 6.70 0 41 2,233 58 0 00 0 00 2 242 09 2 242 09 0 0 0 2 242 09 0 0 0 0 0 0 0 0 0 0 0 0 0	4263 43 0 9361 0 838 41 1 000 248 29 8 1 852 30 3 291 85 4 480 89 80 554 30 0 00 89 879 13 4 180 89 80 554 30 0 00 89 879 13 4 180 99 4 180 99 4 180 99 8 18	4263.43 0.0361 0.0300 250 32.08 232.08 2.332.08 2.332.08 2.332.08 2.332.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08 2.32.08000000000000000000000000000000000	43 1 000 250 30 0 1 101 37 3 25946 4 178 54 72 155 42 0 00 0 00 80 694 80 2272931 3919 88 4188 88 25 35	111 113 111 30 111 32 41 721 80.6 	4263 431 0 9361 0 838 21 0 000 1 77 0 00 1 77 0 0 1 101 32 101 32 1	4263.4.0 0.5222 0.855 47 0.00 0.00 1.05 0.04 (299.34) 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	431 33 44 1 1 1 1 1 1 1 1 1 1 1 1 1	000 05 4.9 028.81 260.52 178.50 356.12 0.00 0.00 0.00 394.03 394.03 	40525.96
STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LOUID FRACTION TEMPERATURE PRESSURE COPONENTS CO2 (Carbon Dioxi MEA MDEA MDEA 420 (Water) C1 (Methane) V2 (Nitrogen) O2 (Oxygen) Total Molar Flow MASS FLOW RATE STD. VOL FLOW RATE STD. VOL FLOW RATE ACTUAL VOL FLOW RATE MOL ECULAR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY LIQUID MASS FLOW RATE STD. VOL	LIME <sup>3</sup> Rhull b.E Blu/Hrft-F Blu/Hrft-F PSIA PSIA LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr L	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026,0,0174 0,0174 0,0174 0,2383	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 0.8545 39 1 000 105 230 1 40 6.70 0 41 2.233 58 0.00 0.01 2.242 09 0 0 0 0 2.242 09 0 0 0 0 0 0 0 0 0 0 0 0 0	4263 43 0.9361 0.838 41 0.00 248 29.8 1.852 30 3.29165 4.18089 4.18089 4.18089 0.00 0.00 0.00 80.554 30 0.00 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 80.554 30 0.00 0.00 80.554 30 0.00 0.00 80.554 30 0.00 0.00 80.554 30 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 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2.332.08 2.332.08 2.332.08 2.332.080	43 1.000 250 30.0 1.101 37 3.259.46 4.178.54 4.178.54 72.155.42 0.00 0.00 0.00 80.694.80 	111 30 1,1,1 3,2 4,1 72,1 80,6 	4263 431 0 9361 0 838 21 0 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 77 000 1 78 54 000 000 000 000 000 000 000	4263.4.4 0.522 0.855 47 0.000 68 30.0 0.000 (298.34) 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 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STD. DENSITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY STREAM NO. LIQUID ERACTION TEMPERATURE PRESSURE COMPONENTS CO2 (Carbon Diovi MEA MIDEA H2O (Watar) C1 (Methane) X2 (Nitrogen) C2 (Oxygen) Total Molar Flow VAPOR MASS FLOW RATE STD. VOL FLOW RATE STD. VOL FLOW RATE MOLECULAR WEIGHT STD. DENSITY GAS COMPRESSIBILITY VISCOSITY HEAT CAPACITY THERMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY HERMAL CONDUCTIVITY INFORMAL CONDUCTIVITY	LIME <sup>3</sup> Rhull b.E Blu/Hrft-F PSIA PSIA LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/Hr LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG/HR LIMG	0,000 105 23,0 2,205,90,0,01 0,00, 112,29 0,000,0,58 0,000 2,318,78 176236 21,12 14,54 47,50,0,174 47,50,0,174 1,1026,0,0174 0,0174 0,0174 0,2383	1443 164 1 3621 0.8545 50 0.000 105 23.0 19.853.09 0.07 0.00 1.010.61 0.00 5.23 0.00 20.868.99 128475917 190.10 130.90 427.47 1.6220 9.9230 0.1570 2.1450	1443 164 1 3621 0 8545 39 1 000 105 230 1 40 6.70 0 41 2,233 58 0 00 0 00 2 242 09 2 242 09 0 0 0 2 242 09 0 0 0 0 0 0 0 0 0 0 0 0 0	4263 43 0 9361 0 838 41 1 000 248 29 8 1 852 30 3 291 85 4 480 89 80 554 30 0 00 89 879 13 4 180 89 80 554 30 0 00 89 879 13 4 180 99 4 180 99 4 180 99 8 18	4263.43 0.0361 0.0300 250 32.08 232.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 2.332.08 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1 1 7 2 5 4 0 0 0 0 0 0 0 0 0 0 0 0 0	4263.4.0 0.5222 0.855 47 0.00 68 30.0 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 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A2006 FEATURNMonL000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000L000 <thl000< th="">L000<thl000< th=""><thl000< th="">L000</thl000<></thl000<></thl000<>	STREAM NAME		Total acid gas from strippers	To train A liquefaction	First stage discharge	To second stage	First stage water KO	2nd stage discharge	To 3rd stage	2nd stage water KO	From 3rd stage	To drier	3rd stage water KO
ENCREGNATION ENCODENTIntoDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD </th <th>STREAM NO.</th> <th></th> <th>50</th> <th>300</th> <th>301</th> <th>302</th> <th>310</th> <th>303</th> <th>304</th> <th>309</th> <th>306</th> <th>305</th> <th>314</th>	STREAM NO.		50	300	301	302	310	303	304	309	306	305	314
PRESBUR         PRO         4         4         2         9         9         7         7         2         5         5         9         4         9         2         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         9         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1         1	APOR FRACTION	Molar	1.000	1.000	1.000	1.000	0.000	1.000	1.000	0.000	1.000	1.000	0.000
ADAR PROVEADE         LONDAR 1         LONDAR 1         LONDAR 2         LONDAR 1	TEMPERATURE	F	105	105	230	95	95	236	95	95	282	90	90
MASSER DIVADIT         Disolation         Dis	PRESSURE	PSIG	4	4	25	19		62	56	56	191	185	185
BRENCY         Bubble V         1 22E-07         1 102E-07         1 102E-07         1 23E-07         1 43E-06         1 12E-07         1 43E-00         1 12E-07         1 13E-07         2 3           COLOSATION         MAS         9 13%         90 13%         90 13%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%         0 00%	MOLAR FLOW RATE	LbMol/Hr	20,642.53	2,948.93	2,948.93	2,877.78	71.16	2,877.78	2,840.86	36.92	2,840.86	2,817.85	23.01
Contension         Jone         France         Franc	MASS FLOW RATE	Lb/Hr	882,394	126,056	126,056	124,773	1,283	124,773	124,106	667	124,106	123,688	418
CD2         S1.3W         S1.5W         S0.5W         S0.7W         S	ENERGY	Btu/Hr	9.22E+07	1.32E+07	1.66E+07	1.25E+07	-1.03E+06	1.63E+07	1.22E+07	-5.34E+05	1.72E+07	1.16E+07	-3.33E+05
H2D         AddS         AddS         AddS         Description         Distribution		Mol %											
Nincean.         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%													0.54%
Immenia         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         <													99.46%
Program0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%0.00%<													0.00%
ARDE         Image         Image <thi< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>0.00%</td></thi<>													0.00%
MCARA FLOW BATE         Lobalité         201402         2 24408         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400	Propane		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MCARA FLOW BATE         Lobalité         201402         2 24408         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400         2 2400													
MASS ED (WARTE       Link       882.344       1/20.066       1/26.066       1/26.73       -       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73       1/24.73													
STU VID. I DW.       MMSCED       188.00       28.66       28.67       27.21       27.27       27.87       2.78.67       25.66         VID.LIGULATURE LINE       MW       109.94 53       15.75.0       5.17.70       6.47.67       4.43.36						-	-						-
ACTUAL VOL, FLOW         ACEVA         19,770,0         ACP, 27,          4,833,12         39,101,4          7,731,35         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,738,36         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138         1,138							-						
NOT ECLUAR WEIGHT         MW         4476         4476         44380         43380         43380         1358         155           DESISTY         LMPP         0.13         0.03         0.23         0.25         0.045         0.0132         0.0152         0.0212         0.0116         156         156         156           VIDEOCRABION LIDUO         C         0.0187         0.0192         0.0193         0.0152         0.0212         0.0116         0.0192         0.0116         0.0192         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116         0.0116 <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td>							-			-			
DENSITY         LbP/F         0.13         0.013         0.023         0.25          0.45         0.53          1.16         1.16         1.16         1.16         1.16         0.0152         0.0152         0.0152         0.0152         0.0152         0.0152         0.0152         0.0152         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154         0.0154							-						
NISCORTY         QP         0.0143         0.0149         0.0149         0.0142         0.0152         0.0212         0.0154           NYDROACARRON LIGUID         NOAR ALCOW RATE         I.MMUMT         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         -         - <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>							-						
HYDROCARRON LOUID         Image										-			
MOLAR FLOW RATE       LMM0Kt       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -		UP.	0.0149	0.0149	0.010/	0.0149	-	0.0193	0.0152		0.0212	0.0154	
MASS.FLOW.RATE         Inhit         Image: standard		LbMol/Hr					_		_				
STD VOL FLOW         EPO <t< td=""><td></td><td></td><td></td><td>_</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>				_									
ACTUAL VAC FLOW         GPM													
DENSITY         LUPE         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .													
MOLECULAR WEIGHT         MV         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .		0	-	-	-		-	-	-		-	-	
VISCOSITY       cp       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .       .			-	-	-	-	-	-	-	-	-	-	
SURFACE TENSION         Dyne/Cm         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .         .			-	-	-	-	-	-	-	-	-	-	
VAPOR FRACTION         Molar         1.000         0.726         0.000         0.000         0.000         1.000         0.000         0.000         0.174         0.           TEMPERATURE         F         90         380         -26         -11         82         82         149         95         24         -31         -           PRESSURF         PSIG         180         180         175         2.003         2.000         169         162         159         5         -           OLAR FLOW RATE         LbMdHr         2.805.88         11.97         2.005.88         2.805.88         19.641.16         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.00%         0.00%         0.00%         0.00%         0.00%         0.00%	STREAM NAME												
VAPOR FRACTION         Modal         1.000         0.726         0.000         0.000         0.000         1.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.000         0.0174         0.           PRESSURE         PSIG         180         180         175         2.003.8         2.805.88         2.805.88         2.014.3         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00% <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>To pipeline</th> <th>compressor</th> <th></th> <th>From subcooler</th> <th>To chiller</th> <th>From chiller</th>								To pipeline	compressor		From subcooler	To chiller	From chiller
TEMPERATURE         F         90         380         -26         -11         82         82         149         95         24         -31         -           PRESSURE         PSIG         180         180         175         2.003         2.000         2.000         169         162         159         5         M           MOLAR FLOW RATE         LbMol/Hr         2.805.88         11.97         2.805.88         2.805.88         13.641         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441         13.5441 <t< td=""><td>STREAM NO</td><td></td><td>condenser</td><td>drier</td><td>condenser</td><td>pump</td><td>liquefaction</td><td></td><td>compressor discharge</td><td>condenser</td><td></td><td></td><td></td></t<>	STREAM NO		condenser	drier	condenser	pump	liquefaction		compressor discharge	condenser			
PERESLIBE         PSIG         140         140         175         2.003         2.000         2.000         169         162         159         5           MOLAR FLOW RATE         LbMol/H         2.805.88         11.97         2.805.88         2.805.88         2.805.88         19.641.16         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43         3.071.43		Molar	condenser 307	drier 311	condenser 312	pump 308	liquefaction 309	313	compressor discharge 400	condenser 401	402	403	404
MOLAR FLOW RATE         LbMol/Hr         2,805.88         11.97         2,805.88         2,805.88         19,641.16         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43         3,071.43	VAPOR FRACTION	Molar	condenser 307 1.000	drier 311 0.726	condenser 312 0.000	90mp 308 0.000	liquefaction 309 0.000	<b>313</b> 0.000	compressor discharge 400 1.000	condenser 401 0.000	<b>402</b> 0.000	<b>403</b> 0.174	<b>404</b> 0.996
MASS FLOW RATE       LbHrlt       123.473       216       123.473       123.473       123.473       123.473       123.473       123.473       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441       135.441	VAPOR FRACTION TEMPERATURE	F	condenser 307 1.000 90	drier 311 0.726 380	condenser 312 0.000 -26	308 0.000 -11	liquefaction 309 0.000 82	<b>313</b> 0.000 82	compressor discharge 400 1.000 149	condenser 401 0.000 95	<b>402</b> 0.000 24	<b>403</b> 0.174 -31	<b>404</b> 0.996 -31
ENERGY         BluHr         1.15E+07         2.63E+04         -8.44E+06         -7.62E+06         1.43E+06         -9.99E+06         2.28E+07         8.00E+05         -5.39E+06         -5.39E+06         1.46           COMPOSITON         Mol %         99.97%         0.90%         99.97%         99.97%         99.97%         99.97%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00	VAPOR FRACTION TEMPERATURE PRESSURE	F PSIG	condenser 307 1.000 90 180	drier 311 0.726 380 180	condenser           312           0.000           -26           175	308 0.000 -11 2,003	liquefaction 309 0.000 82 2,000	<b>313</b> 0.000 82 2,000	compressor discharge 400 1.000 149 169	condenser 401 0.000 95 162	<b>402</b> 0.000 24 159	<b>403</b> 0.174 -31 5	<b>404</b> 0.996 -31 5
COMPOSITON         Mil %         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M         M	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE	F PSIG LbMol/Hr	condenser           307           1.000           90           180           2,805.88	drier 311 0.726 380 180 11.97	condenser           312           0.000           -26           175           2,805.88	308 0.000 -11 2,003 2,805.88	309           0.000           82           2,000           2,805.88	313 0.000 82 2.000 19,641.16	compressor discharge 400 1.000 149 169 3.071.43	condenser 401 0.000 95 162 3.071.43	<b>402</b> 0.000 24 159 3.071.43	<b>403</b> 0.174 -31 5 3,071.43	<b>404</b> 0.996 -31 5 3,071.4
H2O       0.00%       100.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00%       0.00% <th< td=""><td>VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE</td><td>F PSIG LbMol/Hr Lb/Hr</td><td>condenser 307 1.000 90 180 2,805.88 123.473</td><td>drier 311 0.726 380 180 11.97 216</td><td>condenser           312           0.000           -26           175           2.805.88           123.473</td><td>308 0.000 -11 2.003 2.805.88 123.473</td><td>liquefaction 309 0.000 82 2.000 2.805.88 123.473</td><td>313 0.000 82 2,000 19,641.16 864.308</td><td>compressor discharge 400 1.000 149 169 3.071.43 135.441</td><td>condenser 401 0.000 95 162 3.071.43 135.441</td><td><b>402</b> 0.000 24 159 3.071.43 135.441</td><td><b>403</b> 0.174 -31 5 3,071.43 135.441</td><td><b>404</b> 0.996 -31 5 3,071.4 135.44</td></th<>	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE	F PSIG LbMol/Hr Lb/Hr	condenser 307 1.000 90 180 2,805.88 123.473	drier 311 0.726 380 180 11.97 216	condenser           312           0.000           -26           175           2.805.88           123.473	308 0.000 -11 2.003 2.805.88 123.473	liquefaction 309 0.000 82 2.000 2.805.88 123.473	313 0.000 82 2,000 19,641.16 864.308	compressor discharge 400 1.000 149 169 3.071.43 135.441	condenser 401 0.000 95 162 3.071.43 135.441	<b>402</b> 0.000 24 159 3.071.43 135.441	<b>403</b> 0.174 -31 5 3,071.43 135.441	<b>404</b> 0.996 -31 5 3,071.4 135.44
Nitrogen         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.03%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2,805.88 123.473	drier 311 0.726 380 180 11.97 216	condenser           312           0.000           -26           175           2.805.88           123.473	308 0.000 -11 2.003 2.805.88 123.473	liquefaction 309 0.000 82 2.000 2.805.88 123.473	313 0.000 82 2,000 19,641.16 864.308	compressor discharge 400 1.000 149 169 3.071.43 135.441	condenser 401 0.000 95 162 3.071.43 135.441	<b>402</b> 0.000 24 159 3.071.43 135.441	<b>403</b> 0.174 -31 5 3,071.43 135.441	<b>404</b> 0.996 -31 5 3,071.4 135.44
Ammonia         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         <	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2,805.88 123.473 1.15E+07	drier 311 0.726 380 180 11.97 216 2.63E+04	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06	308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06	liquefaction 309 0.000 82 2,000 2,805.88 123.473 -1.43E+06	313 0.000 82 2,000 19,641.16 864.308 -9.99E+06	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05	402 0.000 24 159 3.071.43 135.441 -5.39E+06	<b>403</b> 0.174 -31 5 3.071.43 135.441 -5.39E+06	<b>404</b> 0.996 -31
Propane         0.00%         0.00%         0.00%         0.00%         0.00%         0.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00%         100.00% <td>VAPOR FRACTION TEMPERATURE PRESSURE WOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2</td> <td>F PSIG LbMol/Hr Lb/Hr Btu/Hr</td> <td>condenser 307 1.000 90 180 2,805.88 123.473 1.15E+07 99.97%</td> <td>drier 311 0.726 380 180 11.97 216 2.63E+04 0.00%</td> <td>condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97%</td> <td>9000 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97%</td> <td>liquefaction 309 0.000 82 2,000 2,805.88 123.473 -1.43E+06 99.97%</td> <td>313 0.000 82 2,000 19,641.16 864.308 -9.99E+06 99.97%</td> <td>compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00%</td> <td>condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00%</td> <td>402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00%</td> <td>403 0.174 5 3,071.43 135.441 -5.39E+06 0.00%</td> <td>404 0.996 -31 5 3,071.4 135.44 1.46E+07</td>	VAPOR FRACTION TEMPERATURE PRESSURE WOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2,805.88 123.473 1.15E+07 99.97%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97%	9000 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97%	liquefaction 309 0.000 82 2,000 2,805.88 123.473 -1.43E+06 99.97%	313 0.000 82 2,000 19,641.16 864.308 -9.99E+06 99.97%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00%	403 0.174 5 3,071.43 135.441 -5.39E+06 0.00%	404 0.996 -31 5 3,071.4 135.44 1.46E+07
VAPOR         Image: Constraint of the state of the	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2 H2O	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00%	liquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00%	313 0.000 82 2,000 19,641.16 864.308 -9.99E+06 99.97% 0.00%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00%	403 0.174 5 3,071.43 135.441 -5.39E+06 0.00% 0.00%	404 0.996 -31 5 3,071.4 1.35.44 1.46E+07 0.00%
MOLAR FLOW RATE       LbMo//Hr       2.805.9       8.7       -       -       3.071.4       -       534.9       3.         MASS FLOW RATE       Lb/Hr       123.473       156       -       -       -       135.441       -       23.589       11.         STD VOL FLOW       MMSCED       25.55       0.08       -       -       -       27.97       -       4.87         ACTUAL VOL FLOW       ACFM       1.314.67       6.25       -       -       -       1.522.13       -       1.964.87       11.4         MOLECULAR WEIGHT       MW       44.01       18.02       -       -       -       1.48       -       0.020         VISCOSITY       cP       0.0155       0.0154       -       -       -       0.0099       -       0.0065       1.44.10         MOLAR FLOW RATE       LbMo//Hr       -       2.805.88       2.805.88       19.641.16       -       3.071.43       3.071.43       2.536.49         MOLAR FLOW RATE       LbMo//Hr       -       -       123.472.59       123.472.59       864.308.12       -       135.440.78       111.851.67       145.16         VID VOL FLOW       BPD       -       10.244	VAPOR FRACTION TEMPERATURE PRESSURF MOLAR FLOW RATE MASS FLOW RATF ENERGY COMPOSITON CO2 H2O Nitrogen	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.03%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03%	liquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03%	313 0.000 82 2.000 19,641.16 864.308 9.99E+06 99.97% 0.00% 0.03%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00% 0.00%	condenser 401 0.000 95 162 3.071.43 1.35.441 8.00E+05 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00%	403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00%	404 0.996 -31 5 3.071.4 1.35.44 1.46E+07 0.00% 0.00%
MOLAR FLOW RATE       LbMo//Hr       2.805.9       8.7       -       -       3.071.4       -       534.9       3.         MASS FLOW RATE       Lb/Hr       123.473       156       -       -       -       135.441       -       23.589       11.         STD VOL FLOW       MMSCED       25.55       0.08       -       -       -       27.97       -       4.87         ACTUAL VOL FLOW       ACFM       1.314.67       6.25       -       -       -       1.522.13       -       1.964.87       11.4         MOLECULAR WEIGHT       MW       44.01       18.02       -       -       -       1.48       -       0.020         VISCOSITY       cP       0.0155       0.0154       -       -       -       0.0099       -       0.0065       1.44.10         MOLAR FLOW RATE       LbMo//Hr       -       2.805.88       2.805.88       19.641.16       -       3.071.43       3.071.43       2.536.49         MOLAR FLOW RATE       LbMo//Hr       -       -       123.472.59       123.472.59       864.308.12       -       135.440.78       111.851.67       145.16         VID VOL FLOW       BPD       -       10.244	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2 420 Vitrogen Ammonia	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.03% 0.00%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00% 0.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%	Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%	313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00% 0.00% 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	404 0.996 -31 5 3.071.4 1.35.44 1.46E+07 0.00% 0.00%
MASS FLOW RATE       Lb/Hr       123.473       156       -       -       -       135.441       -       23.589       112         STD VOL FLOW       MMSCED       25.55       0.08       -       -       -       27.97       -       -       48.7         ACTUAL VOL FLOW       ACFM       1.34.67       6.25       -       -       -       1.522.13       -       1.964.87       11.3         MOLECULAR WEIGHT       MW       44.01       18.02       -       -       -       44.10       -       44.10         DENSITY       Lb/F <sup>2</sup> 1.57       0.42       -       -       -       1.48       -       0.0065       0.0         VISCOSITY       cb       0.0155       0.0154       -       -       -       0.0099       -       0.0065       0.0         HYDROCARBON LIQUID       Image: Control of the control of th	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2 420 Vitrogen Ammonia	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.03% 0.00%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00% 0.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%	Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%	313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00% 0.00% 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	404 0.996 -31 5 3.071.4 135.44 1.46E+07 0.00% 0.00% 0.00%
STD VOL FLOW       MMSCEP       25.55       0.08       -       -       27.97       -       48.7         ACTUAL VOL, FLOW       ACEM       1.314.67       6.25       -       -       -       1.522.13       -       1.964.87       11.2         ACTUAL VOL, FLOW       ACEM       1.314.67       6.25       -       -       -       1.522.13       -       1.964.87       11.2         MOLECULAR WEIGHT       MW       44.01       18.02       -       -       -       44.10       -       44.10       -       44.10       -       0.020       0.20       0.021       0.020       0.009       -       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065       0.0065 <td>VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 120 Viltrogen Ammonia Propane</td> <td>F PSIG LbMol/Hr Lb/Hr Btu/Hr</td> <td>condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.03% 0.00%</td> <td>drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00% 0.00% 0.00%</td> <td>condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%</td> <td>pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%</td> <td>Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%</td> <td>313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%</td> <td>compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00% 0.00% 0.00%</td> <td>condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%</td> <td>402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%</td> <td>403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%</td> <td>404 0.996 -31 5 3.071.4 135.44 1.46E+07 0.00% 0.00% 0.00%</td>	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 120 Viltrogen Ammonia Propane	F PSIG LbMol/Hr Lb/Hr Btu/Hr	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.03% 0.00%	drier 311 0.726 380 180 11.97 216 2.63E+04 0.00% 100.00% 0.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%	Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%	313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%	compressor discharge 400 1.000 149 169 3.071.43 135.441 2.28E+07 0.00% 0.00% 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	404 0.996 -31 5 3.071.4 135.44 1.46E+07 0.00% 0.00% 0.00%
ACTUAL VOL. FLOW       ACFM       1.314.67       6.25       -       -       -       1.522.13       -       1.964.87       11.4         MOLECULAR WEIGHT       MW       44.01       18.02       -       -       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       44.10       -       -       44.10       -       -       44.10       -       -       0.000       -       1.964.87       11.2       12.842.18       11.2       1.364.78       11.2       1.0006       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       0.0005       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       -       0.0009       0.0009       -       1.000	VAPOR FRACTION TEMPERATURE TEMPERATURE WOLAR FLOW RATE ENERGY COMPOSITON CO2 220 Vitrogen Ammonia Propane VAPOR MOLAR FLOW RATE	F PSIG LbMol/Hr Btu/Hr Mol %	condenser 307 1.000 90 180 2.805.88 123.473 1.15E+07 99.97% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00%	drier 311 0.726 380 180 11.97 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.0% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%	Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%	313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%	compressor discharge 400 1.000 149 3.071.43 135.441 2.28E+07 0.00% 0.00% 0.00% 0.00% 0.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00% 0.00% 100.00% 100.00%	404 0.996 -31 5 3.071.4 1.365.44 1.46E+07 0.00% 0.00% 0.00% 0.00% 100.00%
MOLECULAR WEIGHT       MW       44.01       18.02       -       -       44.10       -       44.10       -       44.10         DENSITY       Lb/Ft <sup>2</sup> 1.57       0.42       -       -       -       1.48       -       0.0005       0.00         VISCOSITY       cP       0.0155       0.0154       -       -       -       0.0099       -       -       0.0065       0.004         MOLAR FLOW RATE       LbMol/Hr       -       2.805.88       2.805.88       2.805.88       19.641.16       -       3.071.43       3.071.43       2.536.49         MASS FLOW RATE       Lb/Hr       -       10.244       10.244       17.706       -       18.340.78       111.851.67       15.116         STD VOL FLOW       BPD       -       10.244       10.244       71.706       -       18.304       15.116       15.116         ACTUAL VOL FLOW       GPM       -       227.86       224.14       303.64       2.125.46       567.94       50.418       389.85         DENSITY       Lb/Ft <sup>3</sup> -       67.56       68.68       50.70       50.70       -       29.73       33.49       35.77	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON CO2 H2O Vitrogen Ammonia Propane VAPOR MOLAR FLOW RATE MASS FLOW RATE	F PSIG LbMol/Hr Ib/Hr Btu/Hr Mol %	condenser 307 1.000 90 180.8 2.805.84 1.315E+07 99.97% 0.00% 0.00% 0.00% 2.805.9 123.473	drier 311 0.726 380 180 1.1.97 2166 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.0% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00%	condenser 312 0.000 -26 175 2.805.88 123.473 -8.44E+06 99.97% 0.00% 0.03% 0.00%	pump 308 0.000 -11 2.003 2.805.88 123.473 -7.62E+06 99.97% 0.00% 0.03% 0.00%	Iquefaction 309 0.000 82 2.000 2.805.88 123.473 -1.43E+06 99.97% 0.00% 0.03% 0.00%	313 0.000 82 2.000 19.641.16 864.308 -9.99E+06 99.97% 0.00% 0.03% 0.00%	compressor discharge 400 1.000 149 169 3.071.43 1.35.441 2.28E+07 0.00% 0.00% 0.00% 100.00% 100.00%	condenser 401 0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 1.35.441 -5.39E+06 0.00% 0.00% 0.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100	404 0.996 -31 5 3.071.4 1.35.44 1.46E+07 0.00% 0.00% 0.00% 100.00% 100.00% 100.00%
DENSITY       Lb/Ft <sup>2</sup> 1.57       0.42       -       -       -       1.48       -       0.00         VISCOSITY       cP       0.0155       0.0154       -       -       -       0.0099       -       -       0.0065       1         HYDROCARBON LIQUID       Image: Constraint of the state of	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE ENERGY COMPOSITON CO2 420 Vitrogen Mmonia Propane VAPOR MOLAR FLOW RATE STD VOL FLOW	F PSIG LbMol/Hr Ib/Hr Bt//Hr Mol %	condenser           307         1.000           90         180           180.588         123.473           1115±407         99.97%           90.03%         0.00%           0.00%         0.00%           12.805.9         123.473           12.805.9         123.473           2.805.9         123.473           25.55         55	drier 311 0.726 380 180 1.1.97 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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0.000 95 162 3.071.43 135.441 8.00E+05 0.00% 0.00% 0.00%	402 0.000 24 159 3.071.43 135.441 -5.39E+06 0.00% 0.00% 0.00%	403 0.174 -31 5 3.071.43 1.35.441 -5.39E+06 0.00% 0.00% 0.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 100.00% 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0.00% 100.00% 100.00% 134.88 134.88 27.8
VISCOSITY         cP         0.0155         0.0154         -         -         -         0.0099         -         -         0.0065         -           HYDROCARBON LIQUID         Image: Constraint of the state of	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE SUBROY COMPOSITON CO2 20 Vitroaen Ammonia Propane VAPOR MOLAR FLOW RATE MASS FLOW RATE STD VOL FLOW	F PSIG LbMo//Hr I b/Hr Btw/Hr Mol % Lb/Hr Lb/Hr MMSCFD ACFM	condenser           307         1.000           90         180           2.805.88         123.473           1.15E+07         99.97%           90.00%         0.00%           0.00%         0.00%           2.805.9         123.473           2.805.9         123.473           2.805.5         1.314.67	drier 311 0.726 380 180 11.07 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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MOLAR FLOW RATE       IbMol/Hr       -       2.805.88       2.805.88       2.805.88       19.641.16       -       3.071.43       3.071.43       2.536.49         MASS FLOW RATE       Ib/Hr       -       123.472.59       123.472.59       123.472.59       123.472.59       135.400.78       135.440.78       118.51.67       111.851.67         STD VOL FLOW       BPD       -       10.244       10.244       10.244       71.706       -       18.304       15.116         ACTUAL VOL FLOW       GPM       -       227.86       224.14       303.64       2.125.46       -       567.94       504.18       389.85         DENSITY       Lb/Ft <sup>3</sup> -       67.56       68.68       50.70       50.70       -       29.73       33.49       35.77	VAPOR FRACTION TEMPERATURE PRESSURE WOLAR FLOW RATE ENERGY COMPOSITON CO2 H2CO WIVERON Propane VAPOR WOLAR FLOW RATE STD VOL FLOW ACTUAL VOL. FLOW WOLECULAR WEIGHT DENSITY	F PSIG LbMol/Hr Ib/Hr Bt/JrH Mol % LbMol/Hr Lb/Hr MMSCFD ACFM MMSCFD	condenser           307         1.000           90         180           2.805.88         123.473           1.15E+07         99.97%           0.00%         0.03%           0.00%         0.00%           2.805.9         123.473           25.55         1.314.67           44.01         1.57	drier 311 0.726 380 180 11.97 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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MASS FLOW RATE       Ib/Hr       -       123 472.59       123 472.59       123 472.59       864 308.12       -       135 440.78       11.851.67       11.851.67         STD VOL FLOW       BPD       -       -       10.244       10.244       10.244       71.706       -       18.304       15.116         ACTUAL VOL FLOW       GPM       -       -       227.86       224.14       303.64       2.125.46       -       567.94       504.18       389.85         DENSITY       Lb/Ft <sup>3</sup> -       -       67.56       68.68       50.70       50.70       -       29.73       33.49       35.77	VAPOR FRACTION TEMPERATURE PRESSURE MOLAR FLOW RATE MASS FLOW RATE ENERGY COMPOSITON 202 120 120 120 120 120 120 120	F PSIG LbMol/Hr Ib/Hr Bt/JrH Mol % LbMol/Hr Lb/Hr MMSCFD ACFM MMSCFD	condenser           307         1.000           90         180           2.805.88         123.473           1.15E+07         99.97%           0.00%         0.03%           0.00%         0.00%           2.805.9         123.473           25.55         1.314.67           44.01         1.57	drier 311 0.726 380 180 11.97 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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STD VOL FLOW         BPD         -         10.244         10.244         71.706         -         18.304         15.116           ACTUAL VOL FLOW         GPM         -         -         227.86         224.14         303.64         2.125.46         -         567.94         504.18         389.85           DENSITY         Lb/Ft <sup>3</sup> -         67.56         68.68         50.70         50.70         29.73         33.49         35.77	VAPOR FRACTION TEMPERATURE PRESSURE WOLAR FLOW RATE ENERGY COMPOSITON CO2 H2O Witrogen Propane VAPOR MOLAR FLOW RATE STD VOL FLOW ACTUAL VOL, FLOW MOLECUI AR WEIGHT DENSITY HYDROCARBON LIQUID	F PSIG LbMo/Hr Bt//Hr Bt//Hr Mol % Lb/Hr MSCFD ACFM MW/ Lb/Fr	condenser           307         1.000           90         180           2.805.88         123.473           1.15E+07         99.97%           0.00%         0.03%           0.00%         0.00%           2.805.9         123.473           25.55         1.314.67           44.01         1.57	drier 311 0.726 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DENSITY Lb/Ft <sup>3</sup> - 67.56 68.68 50.70 50.70 - 29.73 33.49 35.77	VAPOR FRACTION TEMPERATURE TEMPERATURE VAPOR FLOW RATE VASS FLOW RATE ENERGY COMPOSITON CO2 20 20 20 20 20 20 20 20 20 20 20 20 20	F PSIG LbMol/Hr b/Hr Btw/Hr Mol % HbMol/Hr Lb/Hr MMSCED ACFM MWSCED ACFM	condenser           307         1.000           90         180           2.805.88         123.473           1.15E+07         99.97%           0.00%         0.03%           0.00%         0.00%           2.805.9         123.473           25.55         1.314.67           44.01         1.57	drier 311 0.726 380 180 11.97 2.63E+04 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 0.00% 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# Table 3.4.7: CO2 Compression and Liquefaction System Material and Energy Balance for Concept C

SURFACE TENSION

Dyne/Cm

14.00

0.86

0.86

5.74

10.48

14.49

14.49

16.01

# 3.4.5.4 Equipment List with Data

Equipment data has been presented in the so-called "short spec" format as shown in Appendix II, which provides adequate data for a factored cost estimate.

# 3.4.5.5 Consumption of Utilities

Consumption of utilities for Concept C is defined in Table 3.4.8.

		1 able 5.4. 6:	Utility Consumption for			
		Utility	Amount Consumed	Units	_	
		Natural Gas team (180 psig) Cooling water	21.0 1,130,000 67800	MMSCFD Lb/hr Gpm		
					Power (ea)	
					including	
				Number	0.95	Total
Number				Operating	motor eff	all trains
Of	Tag no.		Description	per train	(kW)	(kW)
Trains	EC 2201	003	1 1	1	10	71
7	EC-2301	-	essor 1st stage air cooler	1	10	71
7	EC-2302	-	essor 2nd stage air cooler	1	10	73
7	EC-2303	CO2 compr	essor 3rd stage air cooler	1	16	109
5	GA-2101 A/E	3 Wa	sh Water Pump	1	19	95
5	GA-2102 A/E	B Direct Con	tact Cooler Water Pump	1	55	274
5	GA-2103	Ric	h Solvent Pump	3	103	1542
	A/B/C/D		1			
5	GA-2104 A/E	B Bottom Dire	ect Contact Cooler Water Pump	1	10	48
9	GA-2201A/B/	C Lea	n Solvent Pump	2	82	1473
9	GA-2202 A/E	B Solvent S	Stripper Reflux Pump	1	3	28
9	GA-2203 A/E	B Fil	ter Circ. Pump	1	12	107
7	GA-2301 A/E	B CO	2 Pipeline Pump	1	184	1288
3	GA-2501		tic metering pump	1	0	0
5	GA-301 A/B		ensate booster pumps	1	148	742
9	GA-2204 A/H		ensate booster pump	1	57	514
5	GB-301	FI	ue Gas Blower	1	2628	13142
5 7	GB-2301		pressor (Motor driven)	1	3730	26110
, 7	GB-2401		e Refrig Compressor	1	2532	17727
1	GB-2401 GB-2500	-	m turbine/ generator	I NA	2332 NA	NA
1	GB-2500 GB-2501		m turbine/ generator	NA	NA	NA
1	0D-2501	nr stea	in turonne/ generator	INA	INA	INA
7	PA-2351	CO	2 Drier Package	1	166	1160
1	PA-2551	C	Cooling Tower	1	2972	2972
			Total			67477

Table 3.4.8:Utility Consumption for Co	Concept C
----------------------------------------	-----------

#### 3.4.5.6 Consumption of Chemicals and Desiccants

Consumption of Chemicals and Desiccants for Concept C is defined in Table 3.4.9.

Chemical	Consumption per day (lbs.)
Caustic (100%)	25200
MEA	700
Corrosion inhibitor	0
Diatomaceous earth	916
Molecular sieve	282
Sodium hypochlorite	10300
Sodium bisulfite	30

#### Table 3.4.9: Chemicals and Desiccants Consumption f or Concept C

This total does not include chemicals provided by the cooling tower service people nor disposal of waste. These are handled as a component of operating costs referred to as contracted services and waste handling, respectively.

#### 3.4.5.7 Design Considerations

The following parameters were optimized for Concept C with the objective of reducing the overall unit cost and energy requirements.

- Solvent Concentration
- Lean Amine Loading
- Rich Amine Loading
- Stripper Feed Temperature
- Absorber Temperature
- Rich /Lean Exchanger approach
- CO<sub>2</sub> Compressor interstage temperatures
- CO<sub>2</sub> Refrigeration Pressure and Temperature

A minimum of 90% recovery was targeted. The above parameters were adjusted to increase the recovery until a significant increase in equipment size and/ or energy consumption was observed. AES Corporation owns and operates a 200 STPD food grade  $CO_2$  production plant in Oklahoma. This plant was designed and built by ABB Lummus Global as a part of the larger power station complex using coal fired boilers. This plant was started up in 1990 and has been operating satisfactorily with lower than designed MEA losses. Table 3.4.10 compares key process parameters for the Concept C design with the AES design.

PROCESS PARAMETER	AEP DESIGN	AES DESIGN
	(Concept C)	
PLANT CAPACITY TPD	10372	200
CO <sub>2</sub> in Feed, % mol	15.7	14.7
O <sub>2</sub> in Feed, % mol	100 ppm	3.4
$SO_2$ in Feed, % mol	1 ppm	10 PPMV (Max)
SOLVENT	MEA/ MDEA	MEA
SOLVENT CONC. %WT	10/25	15 (Actual 17-18%Wt)
LEAN LOADING	0.15	0.10
RICH LOADING	0.44	0.41
STRIPPER FEED TEMP , F	201	194
STRIPPER BOTTOM TEMP F	250	245
FEED TEMP TO ABSORBER, F	105	108
CO <sub>2</sub> RECOVERY %	90.5	90 (ACTUAL 96-97%)
ABSORBER PRESSURE DROP psi	1	1.4
STRIPPER PRESSURE DROP psi	0.6	4.35
R/L EXCHANGER APPROACH,F	10	50
CO <sub>2</sub> COMPRESSOR I/STG TEMP F	105	115
LIQUID CO <sub>2</sub> TEMP F	82	-13
LIQUID CO <sub>2</sub> PRESSURE psi (A)	2015	247

## Table 3.4.10: Key Process Parameters Comparison

#### 3.4.5.8 OSBL Systems

#### Filter Residues:

A pressure leaf filter filters a slipstream of lean amine. Diatomaceous earth is used as a filter-aid for pre-coating the leaves and as a body feed. Filter cycles depend on the rate of flow through the filter, the amount of filter aid applied, and the quantity of contaminants in the solvent. A typical composition of the filter residue is provided in Table 3.4.11 below. These will be disposed of by a contracted service hauling away the drums of spent cake.

#### Table 3.4.11: Filter Residue Composition

MEA	2.6 wt.%
Total Organic Carbon	1.5 wt.%
SiO2	0.03 wt.%
Insolubles	0.03 wt.%
РН	10.0
Specific Gravity	1.0

## Excess Solvent Stripper Reflux Water:

The  $CO_2$  Recovery Facility has been designed to operate in a manner to avoid accumulation of water in the Absorber / Stripper system. Conversely, a continuous make-up stream of water is not required either. By controlling the temperature of the scrubbed flue gas to the absorber, water balance of the MEA/MDEA system can be kept in check. Excess water can accumulate in the Stripper Reflux Drum and can be reused once the system is corrected to operate in a balanced manner. Should water need to be discarded, contaminants will include  $CO_2$  and MEA/MDEA.

#### Secondary Absorber Effluent:

The existing plant uses lime in its flue gas desulfurizer. In the cost estimate of this plant, it has been assumed that the existing plant disposal facilities can include the additional load of the secondary absorber (D-301X).

#### Cooling Tower Blowdown:

The composition limits on cooling tower blowdown are shown in Table 3.4.12:

Component	Specification
Suspended Solids	30 ppm monthly, 100 ppm daily
pH	6.5 to 9
Oil and Grease	15 ppm maximum monthly, 20 ppm maximum daily
Free Chlorine	0.035 ppm

Table 3.4. 12: Filter Residue Composition

There is a thermal limit specification for the entire river. However, the blowdown volume is too small to affect it significantly.

The relief valve discharges from the  $CO_2$  Recovery Unit are discharged to atmosphere. No tie-ins to any flare header are necessary.

#### 3.4.5.9 Plant Layout

The Concept C Plant Layout Drawings listed below are shown in Appendix I. This equipment requires about 8 acres of plot area.

U01-D-0207 Plot Plan – Concept C: De-Oxy Catalyst & Cooling U01-D-0210 Plot Plan – Concept C: Flue Gas Cooling & CO<sub>2</sub> Absorption U01-D-0215 Plot Plan – Concept C: Solvent Stripping U01-D-0206 Plot Plan – Concept C: CO<sub>2</sub> Compression & Liquefaction U01-D-0213 Plot Plan – Concept C: Overall Layout Conceptual Plan U01-D-0202R Plot Plan – Concept C: Modified Overall Site Plan

Plant layout has been designed in accordance with a spacing chart called "Oil and Chemical Plant Layout and Spacing" Section IM.2.5.2 issued by Industrial Risk Insurers.

When discussing layout, the first thing to observe is that no highly flammable materials are handled within the  $CO_2$ Recovery Unit. The open cup flash point of MEA is 200 °F and, therefore, will not easily ignite. In addition to MEA, the corrosion inhibitor is the only hydrocarbon liquid within the battery limits. The flash point of this material is higher than that of MEA and is handled in small quantities.

As the chemicals used in the process present no fire hazard, there is an opportunity to reduce the minimum spacing between equipment from that normally considered acceptable in hydrocarbon handling plants. Regardless, for the drawings that follow, standard spacing requirements, as imposed by IRI have been followed.

The plot area available for the installation of the desired equipment is small. Some equipment items are placed on structures to allow other pieces of equipment to be placed underneath them. This way pumps and other equipment associated with the Absorber can be located under the structure. Locating the pumps under the structure has been considered acceptable because the fluids being pumped are not flammable.

Noise is an issue with the flue gas fan as much as it is with compressors. Discussions with vendors suggest that it will be possible to provide insulation on the fan casing to limit noise to acceptable level. Therefore, it has been assumed that no building needs to be provided for noise reasons.

Having economized on the required plot space as noted above, it was judged not to be practical to divide up the absorbers and strippers that are required into the plot areas initially offered for this purpose (refer to Section 2.1, Figure 2.1.1). Eventually it was agreed that the units would be placed in the northeast corner of the site, about 1200-ft from the Unit 5/6 stack. By having the units all together, the flue gas duct length and MEA piping between the absorber and stripper could be minimized, although the latter impact is not nearly as important as the flue gas routing.

The caustic solution will not freeze but will become very viscous when it gets cold. It will be electric traced.

The plot plan shows a substation in the Stripper area but none for the Absorber area. The assumption is that because the electrical consumption of the Absorber equipment is small (0.23 MW) compared to the Stripper equipment, the equipment can be run directly from the auxiliary power 480 volt power system.

For the Rich/Lean Solvent Exchanger which is a plate and frame type exchanger, area estimates received from vendors based on similar conditions suggest that five units/ train be sufficient for the specified service.

# 4.0 SUMMARY OF SYSTEMS PERFORMANCE AND CARBON DIOXIDE EMISSIONS

This section summarizes overall system performance and  $CO_2$  emissions. Table 4.0.1 shows a comparison of plant performance and emissions for the three  $CO_2$  recovery concepts and the Base Case that has no  $CO_2$  recovery system.

# Table 4.0.1: Overall Plant Performance and CO<sub>2</sub> Emissions Comparison

		(units)	Original Plant (Base)	Concept A MEA	Concept B O2 Fired	Concept C MEA-MDEA
Boiler Parameters		(units)				
Main Steam Flow		(lbm/hr)	3131619	3131651	3131651	3131651
Reheat Steam Flow (to IP turbine)		(lbm/hr)	2853607	2853607	2808612	2853607
Main Steam Pressure		(psia)	2535	2535	2535	2535
Main Steam Temp		(Deg F)	1000	1000	1000	1000
Reheat Steam Temp		(Deg F)	1000	1000	1000	1000
Boiler Efficiency		(percent)	88.13	88.13	90.47	88.13
Flue Gas Flow leaving Economizer		(lbm/hr)	4014743	4014743	3930554	4014743
Flue Gas Temperature leaving Air Heater		(Deg F)	311	311	371	311
Coal Heat Input (HHV)		(10 <sup>6</sup> Btu/hr)	4228.7	4228.7	4140.0	4228.7
<sup>1</sup> (Includes New Oxygen Heater and Parallel FW Heater for Case B)	(LHV)	(10 <sup>6</sup> Btu/hr)	4037.9	4037.9	3953.2	4037.9
CO2 Removal Steam System Parameters						
CO <sub>2</sub> Removal System Steam Pressure		(psia)		65		65
CO <sub>2</sub> Removal System Steam Temp		(Deg F)		478		478
CO <sup>2</sup> Removal System Steam Extraction Flow		(lbm/hr)		1935690	0	1133173
CO <sub>2</sub> Removal System Condensate Pressure (from reboilers)		(psia)		64.7		64.7
CO <sub>2</sub> Removal System Condensate Temperature		(Dea F)		292.7		292.7
Natural Gas Heat Input (HHV) <sup>2</sup>		(10 <sup>°</sup> Btu/hr)		17.7	11.4	885.9
<sup>2</sup> (Includes Desicant Regeneration Case A,B,C and De-Oxy system for Case C)	(LHV)	(10 <sup>°</sup> Btu/hr)		16.0	10.3	798.4
Steam Cycle Parameters		6				
Total Heat Input to Steam Cycle		(10 <sup>°</sup> Btu/hr)	3707.4	3707.4	3745.8	4410.4
Heat Output to CO <sup>2</sup> Removal System Reboilers		(10 <sup>b</sup> Btu/hr)		1953.0		1503.0
Existing Condenser Pressure		(psia)	1.23	1.23	1.23	1.23
Existing Condenser Condensate Flow		(lbm/hr) (10 <sup>6</sup> Btu/hr)	2617295	640768	2588715	1522923
Existing Condenser Heat Loss			2102.8	603.3	2142.6	1412.1
Existing Steam Turbine Generator Output		(kW)	463478	269341	463056	357196
CO <sub>2</sub> Removal System Turbine Generator Output		(kW)	0	62081	0	36343
De-Oxy System Turbine Generator Output (Concept C) Total Turbine Generator Output		(kW)	463478	0 331422	463056	<u>37751</u> 431290
<sup>3</sup> (Includes Boiler Heat Output for the Base Case and Case A, Boiler + PFWH for Ca	ase B, and Bo	(kW) biler + De-Oxy Sy			403030	431290
Auxiliary Power Requirements						
Condensate Pump Power		(kW)	563	481	557	530
Condenser Cooling Water Pump Power		(kW)	5562	1596	5667	3735
Boiler Island Auxiliary Power (Fans & Pulverizers)		(kW)	7753	7753	7804	7753
Coal & Ash Handling System		(kW)	1020	1020	998	1020
FGD & ESP System Auxiliary Power		(kW)	8157	8157	7986	8157
Misc. Auxiliary Power (Lighting, HVAC, Trans, etc)		(kW)	6645	6645	6645	6645
Air Separation Unit Power Reqirement (Case B)		(kW)	0	0	95822	0
CO <sub>2</sub> Removal System Auxiliary Power		(kW)		50355	64229	67477
Total Auxiliary Power		(kW)	29700	76007	189709	95317
Plant Performance Parameters						
Net Plant Output		(kW)	433778	255414	273347	335973
Normalized Net Plant Output (Relative to Base Case)		(fraction)	1.00	0.59	0.63	0.77
Net Plant Efficiency (HHV)		(fraction)	0.3501	0.2053	0.2247	0.2242
Net Plant Efficiency (LHV)		(fraction)	0.3666	0.2150	0.2354	0.2371
Normalized Efficiency (HHV; Relative to Base Case)		(fraction)	1.00	0.59	0.64	0.64
Net Plant Heat Rate (HHV)		(Btu/kwhr)	9749	16626	15188	15223
Net Plant Heat Rate (LHV)		(Btu/kwhr)	9309	15872	14500	14395
Plant CO2-Emissions		(II) as (I)		000.00-	0.000-	007000
Carbon Dioxide Produced		(lbm/hr)	866102	868137	849255	967806
Carbon Dioxide Recovered		(lbm/hr)	0	835053	796238	875653
Carbon Dioxide Emissions		(lbm/hr)	866102	33084	53016	92153
Fraction of Carbon Dioxide Recovered		(fraction)	0	0.962	0.938	0.905
Specific Carbon Dioxide Emissions Normalized Specific CO <sub>2</sub> Emissions (Relative to Base Case)		(lbm/kwhr)	1.997	0.130	0.194	0.274
		(fraction)	1.00	0.065	0.097	0.137
Avoided Carbon Dioxide Emissions (as compared to Base)		(lbm/kwhr)		1.867	1.803	1.722

Several comparisons have been made in this table and throughout the report. Some of the more important comparisons are summarized in this section.

#### **Boiler Performance**

All four cases were analyzed and designed based on the boiler producing a main steam flow of 3,131,619 lbm/hr at conditions of 1000 F and 2535 psia at the turbine. This main steam flow represents the maximum continuous rating (MCR) for the unit. All four cases also provided reheat steam to the turbine at conditions of 1000 °F and 590.8 psia. The boiler performance for the Base Case, Case A, and Case C was identical. Case B, while producing the same main steam flow as the other cases had a slightly lower reheat steam flow because there was less reheat spray required for this case. Boiler efficiency for Case B (90.47%) was somewhat higher than the other cases (88.13%) due primarily to the oxygen firing and the addition of the new oxygen heater and parallel feedwater heater.

#### Steam Cycles

The steam cycles for the four cases were all very different. The Base Case steam cycle is a typical steam cycle with nominal conditions of 2535 psia /  $1000 \,^{\circ}\text{F}$  /  $1000 \,^{\circ}\text{F}$ . Six extraction feedwater heaters are used. The generator in this case produces 463,478 kW.

Case A differs from the Base Case in that it extracts a large portion of steam from the IP/LP crossover pipe. The extracted steam, at about 200 psia is expanded through a new turbine generating power before exhausting into the reboilers of the  $CO_2$  recovery plant at 65 psia. The modified existing steam turbine generator produces 269,341 kW and the new turbine produces 62,081 kW for a total of 331,422 kW. The gross output is reduced by 132,056 kW, about 28 percent, for this case.

The steam cycle for Case B is quite similar to the Base Case. The system is modified slightly with the addition of a new low-pressure feedwater heater in parallel with existing extraction feedwater heaters # 52 and #53 as described in Section 3.1.2. The parallel feedwater heater (PFWH) was used to recover additional sensible heat in the flue gas as a result of reduced air heater performance with oxygen firing. The modified steam cycle system of Case B produces 463,056 kW. This is 422 kW lower than for the Base Case. The gross output for Case B is slightly lower than the Base Case due to less reheat spray being required. Nearly offsetting this is the increased output resulting from the addition of the PFWH.

Case C differs from the Base Case in that a large portion of steam is extracted from the IP/LP crossover pipe that is ultimately used for the solvent regeneration in the reboilers similar to Case A. The amount of steam extracted is however, less for Case C due to two reasons. First, less steam is required per unit of  $CO_2$  recovered and secondly, additional steam is being provided to the reboilers from the de-oxy system. The steam extracted from the existing steam turbine is expanded through a new turbine generating 36,343 kW before exhausting into the reboilers of the  $CO_2$  recovery plant at 65 psia. The high-pressure steam generated in the de-oxy system is expanded through a new turbine providing 37,751 kW of output. A parallel low-pressure feedwater heater, arranged similar to the one used in Case B, is used for low level heat recovery in the de-oxy system. The modified existing steam turbine generator produces 357,196 kW for a total gross output of 431,290 kW. The gross output is reduced by 32,188 kW, about 7 percent, for Case C as compared to the Base Case.

#### **Auxiliary Power and Net Plant Output**

The auxiliary power required for the Base Case is 29,700 kW or about 6.4 percent of the gross output. Net plant output is 433,778 kW. All three  $CO_2$  capture options require large amounts of additional auxiliary power. For Concept A (MEA) auxiliary power is increased to 76,007 kW due primarily to the addition of the  $CO_2$  compression and liquefaction system which delivers the  $CO_2$  as a liquid at 2000 psig. This system consumes 50,355 kW. The total amount of auxiliary power represents about 23 percent of the gross output. Net plant output is reduced to 255,414 kW or about 59 percent of the Base Case output. For Concept B (oxygen fired) auxiliary power is increased to 189,709 kW due primarily to the addition of the air separation unit, which consumes 95,822 kW, and the  $CO_2$  compression and liquefaction system which consumes 64,229 kW. The total amount of auxiliary power represents about 41 percent of the gross output. Net plant output is reduced to 273,347 kW or about 64 percent of the Base Case output. For Concept C (MEA/MDEA) auxiliary power is increased to 95,317 kW due primarily to the addition of the  $CO_2$  compression and liquefaction system which consumes 67,477 kW. The total amount of auxiliary power for Concept C

represents about 22 percent of the gross output. Net plant output is reduced to 335,973 kW or about 77 percent of the Base Case output. Net Plant Output values are compared below in Figure 4.0.1.

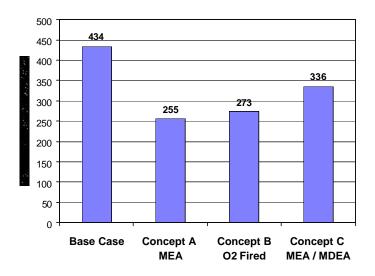


Figure 4.0. 1: Net Plant Electrical Output (Mw)

# Net Plant Heat Rate and Thermal Efficiency

Because of the large energy requirements and/or auxiliary power demands for the new equipment required for the  $CO_2$  capture systems, net plant heat rate and thermal efficiency are degraded substantially relative to the Base Case as shown in Figure 4.0.2. The Base Case plant thermal efficiency (HHV Basis) is about 35.0%, which equates to a net plant heat rate of 9,749 Btu/kwhr. Concept A, with large amounts of steam extracted for solvent regeneration and increased auxiliary power for the  $CO_2$  compression and liquefaction system, has plant thermal efficiency degraded to about 20.5% (16,626 Btu/kwhr). Concept B, with large amounts of auxiliary power for the air separation unit and the  $CO_2$  compression and liquefaction system, has plant thermal efficiency degraded to about 22.5% (15,187 Btu/kwhr). Concept C, with less steam extracted than Concept A for solvent regeneration and increased auxiliary power for the  $CO_2$  compression and liquefaction system, has plant thermal efficiency degraded to about 22.5% (15,223 Btu/kwhr). These results correspond to energy penalties of 41%, 36%, and 36% for Concepts A, B, and C, respectively.

As shown in figure 4.0.1 plant output is reduced significantly with the addition of the  $CO_2$  capture systems. Therefore replacement power is required to restore the original capacity of the unit. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant was analyzed without capturing the  $CO_2$  from its flue gas. The NGCC plant was assumed to generate power with an efficiency of 57.1 percent (LHV basis). The additional  $CO_2$  emitted from the NGCC was 0.762 lbm/kWh. The thermal efficiency of the three concepts including the replacement power systems is also shown in Figure 4.0.2. The efficiencies (HHV basis) range from about 26% to 28% with Concept B being the highest at 28.4%.

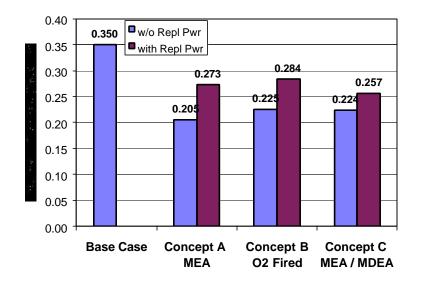


Figure 4.0. 2: Plant Thermal Efficiency (HHV Basis)

# CO<sub>2</sub> Emissions

 $CO_2$  emissions are summarized in Table 4.0.1 for the cases without replacement power. Specific carbon dioxide emissions were reduced from 1.997 lbm/kWh for the Base Case to 0.130, 0.194, and 0.274 lbm/kWh for Concepts A, B, and C, respectively. Figure 4.0.3 illustrates this comparison while also showing the  $CO_2$  captured and the avoided emissions. Figure 4.0.4 compares specific  $CO_2$  emissions both with and without replacement power. Recovery of  $CO_2$  ranged from 91 to 96%. Normalized specific  $CO_2$  emissions for Concepts A, B, and C respectively (without Replacement Power), were 6.5, 9.7, and 13.7 percent of the Base Case value.

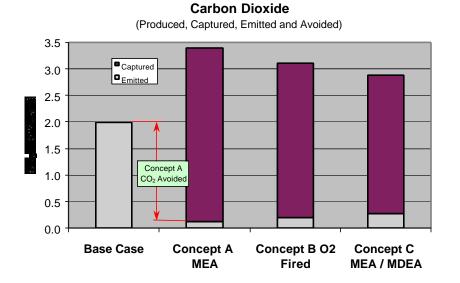


Figure 4.0. 3: Carbon Dioxide Distribution (without replacement power)

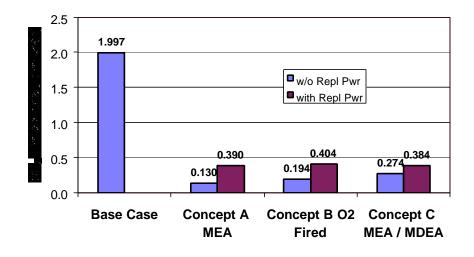


Figure 4.0. 4: Specific Carbon Dioxide Emissions

# 5.0 COST ANALYSIS

The project capital cost estimates, including engineering, procurement and construction (EPC basis), are shown in this section. These costs include all required equipment such as the amine-based  $CO_2$  scrubbing systems of Concepts A and C, the modified FGD system of Concept A, the De-Oxy system of Concept C, the  $CO_2$  compression and liquefaction systems for all three concepts, steam cycle modifications for all concepts, and the air separation unit and the boiler island modifications of Concept B. Boiler island modifications for Concept B are relatively small and include costs for such items as oxygen and gas ducts and dampers, booster fans, parallel feedwater heaters and piping, oxygen heater, and controls and instrumentation.

All these  $CO_2$  capture options produce less net plant power output than the original plant (Base Case). Therefore, costs for replacement power to make up this difference were also calculated. Economic analyses discussed in Section 6 were done both with and without replacement power. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant cost and performance were developed without capturing the  $CO_2$  from its flue gas.

Operating and maintenance (O&M) costs were calculated for all systems. The O&M costs for the Base Case were provided by American Electric Power (AEP). For the retrofit CO<sub>2</sub> capture system evaluations, additional O&M costs were calculated for the new equipment. The variable operating and maintenance (VOM) costs for the new equipment included such categories as chemicals and desiccants, waste handling, maintenance material and labor, and contracted services. The fixed operating and maintenance (FOM) costs for the new equipment includes operating labor only.

# 5.1 Cost Estimation Basis

The following assumptions were made in developing these cost estimates for each concept evaluated:

- Outdoor installation
- Investment in new utility systems is outside the scope
- CO<sub>2</sub> pipeline is outside the scope
- No special limitations for transportation of large equipment
- No protection against unusual airborne contaminants (dust, salt, etc.)
- No unusual wind storms
- No earthquakes
- No piling required
- All releases can go to atmosphere no flare provided
- CO<sub>2</sub> Pump designed to API standards, all other pumps conform to ANSI
- All heat exchangers designed to TEMA "C"
- All vessels are designed to ASME Section VIII, Div 1.
- Annual operating time is 5870 h/yr.
- The investment cost estimate was developed as a factored estimate based on in-house data for the major equipment. Such an estimate can be expected to have accuracy of +/-30%.
- No purchases of utilities or charges for shutdown time have been charged against the project.

Other exclusions from the cost estimate are as follows:

- Soil investigation
- Environmental Permits
- Disposal of hazardous or toxic waste
- Disposal of existing materials
- Custom's and Import duties
- Sales/ Use tax.
- Forward Escalation
- Capital spare parts
- Chemical loading facilities

- Buildings except for Compressor building and electrical substation.
- Financing cost
- Owners cost
- Guards during construction
- Site Medical and Ambulance service
- Cost & Fees of Authorities
- Overhead High voltage feed lines
- Cost to run a natural gas pipeline to the plant (Concept 3C)
- Excessive piling
- Contingency and risk

# 5.2 Boiler Modification Costs

Boiler modification costs for these three  $CO_2$  capture options are relatively minor as compared to the other new equipment required. For this project the Boiler Scope is defined as everything on the gas side upstream of the FGD System. Therefore it includes equipment such as fans, ductwork, ESP, air heater, steam generator, pulverizers, coal and ash handling systems, etc. Not included in the boiler scope is the FGD system. The FGD system modification costs are shown separately in Section 5.4. For Concepts A and C, the Boiler Scope is not modified from the Base Case configuration and as such there are no costs in this category. Concept B Boiler Scope modifications were described in Section 3.3.4 and include such items as sealing the boiler for air leaks, new ductwork dampers and fans for the recirculated flue gas, oxygen heater, parallel low-pressure feedwater heater, and modified controls and instrumentation. The total cost required for the boiler scope modifications of Concept B is \$7,000,000. This estimate includes material, engineering and construction. The expected level of accuracy for this budget level cost estimate is +/-30%.

# 5.3 Carbon Dioxide Separation and Compression System Costs

5.3.1 Concept A

#### **Investment Cost**

Table 5.3.1 shows investment costs for the Concept A  $CO_2$  Separation and Compression System. Included in this table (Acc't. Code - 14200) are the steam cycle modification costs as well as the new letdown turbine and associated electric generator. The steam cycle modifications were described in Section 3.2.3. The Total Installed Cost (TIC) of this equipment is \$393,325,000. The expected level of accuracy for this budget level cost estimate is +/- 30%.

Table 5.3.1:	Concept A CO <sub>2</sub>	Separation and	Compression	System Investment Costs
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Acc't	Description	Pieces	Direct	Labor	Material	Subcontract	Total	%
Code			Manhours	(\$,000)	(\$,000)	(\$,000)	(\$,000)	
11000	Heaters						-	0.0
11200	Exchangers & Aircoolers		44,970	697	28,481		29,178	7.4
12000	Vessels / Filters		5,776	90	3,658		3,748	1.0
12100	Towers / Internals		43,200	670	27,360		28,030	7.1
12200	Reactors		-	-	,			0.0
13000	Tanks		-	-			-	0.0
14100	Pumps		10,078	156	6,383		6,539	1.7
14200	Compressors		100,925	1,564	63,919		65,483	16.6
18000	Special Equipment		10,991	170	6.961		7,131	1.8
	Sub-Total Equipment	436	215.939	3.347	136.762	-	140.109	35.6
21000	Civil		287,919	4,463	9,573		14,036	3.6
21100	Site Preparation		-	-	-		-	0.0
22000	Structures		75,579	1,171	5,607		6,779	1.7
23000	Buildings		39,589	614	1,641		2,255	0.6
30000	Piping		593,833	9,204	24,617		33,821	8.6
40000	Electrical		305,914	4,742	10,941		15,683	4.0
50000	Instruments		251,929	3,905	17,095		21,000	5.3
61100	Insulation		215,939	3,347	7,112		10,459	2.7
61200	Fireproofing		107,970	1,674	2,051		3,725	0.9
61300	Painting		53.985	837	957		1.794	0.5
	Sub-Total Commodities		1,932,656	29,956	79,595	-	109,551	27.9
70000	Construction Indirects						48,343	12.3
	Sub-Total Direct Cost		2,148,595	33,303	216,357	-	298,003	75.8
71000	Constr. Management						2,000	0.5
80000	Home Office Engineering						44,472	11.3
80000	Basic Engineering						5,000	1.3
95000	License fee	Excluded						0.0
19400	Vendor Reps						2,500	0.6
19300	Spare parts						4,000	1.0
80000	Training cost	Excluded						0.0
80000	Commissioning	Excluded						0.0
19200	Catalyst & Chemicals						1,100	0.3
97000	Freight						6,500	1.7
96000	CGL / BAR Insurance							0.0
	Sub-Total						363,575	92.4
91400	Escalation						10,000	2.5
	Contingency	Excluded						0.0
93000	Risk	Excluded						0.0
	Total Base Cost						373,575	95.0
	Contracters Fee						19,750	5.0
	Grand Total						393.325	100.0

Exclusions : Bonds, Taxes, Import duties , Hazerdous material handling & disposal, Capital spare parts,

Catalyst & Chemicals , Commissioning and Initial operations, Buildings other than Control room & MCC.

### **Additional Operating Cost**

Table 5.3.2 shows O&M costs for the Concept A  $CO_2$  Separation and Compression System. They amount to 12,700,000/yr.

# Table 5.3.2: Concept A CO<sub>2</sub> Separation and Compression System Operating & Maintenance Costs

Operating Cost	Variable Costs Amount (\$/ y	r) Fixed Costs Amount (\$/ yr)
Chemical and Desiccant	2,958,000	
Waste Handling	120.000	
Utility Costs*	0*	
Maintenance (Material and Labor)	7,845,000	
Operating Labor**		1,380,000
Contracted Services	392,000	, ,
Column Total	11,320,000	1,380,000
Grand Total (Fixed + Variable)		12,700,000

\*Included with heat rate reduction, operating expense included with power plant modifications operating cost. \*\* Operating labor is 365 days/ year, all other numbers are variable costs and are based on 245 days/ yr.

# 5.3.2 Concept B

#### **Investment Cost**

Table 5.3.3 shows investment costs for the Concept B  $CO_2$  Separation and Compression System. Also included in this table is the cost of the Air Separation Unit (\$138,544,000). The ASU System represents about 50% of the total cost for this concept whose Total Installed Cost (TIC) is \$277,905,000. The expected level of accuracy for this budget level cost estimate is +/- 30%.

Table 3.3.3. Concept D CO <sub>2</sub> Separation and Compression System in resultent Costs	Table 5.3. 3:	Concept B CO <sub>2</sub> Separation and Compression System Investment Costs
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Acc't	Description	Pieces	Direct	Labor	Material	Subcontract	Total	%
Code			Manhours	(\$,000)	(\$,000)	(\$,000)	(\$,000)	
11000	Heaters						-	0.0
11200	Exchangers & Aircoolers		15,060	233	9,538		9,771	3.59
12000	Vessels / Filters		5,722	89	3,624		3,713	1.3
12100	Towers / Internals		6,371	99	4,035		4,134	1.5
12200	Reactors		-	-			-	0.0
13000	Tanks		-	-			-	0.0
14100	Pumps		2,842	44	1,800		1,844	0.7
14200	Compressors		33,098	513	20,962		21,475	7.7
18000	Special Equipment		5,068	79	3,210		3,289	1.2
	Sub-Total Equipment	107	68,162	1.057	43.169	-	44.226	15.9
21000	Civil		102,242	1,585	3,885		5,470	2.0
21100	Site Preparation		-	-	-		-	0.0
	Structures		23,857	370	1,943		2,312	0.8
	Buildings		27,265	423	1,036		1,459	0.5
	Piping		187,444	2,905	8,634		11,539	4.2
	Electrical		96,562	1,497	3,454		4,950	1.8
	Instruments		79,522	1,233	6,044		7,276	2.6
	Insulation		51,121	792	1,295		2,087	0.8
	Fireproofing		34,081	528	648		1,176	0.4
	Painting		28.401	440	367		807	0.3
0.000	Sub-Total Commodities		630.495	9.773	27.304	_	37.077	13.3
70000	Construction Indirects		0001100	0,110			15.720	5.79
	Sub-Total Direct Cost		698,656	10,829	70,473	-	97,022	34.9
	ASU TIC plant cost			,			138,544	49.9
71000	Constr. Management						1,500	0.5
	Home Office Engineering						10,914	3.9
	Basic Engineering						1,500	0.5
	License fee	Excluded					1,000	0.0
	Vendor Reps	LYOIGGOG					1,750	0.6
	Spare parts						2,900	1.0
	Training cost	Excluded					2,000	0.0
	Commissioning	Excluded						0.0
	Catalyst & Chemicals	LAGIGUEU					161	0.0
	Freight						2,114	0.1
	CGL / BAR Insurance						2,114	0.0
30000	Sub-Total						256.405	92.3
01400	Escalation						<b>236,405</b> 7,500	<u>92.3</u> 2.7
	Contingency	Excluded					7,500	2.7
93000		Excluded						
93000							263.905	0.0 95.0
	Total Base Cost Contracters Fee						14,000	5.0

Exclusions : Bonds, Taxes, Import duties , Hazerdous material handling & disposal, Capital spare parts, Catalyst & Chemicals , Commissioning and Initial operations, Buildings other than Control room & MCC.

# **Additional Operating Cost**

Table 5.3.4 shows O&M costs for the Concept B  $CO_2$  Separation and Compression System. They amount to 10,643,000/yr.

	Table 5.3.4:	Concept B CO <sub>2</sub> Separation and Compression System Operating & Maintenance Costs	5
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Operating Cost	Variable Costs Amount (\$/ yr)**	* Fixed Costs Amount (\$/ yr)
Chemical and Desiccant	376,000	
Waste Handling	0	
Utility Costs*	0*	
Maintenance (Material and Labor)	5,700,000	
Operating Labor**	0	261,000**
Contracted Services	1,660,000	
ASU Operating Labor**	0	902,000**
ASU Chemicals and Lubricants	237,400	
ASU Maintenance	1,506,200	
Column Totals	9,480,000	1,163,000
Grand Total (Fixed + Variable)	10,0	643,000

\*Included with heat rate reduction, operating expense included with power plant modifications operating cost.

\*\* Operating labor is 365 days/ year, all other numbers are variable costs and are based on 245 days/ yr.

#### 5.3.3 Concept C

#### **Investment Cost**

Table 5.3.5 shows investment costs for the Concept C  $CO_2$  Separation and Compression System. Included in this table (Acc't. Code - 14200) are the steam cycle modification costs as well as the new letdown turbine and De-Oxy system turbine and associated electric generators. The steam cycle modifications were described in Section 3.4.3. The Total Installed Cost (TIC) of this equipment is \$738,041,000. The expected level of accuracy for this budget level cost estimate is +/- 30%.

Table 5.3. 5:	Concept C CO <sub>2</sub> Separation and Compression System Investment Costs
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Acc't	Description	Pieces	Direct	Labor	Material	Subcontract	Total	%
Code			Manhours	(\$,000)	(\$,000)	(\$,000)	(\$,000)	1
	Heaters		3,947	61	2,500		2,561	0.39
11200	Exchangers & Aircoolers		70,071	1,086	44,378		45,464	6.2
12000	Vessels / Filters		6,611	102	4,187		4,289	0.69
12100	Towers / Internals		81,947	1,270	51,900		53,170	7.2
12200	Reactors		-	-			-	0.0
	Tanks		14	0	9		9	0.0
14100	Pumps		15,320	237	9,703		9,940	1.3
	Compressors		98,073	1,520	62,113		63,633	8.6
18000	Special Equipment		11,424	177	7,235		7,412	1.0
	Sub-Total Equipment	485	287.407	4.455	182.025	-	186.479	25.3
21000	Civil		383,209	5,940	12,742		18,681	2.59
21100	Site Preparation		-	-	-		-	0.0
22000	Structures		100,592	1,559	7,463		9,022	1.2
23000	Buildings		52,691	817	2,184		3,001	0.49
30000	Piping		958,024	14,849	32,764		47,614	6.5
40000	Electrical		407,160	6,311	14,562		20,873	2.8
50000	Instruments		335,308	5,197	22,753		27,950	3.8
61100	Insulation		287,407	4,455	9,465		13,920	1.99
61200	Fireproofing		143,704	2,227	2,730		4,958	0.79
61300	Painting		71,852	1,114	1,274		2,388	0.39
	Sub-Total Commodities		2.739.948	42.469	105.938	-	148.407	20.19
70000	Construction Indirects						68,115	9.2
	Sub-Total Direct Cost		3.027.355	46.924	287.963	-	403.002	54.6
	Constr. Management						2,500	0.3
	Home Office Engineering						49,470	6.7
80000	Basic Engineering						5,000	0.7
95000	License fee	Excluded	ł					0.0
19400	Vendor Reps						2,500	0.3
19300	Spare parts						5,000	0.79
	Training cost	Excluded	ł					0.0
80000	Commissioning	Excluded	ł					0.0
19200	Catalyst & Chemicals	Catalyst	Excluded				222,430	30.19
97000	Freight						8,639	1.29
96000	CGL / BAR Insurance							0.0
	Sub-Total						698,541	94.6
	Escalation						13,500	1.89
93000	Contingency	Excluded	k					0.0
93000	Risk	Excluded	ł					0.0
	Total Base Cost						712,041	96.5
	Contracters Fee						26.000	3.5
	Grand Total						738,041	100.0

Exclusions : Bonds, Taxes, Import duties , Hazerdous material handling & disposal, Capital spare parts, Reactor Catalyst & Chemicals , Commissioning and Initial operations, Buildings other than Control room & MC(

# Additional Operating Cost

Table 5.3.6 shows O&M costs for the Concept C  $CO_2$  Separation and Compression System. They amount to \$26,535,920/yr.

Operating Cost	Variable Costs Amount (\$/ yr)	** Fixed Costs Amount (\$/ yr)
Chemical and Desiccant	1,797,000	
Waste Handling	15,600	
Utility Costs*	0*	
Maintenance (Material and Labor)	22,141,320	
Operating Labor**	0	1,380,000**
Contracted Services	1,202,000	
Column Totals	25,155,920	1,380,000
Total (Fixed + Variable)		26,535,920

\*Included with heat rate reduction, operating expense included with power plant modifications operating cost. \*\* Operating labor is 365 days/ year, all other numbers are variable costs and are based on 245 days/ yr.

#### 5.4 Flue Gas Desulfurization System Modification Costs

Flue Gas Desulfurization System modification costs for these three  $CO_2$  capture options are relatively minor as compared to the other new equipment required. For Concepts B and C, the existing Flue Gas Desulfurization System is not modified from the Base Case configuration and as such there are no costs in this category. The Concept A Flue Gas Desulfurization System modifications, which include the addition of a secondary absorber island, building, booster fan, and ductwork, are described in Section 3.2.4. The total cost required for the Flue Gas Desulfurization System scope modifications of Concept A is \$15,800,000. This estimate includes material, engineering and construction. The expected level of accuracy for this cost estimate is +/-10%.

# 5.5 Charges for Loss of Power during Construction and Operation of the Modified Power Plant System

During the construction period it is assumed the existing Unit No. 5 power plant will be operated in its normal way. The new  $CO_2$  capture equipment is being located some 1500 feet from the Unit No. 5/6 stack (see Appendix I for plant layout drawings) and as such will not impede operation of Unit No. 5 or any of the other units on site. Once construction is completed it has been assumed the final connections between the  $CO_2$  capture systems and the existing power plant can be completed during the annual outage for the unit. Final shake down testing will be completed after the outage.

During plant operation, all these  $CO_2$  capture options produce less net plant output at full load than the original plant (Base Case). Therefore, each concept was analyzed with replacement power to make up for this difference. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant performance and cost was calculated assuming the  $CO_2$  from its flue gas was not captured. The NGCC plant was assumed to cost \$450/kW, installed. Table 5.5.1 shows the NGCC outputs and costs for the three  $CO_2$  capture concepts.

	Concept A	Concept B	Concept C
NGCC Power Output (kW)	178,363	160,430	97,805
NGCC Installed Cost (\$ x 1000)	80,264	72,194	44,012

Table 5.5.1:	NGCC Outputs and Costs for Replacement Power
--------------	----------------------------------------------

# 5.6 Summary of Total Plant Investment Costs

Table 5.6.1 summarizes the total retrofit investment costs required for each of the three Concepts. Two costs are shown for each concept, one with and one without replacement power. Figure 5.6.1 shows the specific investment costs (\$/kW) for the three concepts without replacement power. Two costs are given for each of the three concepts in this figure. The bars on the left are relative to the new plant output and the bars on the right are relative to the original plant output. Figure 5.6.2 shows the specific investment costs (\$/kW) for the three concepts with replacement power These costs were used in the economic evaluation (Section 6) to develop incremental Cost of Electricity values and comparisons.

CO <sub>2</sub> Capture Concept	Units	w/o Repl Pwr	with Repl Pwr	
Concept A	10 <sup>6</sup> US\$	409	489	
	\$/kW	1602	1128	
Concept B	10 <sup>6</sup> US\$	285	357	
	\$/kW	1042	823	
Concept C	10 <sup>6</sup> US\$	738	782	
	\$/kW	2197	1803	

 Table 5.6.1:
 Total Retrofit Investment Capital Costs

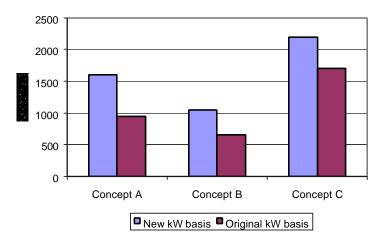
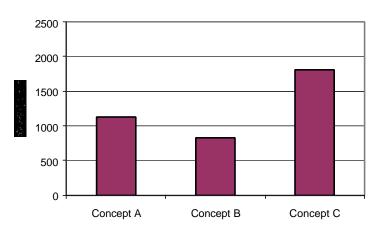
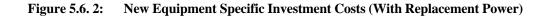


Figure 5.6. 1: New Equipment Specific Investment Costs (Without Replacement Power)





# 6.0 ECONOMIC ANALYSIS

A comprehensive economic evaluation comparing the Base Case study unit and the three retrofit CO<sub>2</sub> capture concepts (A - MEA absorption,  $B - O_2$  Fired with flue gas recycle, and C - MEA/MDEA absorption) was performed. The purpose of the evaluation was to quantify the impact of CO<sub>2</sub> capture on the Cost of Electricity (COE) of this existing coal fired unit. CO<sub>2</sub> mitigation costs were also determined in this analysis. The economic evaluation results are presented as incremental Costs of Electricity (first full year of operation basis). The first year basis is quite representative (at least for the input assumptions used in this study) as the post modification COE for year 10 is only about 7% greater than for year 1. The incremental costs of electricity are incremental relative to the Base Case (air fired without CO<sub>2</sub> capture, i.e., business as usual). Each CO<sub>2</sub> capture option was evaluated both with and without replacement power. Since all these CO<sub>2</sub> capture options produce less net plant output than the original plant (Base Case), the replacement power exactly represents this difference. For cases with replacement power, it was assumed to be generated with a state-of-the-art natural gas fired combined cycle (NGCC) plant. The NGCC plant was analyzed without CO<sub>2</sub> capture from its flue gases. Additionally, economic sensitivity studies were developed for the six primary cases (each of the CO<sub>2</sub> capture options with and without replacement power) to highlight which parameters affected the COE to the greatest extent. A total of 66 economic evaluation cases are reported.

The model used to perform the economic evaluations was the proprietary ALSTOM Power Plant Laboratories' Project Economic Evaluation Pro-Forma. This cash flow model, developed by the Company's Project & Trade Finance group, has the capability to analyze the economic effects of different technologies based on differing capital costs, operating and maintenance costs, fuel costs, and cost of capital assumptions. Various categories of results are available from the model. In addition to cost of electricity, net present value, project internal rate of return, payback period, and other evaluation parameters are available.

In performing the economic evaluations, numerous assumptions were required. Table 6.0.1 lists the primary assumptions used in this analysis.

<b>-</b>								
Economic Assumptions			Financing Terms					
NPV Cash Discount Rate	percent	12.0	Equity	percent	50.0			
Depreciable Life	years	15	Debt	percent	50.0			
			Interest on Loan (APR)	percent	9.0			
Project Schedule			Term of Loan	years	15			
Project Start	date	9/1/01	Return on Equity	percent	12.0			
Construction Period	months	30						
Evaluation Period	years	15	Fuel Information					
			Coal Cost	\$/10 <sup>6</sup> Btu	1.32			
Variable Operating Costs	(Non-Fuel)		Natural Gas Cost	\$/10 <sup>6</sup> Btu	4.00			
Lime Cost (Delivered)	\$/Ton	60						
Ash Disposal Cost	\$/Ton	14						
			Plant Information					
Revenue Information			Capacity Factor	percent	67.0			
Electricity Price	\$/MWhr	32.00	Remaining Operating Life	years	20			
CO <sub>2</sub> Market Price	\$/Ton	0.0	Fixed O&M Costs	\$/kw	16.0			

Table 6.0.1:	<b>Economic Evaluation Study Assumptions</b>
--------------	----------------------------------------------

The following list defines additional assumptions used in all Replacement Power Cases.

- Power Generation Technology: Natural Gas fired Combined Cycle (NGCC) without CO<sub>2</sub> capture
- NGCC Net Plant Heat Rate (HHV basis): 6640 Btu/kWh (GTW, 1998-1999)
- NGCC Net Plant Efficiency (LHV basis): 57.1 percent
- NGCC Investment Cost; Engineered, Procured, Constructed basis (EPC): 450 \$/kW
- NGCC Fixed O&M Cost: 16.92 \$/kW-yr
- NGCC Variable O&M Cost: 0.01 Cents/kWh

As is evident from the above list, the NGCC replacement power calculations were identical for all cases with the only difference between cases being the scaling of various items required for the economic evaluation as a function of output requirement. In other words a "rubber NGCC" was assumed with performance, O&M costs, and specific investment costs assumed constant and not a function of output. This was done such that all economic differences between the cases would be completely attributable to the  $CO_2$  capture technology employed and not influenced by changes in NGCC specific costs, or performance, resulting from economy of scale.

The Economic Sensitivity Study was performed for each of six primary cases. The six primary cases include two cases each for Concepts A, B, and C (one case with and one case without replacement power). The sensitivity study shows the effect on incremental COE and on  $CO_2$  mitigation cost of variations in five parameters of interest.  $CO_2$  mitigation costs were calculated according to Equation (6.1) below. The five parameters varied in this study were investment cost (which included the new  $CO_2$  capture equipment, replacement power equipment, and the book value of the existing plant), coal cost, natural gas cost, capacity factor, and  $CO_2$  byproduct sell price. Eleven evaluations were done for each of the six cases providing a total of 66 economic evaluations from the overall sensitivity study. Table 6.0.2 shows the ranges for each of the five parameters varied in the sensitivity study. Three points were calculated for each parameter (Base Value, Minimum, and Maximum).

$$Mitigation \ Cost = (COE_{Cp} - COE_{Ref}) / (CO_{2 \ Ref} - CO_{2 \ Cp})$$
(6.1)

Where:

Mitigation Cost = \$/Ton of CO<sub>2</sub> Avoided COE = Cost of Electricity (\$/kWh) CO<sub>2</sub> = Carbon Dioxide Emitted (Ton/kWh) Cp = Capture Plant Ref = Reference Plant

Parameter	Units	Base Value	Minimum	Maximum
Investment Cost	\$	as estimated	Base - 25%	Base + 25%
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	3.00	5.00
Capacity Factor	Fraction	0.67	0.60	0.75
CO <sub>2</sub> Byproduct Sell Price	\$/ton	0.00	10.00	20.00

 Table 6.0.2:
 Economic Sensitivity Study Parameters

# 6.1 Concept A Results: CO<sub>2</sub> Separation with Monoethanolamine (MEA) Absorption

This section shows the economic analysis results for Concept A,  $CO_2$  separation with Monoethanolamine Absorption. Results both with and without replacement power are reported including sensitivity results.

#### 6.1.1 Concept A Results without Replacement Power

Figure 6.1.1 shows the economic analysis results using the base parameter values for Concept A (MEA) as compared with the Base Case (air fired without  $CO_2$  capture). This analysis was done without replacement power. The first year incremental cost of electricity for this case was about 6.17 Cents/kWh greater than the Base Case COE.

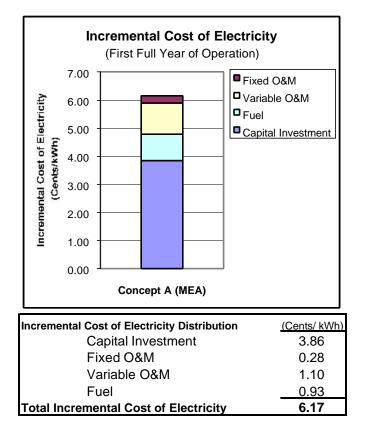


Figure 6.1. 1: Concept A (MEA) Economic Results without Replacement Power

Results for the Concept A sensitivity study, without replacement power, are shown in Table 6.1.1 and Figure 6.1.2. This table and the associated figure show the sensitivity of incremental COE to coal cost, natural gas cost, capacity factor,  $CO_2$  byproduct sell price, and new equipment installed capital cost. Results for the Base parameter values (i.e., Coal Cost =  $1.32 \ \text{s}/10^6$  Btu, Natural Gas Cost =  $4.0 \ \text{s}/10^6$  Btu, Capacity Factor = 67%,  $CO_2$  Byproduct Sell Price =  $0.0 \ \text{s}/\text{Ton}$ , Investment Cost = As Estimated) are shown above in Figure 6.1.1. The base parameter values also represent the point in Figure 6.1.2 where all the sensitivity curves intersect (point 0.0, 0.0). Incremental COE ranges from a low of 2.90 to a high of 7.25 cents/kWh. The most sensitive parameters are  $CO_2$  byproduct sell price, capital cost and capacity factor, in that order, with coal cost and natural gas cost showing significantly less impact on incremental COE.  $CO_2$  mitigation costs ranged from 31-73 \$/Ton of  $CO_2$  avoided with the baseline value at 66 \$/Ton of  $CO_2$  avoided.

### Table 6.1.1: Economic Sensitivity Results for Concept A without Replacement Power

Parameter	Unit		CO2 Capture with MEA, Without Replacement Power									
Power Output												
Net Power Output	kW	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414
Replacement Power	kW	0	0	0	0	0	0	0	0	0	0	0
Total Power Output	kW	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414
Plant Performance												
Net Plant heat Rate	Btu/kWh	16.626	16.626	16.626	16.626	16.626	16.626	16.626	16.626	16.626	16.626	16.626
Net Plant Efficiencv	Fraction	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053	0.2053
CO2 Emitted	lbm/h	33084	33084	33084	33084	33084	33084	33084	33084	33084	33084	33084
CO2 Emitted	lbm/kWh	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130		
Total Capital Cost	\$ (1000's)	495881	495881	495881	495881	495881	495881	495881	495881	495881	371911	619851
Capital Cost	\$/kW	1941	1941	1941	1941	1941	1941	1941	1941	1941	1456	2427
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	6.17	5.96	6.36	6.17	6.18	6.66	5.73	4.54	2.90	5.10	7.25
CO2 Mitigation Cost	\$/ton	66	64	68	66	66	71	61	49	31	51	73

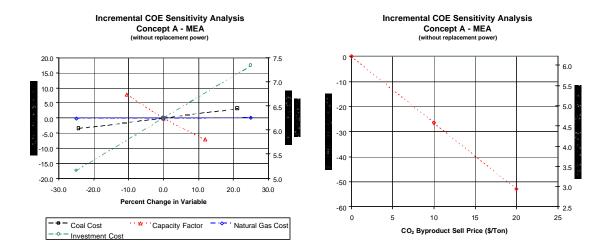


Figure 6.1. 2: Concept A (MEA) Economic Sensitivity Results without Replacement Power

## 6.1.2 Concept A Results with Replacement Power

Figure 6.1.3 shows the economic analysis results using the base parameter values for Concept A (MEA) with replacement power as compared with the Base Case. The first year incremental cost of electricity for this case was about 4.25 Cents/kWh greater than the Base Case COE.

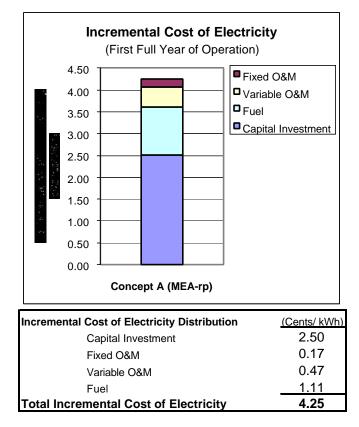


Figure 6.1. 3: Concept A (MEA) Economic Results with Replacement Power

Results for the Concept A sensitivity study, with replacement power, are shown in Table 6.1.2 and Figure 6.1.4. Incremental COE ranges from a low of 2.33 to a high of 4.99 cents/kWh. The most sensitive parameters again are  $CO_2$  byproduct sell price, investment cost and capacity factor, in that order. Natural gas cost shows significantly more impact on incremental COE when replacement power is included as would be expected with the NGCC being used to generate the replacement power. Coal cost, on the other hand, has no impact on incremental COE with replacement power since both the Base Case and Concept A use the same amount of coal and the net electrical output is also the same.  $CO_2$  mitigation costs ranged from 29-73 \$/Ton of  $CO_2$  avoided with the baseline value at 53 \$/Ton of  $CO_2$  avoided.

Parameter	Unit				CO 2 Ca	apture with MI	EA, Including	Replacement	Power			
Power Output												
Net Power Output	kW	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414	255414
Replacement Power	kW	178363	178363	178363	178363	178363	178363	178363	178363	178363	178363	178363
Total Power Output	kW	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778
Plant Performance												
Net Plant heat Rate	Btu/kWh	12.520	12.520	12.520	12.520	12.520	12.520	12.520	12.520	12.520	12.520	12.520
Net Plant Efficiency	%	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726	0.2726
CO2 Emitted	lbm/h	169053	169053	169053	169053	169053	169053	169053	169053	169053	169053	169053
CO2 Emitted	lbm/kWh	0.390	0.390	0.390	0.390	0.390	0.390	0.390	0.390	0.390	0.390	0.390
Total Capital Cost	\$ (1000's)	576144	576144	576144	576144	576144	576144	576144	576144	576144	432108	720180
Capital Cost	\$/kW	1328	1328	1328	1328	1328	1328	1328	1328	1328	996	1660
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	4.25	4.25	4.25	3.97	4.53	4.56	3.97	3.29	2.33	3.52	4.99
CO2 Mitigation Cost	\$/ton	53	53	53	49	56	57	49	41	29	44	62

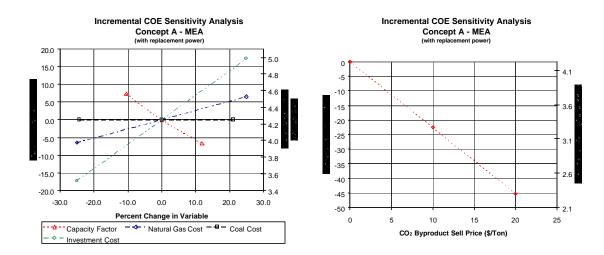


Figure 6.1. 4: Concept A (MEA) Economic Sensitivity Results with Replacement Power

# 6.2 Concept B Results: CO<sub>2</sub> Separation with Oxygen Firing and Flue Gas Re-circulation

This section shows the economic analysis results for Concept B, CO<sub>2</sub> Separation with Oxygen Firing and Flue Gas Re-circulation. Results both with and without replacement power are also reported along with sensitivity results.

6.2.1 Concept B Results without Replacement Power

Figure 6.2.1 shows the economic analysis results using the base parameter values for Concept B (Oxygen Fired) as compared with the Base Case (air fired without  $CO_2$  capture). This analysis was done without replacement power. The first year incremental cost of electricity for this case was about 4.45 Cents/kWh greater than the Base Case COE.

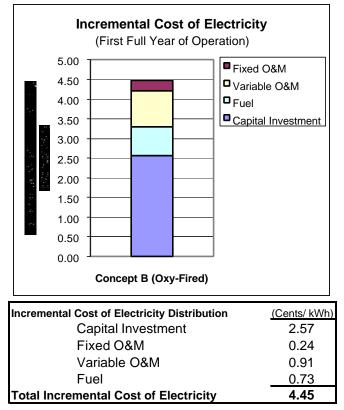


Figure 6.2. 1: Concept B (Oxygen Fired) Economic Results without Replacement Power

Results for the Concept B sensitivity study, without replacement power, are shown in Table 6.2.1 and Figure 6.2.2. Incremental COE ranges from a low of 1.53 to a high of 5.20 cents/kWh. The most sensitive parameters are, again,  $CO_2$  byproduct sell price, investment cost and capacity factor, in that order, with coal cost and natural gas cost showing significantly less impact on incremental COE.  $CO_2$  mitigation costs ranged from 17-58 \$/Ton of  $CO_2$  avoided with the baseline value at 49 \$/Ton of  $CO_2$  avoided.

Parameter	Unit				CO <sub>2</sub> Cap	oture with O2	Firing, Withou	ut Replaceme	nt Power			
Power Output												
Net Power Output	kW	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347
Replacement Power	kW	0	0	0	0	0	0	0	0	0	0	0
Total Power Output	kW	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347
Plant Performance												
Net Plant heat Rate	Btu/kWh	15.188	15.188	15.188	15.188	15.188	15.188	15.188	15.188	15.188	15.188	15.188
Net Plant Efficiencv	Fraction	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247	0.2247
CO2 Emitted	lbm/h	53016	53016	53016	53016	53016	53016	53016	53016	53016	53016	53016
CO2 Emitted	lbm/kWh	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194
Total Capital Cost	\$ (1000's)	371661	371661	371661	371661	371661	371661	371661	371661	371661	278746	464576
Capital Cost	\$/kW	1360	1360	1360	1360	1360	1360	1360	1360	1360	1020	1700
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	4.45	4.27	4.60	4.44	4.45	4.77	4.15	2.99	1.53	3.69	5.20
CO2 Mitigation Cost	\$/ton	49	47	51	49	49	53	46	33	17	41	58

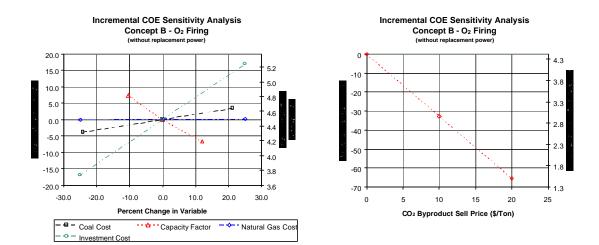


Figure 6.2. 2: Concept B (Oxygen Firing) Economic Sensitivity Results without Replacement Power

## 6.2.2 Concept B Results with Replacement Power

Figure 6.2.3 shows the economic analysis results using the base parameter values for Concept B (Oxygen Firing) with replacement power as compared with the Base Case. The first year incremental cost of electricity for this case was about 3.35 Cents/kWh greater than the Base Case COE.

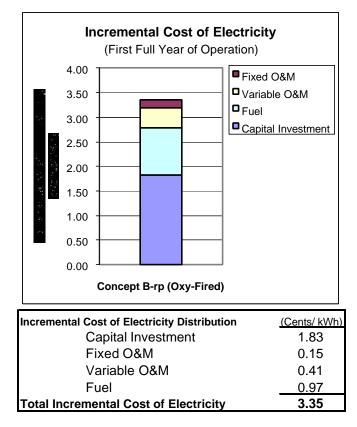


Figure 6.2. 3: Concept B (Oxygen Firing) Economic Results with Replacement Power

Results for the Concept B sensitivity study, with replacement power, are shown in Table 6.2.2 and Figure 6.2.4. Incremental COE ranges from a low of 1.52 to a high of 3.92 cents/kWh. The most sensitive parameters, again, are  $CO_2$  byproduct sell price, investment cost and capacity factor, in that order. Natural gas cost shows significantly more impact on incremental COE when replacement power is included as would be expected with the NGCC being used to generate the replacement power. Coal cost, on the other hand, shows minimal impact on incremental COE with replacement power since both the Base Case and Case A use nearly the same amount of coal and the net electrical output is exactly the same.  $CO_2$  mitigation costs ranged from 19-49 \$/Ton of  $CO_2$  avoided with the baseline value at 42 \$/Ton of  $CO_2$  avoided.

# Table 6.2. 2: Economic Sensitivity Results for Concept B with Replacement Power

Parameter	Unit				CO 2 Cap	ture with O2 F	iring, Includir	g Replaceme	nt Power			
Power Output												
Net Power Output	kW	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347	273347
Replacement Power	kW	160430	160430	160430	160430	160430	160430	160430	160430	160430	160430	160430
Total Power Output	kW	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778
Plant Performance												
Net Plant heat Rate	Btu/kWh	12.026	12.026	12.026	12.026	12.026	12.026	12.026	12.026	12.026	12.026	12.026
Net Plant Efficiency	Fraction	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838	0.2838
CO2 Emitted	lbm/h	175315	175315	175315	175315	175315	175315	175315	175315	175315	175315	175315
CO2 Emitted	lbm/kWh	0.404	0.404	0.404	0.404	0.404	0.404	0.404	0.404	0.404	0.404	0.404
Total Capital Cost	\$ (1000's)	443855	443855	443855	443855	443855	443855	443855	443855	443855	332891	554818
Capital Cost	\$/kW	1023	1023	1023	1023	1023	1023	1023	1023	1023	767	1279
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	3.35	3.36	3.35	3.10	3.60	3.58	3.14	2.44	1.52	2.79	3.92
CO2 Mitigation Cost	\$/ton	42	42	42	39	45	45	39	31	19	35	49

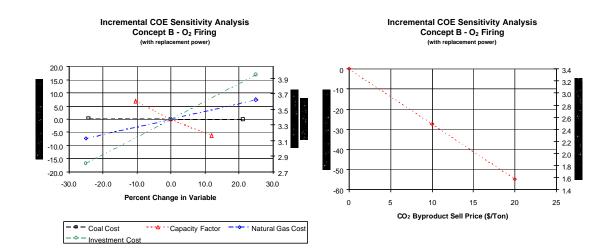


Figure 6.2. 4: Concept B (Oxygen Firing) Economic Sensitivity Results with Replacement Power

## 6.3 Concept C Results: CO<sub>2</sub> Separation with MEA / MDEA

This section shows the economic analysis results for Concept C, CO<sub>2</sub> Separation with MEA / MDEA absorption. Results both with and without replacement power are reported along with sensitivity results. 6.3.1 Concept C Results without Replacement Power

Figure 6.3.1 shows the economic results using the base parameter values for Concept C (MEA /MDEA) as compared with the Base Case (air fired without  $CO_2$  capture). This analysis was done without replacement power. The first

year incremental cost of electricity for this case was about 8.41 Cents/kWh greater than the Base Case COE.

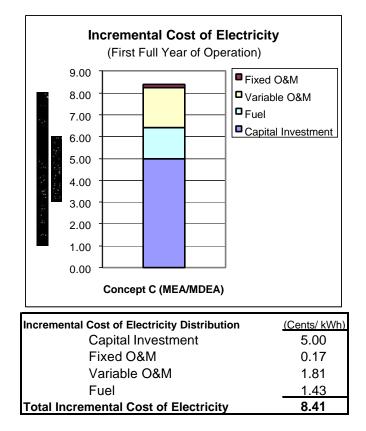


Figure 6.3. 1: Concept C (MEA/MDEA) Economic Results without Replacement Power

Results for the Concept C sensitivity study, without replacement power, are shown in Table 6.3.1 and Figure 6.3.2. Incremental COE ranges from a low of 5.93 to a high of 9.77 cents/kWh. The most sensitive parameters are  $CO_2$  byproduct sell price, investment cost and capacity factor with coal cost and natural gas cost showing significantly less impact on incremental COE.

CO<sub>2</sub> mitigation costs ranged from 69-113 \$/Ton of CO<sub>2</sub> avoided with the baseline value at 98 \$/Ton of CO<sub>2</sub> avoided.

# Table 6.3.1: Economic Sensitivity Results for Concept C without Replacement Power

Parameter	Unit				CO <sub>2</sub> Captu	re with MEA	MDEA, With	out Replacem	ent Power			
Power Output												
Net Power Output	kW	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973
Replacement Power	kW	0	0	0	0	0	0	0	0	0	0	(
Total Power Output	kW	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973
Plant Performance												
Net Plant heat Rate	Btu/kWh	15.223	15.223	15.223	15.223	15.223	15.223	15.223	15.223	15.223	15.223	15.223
Net Plant Efficiency	Fraction	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242	0.2242
CO2 Emitted	lbm/h	92153	92153	92153	92153	92153	92153	92153	92153	92153	92153	92153
CO2 Emitted	lbm/kWh	0.274	0.274	0.274	0.274	0.274	0.274	0.274	0.274	0.274	0.274	0.274
Total Capital Cost	\$ (1000's)	824797	824797	824797	824797	824797	824797	824797	824797	824797	618598	1030996
Capital Cost	\$/kW	2455	2455	2455	2455	2455	2455	2455	2455	2455	1841	3069
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	8.41	8.32	8.49	8.15	8.67	9.01	7.86	7.17	5.93	7.05	9.77
CO2 Mitigation Cost	\$/ton	98	97	99	95	101	105	91	83	69	82	113

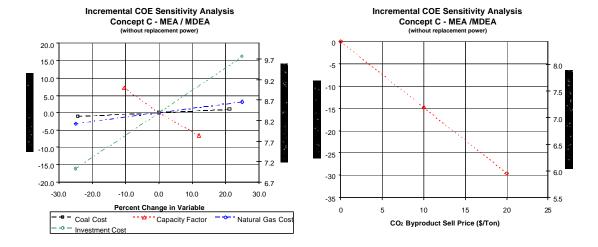


Figure 6.3. 2: Concept C (MEA/MDEA) Economic Sensitivity Results without Replacement Power

## 6.3.2 Concept C Results with Replacement Power

Figure 6.3.3 shows the economic analysis results using the base parameter values for Concept C (MEA / MDEA) with replacement power as compared with the Base Case. The first year incremental cost of electricity for this case was about 6.61 Cents/kWh greater than the Base Case COE.

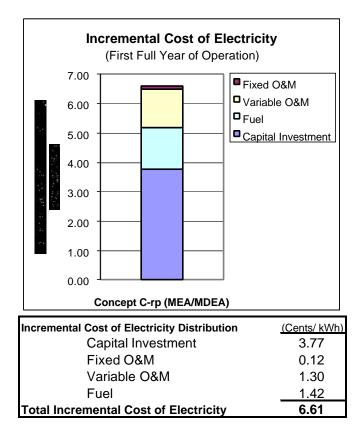
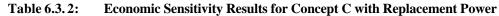


Figure 6.3. 3: Concept C (MEA/MDEA) Economic Results with Replacement Power

Results for the Concept C sensitivity study with replacement power are shown in Table 6.3.2 and Figure 6.3.4. Incremental COE ranges from a low of 4.69 to a high of 7.66 cents/kWh. The most sensitive parameters again are  $CO_2$  byproduct sell price, investment cost and capacity factor. Natural gas cost shows significantly more impact on incremental COE when replacement power is included as would be expected with the NGCC being used to generate the replacement power. Coal cost, on the other hand, shows minimal impact on incremental COE with replacement power since both the Base Case and Case A use the same amount of coal and the net electrical output is exactly the same.

CO<sub>2</sub> mitigation costs ranged from 58-95 \$/Ton of CO<sub>2</sub> avoided with the baseline value at 82 \$/Ton of CO<sub>2</sub> avoided.

1 abic 0a		LCOHOIL	ne bens	iti i ity i	courto i		cept C		placem	cht I Ut		
Parameter	Unit				CO <sub>2</sub> Captu	ure with MEA	/ MDEA, With	out Replacen	nent Power			
Power Output												
Net Power Output	kW	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973	335973
Replacement Power	kW	97805	97805	97805	97805	97805	97805	97805	97805	97805	97805	97805
Total Power Output	kW	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778	433778
Plant Performance												
Net Plant heat Rate	Btu/kWh	13.288	13.288	13.288	13.288	13.288	13.288	13.288	13.288	13.288	13.288	13.288
Net Plant Efficiencv	Fraction	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568	0.2568
CO2 Emitted	lbm/h	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546	166711.546
CO2 Emitted	lbm/kWh	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384
Total Capital Cost	\$ (1000's)	824797	824797	824797	824797	824797	824797	824797	824797	824797	618598	1030996
Capital Cost	\$/kW	1901	1901	1901	1901	1901	1901	1901	1901	1901	1426	2377
Economic Analysis Basis												
Capital Charge Rate	%	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302	0.1302
Fuel Cost (Coal)	\$/MMBtu	1.32	1.00	1.60	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Fuel Cost (Natural Gas)	\$/MMBtu	4.00	4.00	4.00	3.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00
Capacity Factor	Fraction	0.67	0.67	0.67	0.67	0.67	0.60	0.75	0.67	0.67	0.67	0.67
CO2 Price	\$/ton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	20.00	0.00	0.00
Economic Analysis Results												
coe: Incremental	cents/kWh	6.61	6.61	6.61	6.26	6.96	7.06	6.20	5.65	4.69	5.56	7.66
CO2 Mitigation Cost	\$/ton	82	82	82	78	86	88	77	70	58	69	95



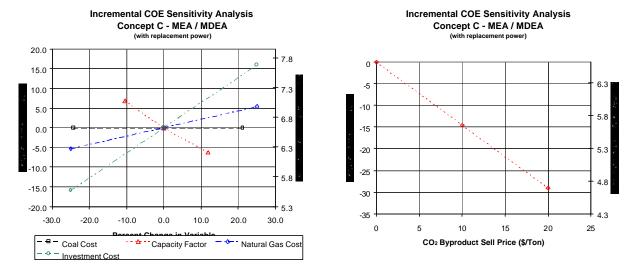


Figure 6.3. 4: Concept C (MEA/MDEA) Economic Sensitivity Results with Replacement Power

## 6.4 Economic Study Summary and Conclusions

A total of 66 CO<sub>2</sub> capture cases were compared in the reported sensitivity studies. All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base Case (air firing without CO<sub>2</sub> capture) ranges from 1.52 to 9.77 Cents/kWh. Similarly CO<sub>2</sub> mitigation costs range from about 17-113 \$/Ton of CO<sub>2</sub> avoided for the range of cases studied. Table 6.4.1 summarizes the economic analysis results for the six primary cases using base parameter values (i.e.; Coal Cost =  $1.32 \,$ \$/10<sup>6</sup> Btu, Natural Gas Cost =  $4.0 \,$ \$/10<sup>6</sup> Btu, Capacity Factor = 67%, CO<sub>2</sub> Byproduct Sell Price = 0.0 \$/Ton, Investment Cost = As Estimated). Figure 6.4.1 shows the incremental COE values for these cases and similarly, Figure 6.4.2 shows the associated CO<sub>2</sub> mitigation costs.

 Table 6.4.1:
 Summary of Economic Analysis Results (for 6 primary cases)

Parameter	Units	Concept A		Conc	ept B	Concept C		
		w/o Repl Pwr	with Repl Pwr	w/o Repl Pwr	with Repl Pwr	w/o Repl Pwr	with Repl Pwr	
Incremental COE	Cents/kWh	6.2	4.3	4.4	3.4	8.4	6.6	
CO2 Mitigation Cost	\$/Ton	68	53	49	42	98	82	

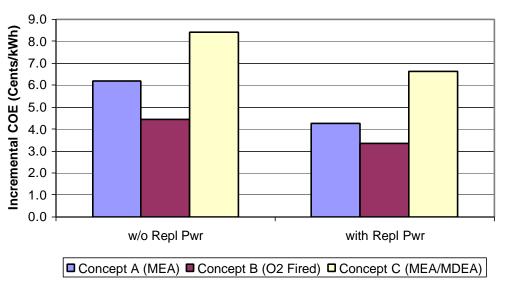


Figure 6.4. 1: Incremental Cost of Electricity (Using Base Parameter Values)

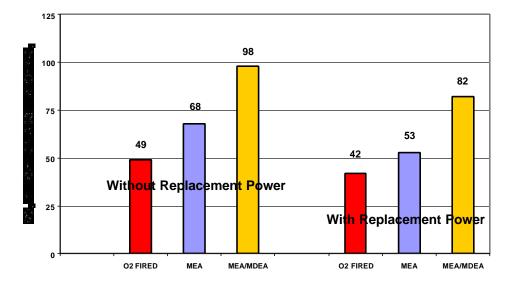


Figure 6.4. 2: Co<sub>2</sub> Mitigation Costs (Using Base Parameter Values)

Concept B (oxygen firing with flue gas recycle) appears to clearly be the best alternative of the three concepts studied based on incremental COE evaluation criteria. Using the base parameters of the sensitivity study for Concept B yields incremental COE values of 3.35 and 4.45 Cents/kWh for cases with and without replacement power, respectively. The actual COE values for Concept B are 20% and 13% lower than the corresponding values for Concept A and 47% and 51% lower than the corresponding values for Concept C for cases with and without replacement power respectively. If  $CO_2$  byproduct can be sold at \$20/ton, incremental COE values are reduced to 1.53 and 1.52 Cents/kWh, respectively. Additional reductions would be possible with capacity factor increases, investment cost decreases or system efficiency increases. Significant investment cost decreases and efficiency increases may be possible as oxygen transport membrane technology develops. Previous internal studies (Liljedahl, et al., 1999) have shown membrane technology to provide specific investment cost (\$/kW) reductions of about 30% and net plant heat rate improvements greater than 20%.

Barring governmental mandates, it is clear that none of these three retrofit concepts will be acceptable to the electric utility industry from the standpoint of cost competitiveness.

# 7.0 COMPARISONS WITH PRIOR WORK

This section provides a comparison of the basic performance,  $CO_2$  emissions, investment costs, and cost of electricity results of this study with selected results from the literature (David and Herzog, 2000; Palkes, et al., 1999; and Liljedahl, et al., 1999). Table 7.0.1 summarizes the pertinent technical results determined in this study (Marion, et al., 2001; Griffin, et al., 2001; and Liljedahl, et al., 2001).

Figures 7.0.1 and 7.0.2 compare net plant heat rates and  $CO_2$  emissions for this study with selected results from the literature (David and Herzog, 2000; Palkes, et al., 1999; and Liljedahl, et al., 1999). This study shows a significantly greater impact on net plant heat rate, for the MEA process, than David and Herzog show. David and Herzog show about a 33% increase in net plant heat rate (e.g. 8,277 vs. 11,037 Btu/kWh; LHV basis) corresponding to an energy penalty of about 25%. This study shows about a 70% increase in net plant heat rate for the MEA system (e.g. 9,309 vs. 15,872 Btu/kWh; LHV basis) corresponding to an energy penalty of about 41%. A partial explanation for this difference can be seen in Figure 7.0.2, which shows specific  $CO_2$  emissions. The present work shows significantly higher  $CO_2$  removal (e.g., 0.906 to 0.059 kg/kWh) than David and Herzog show (e.g. 0.789 to 0.105 kg/kWh). Using the  $CO_2$  emission and heat rate values from these figures, it can be determined that the  $CO_2$  captured for the David and Herzog study is about 23% more  $CO_2$  per unit of original net electrical output). Additionally, this study produced a liquid  $CO_2$  product stream at 2000 psig with product purity meeting the Dakota Gasification Project specification for EOR (Dakota Gasification WebPages). The David and Herzog product stream was reported at 1470 psia and the details regarding purity are not given although purity is probably similar in both cases. Both these differences would help explain at least partially, the efficiency penalty deviation between the two studies.

	(units)	Original Plant (Base)	Concept A MEA	Concept B O2 Fired	Concept C MEA-MDEA
Fuel Paramaters	e				
Coal Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4228.7	4140.0	4228.7
Natural Gas Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)		17.7	11.4	885.9
Total Fuel Heat Input (HHV)	(10 <sup>6</sup> Btu/hr)	4228.7	4246.4	4151.5	5114.6
Steam Cycle Paramaters					
Existing Steam Turbine Generator Output	(kW)	463478	269341	463056	357196
CO2 Removal System Turbine Generator Output	(kW)	0	62081	0	36343
Total Turbine Generator Output	(kW)	463478	331422	463056	431290
Total Auxiliary Power	(kW)	29700	76007	189709	95317
Net Plant Output	(kW)	433778	255414	273347	335973
Overall Plant Performance Paramaters					
Net Plant Efficiency (HHV)	(fraction)	0.3501	0.2053	0.2247	0.2242
Net Plant Efficiency (LHV)	(fraction)	0.3666	0.2150	0.2354	0.2371
Normalized Efficiency (HHV; Relative to Base Case)	(fraction)	1.0000	0.5864	0.6419	0.6404
Net Plant Heat Rate (HHV)	(Btu/kwhr)	9749	16626	15188	15223
Net Plant Heat Rate (LHV)	(Btu/kwhr)	9309	15872	14500	14395
Overall Plant CO <sub>2</sub> Emissions					
Carbon Dioxide Emissions	(lbm/hr)	866102	33084	53016	92153
Specific Carbon Dioxide Emissions	(lbm/kwhr)	1.997	0.130	0.194	0.274
Normalized Specific CO2 Emissions (Relative to Base Case)	(fraction)	1.000	0.065	0.097	0.137
Avoided Carbon Dioxide Emissions (as compared to Base)	(lbm/kwhr)		1.867	1.803	1.722
Specific Carbon Dioxide Emissions	(kg/kwhr)	0.906	0.059	0.088	0.125
Avoided Carbon Dioxide Emissions (as compared to Base)	(kg/kwhr)		0.848	0.818	0.782

## Table 7.0.1: Summary of Performance for Original Plant and CO<sub>2</sub> Capture Study Cases

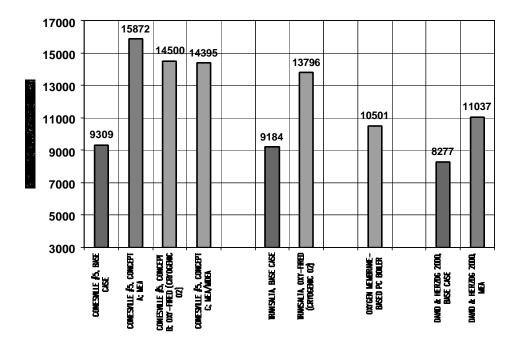


Figure 7.0. 1: Comparative Net Plant Heat Rate Results for Coal Fired Power Plants

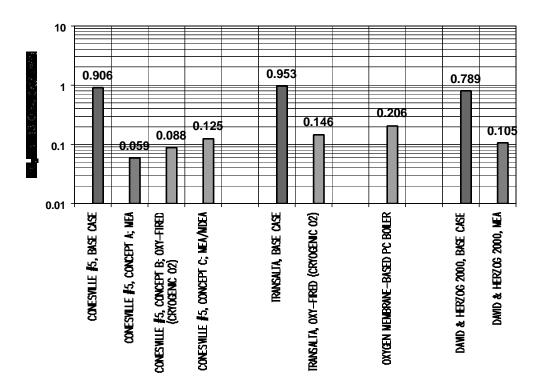


Figure 7.0. 2: Comparative CO<sub>2</sub> Emissions for Coal Fired Power Plants

Investment costs are also significantly different between the studies. David and Herzog (2000) show the cost of the  $CO_2$  processing plant to be about 529 \$/kg/hr of  $CO_2$ . This study shows 1,037 \$/kg/hr of  $CO_2$  for this equipment. The differences in the  $CO_2$  product conditions and purity, discussed above, may represent part of this deviation. Additionally, for this retrofit study, the steam extracted from the existing steam turbine at the IP/LP crossover pipe had to be further expanded in a new letdown turbine before being exhausted to the reboilers for solvent regeneration. The David and Herzog study was for a new plant and therefore may not have required this letdown turbine/generator and the investment cost associated with it. Not enough information is given in their paper to determine if a letdown turbine is used in their particular system. Other savings may also possible for a new plant designed specifically for  $CO_2$  removal. The steam turbine and generator may be significantly less expensive than for a reference plant designed for the same steam flow as a result of the large quantity of extracted low-pressure steam. The low-pressure feedwater heaters and condenser would also be significantly smaller and less expensive. David and Herzog show the incremental capital cost for a new plant, as compared to the reference plant without  $CO_2$  capture, to be about 940 \$/kW as compared to this study, for a retrofit situation, which shows about 1,600 \$/kW.

Ultimately David and Herzog show the incremental cost of electricity to be about 3.3 Cents/kWh as compared to Concept A (MEA) of this study, which shows about 6.2 Cents/kWh. Financial assumptions, while probably not identical for both cases, would likely not cause a large impact on this difference.

With respect to oxy-fuel firing (Palkes, et al., 1999; Liljedahl, et al., 1999), it is seen that producing the oxygen in a ceramic membrane system leads to an improvement in net plant heat rate of more than 20% over the cases whereby the cryogenic method is used to produce oxygen (e.g., 10,501 vs. 13,796 Btu/kWh).  $CO_2$  emissions are somewhat higher with the membrane system (e.g. 0.206 vs. 0.146 kg/kWh) due to natural gas firing in the membrane system air heater. Investment costs were shown to be more than 30% lower. Cost of electricity was not reported in this study.

# 8.0 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

## **Conclusions:**

No major technical barriers exist for retrofitting AEP's Conesville Unit #5 to capture  $CO_2$  for any of the three concepts considered under this study. Nominally, 5-8 acres of new equipment space is needed and is located approximately 1500 feet north of the Unit #5 stack on the existing 200-acre power plant site which accommodates a total of 6 units. If all 6 units on this site were converted to  $CO_2$  capture, it would be difficult if not impossible to accommodate all the new  $CO_2$  capture equipment on the existing site. Energy requirements and power consumption are high, resulting in significant decrease in overall power plant efficiencies, ranging from about 20.5 to 23% as compared to 35% (all HHV basis) for the Base Case. Specific carbon dioxide emissions were reduced from about 2 lbm/kWh for the Base Case to 0.12 - 0.26 lbm/kWh for the study cases. Recovery of  $CO_2$  ranged from 91 to 96%.

Specific investment costs are also high ranging from about 1000 to 2200 k without replacement power, and from about 800 to 1800 k with replacement power. All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base case (air firing without CO<sub>2</sub> capture) ranges from 3.4 to 8.4 k wh. Similarly CO<sub>2</sub> mitigation costs range from about 42-98 t of CO<sub>2</sub> avoided for the range of cases studied.

Concept B (oxygen firing with flue gas recycle) appears to clearly be the best alternative of the three concepts studied from both an efficiency and incremental COE viewpoint for systems designed for very high CO<sub>2</sub> capture (i.e. > 90%). If lower CO<sub>2</sub> capture fractions are considered, it appears that Concept A would likely be the best alternative with capture fractions below some as yet undetermined value. Concept C would also improve considerably with lower capture fractions. This study has confirmed two important issues related to firing coal in a CO<sub>2</sub> -rich flue gas /O<sub>2</sub> mixture:

- Modifications to the existing steam generator unit pressure parts are not required, and as such will also allow the unit to continue to operate in the conventional air fired mode. This is an important consideration as it is unlikely that much new coal-fired capacity can be built in the short term.
- CO<sub>2</sub>-rich flue gas can be cleaned and compressed with a relatively simple system to provide high purity CO<sub>2</sub> for usage or sequestration.

While overall plant performance penalty and investment costs are high, an optimum integration of power generation, air separation, and  $CO_2$  separation and compression systems may significantly improve the overall system efficiency and economics. The major cost item for Concept B is the air separation plant, both from a capital and an operating cost point of view. While in recent years advances have been made in air separation technology which have steadily improved the costs, new membrane based technologies are being researched which promise to provide greatly reduced auxiliary power requirements and investment costs which will significantly improve the overall system efficiency and economics. Previous studies (Liljedahl, et al., 1999) have shown membrane technology, applied to coal-fired boilers, to provide specific investment cost (k/kW) reductions of about 30% and net plant heat rate improvements greater than 20% as compared to cryogenic based air separation.

## **Recommendations for Future Work:**

- A sensitivity study, for Concepts A and C, showing the impact of reducing CO<sub>2</sub> capture percentage on plant efficiency, investment cost, emissions, and cost of electricity. The current work utilized 90% CO<sub>2</sub> capture (nominal). The sensitivity study would investigate nominal CO<sub>2</sub> capture percentages of 70% and 50%.
- Detailed analysis of the existing steam turbine for Concept A: In Concept A about 79% of the steam leaving the intermediate-pressure (IP) turbine is extracted from the IP/LP crossover pipe for solvent regeneration. The capability of the existing low-pressure (LP) turbine to operate under these conditions of very low steam flow should be investigated in detail, preferably by the original equipment manufacturer (OEM).

- Optimization of the amine system reboiler steam pressure for Concepts A and C.
- Concept B detailed boiler system analysis: A startup/shutdown procedure and system design, particularly the transition from air to oxygen firing (including transient conditions) should be developed. Detailed metal temperature analysis for all heat exchanger sections, including operation at part loads should be analyzed. This should also include furnace wall metal temperatures and analysis of the circulation system. The existing fans should be checked (preferably by the OEM's) for operation under the new conditions. The feasibility of operating the boiler under a slight positive pressure to eliminate air infiltration should also be investigated.
- Investigation of Improved oxygen production systems for Concept B, in line with the membrane-based air separation research being conducted by various research groups (e.g., Praxair, Air Products, Norsk Hydro). Also optimization of an integrated boiler and oxygen production system.
- Measurement of furnace heat transfer in  $CO_2/O_2$  environments in a proof of concept boiler simulation facility.
- Improved solvents, which require lower regeneration energy requirements and/or can be regenerated at a lower temperature level.
- Hybrid process using oxygen-enriched combustion and amine based CO<sub>2</sub> absorption, to accrue, simultaneously, both CO<sub>2</sub> capture and drastic NOx emissions reduction.
- Investigation of a new novel high risk CO<sub>2</sub> capture process that would reduce efficiency penalty and retrofit investment cost. This would likely not utilize the existing boiler.

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## APPENDIX I - DRAWINGS

This appendix contains all drawings developed for this project for Concepts A, B, and C and also includes a plot plan of the existing site.

## **Existing Plant:**

66-530.00 Plot Plan – Existing Overall Site before CO<sub>2</sub> Unit Addition

## Concept A:

U01-D-0208Plot Plan – Concept A: Flue Gas Cooling & CO2 AbsorptionU01-D-0214Plot Plan – Concept A: Solvent StrippingU01-D-0204Plot Plan – Concept A: CO2 Compression & LiquefactionU01-D-0211Plot Plan – Concept A: Overall Layout Conceptual PlanU01-D-0200RPlot Plan – Concept A: Modified Overall Site Plan

## Concept B:

U01-D-0203 Plot Plan – Concept B: Air Separation Plants
U01-D-0209 Plot Plan – Concept B: Flue Gas Cooling
U01-D-0205 Plot Plan – Concept B: CO<sub>2</sub> Compression & Liquefaction
U01-D-0212 Plot Plan – Concept B: Overall Layout Conceptual Plan
U01-D-0201R Plot Plan – Concept B: Modified Overall Site Plan

#### **Boiler Modifications:**

U00-E-0551R General Arrangement - Side Elevation for Concept B U00-E-0552R General Arrangement - Plan View "B-B" for Concept B U00-E-0585R General Arrangement - Plan View "A-A" for Concept B

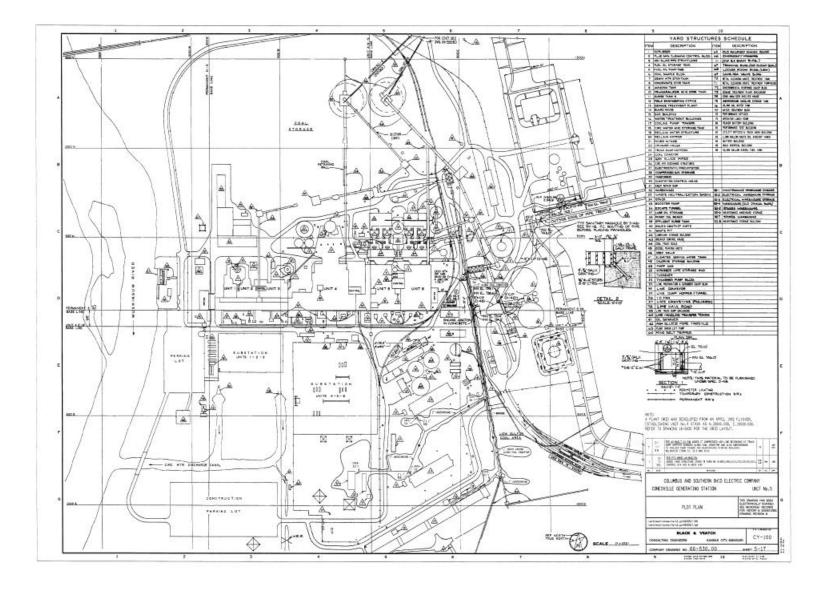
## Concept C:

U01-D-0207 Plot Plan – Concept C: De-Oxy Catalyst & Cooling
U01-D-0210 Plot Plan – Concept C: Flue Gas Cooling & CO<sub>2</sub> Absorption
U01-D-0215 Plot Plan – Concept C: Solvent Stripping
U01-D-0206 Plot Plan – Concept C: CO<sub>2</sub> Compression & Liquefaction
U01-D-0213 Plot Plan – Concept C: Overall Layout Conceptual Plan
U01-D-0202R Plot Plan – Concept C: Modified Overall Site Plan

# **Existing Plant:**

The existing plant site drawing is shown below:

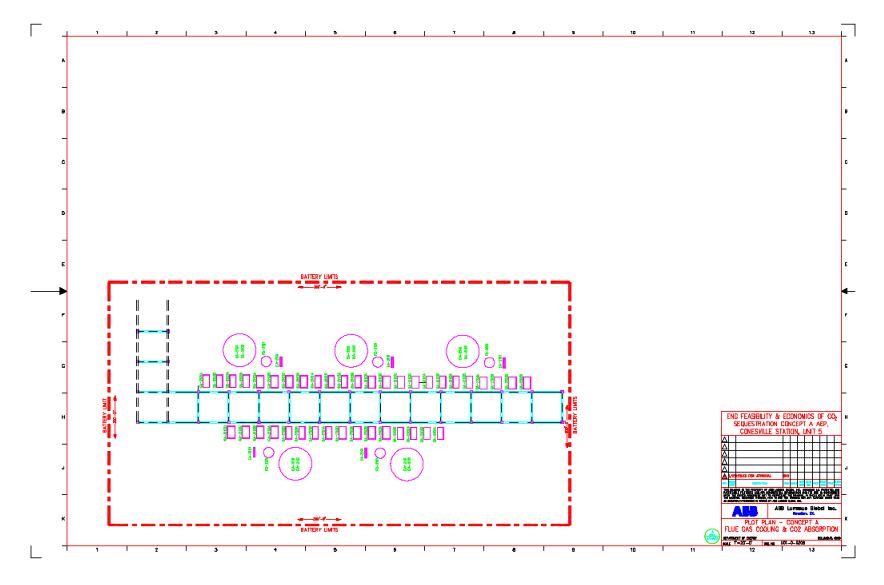
66-530.00 Plot Plan – Existing Overall Site before  $CO_2$  Unit Addition

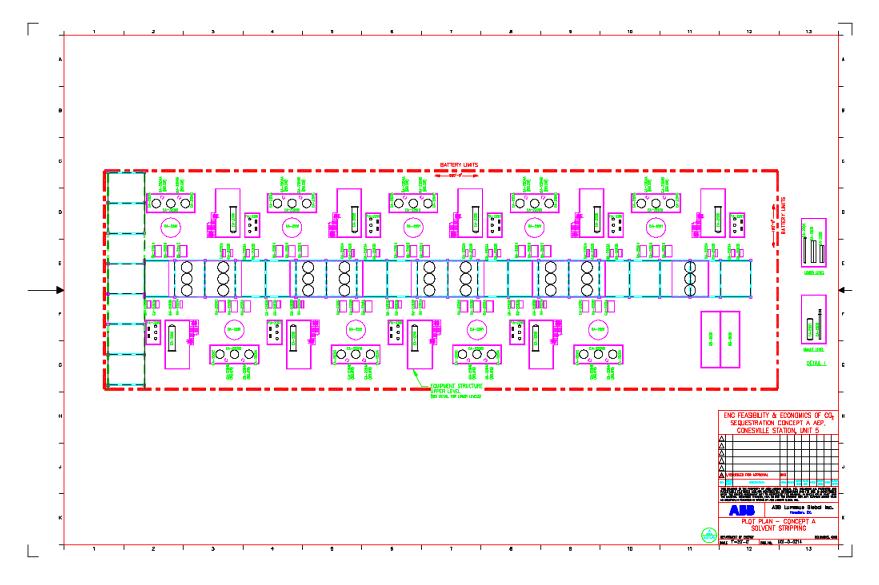


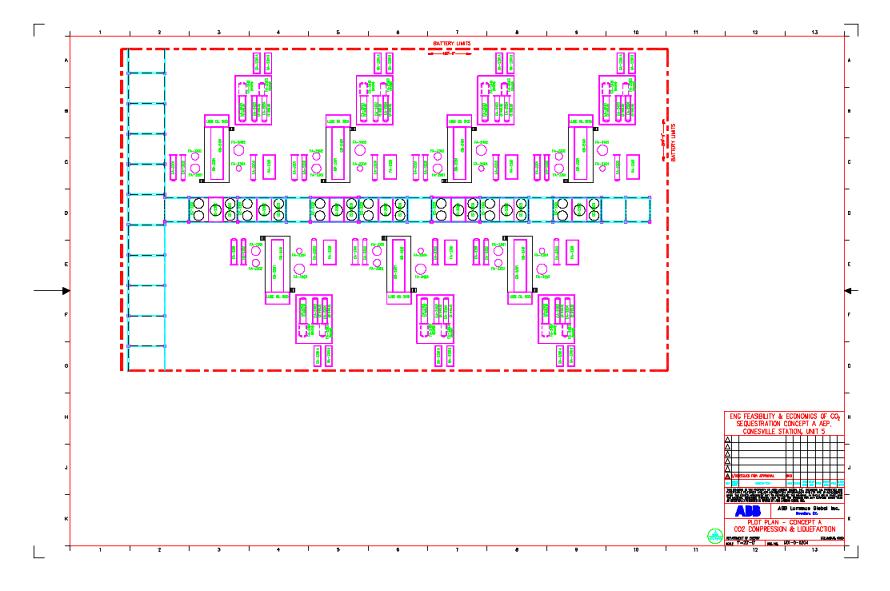
# Concept A:

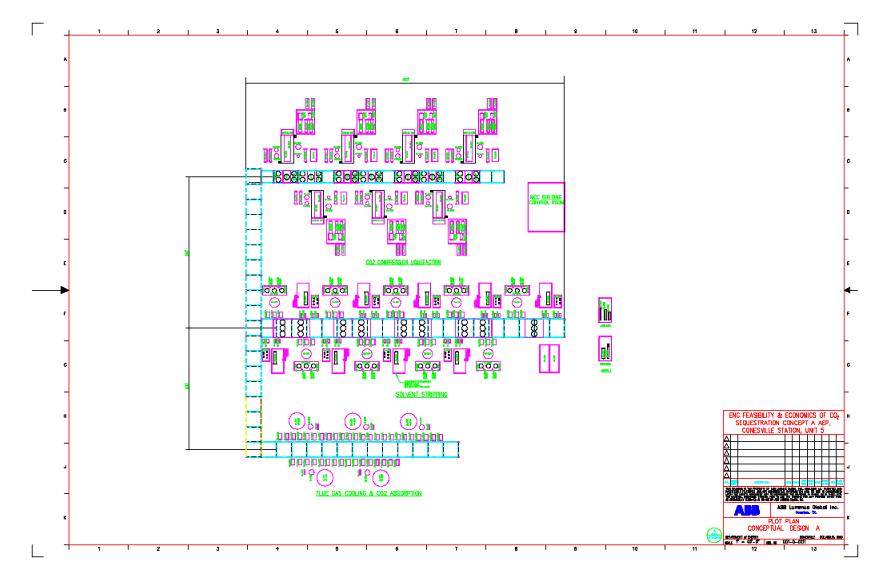
The plant layout drawings prepared for the Concept A CO<sub>2</sub> Recovery System are as follows:

U01-D-0208 Plot Plan – Concept A: Flue Gas Cooling & CO<sub>2</sub> Absorption U01-D-0214 Plot Plan – Concept A: Solvent Stripping U01-D-0204 Plot Plan – Concept A: CO<sub>2</sub> Compression & Liquefaction U01-D-0211 Plot Plan – Concept A: Overall Layout Conceptual Plan U01-D-0200 Plot Plan – Concept A: Modified Overall Site Plan

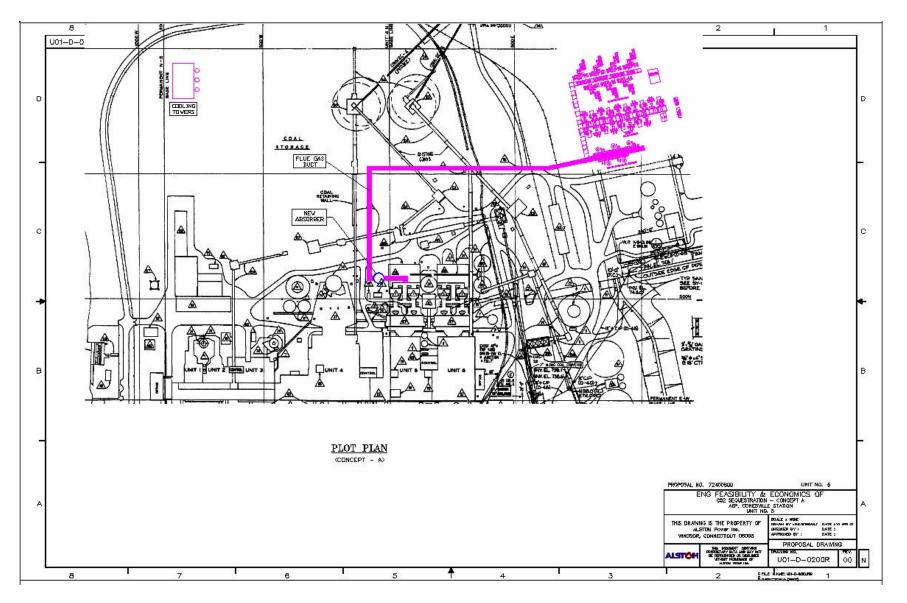








# VOLUME I. AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5 $\rm CO_2$ CAPTURE RETROFIT STUDY



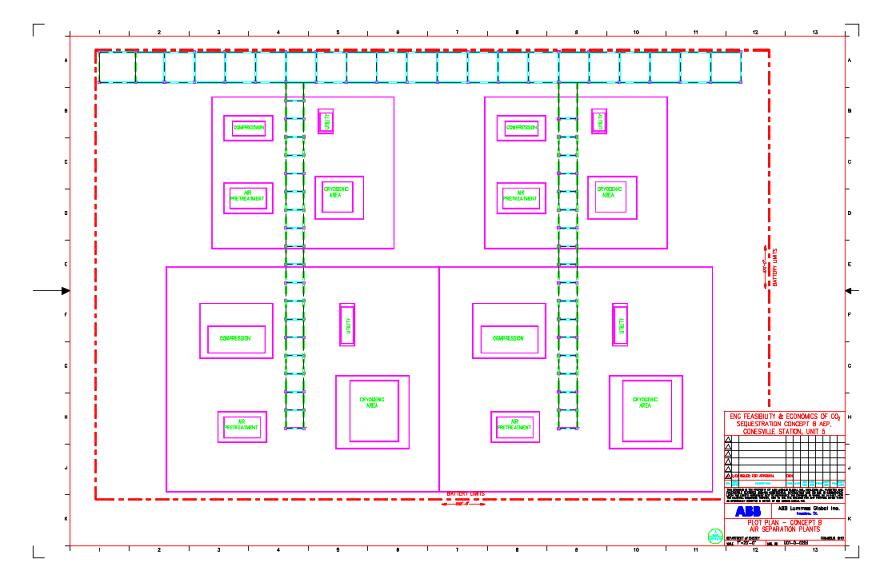
# Concept B:

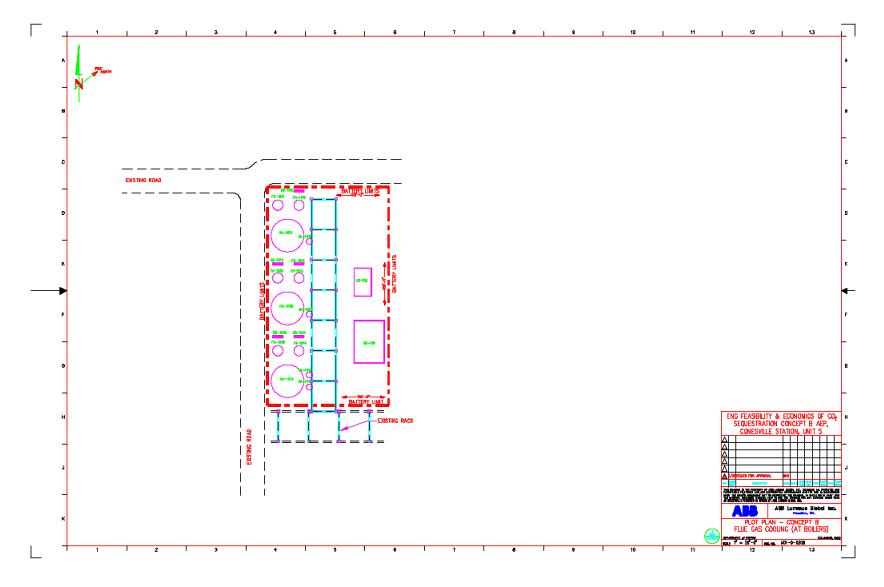
The plant layout drawings prepared for the Concept B Air Separation Unit & CO<sub>2</sub> Recovery System are as follows:

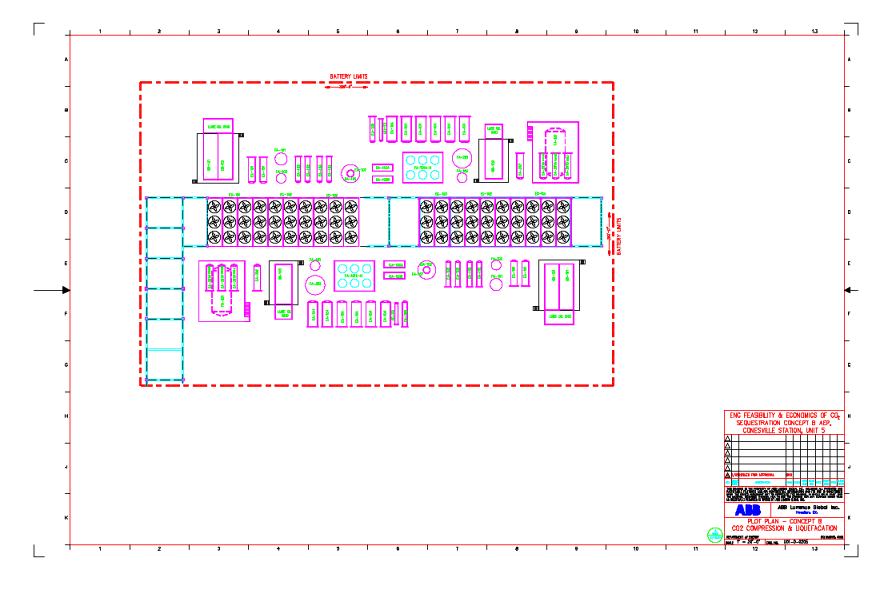
U01-D-0203 Plot Plan – Concept B: Air Separation Plants U01-D-0209 Plot Plan – Concept B: Flue Gas Cooling U01-D-0205 Plot Plan – Concept B: CO<sub>2</sub> Compression & Liquefaction U01-D-0212 Plot Plan – Concept B: Overall Layout Conceptual Plan U01-D-0201 Plot Plan – Concept B: Modified Overall Site Plan

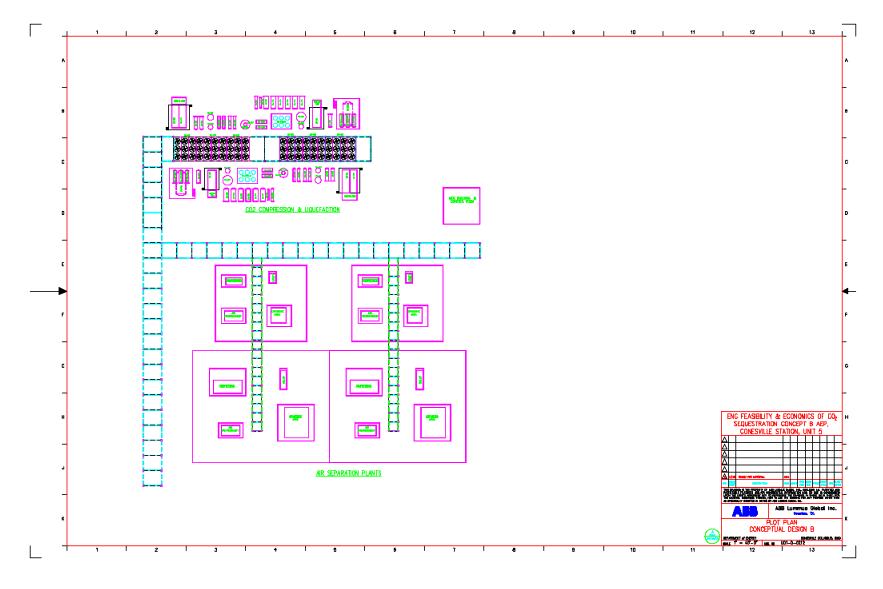
The boiler modification drawings prepared for the Concept B are as follows:

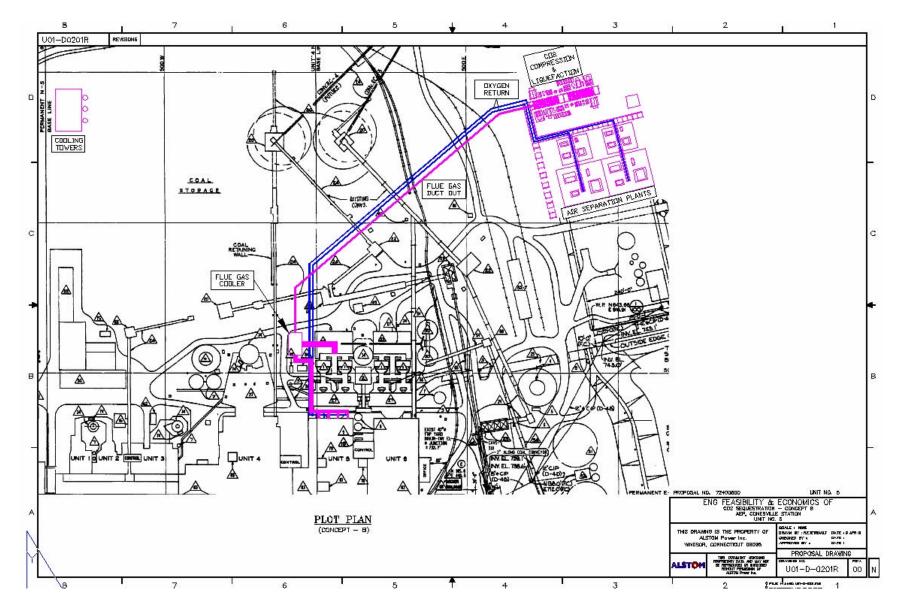
U00-E-0551- General Arrangement - Side Elevation for "Concept B" U00-E-0552 - General Arrangement - Plan View "B-B" for "Concept B" U00-E-0585 - General Arrangement - Plan View "A-A" for "Concept

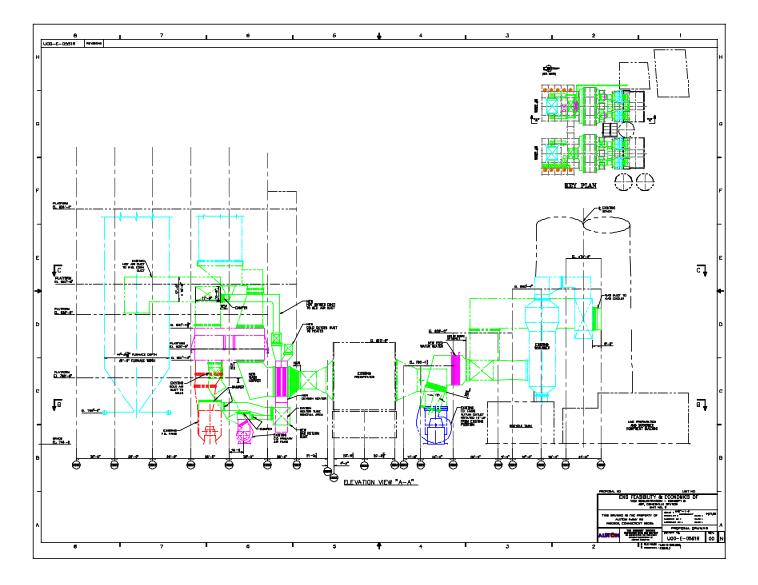


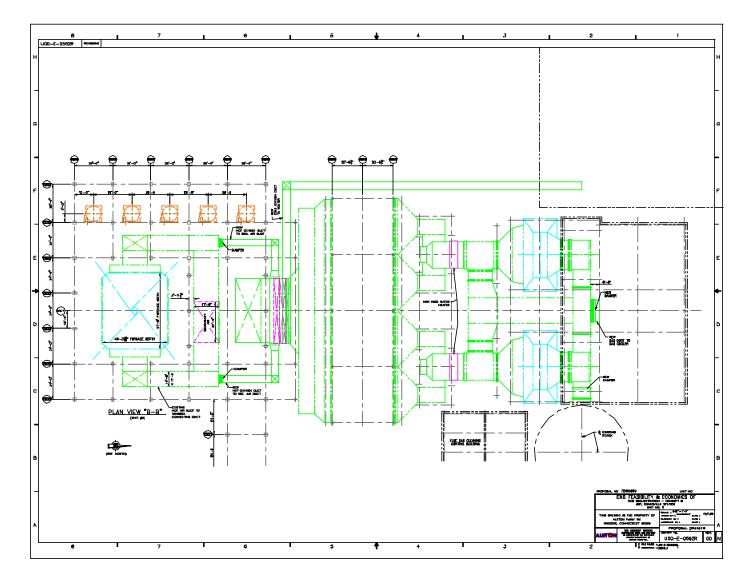


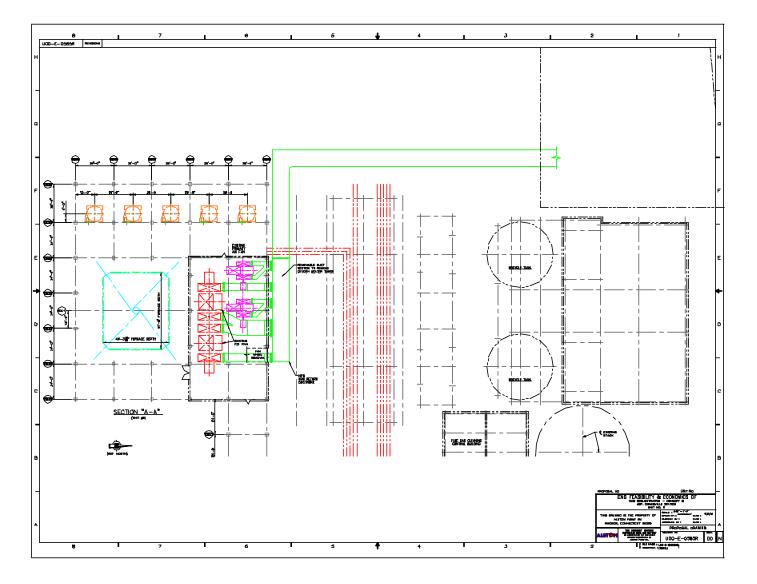








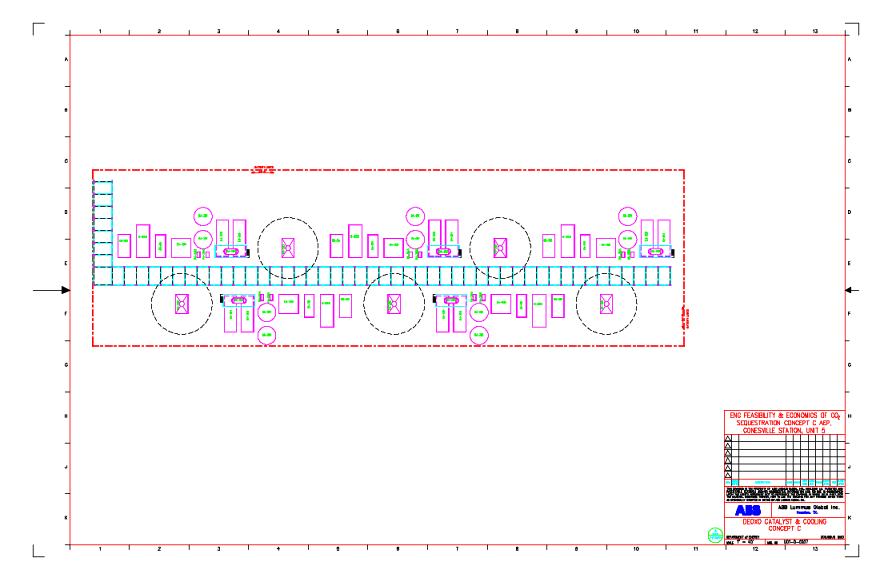


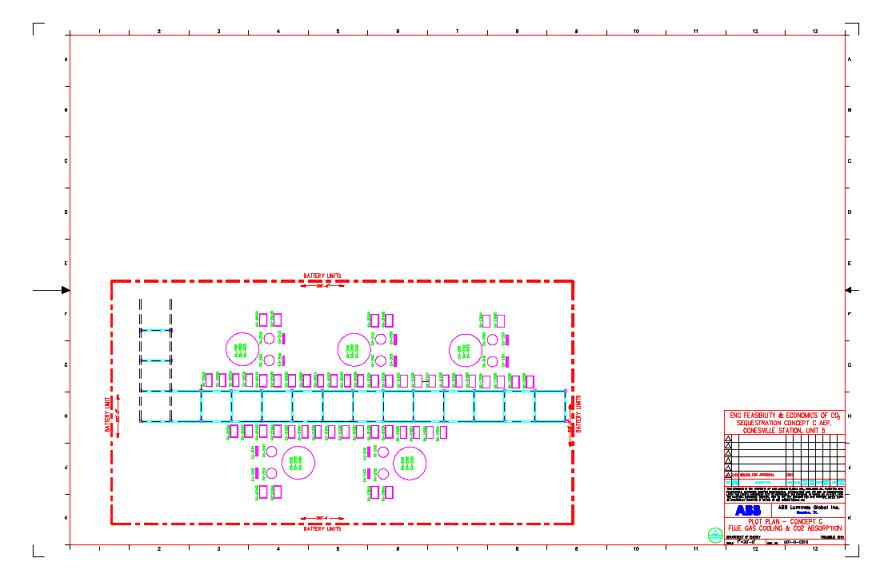


# **Concept C:**

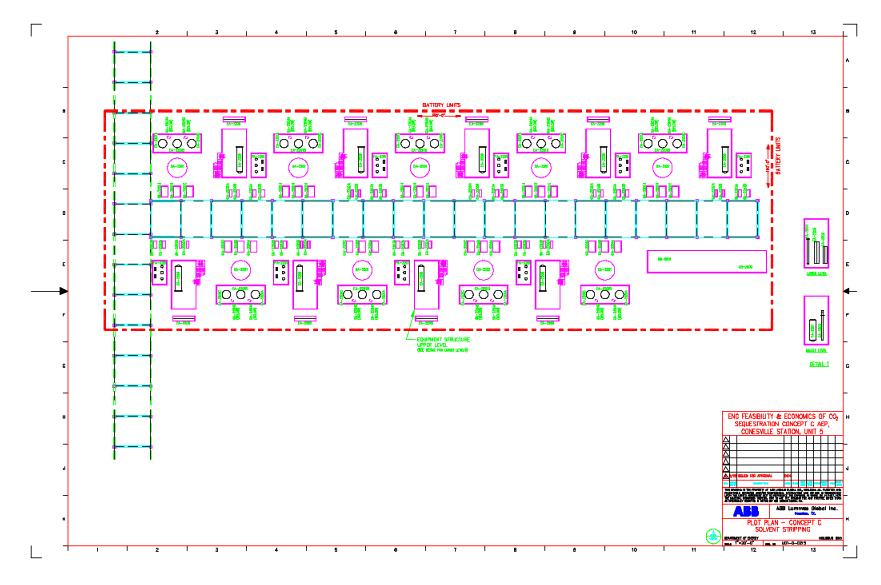
The plant layout drawings prepared for the Concept C CO<sub>2</sub> Recovery System are as follows:

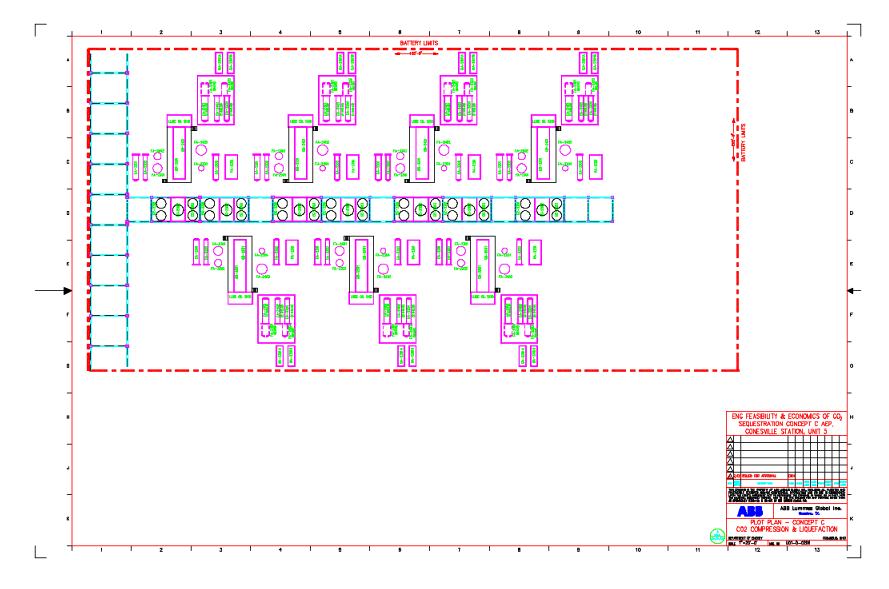
U01-D-0207 Plot Plan – Concept C: De-Oxy Catalyst & Cooling U01-D-0210 Plot Plan – Concept C: Flue Gas Cooling & CO<sub>2</sub> Absorption U01-D-0215 Plot Plan – Concept C: Solvent Stripping U01-D-0206 Plot Plan – Concept C: CO<sub>2</sub> Compression & Liquefaction U01-D-0213 Plot Plan – Concept C: Overall Layout Conceptual Plan U01-D-0202 Plot Plan – Concept C: Modified Overall Site Plan



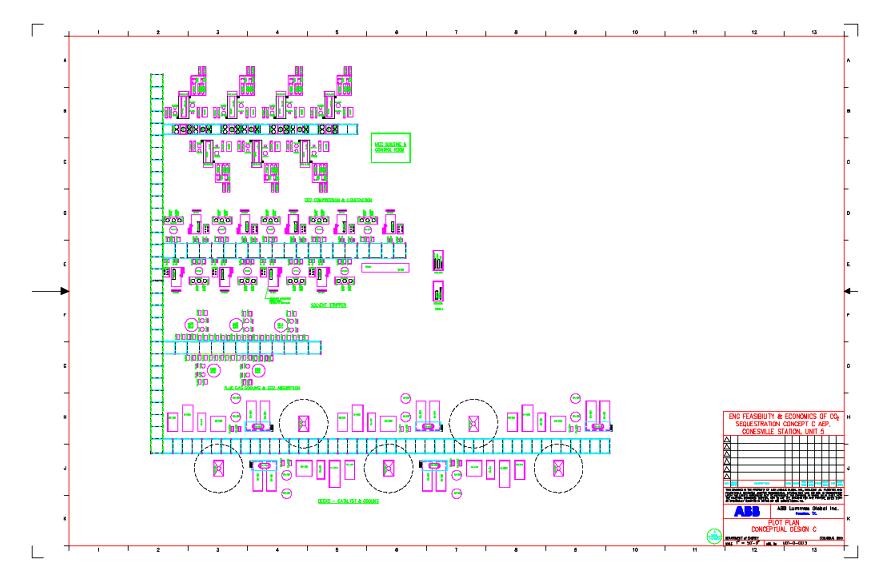


#### VOLUME I. AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5 CO<sub>2</sub> CAPTURE RETROFIT STUDY

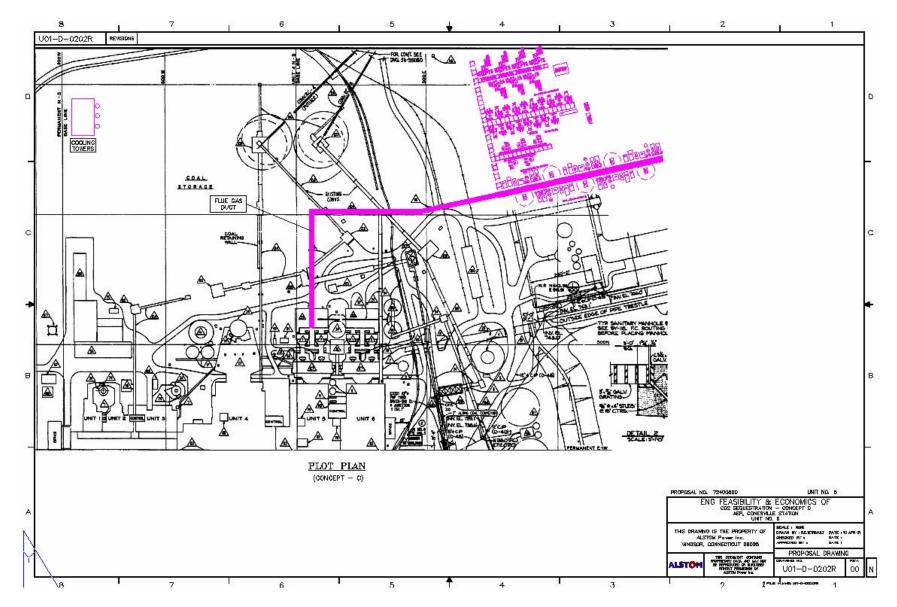




#### VOLUME I. AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5 CO<sub>2</sub> CAPTURE RETROFIT STUDY



# VOLUME I. AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5 $\rm CO_2$ CAPTURE RETROFIT STUDY



# APPENDIX II - EQUIPMENT LISTS

This appendix contains equipment lists for the CO<sub>2</sub> Capture Systems of Concepts A, B, and C.

Concept A E	quipment List	and Data:
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Number of Trains	Tag no.	Description	Size Parameters	Material
5	DA-2101	Direct Contact Flue Gas Cooler	27' ID x 34' S/S, DP 2.5 psig/ 0.7 psi vac	CS/SS
5	DA-2102	CO2 Absorber	27' ID x 92' S/S, DP 2.5 psig/ 0.7 psi vac	CS/SS
9	DA-2201	Solvent Stripper	16' ID x 100' S/S, DP 35 psig/ FV	CS/SS
9	EA-2201	Solvent Stripper Reboiler	217 MMBTU/HR DP S/T, 50 psig/ 60 psig	CS/SS
9	EA-2203	Solvent Stripper Reclaimer	5.6 MMBTU/HR, DP S/T, 120 psig/ 190 psig	CS/TI
9	EA-2204	Solvent Reclaimer Effluent Cooler	5 MMBTU/HR, DP S/T, 125 psig, 100 psig	CS/TI
9	EA-2206	Solvent Stripper CW Condenser	41.6 MMBTU/HR, DP S/T, 35 psig/ 100 psig	SS/TI
7	EA-2301	CO2 Compr. 1st Stage Aftercooler	1.9 MMBTU/HR, DP S/T, 75 psig/ 100 psig	SS/TI
7	EA-2302	CO2 Compr. 2nd Stage Aftercooler	1.3 MMBTU/HR, DP S/T, 125 psig/ 100 psig	SS/TI
7	EA-2303	CO2 Compr. 3rd Stage Aftercooler	1 MMBTU/HR, DP S/T, 235 psig/ 100 psig	CS/TI
7	EA-2304	CO2 Condenser	19 MMBTU/hr DP S/T, 235 psig/ 300 psig	CS/TI
5	EA-2101	Direct Contact Flue Gas Water Clr	4.8 MMBTU/HR, DP P/U, 50 psig/ 100 psig	TI
9	EA-2205	Rich / Lean Solvent Exchanger		SS316
9	EA-2202	Lean Solvent Cooler	101.8 MMBTU/HR, DP P/U 135 psig/ 100 psig	TI
7	EA-2401	Propane Refrig Condenser	20.45 MMBTU/HR, DP S/T, 300 psig/ 100 psig	CS/CS
7	EA-2402	Propane Refrig Subcooler	5.9 MMBTU/HR, DP S/T, 300 psig/ 2500 psig	CS/LTCS
7	EC-2301	CO2 compressor 1st stage air cooler	2.94 MMBTU/HR, DP 75 psig	SS
7	EC-2302	CO2 compressor 2nd stage air cooler	3.1 MMBTU/HR, DP 125 psig	SS
7	EC-2303	CO2 compressor 3rd stage air cooler	4.6 MMBTU/HR, DP 235 psig	SS
9	EC-2201	Solvent stripper bottoms cooler	80.3 MMBTU/HR, DP 135 psig	SS
9	FA-2201	Solvent Stripper Reflux Drum	5' ID x 16' S/S, DP 35 psig/ FV	304L
7	FA-2301	CO2 Compressor 2st Stage Suction Drum	7'- 6" ID x 10' S/S, DP 75 psig	CS/SS
7	FA-2302	CO2 Compressor 3rd Stage	6' ID x 10' S/S, DP 125 psig	CS/SS

		Suction Drum		
7	FA-2303	Liquid CO2 Surge Drum	4'- 6" ID x 14' S/S, DP 235 psig	KCS
7	FA-2304	CO2 Compressor 3rd stage	4' 6" ID x 10' S/S, DP 235 psig	CS/SS
		Discharge KO Drum		
7	FA-2401	Propane Refrig Surge Drum	10' ID x 30' S/S, DP 300 psig	CS
7	FA-2402	Propane Refrig Suction Scubber	8' 6" ID x 12' S/S, DP 300 psig	LTCS
3	FB-2503	Caustic day tank	2' ID x 4' S/S, DP atm	CS
5	FD-2101	DCC Water Filter	205 gpm, DP 35 psig	SS
5	GA-2101	Wash Water Pump	1425 gpm, DP 29 psi	DI/SS
	A/B			
5	GA-2102 A/B	Direct Contact Cooler Water Pump	205 gpm, DP 36 psi	SS/SS
5	GA-2103	Rich Solvent Pump	3450 gpm, DP 92 psi	SS/SS
0	A/B/C/D	Lasar Calasar Damar	2000 and DD 95 mi	00/00
9	GA- 2201A/B/ C	Lean Solvent Pump	3000 gpm, DP 85 psi	SS/SS
9	GA-2202	Solvent Stripper Reflux Pump	310 gpm, DP 75 psi	DI/SS
	A/B	Sorvent Surpper Rentax Fump	sto gpin, Di 75 psi	01/00
9	GA-2203 A/B	Filter Circ. Pump	290 gpm, DP 91 psi S	
9	GA-2204	LP Condensate Booster Pump	512 gpm, DP 237 psi	CI/SS
_	A/B			
7	GA-2301 A/B	CO2 Pipeline Pump	217 gpm, DP 1815 psi	CS/CS
3	GA-2501	Caustic metering pump	.45 gpm, DP 50 psi	SS
5	011 2501	Cuusile metering pump	. to gpin, Dr 50 psi	55
7	GB-2301	CO2 Compressor (Motor driven)	4480 hp	SS wheels
7	GB-2401	Propane Refrig Compressor	3075 hp	LTCS
1	GB-2500	LP steam turbine/ generator	83365 hp	
9	PA-2551	Corrosion Inhibitor Package	Metering, 25 lb/ hr	
9	PA-2251	Solvent Filter Package	140 gpm	
7	PA-2351	CO2 Dryer Package	4 driers, 200 hp compressor, elec hea	ater, cooler
1		Crane for Compr. Bldg.	· · · · · · · · · · · · · · · · · · ·	,
		Flue gas ducting		
1	PA-2551	Cooling Tower	22000 gpm, includes basin, pumps injection	, chlorine
1	PA-2552	Cooling tower blowdown	100 gpm sand filters and dechlor	rinator,
		treatment package	hypochlorite	,
			storage tank	

# **Concept B Equipment List and Data:**

Number				
of Trains	Tag No.	Service	Sizing Parameters	MOC
1	DA DA-101	Columns and Towers Direct Contact Flue Gas Cooler	27' ID x 30' S/S, DP 10 psig, 3 psi	CS w/ SS
2	A/B/C DA-102	CO2 Rectifier	vacuum 6'/ 13' ID x 30'/ 10' S/S, DP 425 psig	liner LTCS
	Е	Heat Transfer Equipment	Pare	
	EA	Chall & Tube Fucher corre		
2	EA EA-101	Shell & Tube Exchangers Flue Gas Compressor 1 Stage Trim Cooler	7.25 MMBTU/h, DP S/T, 85 psig/ 85 psig	CS/SS
2	EA-102	Flue Gas Compressor 2 Stage Trim Cooler	4.2 MMBTU/HR, DP S/T, 175 psig/ 125 psig	CS/SS
2	EA-103	Flue Gas Compressor 3 Stage Trim Cooler	4.1 MMBTU/HR, DP S/T, 425 psgi/ 300 psig	CS/SS
2	EA-104	CO2 Condenser	64.3 MMBTU/HR, DP S/T, 300 psig/ 425 psig	LTCS/ LTCS
2	EA-201	Refrig condenser	68.8 MMBTU/HR, DP S/T, 300 psig/ 200 psig	CS/CS
2	EA-202	Refrig Subcooler	20 MMBTU/HR, DP S/T, 300 psig/ 2500 psig	CS/LTCS
2	EA-107	CO2 Rectifier Condenser	5.2 MMBTU/HR, DP S/T, 425 psig/ 425 psig	SS/SS
	EA -108	Rectifier Ovhd Interchanger	1.6 MMBTU/HR, DP S/T, 425 psig/ 425 psig	LTCS/SS
	EB	Plate Exchangers		
1	EB-101	Water Cooler	Total 313 MMBTU/HR, DP P/U, 65 psig/ 100 psig	CS
	EC	Air Coolers		
2	EC-101	Flue Gas Compressor 1 Stage Aftercooler	25.5 MMBTU/HR, DP 85 psig	SS
2	EC-102	Flue Gas Compressor 2 Stage Aftercooler	21.6 MMBTU/HR, DP 175 psig	SS
2	EC-103	Flue Gas Compressor 3 Stage Aftercooler	21.4 MMBTU/HR, DP 425 psig	SS
	FH	Heaters		
2	FH-101	Dryer Regeneration Gas Heater	Gas fired, 8.5 MBTU/HR	
	FA	Drums and Vessels		
2	FA-101	Flue Gas Compressor 2nd Stage Suction Drum	10' ID x 26' S/S, DP 85 psig	CS w/ SS liner
2	FA-102	Flue Gas Compressor 3rd Stage Suction Drum	8' ID x 20' S/S DP 175 psig	CS w/ SS liner
2	FA-103	Flue Gas Compressor Third Stage Discharge K/O Drum	8' ID x 12' S/S, DP 425 psig	CS w/ SS liner
2	FA-201	Refrig Surge Drum	16' ID x 34' S/S DP 300 psig	CS
2	FA-202	Refrig Suction Srubber	16' ID x 16' S/S, DP 300 psig	ITCS

1	FD FD-101	Filters and Dryers Water Filter	6 units, 2422 gpm each, DP 50	SS
			psig	
2	FD-102	Flue Gas Filter	2718 ACFM, DP 425 psig	CS
	FF	Dryers (Desiccant Type)		
2	FF-101 A/H	Flue Gas Dryer	Six Vessels, 5 drying, 1 regeneration	CS
	GA	Pumps Centrifugal		
1	GA-101	Water Pump	4900 gpm, DP 35 psi	CI w/ SS
2	A/B/C/D GA-103A/B	CO2 Binalina muna	800 mm DD 1655 m	impeller
2	GA-103A/B	CO2 Pipeline pump	800 gpm, DP 1655 psi	ITCS
	GB	Compressors & Blowers		
2	GB-101	Flue Gas Compressor	3 stages Includes Lube/Seal Oil	SS
		_	Systems, 18818 kW	
2	GB-102	Propane Refrig Compressor	2 Stage, Includes lube oil/ seal oil	ITCS
			system, 7188 kW	
1	GB-100	Flue Gas Blower	2750 HP	SS
1	GB-103	Flue Gas Booster	500 HP	SS
	PA	Deckered Equipment		
1	PA-101A/B	Packaged Equipment Large Air Separation Unit	2025 tong/ day $000$ / mum $02$	
1	PA-101A/B PA-102 A/B		3925 tons/ day 99% pure O2	
		Small Air Separation Unit	550 tons/ day 99% pure O2	
1	PA-103	Cooling Tower	93200 gpm Includes pumps, basin, and chlorine injection, hypochlorite storage tank	
1	PA-104	Cooling Tower Make-up water		
		Purification unit		
		Ducting		

# Concept C Equipment List and Data:

Number of				
Trains	Tag no.	Description	Size Parameters	Material
5	D-301X	Flue gas scrubber	192500 ACFM, 213 lb/hr SO2	316L
5	DA-301	De-oxy Catalyst Reactor	2 shells 32' dia x 50' S/S DP 14 psig	CS w/ refractory
5	DA-302	Reactor Effluent/ Steam Drum	8' 6" ID x 16' S/S, DP 2000 psig	CS
5	DA-303	De-oxy Catalyst Reactor 2		
5	DA-2101	Direct Contact Flue Gas Cooler	27' ID x 34' S/S, DP 2.5 psig/ 0.7 psi vac	CS/SS
5	DA-2102	CO2 Absorber	27' ID x 92' S/S, DP 2.5 psig/ 0.7 psi vac	CS/SS
5	DA-2103	Bottom Direct Contact Flue Gas Cooler	27' ID x 20' S/S, DP 2.5 psig/ 0.7 psi vac	CS/SS
9	DA-2201	Solvent Stripper	16' ID x 100' S/S, DP 35 psig/ FV	CS/SS
5	EA-301	Feed/ Effluent Exchanger	167.8 MMBTU/HR, DP 5 psig, 5 psig	CS
5	EA-303	Reactor effluent/ steam superheater	24 MMBTU/HR, DP 2100 psig	CS
5	EA-304	Reactor effluent/ steam generator	70 MMBTU/HR, DP 2100 psig	CS
5	EA-305	Dry Flue Gas Cooler	42.5 MMBTU/HR, DP 350 psig	CS
9	EA-2201	Solvent Stripper Reboiler	167 MMBTU/HR DP S/T, 50 psig/ 60 psig	CS/SS
9	EA-2203	Solvent Stripper Reclaimer	5.6 MMBTU/HR, DP S/T, 120 psig/ 190 psig	CS/TI
9	EA-2204	Solvent Reclaimer Effluent Cooler	5 MMBTU/HR, DP S/T, 125 psig, 100 psig	CS/TI
9	EA-2206	Solvent Stripper CW Condenser	45.7 MMBTU/HR, DP S/T, 35 psig/ 100 psig	SS/TI
9	EA-2208	Solvent stripper bottoms cooler	66.7 MMBTU/HR, DP P/U 135 psig/ 100 psig	SS/TI
7	EA-2301	CO2 Compr. 1st Stage Aftercooler	2 MMBTU/HR, DP S/T, 75 psig/ 100 psig	SS/TI
7	EA-2302	CO2 Compr. 2nd Stage Aftercooler	1.35 MMBTU/HR, DP S/T, 125 psig/ 100 psig	SS/TI
7	EA-2303	CO2 Compr. 3rd Stage Aftercooler	1.1 MMBTU/HR, DP S/T, 235 psig/ 100 psig	CS/TI
7	EA-2304	CO2 Condenser	20 MMBTU/hr DP S/T, 235 psig/ 300 psig	CS/TI
5	EA-2101	Direct Contact Flue Gas Water Clr	77.3 MMBTU/HR, DP P/U, 50 psig/ 100 psig	TI
9	EA-2205	Rich / Lean Solvent Exchanger	133 MMBTU/HR, DP P/P, 135 psig/ 155 psig	SS316
9	EA-2202	Lean Solvent Cooler	60 MMBTU/HR, DP P/U 135 psig/ 100 psig	TI
7	EA-2401	Propane Refrig Condenser	22 MMBTU/HR, DP S/T, 300 psig/ 100 psig	CS/CS
7	EA-2402	Propane Refrig Subcooler	6.2 MMBTU/HR, DP S/T, 300 psig/ 2500 psig	CS/LTC

7	EC-2301	CO2 compressor 1st stage air	3.2 MMBTU/HR, DP 75 psig	SS
7	EC-2302	cooler CO2 compressor 2nd stage air	3.3 MMBTU/HR, DP 125 psig	SS
7	EC-2303	cooler CO2 compressor 3rd stage air	4.9 MMBTU/HR, DP 235 psig	SS
		cooler		
9	FA-2201	Solvent Stripper Reflux Drum	5' ID x 16' S/S, DP 35 psig/ FV	304L
9 7	FA-2301	CO2 Compressor 2st Stage Suction Drum	7'- 6" ID x 10' S/S, DP 75 psig	CS/SS
7	FA-2302	CO2 Compressor 3rd Stage Suction Drum	6' ID x 10' S/S, DP 125 psig	CS/SS
7	FA-2303	Liquid CO2 Surge Drum	4'- 6" ID x 14' S/S, DP 235 psig	KCS
7	FA-2304	CO2 Compressor 3rd stage Discharge KO Drum	4' 6" ID x 10' S/S, DP 235 psig	CS/SS
7	FA-2401	Propane Refrig Surge Drum	10' ID x 30' S/S, DP 300 psig	CS
7	FA-2402	Propane Refrig Suction Scubber	8' 6" ID x 12' S/S, DP 300 psig	LTCS
3	FB-2503	Caustic day tank	2' ID x 4' S/S, DP atm	CS
5	FD- 2101A/B	DCC Water Filter	1645 gpm each, DP 35 psig	SS
5	FH- 302	Start-up heater	54.6 MMBTU/HR	CS
5	GA-301 A/B	HP Condensate Booster pumps	163 gpm, DP 1500 psi	DI/SS
5	GA-2101 A/B	Wash Water Pump	1425 gpm, DP 29 psi	DI/SS
5	GA-2102 A/B	Direct Contact Cooler Water Pump	3289 gpm, DP 36 psi	SS/SS
5	GA-2103 A/B/C/D	Rich Solvent Pump	2435 gpm, DP 92 psi	SS/SS
5	GA-2104 A/B	Bottom Direct Contact Cooler Water Pump	325 gpm, DP 36 psi	SS/SS
9	GA- 2201A/B/C	Lean Solvent Pump	2095 gpm, DP 85 psi	SS/SS
9	GA-2202 A/B	Solvent Stripper Reflux Pump	310 gpm, DP 75 psi	DI/SS
9	GA-2203 A/B	Filter Circ. Pump	290 gpm, DP 91 psi	SS/SS
9	GA-2204 A/B	LP Condensate Booster Pump	395 gpm, DP 237 psi	DI/SS
7	GA-2301 A/B	CO2 Pipeline Pump	228 gpm, DP 1815 psi	CS/CS
3	GA-2501	Caustic metering pump	.45 gpm, DP 50 psi	SS
5	GB-301	Flue Gas Blower	3350 hp	SS
7	GB-2301	CO2 Compressor (Motor driven)	4750 hp	SS wheels
7	GB-2401	Propane Refrig Compressor	3225 hp	LTCS
1	GB-2500	LP steam turbine/ generator	48809 hp	
1	GB-2501	HP steam turbine/ generator	52421 hp	

9 7	PA-2251 PA-2351	Solvent Filter Package CO2 Dryer Package	140 gpm 4 dryers, 200 hp compressor, fired heater, cooler
1		Crane for Compr. Flue gas ducting	
1	PA-2551	Cooling Tower	67500 gpm, includes basin, pumps, chlorine injection
1	PA-2552	Make-up water purification package	1570 gpm clarifier w/ b/d sump and pump, and CT b/d dechlorinator, hypochlorite storage tank

VOLUME I. AMERICAN ELECTRIC POWER'S CONESVILLE POWER PLANT UNIT NO. 5  ${\rm CO}_2$  CAPTURE RETROFIT STUDY

# VOLUME II

# ENGINEERING FEASIBILITY AND ECONOMICS OF $CO_2$ CAPTURE ON AN EXISTING COAL-FIRED POWER PLANT

#### FINAL REPORT

#### VOLUME II BENCH-SCALE TESTING AND COMPUTATIONAL FLUID DYNAMICS (CFD) EVALUATION

#### SUBMITTED BY

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#### AND

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#### Disclamer

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#### Public Abstract

ALSTOM Power Inc.'s Power Plant Laboratories (ALSTOM) has teamed with American Electric Power (AEP), ABB Lummus Global Inc. (ABB), the US Department of Energy National Energy Technology Laboratory (DOE NETL), and the Ohio Coal Development Office (OCDO) to conduct a comprehensive study evaluating the technical feasibility and economics of alternate  $CO_2$  capture and sequestration technologies applied to an existing US coal-fired electric generation power plant.

The motivation for this study was to provide input to potential US electric utility actions concerning GHG emissions reduction. If the US decides to reduce  $CO_2$  emissions, action would need to be taken to address existing power plants. Although fuel switching from coal to natural gas may be one scenario, it will not necessarily be a sufficient measure and some form of  $CO_2$  capture for use or disposal may also be required. The output of this  $CO_2$  capture study will enhance the public's understanding of control options and influence decisions and actions by government, regulators, and power plant owners in considering the costs of reducing greenhouse gas  $CO_2$  emissions.

The total work breakdown structure is encompassed within three major reports, namely: (1) Literature Survey, (2) AEP's Conesville Unit #5 Retrofit Study, and (3) Bench-Scale Testing and CFD Evaluation. The report on the literature survey results was issued earlier by Bozzuto, et al. (2000). Reports entitled "AEP's Conesville Unit #5 Retrofit Study" and "Bench-Scale Testing and CFD Evaluation" are provided as companion volumes, denoted Volumes I and II, respectively, of the final report. The work performed, results obtained, and conclusions and recommendations derived therefrom are summarized below.

#### Volume I

The Volume I report discusses three retrofit technology concepts, which were evaluated in conjunction with AEP's Conesville Unit #5, namely:

- **Concept A:** Coal combustion in air, followed by CO<sub>2</sub> separation with Kerr-McGee/ABB Lummus Global's commercial MEA-based absorption/stripping process
- **Concept B:** Coal combustion with O<sub>2</sub> firing and flue gas recycle (oxy-fuel firing)
- **Concept C:** Coal combustion in air with oxygen removal and CO<sub>2</sub> separation by a mixture of primary and tertiary amines, i.e., monoethanolamine (MEA)/methyldiethanolamine (MDEA).

Each of these technologies was evaluated against a baseline case, without  $CO_2$  capture, from the standpoints of performance, impacts on power generating cost, and  $CO_2$  emissions. AEP's 450 MW Conesville Unit No. 5, located in Conesville, Ohio, was used for the power plant case study. All technical performance and cost results associated with the available options were evaluated in a comparative manner.

#### **Major conclusions:**

- No major technical barriers exist for retrofitting AEP's Conesville Unit #5 to capture CO<sub>2</sub> for any of the three concepts considered under this study.
- Concept B (oxygen firing with flue gas recycle) appears clearly to be <u>the best</u> alternative of the three concepts studied from both an efficiency and incremental COE viewpoint. This study has confirmed two important issues related to firing coal in a CO<sub>2</sub>-rich flue gas / O<sub>2</sub> mixture:
  - Modifications to the existing steam generator unit pressure arts are not required, and as such will also allow the unit to continue to operate in the conventional air- fired mode.
- CO<sub>2</sub>-rich flue gas can be cleaned and compressed with a relatively simple system to provide high purity CO<sub>2</sub> for usage or sequestration.
- Energy requirements and power consumption are high, resulting in significant decreases in overall power plant efficiencies (HHV basis), ranging from efficiencies of 20.5 to 22.5%, as compared to 35.0% for the Base case (air

firing without  $CO_2$  capture), which is equivalent to an energy penalty ranging from 36% to 41%. That is, the net power plant output was reduced to 77% - 59%.

- Specific investment costs are high, ranging from about 800 to1800 \$/kW and from 1000 to 2200 \$/kW, corresponding to scenarios with and without replacement power, respectively.
- All cases studied indicate significant increases to the COE as a result of CO<sub>2</sub> capture. The incremental COE as compared to the Base case (air firing without CO<sub>2</sub> capture) ranges from 3.4 to 8.4 ¢/kWh. Similarly CO<sub>2</sub> mitigation costs range from about 42-98 \$/ton of CO<sub>2</sub> avoided for the range of cases studied.
- Specific carbon dioxide emissions were reduced from about  $2 lb_m/kWh$  for the Base case to  $0.13 0.27 lb_m/kWh$  for the study cases. Recovery or capture of CO<sub>2</sub> ranged from 91 to 96%.
- Nominally, 5-8 acres of new equipment space is needed for Unit #5 alone on the existing 200-acre power plant site, which accommodates a total of 6 units with a total power generating capacity of 2,080 MW.

#### Major recommendations:

- A sensitivity study, for Concepts A and C, showing the impact of reducing CO<sub>2</sub> capture percentage on plant efficiency, investment cost, emissions, and cost of electricity. The current work utilized 90% CO<sub>2</sub> capture (nominal). The sensitivity study would investigate nominal CO<sub>2</sub> capture percentages of 70% and 50%.
- Detailed analysis of the existing steam turbine for Concept A: In Concept A about 79% of the steam leaving the intermediate-pressure (IP) turbine is extracted from the IP/LP crossover pipe for solvent regeneration. The capability of the existing low-pressure (LP) turbine to operate under these conditions of very low steam flow over the load range should be investigated in detail, preferably by the original equipment manufacturer (OEM).
- Optimization of the amine system reboiler steam pressure for Concepts A and C.
- Concept B detailed boiler system analysis: A startup/shutdown procedure and system design, particularly the transition from air to oxygen firing (including transient conditions) should be developed. Detailed metal temperature analysis for all heat exchanger sections, including operation at part loads should be analyzed. This should also include furnace wall metal temperatures and analysis of the circulation system. The existing fans should be checked (preferably by the OEM's) for operation under the new conditions. The feasibility of operating the boiler under a slight positive pressure to eliminate air infiltration should also be investigated.
- Investigation of Improved oxygen production systems for Concept B, in line with the membrane-based air separation research being conducted by various research groups (e.g., Praxair, Air Products, Norsk Hydro). Also optimization of an integrated boiler and oxygen production system.
- Measurement of furnace heat transfer in CO<sub>2</sub>/O<sub>2</sub> environments in a proof of concept boiler simulation facility.
- Improved solvents, which require lower regeneration energy requirements and/or can be regenerated at a lower temperature level, similar to MHI's KS1 system, but for coal-firing application.
- Hybrid process using oxygen-enriched combustion and amine based CO<sub>2</sub> absorption, to accrue, simultaneously, both CO<sub>2</sub> capture and drastic NOx emissions reduction.
- Investigation of a new novel high risk CO<sub>2</sub> capture process that would reduce efficiency penalty and retrofit investment cost. This would likely not utilize the existing boiler.

#### Volume II

ALSTOM Power Inc.

The bench-scale testing consisted primarily of drop-tube (DTFS-1) and thermo-gravimetric analyses (TGA). Three cases were investigated: (1) an air-fired case (Base case); (2) a case in which the  $N_2$  was replaced by an equal mass of CO<sub>2</sub> (Constant Mass case); and (3) a case in which the  $N_2$  volume was replaced by an equal volume of CO<sub>2</sub> (Constant Volume case). The Constant Mass case represents the appropriate retrofit scenario in a commercial pulverized coal firing application, albeit without flue gas recycling.

#### Major conclusions:

#### (a) Based on TGA results

• *B*oth the Conesville Unit #5 and Pittsburgh Seam #8 coals have, for air (Base case) and O<sub>2</sub>/CO<sub>2</sub> environments (Constant Mass/Volume cases), similar burning characteristics, as they both go to completion within the same temperature range (550-575 °C). Burning either of the coals in air or any of the O<sub>2</sub>/CO<sub>2</sub> mixture ratios used here would produce virtually identical results; and (2) both coals have similar reactivity characteristics.

#### (b) Based on DTFS-1 results

- Residence time, as expected, has a significant impact on the overall coal combustion efficiency, and hence, on the unburned carbon emission in the fly ash for both coals under consideration. That is, while the combustion efficiency for both coals is only about 80% (dry-ash-free coal basis) at 0.2 sec., it is more than 98% at greater than 0.5 sec. Correspondingly, unburned carbon emissions range from about 65% to about 2% (dry fly ash basis).
- The impact of reaction medium is also significant. While the overall combustion efficiencies do not seem to exhibit significant differences between the baseline and Constant Mass firing, the more sensitive parameter, unburned carbon (UBC) in the fly ash, on the other hand, clearly shows better performance for the Constant Mass case. That is, the UBC at the furnace outlet was about a factor of 4.5 lower for the Constant Mass case (~2% vs. 9%). This is believed to be due to higher reactant gas temperature, and yet longer residence (0.77 sec. vs. 0.57 sec.). It appears, from the shape of the UBC profiles, that, if given enough residence time, these differences would narrow down considerably, implying that the ultimate performance in both mediums would be similar.
- The coal sample from Conesville Unit #5 appears to perform better than the sample from Pittsburgh seam #8 coal (e.g., 9% vs. 12.5% UBC for the air firing case). However, based on the shape of the UBC profiles, it can be seen that if given additional residence time, they would both be expected to perform similarly.
- NOx emission from oxy-fuel firing is about a factor of 3 (0.73 vs. 2.25 lb/MMBtu) lower than that of the Base case. Correspondingly, sulfur dioxide is lower by about 19% (3.6 vs. 4.3 lb/MMBtu), and CO is significantly lower (0.09 lb/MMBtu vs. a negligible amount).

#### (c) Based on CFD results

- The baseline case exhibits higher carbon-in-ash (by 1.6 percentage points), higher outlet NOx emissions (by a factor of 2), and higher outlet CO (by a factor of 2) than the Concept-B case. These same computational trends are also qualitatively exhibited by the bench-scale testing.
- The baseline case exhibits a slightly higher peak gas temperature (maximum difference of about 200 °F), and a correspondingly higher average (cross-sectional) gas temperature (difference of 90 °F at the HFOT), than that of the Concept-B case.
- The net wall absorption in the furnace region for the baseline case is larger (by less than 1%) than that of the Concept-B case. However, a significant variation in both calculated and experimental irradiation to the wall between baseline and oxy-firing scenarios was also found in the literature (e.g., +6 to -18%). Differences may be partially attributed to the sensitivity of the irradiation and local emissivities to the aerodynamic and flame patterns, which are, in turn, a function of the furnace and firing system. It is suggested that radiatively absorbing gas species can either enhance or inhibit the irradiation in the vicinity of the wall, depending upon their local temperature and their relative spatial placement.

#### Major recommendations:

- Carry out a systematic coal fundamentals study concerning this field of endeavor. This study should be geared toward the creation of a database of information depicting the impact of coal nature (using coals of various rank coming from both domestic and international sources) when fired in an oxy-fuel environment on:
  - > Coal devolatilization and char oxidation kinetics, and unburned carbon emissions in the fly ash
  - Acid rain-related gaseous (NOx, SO<sub>2</sub>, and CO) emissions
  - > Air toxics, particularly, mercury (Hg), volatile organic compounds (VOCs), and particulate emissions.
- Derive furnace heat transfer data from natural gas and coal firing in an oxy-fired pilot-scale furnace, which simulates the temperature/time history of a boiler. Use first the data from natural gas firing to validate the CFD code, without the complication of burning particles transiting the boiler. Apply the experience learned from modeling a natural gas fired boiler to model the coal-fired boiler.

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# **Executive Summary**

#### Background

International discussions continue to debate the need for reductions in emission levels of green house gases (GHG). Because fossil fuel fired power plants are among the largest and most concentrated producers of  $CO_2$  emissions, it stands to reason that recovery of  $CO_2$  from the flue gas of such plants has been identified as one of the primary means for reducing  $CO_2$  emissions.

ALSTOM Power Inc.'s Power Plant Laboratories (ALSTOM) teamed with American Electric Power (AEP), ABB Lummus Global Inc. (ABB), the US Department of Energy National Energy Technology Laboratory (DOE NETL), and the Ohio Coal Development Office (OCDO) to conduct a comprehensive study evaluating the technical and economic feasibility of three alternate  $CO_2$  capture technologies applied to an existing US coal-fired electric generation power plant. The steam generator analyzed in this study is the Conesville No. 5 unit, operated by American Electric Power (AEP) of Columbus, Ohio. This steam generator is a nominal 450 MW, coal-fired, subcritical pressure, controlled circulation unit. It has a single cell furnace that employs corner-fired, tilting, tangential burners and which fires bituminous coal from the state of Ohio. The flue gas leaving the boiler system is cleaned of particulate matter in an electrostatic precipitator (ESP) and of  $SO_2$  in a lime-based flue gas desulfurization (FGD) system before being discharged to the atmosphere.

ALSTOM is managing and performing the subject study from its US Power Plant Laboratories office in Windsor, CT. ABB, from its offices in Houston, Texas, is participating as a sub-contractor. AEP is participating by offering their Conesville Generating Station as the case study and cost sharing consultation, along with relevant technical and cost data. AEP is one of the largest US utilities, and as the largest consumer of Ohio coal, is bringing considerable value to the project. Similarly, ALSTOM and ABB are well established as global leaders in the design and manufacturing of steam generating equipment, petrochemical, and  $CO_2$  separation technology. The DOE National Energy Technology Laboratory and the Ohio Coal Development Office provided consultation and funding. All participants contributed to the cost share of this project.

#### Objectives

The motivation for this study was to provide input to potential US electric utility actions concerning GHG emissions reduction. If the US decides to reduce  $CO_2$  emissions, action would need to be taken to address existing power plants. Although fuel switching from coal to natural gas may be one scenario, it will not necessarily be a sufficient measure and some form of  $CO_2$  capture for use or disposal may also be required. The output of this  $CO_2$  capture study will enhance the public's understanding of control options and influence decisions and actions by government, regulators, and power plant owners in considering the costs of reducing greenhouse gas  $CO_2$  emissions.

The key goals of the study were to evaluate the impacts on the plant output, efficiency, and  $CO_2$  emissions, resulting from the addition of the  $CO_2$ -capture systems. Cost estimates were developed for the systems required to produce, extract, clean and compress the  $CO_2$ , which could then be available for use in enhanced oil or gas recovery or sequestration. Additionally, the impact of  $CO_2$  capture on the cost of electricity (COE) and on the mitigation cost for  $CO_2$  (\$/ton of  $CO_2$  avoided) was also evaluated.

#### Work Scope

The total work breakdown structure is encompassed within three major reports, namely: (1) Literature Survey, (2) AEP's Conesville Unit #5 Retrofit Study, and (3) Bench-Scale Testing and CFD Evaluation. The report on the literature survey results was issued earlier by Bozzuto, et al. (2000). The report entitled "AEP's Conesville Unit #5 Retrofit Study" constitutes Volume I of the final report.

"Bench-Scale Testing and CFD Evaluation" is presented herein as the Volume II report. The work performed, results obtained, and conclusions and recommendations derived therefrom are summarized in the sections that follow.

#### **Bench-Scale Testing**

The overall objective of the (Volume II) work segment was to provide critical technical information for evaluating a single option, selected from the three retrofit technology options available, which had the highest probability of realizability. The final option selected was that denoted as: "Coal Combustion in an  $O_2/CO_2$  Environment with  $CO_2$  Recycle." Specific objectives were two-fold: (1) bench-scale testing was to provide experimental combustion and emissions performance data on a specific Ohio coal under conditions where the fuel was to be burned in mixtures of  $CO_2$  and  $O_2$ ; and (2) a computational fluid dynamics (CFD) modeling effort was to utilize design and operating information from a commercial boiler burning Ohio coal in order to establish a calculation for the conventional burning of coal (in air), and then to evaluate performance in the same commercial unit for the burning of the same coal in mixtures of  $CO_2$  and  $O_2$ .

Bench-scale results provided surrogate combustion kinetics, NOx, CO, SO<sub>2</sub> and unburned carbon results on the coal that is presently burned in the Conesville Boilers Units #5 and 6 under conditions that represent conventional combustion (in air) and in various mixtures of  $CO_2$  and  $O_2$ . A knowledge of the actual combustion and emissions data from Conesville Unit #5 provided a means whereby the baseline bench-scale results in air were referenced and interpreted; in a sense, it allowed "calibration" of the bench-scale experimental facility to a given point of reference. Referencing the baseline bench-scale results to the actual furnace emissions data allowed a more accurate interpretation of the bench-scale results of the  $CO_2$ - $O_2$  mixtures and permitted a more reliable/extrapolation of how an actual retrofitted boiler would respond to the same  $CO_2$ - $O_2$  mixtures.

The completed literature survey, performed under an initial task of this project (Bozzuto, et al., 2000), indicated that no fundamental combustion performance had been carried out on any coal in  $CO_2/O_2$  media. Hence, the work scope provided first-of-a-kind information to the project. Information derivation and application was carried out as follows:

- First, bench-scale testing of the Conesville coal was carried out in both air (to provide baseline information) and in two mixtures of CO<sub>2</sub> and O<sub>2</sub>.
- A comparison of the information on combustion performance in air with information from ALSTOM's proprietary database permitted ALSTOM to select char oxidation kinetic parameters to be used on a surrogate basis during the calibration of the CFD cases.

#### **Coal Characteristics**

ASTM standard analyses and ash chemistry analyses were performed for coal samples from AEP's Conesville Unit #5 and Pittsburgh #8 seam. Both of these coal samples are typical of good Eastern US bituminous steaming coals, with fuel values (i.e., FC/VM ratios) of 1.4 and 1.3, respectively. Both coals have high sulfur contents and exhibit medium potentials for slagging the boiler waterwall and convective pass.

#### **TGA Results**

The coal samples were size graded to 200x400 mesh. These size-graded materials were subsequently tested in the thermo-gravimetric analyzer (TGA) and the drop-tube furnace system (DTFS-1) equipment to determine their reactivities and unburned carbon emission propensities.

Three cases were evaluated for each coal. The Base case consisted of burning the coal in air. The Constant Mass case consisted of burning the coal in an  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was maintained and the mass of  $N_2$  used in the Base case was replaced with an equal mass of  $CO_2$ . The Constant Volume case consisted burning the coal in  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was again maintained and the volume of  $N_2$  used in the Base case was replaced with an equal volume of  $CO_2$ .

The combustion efficiency profiles from the TGA indicate that both the Conesville and Pittsburgh #8 coals, for both the air (Base case) and  $O_2/CO_2$  environments (Constant Mass/Volume cases), have similar burning characteristics, as they both go to completion within the same temperature range (550-575°C). Additional analysis of the weight loss as a function of time, as well as the temperature at which the maximum reaction rate occurs, confirms that: (1) burning either of the coals in air or any of the  $O_2/CO_2$  mixture ratios used will produce virtually identical results; and (2) both coals have similar reactivity characteristics.

### **Drop-Tube Combustion Furnace System-1 Results**

The DTFS-1 testing was used to derive quantitative information on the impact of various operating parameters such as particle size, stoichiometry and temperature/time history on unburned carbon loss and gaseous (NOx, CO and SO<sub>2</sub>) emissions. The coal feed rate was adjusted for each coal such that the overall stoichiometry ( $\lambda$ ) was ~2.50, which is the stoichiometry required to achieve reasonably low unburned carbon emissions in the drop tube. The DTFS-1 was operated in a laminar flow regime, with a Reynolds number in the 150-225 range; the maximum residence time for the conditions evaluated was about 0.8 seconds. DTFS-1 results showed the following:

- Residence time has, as expected, a significant impact on the overall coal combustion efficiency, and hence, on the unburned carbon emission in the fly ash for both coals under consideration. That is, while the combustion efficiency for both coals is only about 80% (dry-ash-free coal basis) at 0.2 sec residence time, it is more than 98% at greater than 0.5 sec. residence times. Correspondingly, unburned carbon emissions range from about 65% to less about 2% (dry fly ash basis) for the same residence times.
- The impact of reaction medium is also significant. While the overall combustion efficiencies do not seem to exhibit significant differences between the baseline and Constant Mass firing, the more sensitive parameter, unburned carbon (UBC) in the fly ash, on the other hand, clearly shows better performance for the Constant Mass case. That is, the UBC at the furnace outlet was more than a factor of 4.5 lower for the Constant Mass case (~2% vs. 9%). This is believed to be due to higher reaction temperature, and yet longer residence time (0.77 sec. vs. 0.57 sec.). It appears, from the shape of the UBC profiles, that, if given enough residence time, these differences would considerably narrow down, implying that the performance in both mediums would be similar.
- The coal sample from Conesville Unit #5 appears to perform better than the sample from Pittsburgh seam #8 coal (e.g., 9% vs. 12.5% UBC for the air firing case). However, based on the shape of the UBC profiles, it can be seen that if given additional residence times, they would both be expected to perform similarly.
- NOx emission from oxy-fuel firing is about a factor of 3 (0.73 vs. 2.25 lb/MMBtu) lower than that of the Base case. Correspondingly, sulfur dioxide is lower by about 19% (3.6 vs. 4.3 lb/MMBtu), and CO is significantly lower (0.09 lb/MMBtu vs. a negligible amount).
- The gaseous emission trends are consistent with results reported by others (Thambimuthu, et al.; 1998; Weller, et al., 1985) and by the CFD results of the present study (Section 3.0, below).

# **CFD** Analysis

ALSTOM Power uses a commercial CFD code (denoted FLUENT<sup>TM</sup>) from Fluent Inc. for its simulations of furnaces and auxiliary equipment. Case preparation of a boiler for the Fluent code was initiated with the collection of the geometry data (from blueprints and schematics), the free areas of the nozzles, and the operating conditions. A CFD grid or mesh was prepared using a combination of EXCEL spreadsheets and a grid-generation package (denoted GAMBIT<sup>TM</sup>) supplied by Fluent Inc. The total number of cells in the grid was approximately 315,000.

Two cases have been compared using the FLUENT<sup>™</sup> CFD code – a baseline, nominal 15% excess air case (Case 1 or Base case), and a recirculated flue gas, oxy-fired case (Case 2 or Concept-B case). In the Concept-B case, the nitrogen was largely replaced by carbon dioxide. The cases have been compared on the basis of equivalent nozzle/inlet areas, as well as an equivalent coal-to-oxygen feed ratio (by mass).

The baseline case was calibrated to known furnace performance and operating conditions. Calibration is required because of the uncertainty associated with wall fouling factors, particle reactivities, etc. "Implicit" boundary conditions that were matched during the baseline calibration included:

- the unburned carbon (UBC) in the fly ash (i.e., carbon-in-ash value) at the outlet of the computational domain
- the outlet NOx emissions value at the outlet of the computational domain
- the "horizontal furnace outlet temperature (HFOT)," which is the mass-weighted average temperature across the plane at the apex of the arch (i.e. the horizontal furnace outlet plane or HFOP).

Both the UBC and NOx emissions values were derived from experimental measurements (usually taken downstream of the air preheater). The HFOT value was calculated by an in-house, proprietary design package denoted the Reheat Boiler Program (RHBP). An iterative trial-and-error method was used to calibrate the baseline case by changing the input parameters for char oxidation, NOx, and waterwall conduction resistance, until (after a number of runs) the code calculations matched the desired UBC, the NOx value, and the HFOT, respectively.

Lateral and vertical waterwall heat flux or absorption distributions, as well as the overall heat transfer in the lower and upper furnace, were extracted from the CFD calculations. Total and sectional (area-weighted) waterwall heat absorption rates, in addition to peak heat absorption values, were used to quantify the heat absorption rates that constitute one of the metrics used as a basis of comparison between the cases. Metrics utilized to compare the cases include:

- the unburned carbon (UBC) in the fly ash at the outlet of the computational domain
- the outlet NOx emissions value at the outlet of the computational domain
- the horizontal (and/or vertical) furnace outlet temperature(s) (FOT)
- the outlet CO emissions value at the outlet of the computational domain
- total, sectional, and peak waterwall heat flux or absorption rates

Some of the metrics for the two cases, such as NOx, were compared on a basis that is scaled or referenced to the baseline value, since relative trends may be a more reliable indicator of the expected performance than the absolute magnitudes of the metrics. Line and contour plots for variables of interest were prepared at selected horizontal or vertical planes, as appropriate.

The predictions provided a relative indication of the changes that occurred in the oxy-firing case as a result of deviation from the baseline operating conditions. The difference in inlet nozzle velocities, mixture specific heats, and radiative properties between  $CO_2$  and  $N_2$  had a visible impact on the performance criteria and metrics of interest, e.g., HFOT, waterwall heat flux distributions, NOx emissions, and unburned carbon in the fly ash. Overall, the CFD runs served to provide insight into the flow and reaction patterns of the lower furnace, as well as to provide relative changes in emissions and residual carbon values at the exit plane as a result of changes in operating conditions.

# **CFD Results and Conclusions**

The following computational results have been highlighted:

- The baseline case exhibits higher carbon-in-ash (by 1.6 percentage points), higher outlet NOx emissions (by a factor of 2), and higher outlet CO (by a factor of 2) than the Concept-B case. These same computational trends are also qualitatively exhibited by the bench-scale testing.
- The baseline case exhibits a slightly higher peak gas temperature (maximum difference of about 200 °F), and a correspondingly higher average (cross-sectional) gas temperature (difference of 90 °F at the HFOT), than that of the Concept-B case.
- The net wall absorption in the furnace region for the baseline case is larger (by less than 1%) than that of the Concept-B case. (Conversely, the net wall absorption for the baseline calculation with the RHBP was found to be about 6% lower than the Concept-B case calculated by the RHBP.)

Explanations for the observed trends must rely on physical property differences between the nitrogen, which dominates in the baseline case, and carbon dioxide, which largely supplants the nitrogen in the Concept-B case. The physical species properties and the anticipated consequences are itemized below:

- 1. <u>Higher molecular weight of CO<sub>2</sub> relative to N<sub>2</sub></u>. For equivalent inlet areas, and as a result of the molecular weight and associated density differences, the baseline case will exhibit larger inlet velocities and a higher penetration capability than the Concept-B case. The inlet velocity differences will further serve to impact the aerodynamic, particle trajectory, mixing, and flame patterns.
- 2. <u>Higher specific heat of  $CO_2$  relative to  $N_2$ </u>. For an equivalent local heat release and heat transfer, the higher specific heat of carbon dioxide will serve to decrease the overall flame temperatures of the recycled flue gas mixture in the Concept-B case, relative to the baseline case.
- 3. <u>Higher gas emissivity and absorptance of  $CO_2$  relative to  $N_2$ </u>. For an equivalent local gas temperature, the higher emissivity of  $CO_2$ , relative to the optically transparent  $N_2$ , should serve to increase the absorption coefficient (and the irradiation to the wall) in the recycled flue gas case (Concept-B) relative to the baseline case.

The three physical properties listed above may have compensatory rather than cumulative effects. In the present CFD calculations, the resultant, local gas temperatures are not equivalent in the two cases. The higher specific heat of the carbon dioxide, and the associated lower gas temperatures in the Concept-B case, will tend to offset somewhat or compensate for the expected increase in the wall absorption (i.e., anticipated due to the enhanced emissivity of the  $CO_2$ .) Furthermore, the spatial distribution of the carbon dioxide across the cross-section may be important; it is hypothesized that high concentrations of  $CO_2$  in the cooler gas mixtures between the wall and the flame may actually act to inhibit the net radiative flux to the walls.

The trend calculated by the CFD code, with respect to the furnace temperature at the HFOP, appears to be qualitatively aligned with the trend calculated by the in-house RHBP code. However, the difference in wall absorption for the Concept-B case relative to the baseline case, calculated by FLUENT<sup>M</sup> (change of -1%), does not fully agree with the results of the RHBP (change of +6%). Computed and/or experimental trends that indicate that oxy-firing may induce either an increase in wall absorption (+6%) or a decrease in wall absorption (-18%), relative to the baseline case, are supported in the literature. It is suggested that the absorptive properties of a local CO<sub>2</sub>-containing gas mixture in the vicinity of the wall may either act to enhance or inhibit the incident radiative flux to the wall, depending upon its relative spatial placement and mixture temperature. For example, a low-temperature, CO<sub>2</sub>-rich mixture near the wall would absorb the radiative flux from the interior "fireball" region; a portion of the energy would be re-emitted at the lower gas temperature, and the remainder of the energy would be used to heat up the gas. The result would be a net reduction in the incident radiative flux to the wall. Conversely, a high-temperature, CO<sub>2</sub>-rich mixture near the wall would emit at its local gas temperature, thus enhancing the incident radiative flux to the wall. Therefore, it is suggested that the relative spatial relationships of the cool and hot gas mixtures, the relative composition of the absorbing media, and the proximity of that media to the wall (as induced by the furnace and firing system aerodynamics), may significantly impact the gas-phase irradiation to the wall. Indeed, the aerodynamic and flame patterns that prevail in a given air-fired or oxy-fired furnace may conceivably have as strong an impact on the net wall absorption as the physical property differences themselves (gas-phase emissivity, specific heat, etc.)

The results of computational tools (such as CFD and the RHBP) should be viewed as being qualitative in nature, particularly when they are asked to produce calculations outside of the experience base for which they have been validated. Certainly, the gas-phase and particle-phase radiation property submodels could be enhanced in both codes, and the impact of spatial gradients (caused by the interleaving of hot and cool regions of varying CO<sub>2</sub> composition) on radiative wall flux needs to be investigated more fully. CFD computations have been utilized to gain a more in-depth qualitative understanding of aerodynamic and flame patterns in combustion systems, but have not yet been integrated into routine boiler design procedures. At the present time, the ALSTOM design standards are based upon the experience and expertise built into the RHBP and other design protocols, and those standards must be adhered to in any new design project in order to mitigate risk. Therefore, the results of the RHBP must be regarded as the default standard, both from an engineering experience viewpoint and from a rules-based design viewpoint. However, additional validation work needs to be done in order to confirm the trends for oxy-firing scenarios.

Although differences in physical properties of the transport gases (e.g., air-firing versus oxy-firing) may initially induce undesirable deviations from the performance goals of a field unit, the designer and engineer views such alterations as challenges rather than insurmountable obstacles. Much can be done in the way of operating condition optimization (e.g., spray and nozzle tilt), without major retrofits, to realign steam temperatures and wall absorptions with their desired, target values. Design parameters are often in conflict, and the intelligent designer must work to balance various parameters and operating conditions to achieve the desired outcome. The CFD work performed here was based on certain constraints to maintain equivalency for comparison purposes, which would not necessarily be the case in the field. For example, a potential decrease in furnace wall absorption of several percentage points could be nullified through manipulation of various operating parameters. If required, firing system retrofits and surface modifications could be performed to handle more severe decreases in absorption; certainly new unit design could easily accommodate any necessary alterations in design philosophy.

#### **Recommendations for Future Work**

There is, to the authors' knowledge, no fundamental coal combustion work being carried out elsewhere to determine the impact of coal nature in an oxy-fuel environment on unburned carbon and gaseous and particulate emissions. Hence, the following is recommended:

- Carry out a systematic coal fundamentals study concerning this field of endeavor. This study should be geared toward the creation of a database of information depicting the impact of coal nature (using coals of various rank coming from both domestic and international sources) when fired in an oxy-fuel environment on:
  - > Coal devolatilization and char oxidation kinetics, and unburned carbon emissions in the fly ash
  - Acid rain-related gaseous (NOx, SO<sub>2</sub>, and CO) emissions
  - > Air toxics, particularly mercury (Hg), volatile organic compounds (VOCs), and particulate emissions.
- Derive furnace heat transfer data from natural gas and coal firing in an oxy-fired pilot-scale furnace, which simulates the temperature/time history of a boiler. Use first the data from natural gas firing to validate the CFD code, without the complication of burning particles transiting the boiler. Apply the experience learned from modeling a natural gas-fired boiler to model the coal-fired boiler.

# 1.0 BACKGROUND/OBJECTIVES

ALSTOM Power Inc.'s Power Plant Laboratories led a team, which performed a study titled "Engineering Feasibility and Economics of  $CO_2$  Capture on an Existing Coal-Fired Power Plant," under the auspices of the OCDO and DOE NETL. The other team members were ABB Lummus Global Inc. and American Electric Power (AEP).

The overall objective of this project was to evaluate the technical feasibility and the economics of alternate  $CO_2$  capture and sequestration/use technologies for retrofitting an existing coal-fired power plant. Three alternate  $CO_2$  capture systems (see Section 3 of Volume I) were evaluated, with attention being given to the impact of such systems on an existing boiler, the auxiliary components of the boiler, the boiler and overall plant performance, and the power plant costs, including the cost of electricity.

The overall objective of this work segment was to provide critical technical information for evaluating one of the three retrofit technology options, namely "Coal Combustion in an  $O_2/CO_2$  Environment with  $CO_2$  Recycle." Specific objectives were two-fold: (1) bench-scale testing was to provide experimental combustion and emissions performance data on a specific Ohio coal under conditions where the fuel was to be burned in mixtures of  $CO_2$  and  $O_2$ ; and (2) a computational fluid dynamics (CFD) modeling effort was to utilize design and operating information from a commercial boiler burning Ohio coal in order to establish a calculation for the conventional burning of coal (in air), and then to evaluate performance in the same commercial unit for the burning of the same coal in mixtures of  $CO_2$  and  $O_2$ .

Bench-scale results provided surrogate combustion kinetics, NOx, CO, SO<sub>2</sub> and unburned carbon results on the coal that is presently burned in the Conesville Boilers Units #5 and 6 under conditions that represent conventional combustion (in air) and in various mixtures of  $CO_2$  and  $O_2$ . A knowledge of the actual combustion and emissions data from Conesville Unit #5 provided a means whereby the baseline bench-scale results in air were referenced and interpreted; in a sense, it allowed "calibration" of the bench-scale experimental facility to a given point of reference. Referencing the baseline bench-scale results to the actual furnace emissions data allowed a more accurate interpretation of the bench-scale results of the  $CO_2$ - $O_2$  mixtures and permitted a more reliable/extrapolation of how an actual retrofitted boiler would respond to the same  $CO_2$ - $O_2$  mixtures.

The completed literature survey, performed under an initial task of this project (Bozzuto, et al., 2000), indicated that no fundamental combustion performance had been carried out on any coal in  $CO_2/O_2$  media. Hence, the work scope provided first-of-a-kind information to the project. Information derivation and application was carried out as follows:

- First, bench-scale testing of the Conesville coal was carried out in both air (to provide baseline information) and in various mixtures of CO<sub>2</sub> and O<sub>2</sub>.
- A comparison of the information on combustion performance in air with information from ALSTOM's proprietary database permitted ALSTOM to select char oxidation kinetic parameters to be used on a surrogate basis during the calibration of the CFD cases.

# 2.0 BENCH-SCALE TESTING

# 2.1 Introductory Remarks

ALSTOM Power's DTFS-1 has been used extensively over the years to derive, among other things, the following information (Nsakala, et al., 1986; Nsakala, et al., 1991; Thornock, et al., 1993):

- High temperature volatile matter yields from coals over the whole ASTM rank spectrum and from various synthetic solid fuels (petroleum cokes, refused-derived fuels, process coal gasification chars, beneficiated coal-based fuels, etc.).
- Fuel nitrogen conversion from coals over the whole ASTM rank spectrum and from the same various synthetic solid fuels given above.
- Gasification and devolatilization kinetic parameters for coals over the whole ASTM rank spectrum and for the same various synthetic solid fuels given above.
- Oxidation kinetic parameters of chars prepared from coals over the whole ASTM rank spectrum and from the same various synthetic solid fuels given above.

This information is used, where appropriate, in conjunction with coal combustion modeling with CFD and other proprietary in-house codes for the purpose of predicting (principally) unburned carbon loss and NOx emissions in pulverized fuel fired utility power boilers.

# 2.2 Analysis of Test Coals

Tables 2.1 and 2.2 present the ASTM standard analyses and ash chemistries of coal samples from AEP's Conesville Unit #5 and Pittsburgh #8 seam. Both of these coal samples are typical of good Eastern US bituminous steaming coals, with fuel values (i.e., FC/VM ratios) of 1.4 and 1.3, respectively. Consistent with the majority of the coal samples from this geological province, they have high sulfur contents (2.4 and 3.5 lb<sub>m</sub> S/MMBtu, respectively). Their coal ashes are typical of "Eastern" coal ashes, in which the iron contents are greater than the sums of alkali and alkaline earth contents. Based on the commonly used ash slagging and fouling indices, in conjunction with ash contents and fusibility temperatures, these coal ashes have only medium potentials of slagging the boiler waterwall and convective pass. The plant personnel from Conesville Generating Station confirmed this behavior, with respect to their Unit #5.

The coal samples in Table 2.1 were size graded to 200x400 mesh. These size-graded materials (Table 2.3) were subsequently tested in the TGA and DTFS-1 equipment to determine their reactivities and unburned carbon emission propensities. It is important to note that the chemical compositions of these size fractions are comparatively consistent with those of the parent coal samples they were prepared from.

QUANTITY	CONESVILLE #5 COAL (byAb)		PITTSBURGH #8 COAL	
	As Rec'd	daf	As Rec'd	daf
Coal Properties				
Moisture	10.1		8.2	
Volatile Matter	32.7	41.6	34.8	43.9
Fixed Carbon (Diff.)	45.9	58.4	44.5	56.1
Ash	11.3		12.5	
	11.0		12.0	
Hvdroaen	4.3	5.5	3.9	4.9
Carbon	63.2	80.4	64.3	81.1
Sulfur	2.7	3.4	4.1	5.2
Nitrogen	1.3	1.7	1.2	1.5
Oxvaen (Diff.)	7.1	9.0	5.8	7.3
FC/VM	1.40		1.28	
Sulfur loading, lb.S/MMBtu	2.39		3.50	
0.				
HHV (Btu/lb.)	11293	14368.	11726	14787.
b. Ash/MMBtu	10.0		10.7	
HGI	50		63	
Ash Properties				
Fusibility Temperatures, (°F)				
<u>I.T.</u>	2125		2140	
<u>S.T.</u>	2140		2185	
н.т.	2165		2240	
F.T.	2180		2290	
Ash Comp., (Wt.%, Dry)				
SiO <sub>2</sub>	45.9		47.7	
Al <sub>2</sub> O <sub>3</sub>	21.7		19.9	
Fe <sub>2</sub> O <sub>3</sub>	20.4		22.9	
CaO	2.9		3.0	
MgO	0.9		0.7	
Na <sub>2</sub> O	0.9		0.6	
K <sub>2</sub> O	2.0		2.1	
TiO <sub>2</sub>	1.1		1.0	
P <sub>2</sub> O <sub>5</sub>	0.3		0.5	
SO₃	3.0		1.5	
MnO	0.1		0.1	
TOTAL	99.2		99.9	

# Table 2. 1: Standard ASTM Analysis of Test Coals

	Conesville Unit #5		Pittsburgh #8		
PARAMETER		Coal	Coal		
	Data		Data		
Fusibility Temperatures (°F)					
I.T.	2125		2140		
S.T.	2140		2185		
H.T.	2165		2240		
F.T.	2180		2290		
Composition, Wt.% (dry)					
SiO <sub>2</sub>	45.9		47.7		
Al <sub>2</sub> O <sub>3</sub>	21.7		19.9		
Fe <sub>2</sub> O <sub>3</sub>	20.4			22.9	
CaO	2.9		3.0		
MgO	0.9		0.7		
Na <sub>2</sub> O	0.9		0.6		
K <sub>2</sub> O	2.0		2.1		
TiO <sub>2</sub>	1.1		1.0		
P <sub>2</sub> O <sub>5</sub>	0.3		0.5		
SO3	3.0		1.5		
Total		99.1		99.9	
Coal Sulfur Content, Wt.% (dry)	3.0		4.4		
Ash Type	Eastern Bit.		Eastern Bit.		
Slagging Index Definition					
Bituminous Ash: $R_S = B/A^*S$					
Lignitic Ash: $R_{S}^{*} = [Max (H.T.)+4*Min(I.T.)]/5$					
Slagging Index & Potential	Index	Potential	Index	Potential	
Bituminous Ash: $R_s = B/A^*S$	1.18		1.88		
$R_S < 0.6 = Iow$					
0.6 <r<sub>s&lt;2.0 = medium</r<sub>					
2.0 <r<sub>s&lt;2.6 = high</r<sub>					
R <sub>s</sub> >2.6 = severe					
Lignitic Ash: R* <sub>S</sub> = [Max (H.T.)+4*Min(I.T.)]/5		Medium		Medium	
R <sub>s</sub> * > 2450 = low					
2250 <r<sub>s*&lt; 2450 = medium</r<sub>					
$2150 < R_s^* < 2250 = high$					
R <sub>s</sub> *<2100 = severe					
Fouling Index Definition					
Bituminous Ash: $R_F = B/A^*Na_2 O$					
Lignitic Ash, Na <sub>2</sub> O, when CaO+MgO+Fe <sub>2</sub> O <sub>3</sub> >20% (w/w)	TRUE		TRUE		
Lignitic Ash, Na <sub>2</sub> O, when CaO+MgO+Fe $_2O_3 < 20\%$ (w/w)					
Fouling Index & Potential	Index	Potential	Index	Potential	
Bituminous Ash: $R_F = B/A^*Na_2O$	0.36		0.26		
$R_{\rm F} < 0.2 = low$		Marilium		Maralium	
0.2 < R <sub>F</sub> < 0.5= medium		Medium		Medium	
$0.5 < R_F < 1.0 = high$		l			
R <sub>F</sub> >1.0 = severe		ļ			
Lignific Ash No.O. when Co.O. McO. Co. 000/ ( / )	0.9	L	0.6		
Lignitic Ash, Na <sub>2</sub> O, when CaO+MgO+Fe $_2O_3 > 20\%$ (w/w)	0.9		0.0		
$Na_2O < 3 = low to medium$					
3 <na<sub>2O &lt; 6 = high Na<sub>2</sub>O &gt; 6 = severe</na<sub>		ļ			
1420 2 0 - 367616					
			0.6		
	0.0				
Lignitic Ash, Na <sub>2</sub> O, when CaO+MgO+Fe <sub>2</sub> O <sub>3</sub> <20% (w/w)	0.9		0.0		
$Na_2O < 1.2 = low to medium$	0.9		0.0		
	0.9	-	0.0		

# Table 2. 2: Characteristics of Test Coal Ash Samples

	CONESVILLE	E #5 COAL	PITTSBURGH #8 COAL (200x400 Mesh)		
QUANTITY	(400x400	Mesh)			
	As Rec'd	daf	As Rec'd	daf	
Moisture	3.6		1.1		
Volatile Matter	36	41.6	38.2	44.2	
Fixed Carbon (Diff.)	50.5	58.4	48.1	55.8	
Ash	9.9		12.7		
Hydrogen	4.5	5.2	4.4	5.1	
Carbon	69.1	79.9	70.6	81.8	
Sulfur	3.1	3.6	5.2	6.1	
Nitrogen	1.4	1.6	1.3	1.5	
Oxygen (Diff.)	8.4	9.7	4.8	5.5	

# Table 2. 3: Proximate and Ultimate Analyses of Size Graded Coal Samples

# 2.3 Combustion Evaluation of Size-Graded Coal Samples

The coal samples, whose analyses are given in Table 2.3, were combustion tested in both a Thermo-Gravimetric Analysis (TGA) apparatus and a Drop Tube Furnace System-1 (DTFS-1). The equipment, experimental procedures, and conclusions are presented in the succeeding sections.

# 2.3.1 Thermo-Gravimetric Analysis (TGA)

The TGA apparatus, experimental procedure, and results are presented below.

# 2.3.1.1 TGA Description and Procedure

ALSTOM uses a Perkin-Elmer TGA Model 7 (Figure 2.1) to obtain specific reactivity parameters of fuels and limestones, among other things. The TGA is also used to derive the "micro-proximate" analyses of coals and coal chars, based on a test protocol developed in-house. Testing was conducted as follows. About 4-6 mg of sample was placed in the TGA sample pan. The sample amount was such that it distributed over the bottom of the pan almost as a monolayer, thus minimizing  $O_2$  mass transfer control phenomenon during combustion. Equal amounts of nitrogen (which serves to protect the balance) and air is allowed to pass through the reaction tube containing the coal sample. The temperature control mechanism is actuated, such that the heating rate is maintained at 10 °C/min from room temperature to the completion of combustion. Both weight loss and rate of rate of weight loss are monitored and recorded throughout the combustion process. The information from this testing is used, as shown in the next section, to derive combustion efficiency curves, and "pseudo" surface reaction kinetic parameters of the test coals as a function of reaction medium.

Three cases were evaluated for each coal. Fifty cc/min of  $N_2$  gas were admitted into the balance compartment to protect it from over-heating. The Base case consisted of burning the coal in 50 cc/min of air. The Constant Mass case consisted of burning the coal in an  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was maintained and the mass of  $N_2$  used in the Base case was replaced with an equal mass of  $CO_2$ . The Constant

Volume case consisted of burning the coal in  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was again maintained and the volume of N<sub>2</sub> used in the Base case was replaced with an equal volume of CO<sub>2</sub>.

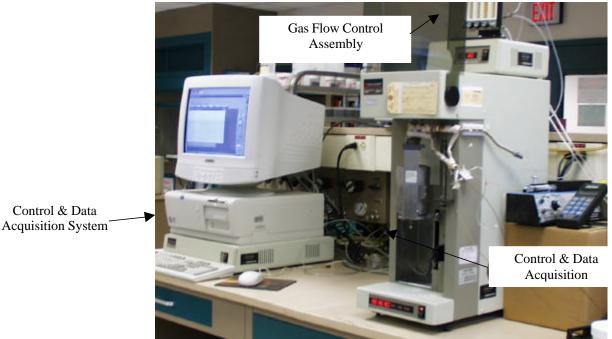


Figure 2.1.	Thermo-Gravimetric Analyzer	(TGA)
riguit 2.1.	Thermo-Orayinicule Analyzer	(IUA)

		Bala	ince		Combustion Air								Com	b.Med. (	Comp.	
Combustion		Cooli	ngN₂	Total	Air		2	N	2	с	02	Grand	Total		(Vol. %	.)
Medium	Case	(cc/min)	(g/min)	(cc/min)	(g/min)	(cc/min)	(g/min)	(cc/min)	(g/min)	(cc/min)	(g/min)	(cc/min)	(g/min)	N <sub>2</sub>	CO <sub>2</sub>	<b>O</b> <sub>2</sub>
Air	Baseline	50	0.0573	50	0.0592	10.5	0.01373	39.5	0.04524	0.0	0.0	100.0	0.1162	89.5		10.5
O <sub>2</sub> /CO <sub>2</sub> Mixture	Constant Mass	50	0.0573	0.0	0.0	10.5	0.01373	0.0	0.0	25.2	0.0452	85.7	0.1162	58.4	29.4	12.3
																<u> </u>
O <sub>2</sub> /CO <sub>2</sub> Mixture	Constant Volume	50	0.0573	0.0	0.0	10.5	0.01373	0.0	0.0	39.5	0.071	100.0	0.1420	50.0	39.5	10.5

All flow rates @ 25 °C & 1 atm.

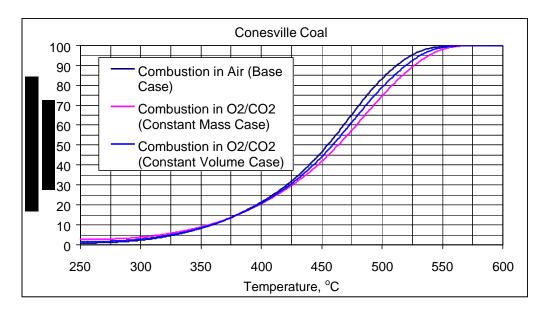
## 2.3.3.2 TGA Results

As stated in Section 2.2, the TGA evaluation was carried out on the 200x400-mesh samples identified in Table 2.3. Results from this evaluation are presented in Figures 2.2 to 2.4.

The combustion efficiency profiles, shown in Figure 2.2, indicate that some subtle differences seem to exist between coal firing in air and  $O_2/CO_2$  mediums. A close examination of the data, however, shows that these differences are within experimental error for this type of testing. The results further indicate that both coals have similar burning characteristics, as they both go to completion within the same temperature range (550-575 °C).

The differential thermo-gravimetric analysis profiles, derived from the first derivative of weight loss with time (i.e., -dW/dt) are shown in Figure 2.3. One of the parameters traditionally used to interpret these curves is the Tkp. This parameter is, by definition, the temperature at which maximum heat evolution or reaction rate occurs. The values for the Conesville Unit #5 coal range from 472 to 479 °C; the corresponding values for Pittsburgh #8 coal fall in the 462 to 479 °C range. Clearly, these numbers are in such a narrow range that it can be concluded that: (1) burning either of the coals in air or any of the  $O_2/CO_2$  mixture ratios used will produce virtually identical results; and (2) both coals have similar reactivity characteristics. These results are consistent with those reported in Figure 2.2.

The combustion efficiency curves in Figure 2.2 were used to derive first-order reaction kinetic parameters, assuming that the effects of  $O_2$  mass transfer in the fixed-bed TGA were minimal and could be neglected. Results are plotted in Figure 2.4 as logKs versus 1000/, where Ks is the "pseudo" surface reactivity rate parameter (sec<sup>-1</sup>), and T (°K) is the reaction temperature. These results are consistent with those reported in Figures 2.2 and 2.3.



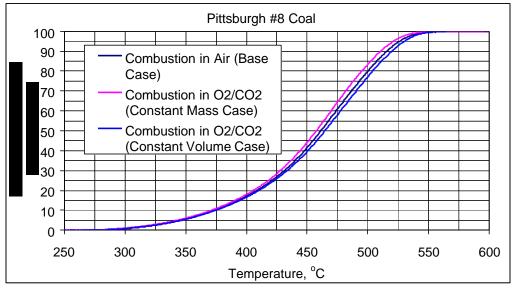
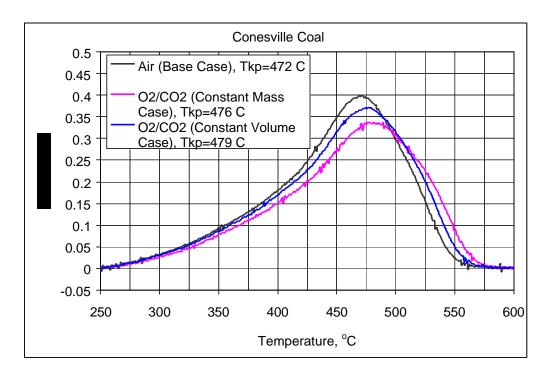


Figure 2.2: TGA Coal Combustion Efficiency Profiles



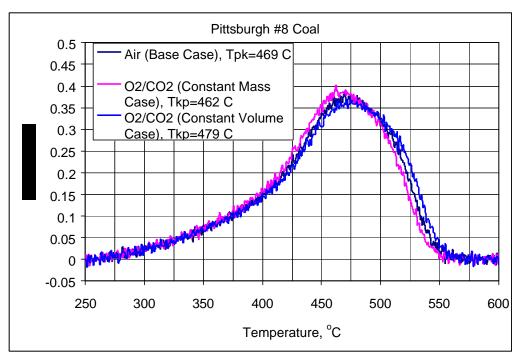
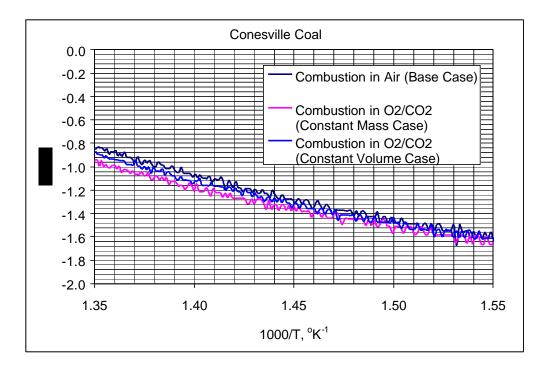


Figure 2. 3: Differential Thermo-Gravimetric Analysis Profiles



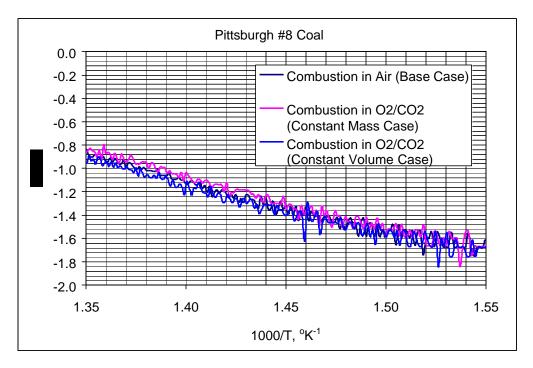


Figure 2.4: TGA Reaction Rates of Coal Samples

# 2.3.2 Drop Tube Furnace System-1 (DTFS-1) Testing

The test facility, testing procedures used, and results obtained therefrom are discussed in the following sections.

## 2.3.2.1 DTFS-1 Description and Testing Procedure

ALSTOM's Drop Tube Furnace System-1 (DTFS-1) (Figure 2.5) is comprised of a 1-inch inner diameter, horizontal tube, gas pre-heater and a 2-inch inner diameter, vertical tube, test furnace for providing controlled temperature conditions to study devolatilization, gasification and/or combustion phenomena. This entrained flow reactor, which is electrically heated with silicon carbide elements, is capable of heating reacting particles to temperatures of up to 2700 °F and sustaining particle residence times of up to about one second to simulate the suspension firing conditions encountered in pulverized coal-fired boilers.

The DTFS-1 testing procedure entails the following: (1) the fuel is fed at a precisely known rate through a water-cooled injector into the test furnace reaction zone; (2) the fuel and its carrier gas are allowed to rapidly mix with a pre-heated down-flowing secondary gas stream; (3) devolatilization, gasification, or combustion is allowed to occur for a specific time (dictated by the transit distance); (4) reactions are rapidly quenched by aspirating the mixture into a water-cooled sampling probe; (5) the solids are separated from gaseous products in a filter medium; and (6) an aliquot of the effluent gas stream is sent to a dedicated Gas Analysis System (GAS) for on-line determination of NOx, SO<sub>2</sub>, O<sub>2</sub>, CO<sub>2</sub>, CO, and THC (total hydrocarbons) concentrations. Minor gaseous components (HCN, NH<sub>1</sub>, CH<sub>1</sub>, VOCs, PAHs, etc.) can be measured, if required, with existing ancillary equipment (a gas chromatograph and / or a Fourier transform infrared spectrometer). A LabView-based data acquisition system records, on demand, all relevant test data for subsequent retrieval and processing. The LabView software package is also used to control the gas flow rates into the furnace.

An ash tracer technique (Nsakala, et al., 1977; Nsakala, et. Al., 1986) is used in conjunction with the proximate analyses of feed samples and chars subsequently generated in the DTFS-1 to calculate the devolatilization, gasification or combustion efficiency as a function of operational parameters (particle temperature, particle residence time, fuel fineness, reaction medium, etc.). A proprietary software package can, alternatively, use the information on concentrations of  $CO_2$ , CO, and THC (if available) in the effluent gas streams to calculate carbon conversion rates under prevailing conditions.

The DTFS-1 testing is normally used to derive quantitative information on the impact of various operating parameters such as particle size, stoichiometry and temperature/time history on unburned carbon loss and gaseous (NOx, CO and  $SO_2$ ) emissions.

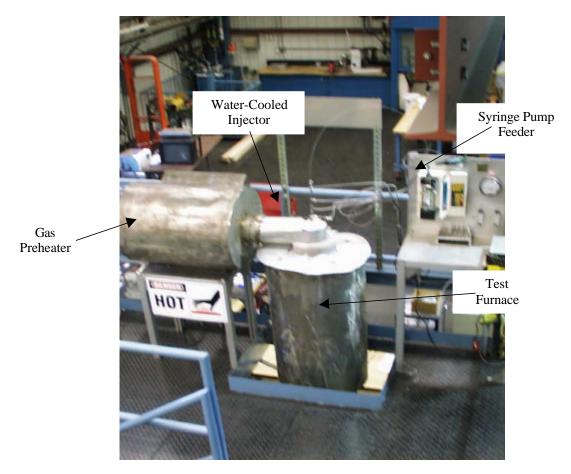


Figure 2.5: ALSTOM Power's Drop-Tube Furnace System-1 (DTFS-1)

Three cases were evaluated for each coal (Table 2.5). The Base case consisted of burning the coal in 15 l/min of air. The Constant Mass case consisted of burning the coal in an  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was maintained and the mass of  $N_2$  used in the Base case was replaced with an equal mass of  $CO_2$ . The Constant Volume case consisted of burning the coal in an  $O_2/CO_2$  mixture, such that the mass of  $O_2$  used in the Base case was again maintained and the volume of  $N_2$  used in the Base case was replaced with an equal volume of  $CO_2$ .

The rationale for selecting these three test cases is as follows. The Base case represents coal combustion in air, consistent with a "business as usual" scenario. The Constant Mass case represents a realistic scenario if coal were to be fired in an  $O_2$ /recycled flue gas environment. The Constant Volume case also represents coal combustion in an  $O_2$ /recycled flue gas environment, although in this case the  $CO_2$  volume is conserved vis-à-vis the  $N_2$  it would displace from the air. Table 2.5 shows that the total gas volumetric flow rates for the Constant Mass and Constant Volume cases are, respectively, lower than and equal to that of the Base case (10.7 l/min and 15.0 l/min versus 15.0 l/min, at 25 °C and 1 atm.). Hence, all other things being equal, the gas residence times in the furnace for the Constant Mass and Constant Volume cases would be, respectively, longer than and equal to the gas residence time for the Base case.

The coal feed rate was adjusted for each coal such that the overall stoichiometry (1) was ~2.50. This value is more than a factor of 2 higher than the typical value encountered in pulverized coal firing applications. It was known, from previous experience, that in order to achieve reasonably low unburned carbon emissions in the drop tube, it was necessary to conduct these experiments in such oxygen-rich environments. This mode of operation is necessitated for two principal reasons, namely: (1) the DTFS-1 operates in a laminar flow regime,

with a Reynolds number in the 150-225 range; and (2) the maximum residence time for the conditions evaluated was about 0.8 seconds.

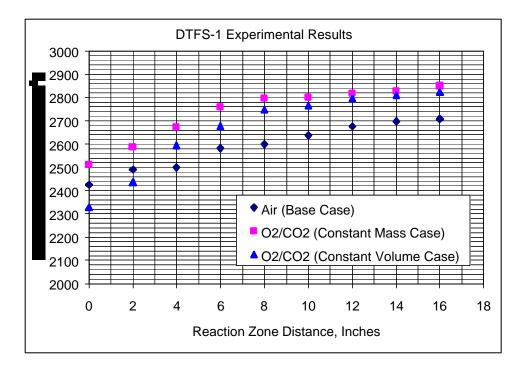
			Combustion Air								Overall	Com	b.Med. C	comp.	
Combustion		Tota	al Air		<b>O</b> <sub>2</sub>	N	k	с	O <sub>2</sub>	Grand	Total	Stoichiometry		(Vol. %)	
Medium	Case	(I/min)	(g/min)	(l/min)	(g/min)	(l/min)	(g/min)	(l/min)	(g/min)	(I/min)	(g/min)	(1)	N <sub>2</sub>	CO <sub>2</sub>	<b>O</b> <sub>2</sub>
Air	Baseline	15.00	17.76	3.15	4.12	11.85	13.57	0.00	0.00	15.00	17.69	2.5	79.0		21.0
O2/CO2 Mixture	Constant Mass	0.00	0.00	3.15	4.12	0.00	0.00	7.55	13.57	10.70	17.69	2.5		70.5	29.5
O <sub>2</sub> /CO <sub>2</sub> Mixture	Constant Volume	0.00	0.00	3.15	4.12	0.00	0.00	11.85	21.31	15.00	25.43	2.5		79.0	21.0

## Table 2. 5: DTFS-1 Test Matrix

All flow rates @ 25 °C & 1 atm.

## 2.3.2.2 Reactant Gas Temperature Measurements

A suction pyrometer was used to measure, for each of the three study cases, the gas temperature profile along the axis of the DTFS-1 reaction chamber. In addition to the in-furnace measurements, heat transfer calculations were performed for each case to predict the impact of the reactant gas characteristics on its temperature profile along the axis of the DTFS-1 reaction chamber. The predictions were based on the exact DTFS-1 operating conditions for the same three study cases. The measurements (Figure 2.6) indicate the following gas temperature profile trend:  $T_{Base case} < T_{Constant}$  volume case  $< T_{Constant Mass case}$ . The reason for this occurrence is that CO<sub>2</sub>, unlike N<sub>2</sub>, is capable of absorbing energy radiated from the furnace walls. CO<sub>2</sub> has a greater specific heat than N<sub>2</sub> (Figure 2.7), but as is evident from the Constant Mass case, the ability of the CO<sub>2</sub> to absorb/emit radiation dominates and causes the CO<sub>2</sub>-rich gas to achieve higher temperatures than the N<sub>2</sub>-rich case. The trends exhibited by the theoretical heat transfer model, developed to predict gas temperatures, supported those found experimentally (Figure 2.6).



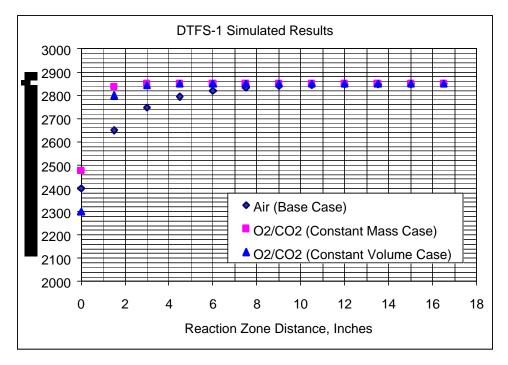


Figure 2.6: Measured and Predicted Gas Temperatures in the DTFS-1

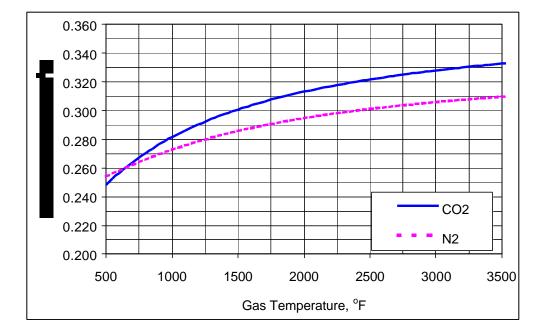


Figure 2.7: Specific Heats of Nitrogen and Carbon Dioxide as a Function of Temperature

It should be borne in mind that the heat transfer calculations were made only to validate the trends of the gas temperatures measured in the DTFS-1. No attempts were made to calibrate those calculations to the measurements.

When gas mass flow rates, temperatures, and furnace geometry are taken into consideration together the corresponding gas residence times (t) indicated the following trend:  $t_{Constant Volume case} < t_{Base case} < t_{Constant Mass case}$ . The impacts of these trends or lack thereof, on unburned carbon and gaseous emissions, will be discussed in Section 2.3.2.3.

# 2.3.2.3 Unburned Carbon and Gaseous Emission Results

It is important to reiterate at the outset (See Section 2.3.2.1) that: (1) the DTFS-1 is operated in a laminar flow regime, with a Reynolds number in the 150-225 range; and (2) the maximum residence time for the conditions evaluated was about 0.8 sec. Hence, in order to achieve reasonably low unburned carbon emissions at the furnace outlet, the DTFS-1 was operated at a rather high overall oxygen/fuel stoichiometric ratio (i.e.,  $\mathbf{1} \sim 2.5$  versus the typical value of ~1.2 encountered in pulverized coal firing applications). Consequently, the unburned carbon and gaseous emission results reported here should be interpreted strictly on a relative basis only, as no attempt was made to correlate them with field (i.e., Conesville Unit #5) performance results.

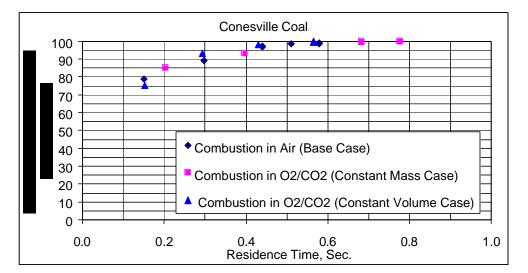
Table 2.6 summarizes the unburned carbon (UBC) results obtained from firing the coal samples from Conesville Unit #5 and Pittsburgh #8 seam under the three study cases discussed above. Figures 2.8 and 2.9 are plots of coal combustion efficiency and unburned carbon in fly ash as a function of gas residence time.

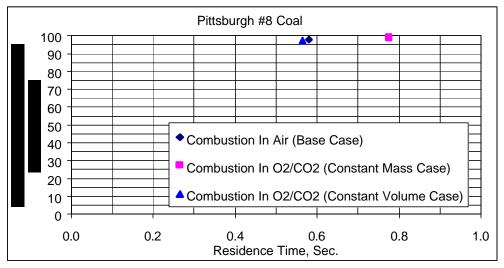
# Table 2. 6: Summary of DTFS-1 Test Results on Coal Combustion Efficiencies and Unburned Carbon in Fly Ashes

		Combustion in Air						
		Cone	sville Unit #5 Coal	Pittsb	urah #8 Seam Coal			
Reaction Zone Length (inches)	Gas Residence Time (sec)	UBC in Fly Ash (% dry)	Coal Combustion Efficiency (%daf)	UBC in Fly Ash (% dry)	Coal Combustion Efficiency (%daf)			
4	0.15	64.52	78.74					
8	0.30	47.70	89.18					
12	0.44	20.48	97.20					
12	0.44	22.71	96.90					
14	0.51	11.34	98.59					
16	0.58	8.47	99.00	12.53	87.55			
16	0.58	8.49	99.10					
16	0.58	9.58	98.70					

		Combustion in O <sub>2</sub> /CO <sub>2</sub> , Constant Mass Case					
		Cone	sville Unit #5 Coal	Pittsb	urah #8 Seam Coal		
Reaction Zone Length	Gas Residence Time	UBC in Fly Ash	Coal Combustion Efficiency	UBC in Fly Ash	Coal Combustion Efficiency		
(inches)	(sec)	(% drv)	(%daf)	(% drv)	(%daf)		
4	0.20	51.07	85.23				
8	0.40	39.13	93.01				
12							
14	0.68	3.41	99.63				
16	0.78	2.27	99.75	6.16	93.56		
16	0.78	1.92	99.81	7.23	92.90		

			Combustion in O2/CO2,	Constant Volume Case			
	Gas	Cone	sville Unit #5 Coal	Pittsb	urah #8 Seam Coal		
Reaction Zone Length	Gas Residence Time	UBC in Fly Ash	Coal Combustion Efficiency	UBC in Fly Ash	Coal Combustion Efficiency		
(inches)	(sec)	(% dry)	(%daf)	(% dry)	(%daf)		
4	0.15	66.61	75.32				
8	0.29	38.67	93.14				
12	0.43	16.05	98.00				
14							
16	0.57	1.23	99.91	16.05	84.33		
16	0.57	3.00	99.67				
16	0.57	5.29	99.64				





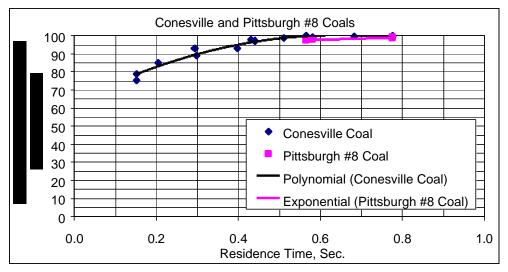
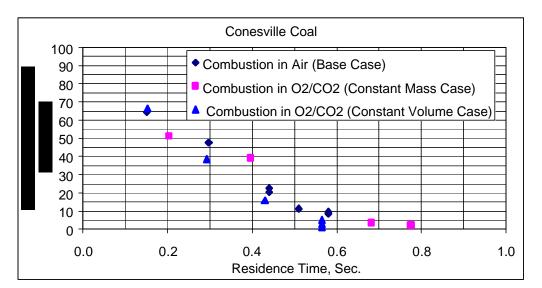
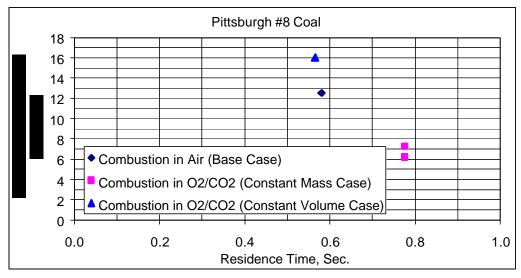
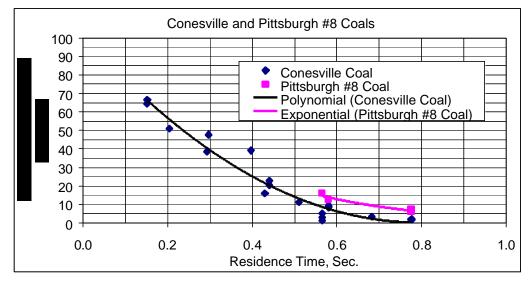


Figure 2.8: DTFS-1 Generated Coal Combustion Efficiency Profiles

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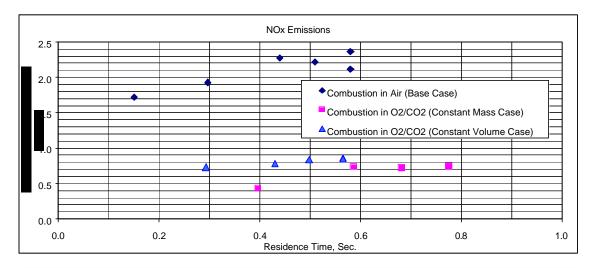
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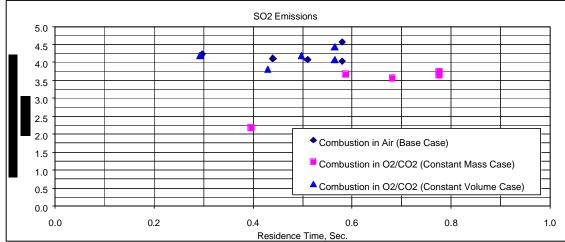
Figures 2.8 and 2.9 indicate that residence time has, as expected, a significant impact on the overall coal combustion efficiency, and hence, on the unburned carbon emission in the fly ash for both coals under consideration. That is, while the combustion efficiency for both coals is only about 80% (dry-ash-free coal basis) at 0.2 sec residence time, it is more than 98% at 0.8 sec. residence time. Correspondingly, unburned carbon emissions range from about 65% to less about 2% (dry fly ash basis) for the same residence times. The second point that can be made is that for the given thermal regime in the DTFS-1, the impact of reaction medium is significant. While the overall combustion efficiencies do not seem to exhibit significant differences between the baseline and Constant Mass firing, the more sensitive parameter, unburned carbon (UBC) in the fly ash, on the other hand, clearly shows better performance for the Constant Mass case. That is, the UBC at the furnace outlet was more than a factor of 4.5 lower for the Constant Mass case (~2% vs. 9%). This is believed to be due to higher reaction temperature, and yet longer residence by 35% (0.77 sec. vs. 0.57 sec.). It appears, from the shape of the UBC profiles, that, if given enough residence times, these differences would considerably narrow down. Finally, it appears that the coal sample from Conesville Unit #5 performs better than the sample from Pittsburgh #8 coal seam (e.g., 9% vs. 12.5% UBC for the air firing case). However, if given additional residence times, they would both be expected to perform similarly.

The ultimate conclusion is that unburned carbon emission for the Constant Mass case, which represents the appropriate retrofit scenario in a commercial pulverized coal firing application (i.e., the mass of  $CO_2$  in the  $O_2/CO_2$  combustion medium displaces the same mass of  $N_2$  in the combustion air), provides a significant advantage over air firing. This is, presumably, because of the relatively higher temperature, and yet longer combustion process time that the Constant Mass case provides.

Table 2.2.7 and Figure 2.10 show gaseous (NOx, CO, and SO<sub>2</sub>) emissions results obtained from burning the coal sample from Conesville Unit #5 in air and O<sub>2</sub>/CO<sub>2</sub> combustion mediums. These results indicate significant increases in NOx, slight increases in SO<sub>2</sub>, and significant decreases in CO emissions as a function of increasing residence time. This is due to, as expected, correspondingly improved overall coal combustion efficiency with time. The NOx emission reduction from air firing (Base case) to oxy-fuel firing (i.e., O<sub>2</sub>/CO<sub>2</sub> combustion mediums) is about a factor of 3 (0.73 vs. 2.25 lb/MMBtu). The trend is consistent with results reported by others (Thambimuthu, et al.; 1998; Weller, et al., 1985) and by the CFD results of the present study (Section 3.0, below). However, Thambimuthu, et al. and Weller, et al. reported reductions ranging up to only about 30%. Hence, it is not clear whether the superstoichiometry utilized in the present experiment ( $\lambda \sim 2.5$ ) exaggerates the difference. Sulfur dioxide for oxy-fuel firing is lower by about 19% than the corresponding value for air firing (3.6 vs. 4.3 lb/MMBtu). CO for oxy-fuel firing was lower than the corresponding values for air firing (0.09 lb/MMBtu vs. a negligible amount).

The ultimate conclusion from gaseous emission findings is that the Constant Mass case does seem to provide (1) a significant advantage over air firing, with respect to NOx and CO emissions; and (2) a slight advantage over air firing, with respect to  $SO_2$  emission.





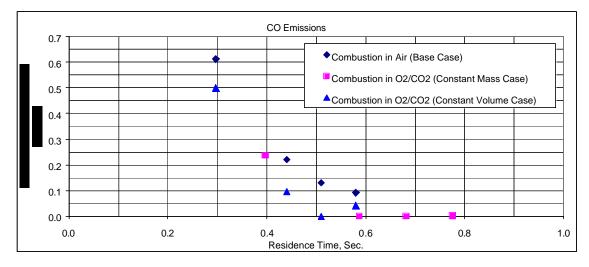


Figure 2. 10: DTFS-1 Generated NOx, CO and SO<sub>2</sub> Emissions

Reaction	Gas	Combustion in Air						
Zone	Residence	UBC	Coal					
Length	Time	in Fly Ash	Comb. Eff.	NOx	SO <sub>2</sub>	CO		
(inches)	(sec)	(% dry)	(%daf)	(lb/MMBtu)	(lb/MMBtu)	(lb/MMBtu)		
4	0.15	64.52	78.74	1.72	4.56			
8	0.30	47.70	89.18	1.93	4.22	0.61		
12	0.44	20.48	97.20			0.22		
12	0.44	22.71	96.90	2.27	4.11			
14	0.51	11.34	98.59	2.22	4.08			
16	0.58	8.47	99.00	2.36	4.57	0.13		
16	0.58	8.49	99.10	2.11	4.04	0.09		
16	0.58	9.58	98.70					

# Table 2. 7: Summary of DTFS-1 Test Results on Gaseous emissions from Conesville Unit #5 Coal Combustion

Reaction	Gas	С	Combustion in O <sub>2</sub> /CO <sub>2</sub> , Constant Mass Case						
Zone	Residence	UBC	Coal						
Length	Time	in Fly Ash	Comb. Eff.	NOx	SO <sub>2</sub>	CO			
(inches)	(sec)	(% dry)	(%daf)	(lb/MMBtu)	(lb/MMBtu)	(lb/MMBtu)			
4	0.20	51.07	85.23			0.54			
8	0.40	39.13	93.01	0.43	2.17	0.24			
12				0.74	3.67				
14	0.68	3.41	99.63	0.72	3.56	0.00			
16	0.78	2.27	99.75	0.73	3.63	0.00			
16	0.78	1.92	99.81		3.74				

Reaction	Gas	Co	Combustion in $O_2/CO_2$ , Constant Volume Case						
Zone Length	Residence Time	UBC in Fly Ash	Coal Comb. Eff.	NOx	SO <sub>2</sub>	со			
(inches)	(sec)	(% dry)	(%daf)	(lb/MMBtu)	(lb/MMBtu)	(lb/MMBtu)			
4	0.15	66.61	75.32						
8	0.29	38.67	93.14	0.73	4.19	0.50			
12	0.43	16.05	98.00	0.78	3.82	0.10			
14				0.84	4.18	0.00			
16	0.57	1.23	99.91	0.85	4.08	0.04			
16	0.57	3.00	99.67		4.43				
16	0.57	5.29	99.64						

# 2.3.3 Conclusions and Recommendations for Future Work

The conclusions and recommendations that were derived from this bench-scale testing campaign are given below.

## 2.3.3.1 Conclusions

A series of conclusions can be drawn from the results from combustion testing of the coal samples from Conesville Unit #5 and Pittsburgh #8 seam in both TGA and DTFS-1 equipment, namely:

- TGA results indicate that subtle differences exist between: (1) coal firing in air and in O<sub>2</sub>/CO<sub>2</sub> mediums; and (2) Conesville Unit #5 coal and Pittsburgh Seam #8 coal. A close examination of the data, however, indicates that these differences are within experimental errors. Hence, it can be concluded that both coals can be expected to perform similarly under the experimental constraints specified in this study.
- DTFS-1 results showed the following:
  - Residence time has, as expected, a significant impact on the overall coal combustion efficiency, and hence, on the unburned carbon emission in the fly ash for both coals under consideration. That is, while the combustion efficiency for both coals is only about 80% (dry-ash-free coal basis) at 0.2 sec residence time, it is more than 98% at greater than 0.5 sec. residence times. Correspondingly, unburned carbon emissions range from about 65% to less about 2% (dry fly ash basis) for the same residence times.
  - The impact of reaction medium is also significant. While the overall combustion efficiencies do not seem to exhibit significant differences between the baseline and Constant Mass firing, the more sensitive parameter, unburned carbon (UBC) in the fly ash, on the other hand, clearly shows better performance for the Constant Mass case. That is, the UBC at the furnace outlet was more than a factor of 4.5 lower for the Constant Mass case (~2% vs. 9%). This is believed to be due to higher reaction temperature, and yet longer residence (0.77 sec. vs. 0.57 sec.). It appears, from the shape of the UBC profiles, that, if given enough residence times, these differences would considerably narrow down, implying that the performance in both mediums would be similar.
  - The coal sample from Conesville Unit #5 appears to perform better than the sample from Pittsburgh seam #8 coal (e.g., 9% vs. 12.5% UBC for the air firing case). However, base on the shape of the UBC profiles, it can be seen that if given additional residence times, they would both be expected to perform similarly.
  - NOx emission from oxy-fuel firing is about a factor of ~3 (0.73 vs. 2.25 lb/MMBtu) lower than that of Base case. Correspondingly, sulfur dioxide is lower by about 19% (3.6 vs. 4.3 lb/MMBtu), and CO is significantly lower (0.09 lb/MMBtu vs. a negligible amount).
  - The gaseous emission trends are consistent with results reported by others (Thambimuthu, et al.; 1998; Weller, et al., 1985) and by the CFD results of the present study (Section 3.0, below).

#### 2.3.3.2 Recommendations for Future Work

There is, to the authors' knowledge, no fundamental coal combustion work being carried out elsewhere to determine the impact of coal nature in an oxy-fuel environment on unburned carbon and gaseous and particulate emissions. Hence, the following is recommended:

- Carry out a systematic coal fundamentals study concerning this field of endeavor. This study should be geared toward the creation of a database of information depicting the impact of coal nature (using coals of various rank coming from both domestic and international sources) when fired in an oxy-fuel environment on:
  - > Coal devolatilization and char oxidation kinetics, and unburned carbon emissions in the fly ash

- Acid rain-related gaseous (NOx, SO<sub>2</sub>, and CO) emissions
- > Air toxics, particularly mercury (Hg), volatile organic compounds (VOCs), and particulate emissions.
- Derive furnace heat transfer data from natural gas and coal firing in a pilot-scale furnace, which simulates the temperature/time history of a boiler. Use first the data from natural gas firing to validate the CFD code, without the complication of burning particles transiting the boiler. Apply the experience learned from modeling a natural gas flame to model the coal-fired flame.

# 3.0 CFD Evaluation Of Conesville Boiler No. 5

## 3.1 Introduction

ALSTOM Power has made a strong commitment to computational fluid dynamics (CFD) and has effectively used CFD in many applications, e.g., design and optimization of coal-, oil-, and gas-fired boilers, pulverizers, air heaters, electrostatic precipitators, cyclones, and scrubbers. At any given time, there are 8 to 10 individuals performing CFD simulations on approximately 40 CPU's, including both workstations and multi-processor servers.

With respect to boiler performance, significant CFD and combustion modeling research efforts have been conducted at ALSTOM Power to characterize and optimize the performance of tangentially-fired and wall-fired furnaces. These projects have demonstrated the impact of fluid dynamics, gas phase stoichiometry, and heat input on the combustion efficiency and boiler emissions for a variety of commercial boiler applications. Synopses of recent studies that have been permitted to enter the public domain include the prediction of furnace gas temperatures and species concentrations for NOx reduction with recirculated flue gas (Richards, et al., 1997), furnace waterwall species concentrations for improvement to deposition and slagging performance (Hart, et al., 1998), and design of a low NOx burner (Haynes, et al., 1996). (Overview papers on CFD at ALSTOM Power include Marion, et al., 1995 and Fiveland, 2000.)

CFD modeling is considered to be the most cost-effective approach to assess flow and mixing related phenomena for reacting flow conditions, and was therefore proposed for this work.

# 3.2 Grid Preparation

American Electric Power's Conesville Unit #5 boiler has been described in detail in Volume I of this report (Bozzuto, et al., 2001); however, certain features will be reviewed below to introduce the grid and case preparation.

In general, the Conesville unit can be described as a nominal 450 MW-gross, tangentially coal fired, subcritical pressure, controlled circulation, radiant reheat unit. The furnace is a single cell design utilizing five elevations of tilting tangential coal burners. The unit fires a mid-western bituminous coal. The coal is supplied to the five elevations with five RP-903 coal pulverizers. The unit is designed to generate about  $3.1 \times 10^6$  lbm/hr of steam at 2400 psi and 1005 °F with reheat also to 1005 °F. The boiler is equipped with a number of superheater surfaces, including a low temperature superheater (horizontal), finishing superheater, a radiant superheat division panel section, and the superheater platen section. The reheater consists of a low temperature radiant wall section followed by a spaced finishing section. The economizer section consists of four banks of spiral finned tubes. Outlet steam temperature control is provided with desuperheating spray and burner tilt. The dimensions of the boiler unit are 51' 8" in width, 44' 3-15/16" in depth (to the rear wall), and 170' 10-1/4" in height. A sectional side view of this boiler is shown in Figure 3.1.

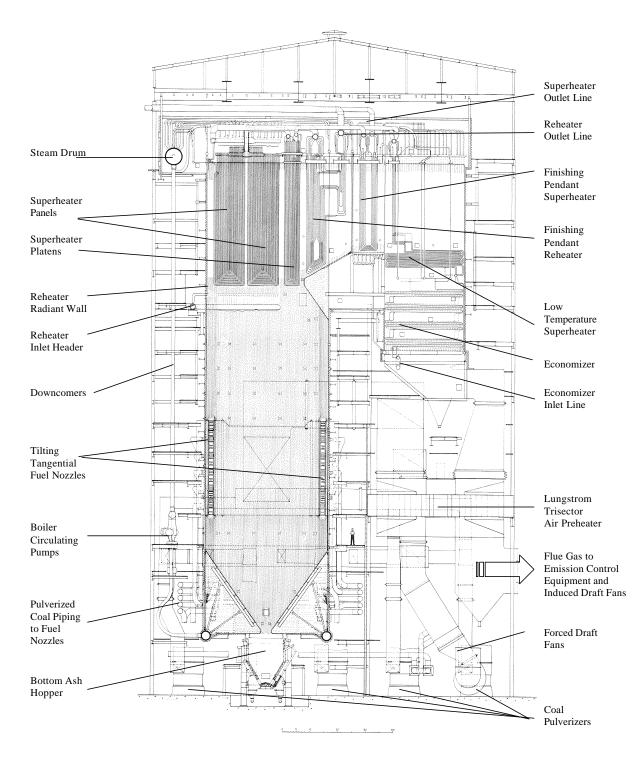


Figure 3.1: Sectional Side View of the Conesville Unit #5 Steam Generator

ALSTOM Power uses a commercial CFD code (denoted FLUENT<sup>™</sup>) from Fluent Inc. (Lebanon, NH) for its simulations of furnaces and auxiliary equipment. Case preparation of a boiler for the Fluent code is initiated with the collection of the geometry data (from blueprints and schematics), the free areas of the nozzles, and the operating conditions. A CFD grid or mesh is prepared using a combination of EXCEL spreadsheets and a grid-generation package (denoted GAMBIT<sup>™</sup>) supplied by Fluent Inc. Skeletal and external isometric views of the computational domain are shown in Figure 3.2.

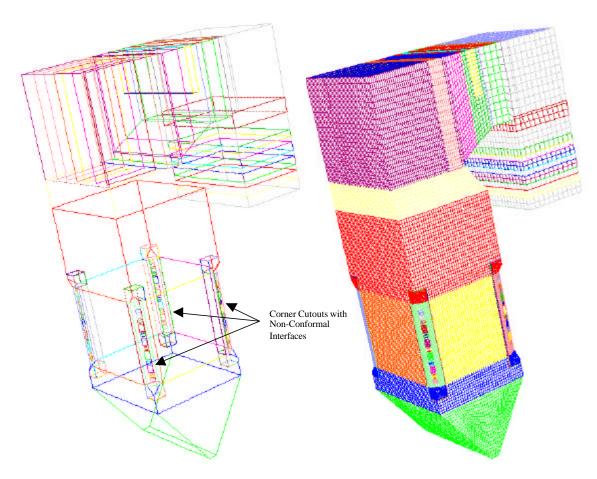


Figure 3.2: Isometric Views of the Conesville Unit #5 Computational Domain

The framework or skeletal view above shows square cutouts in the corners that encompass the windboxes. These square cutouts contain cells that are smaller (by a factor of 2 in each coordinate direction) than the cells in the interior of the domain, thus allowing the windbox region to receive a greater concentration of cells than in the interior. The enhanced cell concentration in the windbox region permits greater resolution of the relatively small nozzle openings and the high gradient regions associated with discrete jets. The interfaces between each of the corner cutouts and the domain interior are referred to (by Fluent Inc.) as "non-conformal" interfaces. Such interfaces permit grids of dissimilar type and size to seamlessly interact with each other along any given plane and preserve the conservation of all relevant quantities (e.g., mass, momentum, and energy).

Close-ups of the grid from a side view of the boiler are shown in Figure 3.3. Besides the non-conformal interfaces around the windboxes, another non-conformal grid interface is utilized in the convective pass, permitting the grid to coarsen (by a factor of 2 in each coordinate direction) into the backpass. The grid in the computational domain is composed primarily of hexahedral elements. Tetrahedral elements are utilized only at the top and bottom of the windbox to assist in a geometric transition. Pyramidal elements are used at the interface between the tetrahedrons and the hexahedrons. The total number of cells in the grid is 314,176.

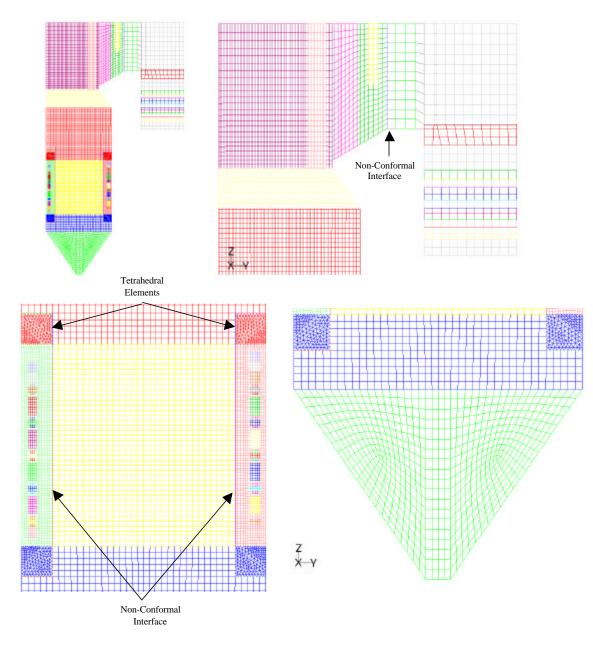
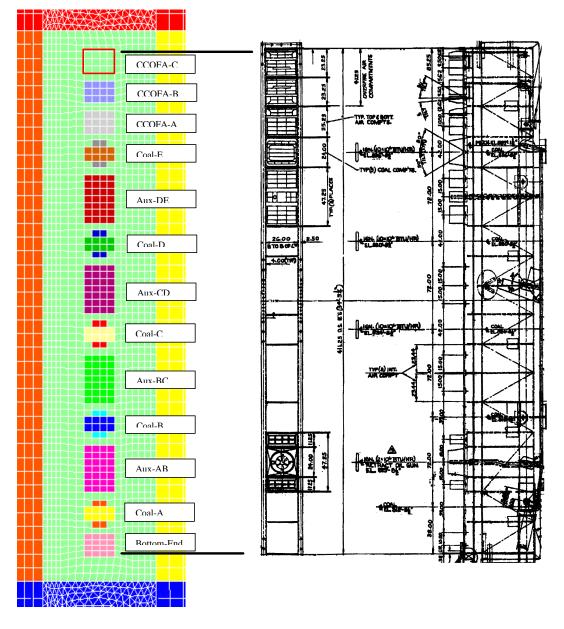


Figure 3. 3: Side Views of the Conesville Unit #5 Exterior Grid

Conesville Unit No. 5 is equipped with a tangential firing system, consisting of 3 close-coupled overfire air (CCOFA) register elevations, and 5 coal nozzle elevations. The main and CCOFA windbox widths are equal to 26 inches and the coal nozzle ID is equal to 19.25 inches. The tip/nozzle free areas were extracted from the firing system windbox selection sheets and the nozzle elevations were calculated from the available blueprints. A computational representation of the windbox and nozzles, which is necessarily crude in comparison to the details of the actual hardware, is shown in Figure 3.4. The computational inlet designations (i.e., CCOFA-C, etc.) are also shown. The small inlets on the top and bottom of each computational coal nozzle represent the flow area associated with the fuel-air stream, which in actuality, flows into the furnace around the periphery of the primary coal pipe/tip.



# Figure 3.4: Detailed Drawing of Windbox and Corresponding Side View of Grid Depicting Nozzle Openings

The direction of swirl rotation in Conesville Unit 5 (as viewed from the top of the boiler), is shown below in Figure 3.5. The direction of the "fireball rotation" is counter-clockwise. The normal firing angles are at 44 degrees and at 36 degrees for the pairs of opposed jets.

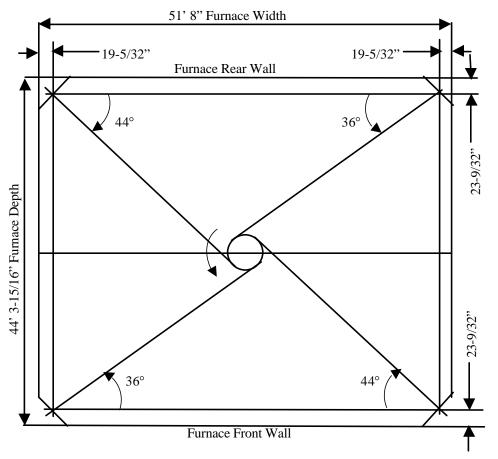


Figure 3. 5: Cross-Sectional View of Normal Firing Angles for Conesville Unit 5

The corresponding grid on the cross-section, in the vicinity of the windbox, is shown in Figure 3.6. As explained before, a 2:1 change in cell dimension occurs across the non-conformal interface in the windbox region, thus allowing a greater grid density to be concentrated in the immediate vicinity of the nozzle inlets. The grid in the windbox region consists of hexahedral cells, although they may be slightly skewed to accommodate the corner fillets (comprising the windbox).

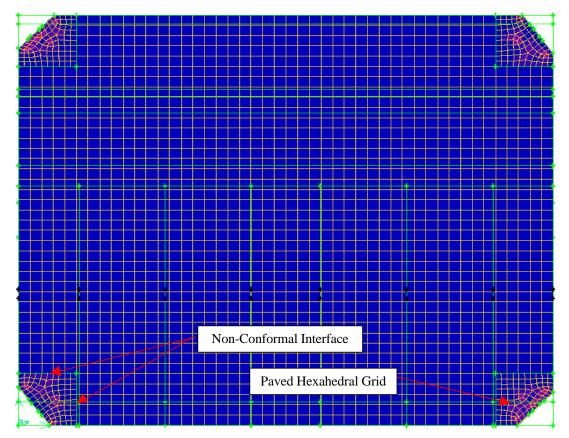


Figure 3. 6: Cross-Sectional View of Grid, in the Vicinity of the Windbox, for Conesville Unit 5

# 3.3 Baseline Calibration Procedure and Strategy

Typically, in an applications project, as in the present study, the first CFD case that is prepared and run is used to evaluate the furnace performance under its baseline combustion conditions. Many of the boundary conditions, such as velocity and temperature, constitute "explicit" boundary conditions and are defined as part of the input. However, a few boundary conditions (or equality constraints) are "implicitly" defined and are derived either from experimental measurements or external calculations. While "implicit" boundary conditions are not explicitly defined as inputs, it is understood that such boundary conditions must nevertheless be matched by the post-run results. Such "implicit" boundary conditions include:

- the unburned carbon (UBC) in the fly ash (i.e., carbon-in-ash value) at the outlet of the computational domain
- the outlet NOx emissions value at the outlet of the computational domain
- the "horizontal furnace outlet temperature (HFOT)," which is the mass-weighted average temperature across the plane at the apex of the arch (i.e. the horizontal furnace outlet plane or HFOP).

Both the UBC and NOx emissions values originate from experimental measurements (usually taken downstream of the air preheater). The HFOT value is calculated by an in-house, proprietary design package denoted the Reheat Boiler Program (RHBP). The Reheat Boiler Program, running in its reverse/calibration mode, is fed the excess air, windbox nozzle tilts, all known steam-side parameters, the fuel flow rate, and other general and geometric parameters, and in turn, calculates the HFOT (as well as the wall heat transfer fouling factors, the tube bank surface effectiveness factors, the gas flow rates, and the amount of superheat/reheat spray, if applicable).

In the CFD calculation, the char oxidation input parameters control the final amount of residual carbon in the fly ash, the NOx kinetic input parameters largely control the outlet NOx values, and the overall resistance to heat transfer through the waterwall and superheater surfaces and deposits controls the HFOT. An iterative trial-and-error method is used to calibrate the baseline case by changing the input parameters for char oxidation, NOx, and waterwall conduction resistance, until (after a number of runs) the code calculations match the desired UBC, the NOx value, and the HFOT, respectively. Such an iterative procedure for calibration is required since many of the input parameters and boundary conditions are not known with sufficient accuracy to be specified in an *a priori* manner, and calibration tends to compensate for the accrued uncertainty.

In the present study, the above procedure was used to calibrate the baseline case to the desired UBC (as dictated by experimental field data) and to the desired HFOT (as dictated by the RHBP results). Since the CFD code (i.e., the FLUENT<sup>TM</sup> code) did not provide sufficient access to the NOx kinetic parameters, the calculated baseline NOx results were scaled to the baseline experimental values.

# 3.4 CFD Test Matrix

Two main cases were analyzed in this CFD modeling study. The scope of the modeling work consisted of the baseline case and one subsequent case entailing oxy-firing (i.e., firing the coal in  $O_2$ - and  $CO_2$ -rich recycled flue gas. A description of each of the cases is provided in Table 3.1.

Case	Case Description	Nominal Inlet O <sub>2</sub> Mole Percent (Dry)	Nominal Inlet CO <sub>2</sub> Mole Percent (Dry)	Nominal Inlet N <sub>2</sub> Mole Percent (Dry)
1	Base Case: Nominally 15% Excess Air	21	0	79
2	Concept B Case: FGR / Oxy-Firing	29	65	6

Table 3. 1: Matrix of CFD Cases

Case 1 is the Base case or baseline case, which corresponds to a nominal 15% excess air and maximum continuous rating (MCR) load conditions. As discussed above, specific input parameters have been iteratively modified until calibration with the selected implicit boundary conditions was achieved to a reasonable approximation.

The FLUENT<sup>TM</sup> code, calibrated with the baseline combustion conditions, was subsequently used to evaluate the impact of oxy-firing the coal, with a prescribed  $CO_2/O_2$  mole ratio. In comparison with the baseline run (Case 1), the Concept-B case (Case 2) displaces the mass of  $N_2$  by an equivalent mass of  $CO_2$  (approximately). Since the molecular weight of  $CO_2$  is greater than that of  $N_2$  by a factor of approximately 1.57, the density of  $CO_2$  will be correspondingly greater than that of  $N_2$ , and the velocity of the recirculated flue gas streams through the windbox nozzles will therefore be smaller (by, e.g., 36% for pure streams) than that of the baseline case (for the same nozzle free area). Based on the presumption that windbox retrofits should not be required in any application of the proposed advanced FGR technology, a decision was made to preserve the same (computational) inlet nozzle area for both cases; therefore, both cases were compared on an equivalent inlet-area basis, rather than on an equivalent inlet-velocity basis.

Lateral and vertical waterwall heat flux or absorption distributions, as well as the overall heat transfer in the lower and upper furnace, have been extracted from the CFD calculations. Total and sectional (area-weighted) waterwall heat absorption rates, in addition to peak heat absorption values, have been used to quantify the heat absorption rates that constitute one of the metrics used as a basis of comparison between the cases. Metrics utilized to compare the cases include:

- the unburned carbon (UBC) in the fly ash at the outlet of the computational domain
- the outlet NOx emissions value at the outlet of the computational domain
- the horizontal (and/or vertical) furnace outlet temperature(s) (FOT)
- the outlet CO emissions value at the outlet of the computational domain
- total, sectional, and peak waterwall heat flux or absorption rates

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Some of the metrics for the two cases, such as NOx, will be compared on a basis that is scaled or referenced to the baseline value, since relative trends may be a more reliable indicator of the expected performance than the absolute magnitudes of the metrics. Line and contour plots for variables of interest will be shown at selected horizontal or vertical planes, as appropriate.

The predictions provide a relative indication of the changes that may occur as a result of deviation from the baseline operating conditions. The difference in inlet nozzle velocities, mixture specific heats, and radiative properties between  $CO_2$  and  $N_2$  have an impact on the performance criteria and metrics of interest, e.g., HFOT, waterwall heat flux distributions, NOx emissions, and unburned carbon in the fly ash. Overall, the CFD runs serve to provide insight into the flow and reaction patterns of the lower furnace, as well as to provide relative changes in emissions and residual carbon values at the exit plane as a result of changes in operating conditions.

# 3.5 Input and Boundary Conditions

The case selected as the "Base case" is not strictly a replication of the experimental test data at one operating condition of the Conesville Unit No. 5. Rather, the Base case is defined as being a composite case which is representative of the available control room or board data over multiple test days. The board data encompasses variations in excess air conditions (14.1% to 18.1%), tilts, and burners designated as being out of service (BOOS)). From the array of operating conditions available in the board data, specific operating parameters were selected, which collectively constituted the "Base case" operating conditions. A RHBP simulation of the selected Base case test conditions helped to further delineate and refine some of the operating condition parameters.

Based on the project goals and requirements for flue gas recirculation and oxy-firing, the operating conditions of the Concept-B case were also subsequently defined. A RHBP run was conducted to study and evaluate the Concept-B case.

The mass flow rates, excess air conditions, inlet temperatures, tilts, etc. calculated in the RHBP runs were utilized directly in the CFD runs. A summary of the overall input parameters applied to the two cases are shown in Table 3.2.

	Base Case	Comport D Cogo	
Parameters	(15% Excess Air)	Concept B Case (Oxy-Firing)	
	(	(- <b>,</b> 8/	
Total Secondary Gas $(lb_m/hr) =$	2,968,935	2,933,877	
Total Primary Gas (lb <sub>m</sub> /hr) =	724,580	671,503	
Total Gas (lb <sub>m</sub> /hr) =	3,693,515	3,605,380	
Total (As Rec'd) Coal $(lb_m/hr) =$	374,455	366,603	
Total (Moisture-Free) Coal $(lb_m/hr) =$	336,635	329,576	
Total (DAF) Coal (lb <sub>m</sub> /hr) =	294,322	288,150	
$O_2$ :Coal Feed Ratio (by Mass) =	2.253	2.251	
% Excess $O_2$ (by Mass) =	13.75	13.64	
For Complete Combustion:			
% Exit O <sub>2</sub> (by Volume, Dry) =	2.594	3.599	
% Exit $O_2$ (by Volume, Wet) =	2.351	3.083	
% Exit $O_2$ (by Mass, Dry) =	2.687	2.698	
% Exit $O_2$ (by Mass, Wet) =	2.534	2.520	

# Table 3. 2: Overall Mass Flow Rate Parameters

As shown in the above table, the primary criterion used to put the two cases on an equivalent basis for comparison purposes was the oxygen-to-coal ratio (by mass), designated to be approximately 2.252. Additional input parameters, including the inlet gas composition, are provided in Table 3.3.

Parameters	Base Case (15% Excess Air)	Concept B Case (Oxy-Firing)
r al ameters	(15 % Excess All)	(Oxy-Filling)
Primary Gas Mass Fraction:		
N <sub>2</sub>	75.872	3.967
$O_2$	22.845	2.627
H <sub>2</sub> O	1.283	2.867
$CO_2$	0.000	90.513
SO <sub>2</sub>	0.000	0.026
Secondary Gas Mass Fraction:		
• N <sub>2</sub>	75.872	4.011
0 <sub>2</sub>	22.845	27.528
H <sub>2</sub> O	1.283	2.115
$CO_2$	0.000	66.327
SO <sub>2</sub>	0.000	0.019
Inlet Primary Gas Temperature (°F)=	156	140
Inlet Secondary Gas Temperature ( $^{\circ}F$ ) =	614	552
Inter Secondary Gas Temperature (T)-		
Nozzle Tilt (Degrees)=	-10	-10

# Table 3. 3: Overall Gas Property and Input Parameters

The same coal composition for the mid-western bituminous fuel was utilized for both cases and is shown in Table 3.4.

Coal Ultimate Analysis		Coal Proximate Analysis		
	As-Received Basis (Weight %)		As-Received Basis (Weight %)	
Carbon	63.2			
Hydrogen	4.3			
Nitrogen	1.3			
Sulfur	2.7	Volatile Matter	32.7	
Oxygen	7.1	Fixed Carbon	45.9	
Moisture	10.1	Moisture	10.1	
Ash	11.3	Ash	11.3	
Total	100.0	Total	100.0	
Higher He	Higher Heating Value (Btu/lb <sub>m</sub> ) =		(As-Rec'd Basis)	

# Table 3. 4: Coal Composition and Heating Value

The mass flow rates for the secondary gas feed streams are shown in Table 3.5.

		Base Case (15% Excess Air)		Concept B Case (Oxy-Firing)	
Compartment /	Damper	Mass	Average	Mass	Average
Nozzle	Position	Flow Rate	Velocity	Flow Rate	Velocity
Name	(% Open)	(lb <sub>m</sub> /hr/elev)	(ft/s)	(lb <sub>m</sub> /hr/elev)	(ft/s)
				_	
CCOFA-C	0.0	74,671	48.1	73,789	33.8
CCOFA-B	49.7	286,760	184.8	283,374	130.0
Top Air / CCOFA-A	20.0	121,270	72.2	119,838	50.8
Coal-E (Fuel-Air)	60.0	108,016	217.7	106,741	153.1
Aux Air DE	33.0	412,925	115.0	408,049	80.9
Coal-D (Fuel-Air)	60.0	108,016	217.7	106,741	153.1
Aux Air CD	33.0	412,925	115.0	408,049	80.9
Coal-C (Fuel-Air)	60.0	108,016	217.7	106,741	153.1
Aux Air BC	33.0	412,925	115.0	408,049	80.9
Coal B (Fuel-Air)	60.0	108,016	217.7	106,741	153.1
Aux Air AB	33.0	397,744	115.0	393,048	80.9
Coal A (Fuel-Air)	0.0	23,874	48.1	23,593	33.8
Bottom-End Air	70.0	393,774	234.6	389,124	165.0
			% of		% of
Totals:			Total Gas		Total Gas
Total Sec Through Windbox		2,968,935	80.38	2,933,877	81.37
CCOFA		482,701	13.07	477,001	13.23
Total Windbox - CCOFA		2,486,234	67.31	2,456,876	68.14
Aux Air		1,636,520	44.31	1,617,196	44.86
Fuel-Air/Gas		455,940	12.34	450,556	12.50
Bottom-End Air/Gas		393,774	10.66	389,124	10.79
	ľ			1	

Table 3. 5:	Mass Flow	Rates for	the Secondary	<b>Gas Feed Streams</b>
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The damper positions for the top two CCOFAs were extracted from field board data. The other damper positions were estimated, based upon ALSTOM Power's experience. A proprietary EXCEL spreadsheet calculator, denoted the Firing Zone Stoichiometry Calculations (FZSC) spreadsheet, was used to modify the damper positions slightly until the desired windbox-to-furnace  $\Delta p$  of 6.4 inches-of-water-gauge and the desired excess air (XA) were achieved. (The desired windbox-to-furnace  $\Delta p$  of 6.4 inches-of-water-gauge corresponds to a field measurement from the Conesville Unit No. 5 board data at a relatively low excess air condition of 14.1%.)

The mass flow rates for the primary gas and coal feed streams are shown in Table 3.6.

	1.1.1.1.1.1 Base Case (15% Excess Air)		1.1.1.1.1.2 Concept B Case (Oxy-Firing)			
Nozzle	Primary Air	Average	Coal	Primary Gas	Average	Coal
	Mass Flow	Air	Mass Flow	Mass Flow	Gas	Mass Flow
	Rate	Velocity	Rate	Rate	Velocity	Rate
	(lb <sub>m</sub> /hr/elev)	(ft/s)	(lb <sub>m</sub> /hr/elev)	(lb <sub>m</sub> /hr/elev)	(ft/s)	(lb <sub>m</sub> /hr/elev)
Coal E	178,909	96.2	93,614	165,803	60.8	91,650.8
Coal D	178,909	96.2	93,614	165,803	60.8	91,650.8
Coal C	178,909	96.2	93,614	165,803	60.8	91,650.8
Coal B	178,909	96.2	93,614	165,803	60.8	91,650.8
Coal A	8,945	4.8	0	8,290	3.0	0.0
Total:	724,580		374,455	671,503		366,603.0

# Table 3. 6: Mass Flow Rates for the Primary Gas and Coal Feed Streams

It should be noted that the bottom coal elevation (Coal A) has been designated as being out of service (OOS) for these two cases. For the Coal-A nozzle, the coal mass flow rate is completely turned off and only a small amount (e.g., 5% of the normal allocation) of air or gas is permitted to pass through the coal nozzle (i.e., to help purge and cool the nozzle).

The inlet turbulence intensity was arbitrarily set at 10% of the mean velocity. The dissipation length scale for the turbulence was calculated using an effective hydraulic diameter for the inlet.

As mentioned previously, the overall wall absorption and the HFOT constitute implicit boundary conditions. The RHBP is the external resource which is used to provide values for the tube bank heat extraction, the overall wall absorption, and the HFOT. The overall resistance to wall heat transfer in the CFD computation is iteratively changed until the calculated implicit boundary condition constraint (i.e., wall absorption and HFOT) matches the RHBP values to within acceptable accuracy. Since the wall absorption computed by the CFD must ultimately match the wall absorption calculated by the RHBP, a brief tutorial of the RHBP nomenclature is required. The RHBP arbitrarily divides the furnace and convective pass into the sections shown in Figure 3.7.

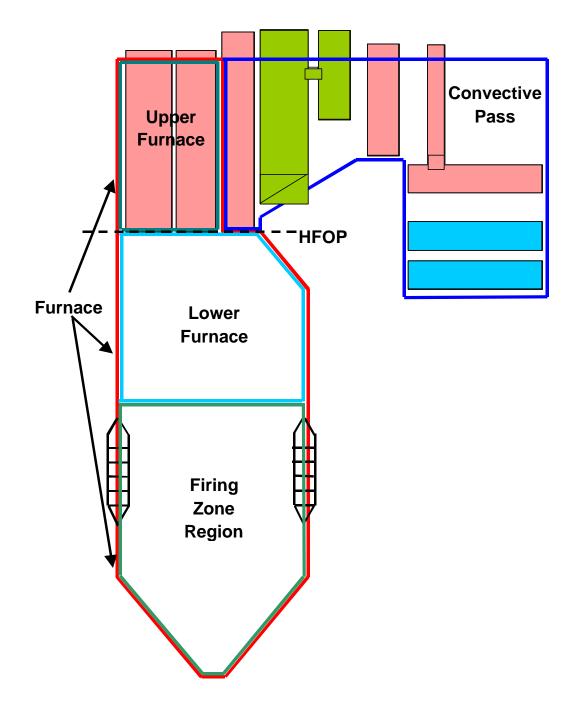


Figure 3.7: Furnace and Backpass Sections Specific to the RHBP

The "furnace" volume (outlined in Figure 3.7) is defined within the RHBP to include most of the radiant wall sections and extends from the bottom of the coutant to the roof of the upper furnace; it does not include the convective pass section, nor the superheater platen tube bank. The "furnace" volume encompasses 3 partitioned sections. The first section is the "firing zone" region, which extends from the bottom of the coutant to several feet above the top coal elevation. The "lower furnace" section extends from the top of the firing zone section to the HFOT plane. The "upper furnace" section extends from the HFOT to the roof and encompasses the superheater division panels, but not the superheater pendant platens. For all surfaces in the "furnace" volume, the RHBP generates the appropriate fouling factors.

The convective pass and backpass volume is defined by the RHBP to encompass all of the tube banks and their bounding surfaces, with the exception of the division panels. For convenience sake, the RHBP treats the convective pass volume differently than it does the furnace volume. For the convective section, the RHBP generates surface effectiveness factors, rather than fouling factors.

The HFOP is at the apex of the arch. The VFOP (not shown) is defined by the RHBP as being at the inlet to the superheater platen (both along the top and along the bottom of the platen), but this definition will be modified later on. The nomenclature utilized by the RHBP (with the exception of the VFOP definition), will be adhered to in the ensuing discussion.

The material properties and relative amounts of slag and fouling deposits found locally on the superheater division panels and the bounding tube walls are usually not known *a priori*. Consequently, the surface resistance to heat transfer in the CFD computation must be iteratively adjusted throughout the furnace volume in order to match the horizontal furnace outlet temperature (HFOT) calculated by the RHBP. For heat transfer to the computational waterwalls, radiant reheat surfaces, and superheat surfaces, the boundary conditions were prescribed using an effective overall surface resistance (or overall fouling factor) and a back-side (steam) temperature. It should be noted that the fouling factors calculated by the RHBP are not utilized directly in the CFD computation. Since the radiation and heat transfer submodels in the RHBP are significantly different than those found in a CFD code, it follows that the fouling factors and emissivities generated by the RHBP may also be quite different from those calculated by the CFD code.

In the waterwalls, the backside (two-phase) steam-water temperature corresponds to saturated conditions and was assigned a temperature of 680 °F. Since the fouling factor must be iteratively changed in the CFD calculation in order to calibrate the wall absorption and HFOT to the RHBP value, all of the backside steam temperatures were equated to the (constant) saturation steam temperature, including the radiant reheat and superheat surfaces. Although the superheat temperatures in the bounding surfaces will be higher than the saturation temperature, the goal of the calibration exercise was principally to match the overall absorption in the furnace proper, the convective pass being secondary, and the approximation was thought to be acceptable. The wall heat transfer parameters found to calibrate the Base case to the RHBP results are shown in Table 3.7.

Interior Wall Surface	Internal Wall Emissivity	Overall Fouling Factor (hr-ft <sup>2</sup> -°F/Btu)
Coutant and Wall Below Windbox Firing Zone Lower Furnace Waterwall (Above Windbox) Radiant Reheat Walls (Lower Furnace) Upper Furnace Waterwalls/Radiant Reheat Upper Furnace Roof Superheater Division Panels Convective Pass and Backpass Roof of Convective Pass and Backpass	0.80 0.75 0.75 0.65 0.65 0.65 0.75	$\begin{array}{c} 0.0175\\ 0.0232\\ 0.0258\\ 0.0247\\ 0.0378\\ 0.0258\\ 0.0378\\ 0.0232\\ 0.0142 \end{array}$
Backside Wall / Steam Temperature (°F) =	680	

# Table 3. 7: Wall Heat Transfer Parameters in the CFD Cases

One of the quantifiable metrics selected as a means of comparing the Base case and the Concept-B case is the overall wall absorption. In order to compare the two cases on an equivalent basis, it was deemed necessary to maintain the same fouling factors throughout the "furnace" volume in both cases. Therefore, the two corresponding RHBP runs were generated with the same fouling factors. However, convective section surface effectiveness factors and tube bank absorptions could not also be forced to be identical for the two cases in order to permit the RHBP to converge to a physical solution based on its solution constraints (i.e., prescribed superheat and reheat temperatures).

The tube banks are approximated as porous media in the CFD cases; parameters describing the pressure drop through each tube bank are calculated from industry design standards. The RHBP is used to evaluate the steam side performance and to estimate the furnace outlet temperature and the heat duty of the various tube bank sections. The amount of heat extracted from each tube bank, as calculated from the RHBP, with the exception of the superheater division panels (which are calculated with the resistance and backside temperature approach), are shown in Table 3.8. The tube bank absorption quantities also include the absorption through any nearby screen tubes.

	Base Case (15% Excess Air)	Concept B Case (Oxy-Firing)
Tube Bank	Heat Transferred to Steam in Banks (Btu/hr)	Heat Transferred to Steam in Banks (Btu/hr)
Superheater Pendant Platen Reheater Pendant Platen (Front) Assemblies Reheater Finishing Section Superheater Finishing Section Superheater Low Temp (Vertical) Pendant Section Superheater Horizontal Spaced Rear Assemblies Economizer Assembly	3.957E+08 1.424E+08 2.397E+08	2.942E+08 3.753E+08 1.286E+08 2.194E+08 1.253E+08 2.807E+08 4.594E+08
Totals:	2.012E+09	1.883E+09

## Table 3. 8: Energy Extracted from Tube Banks

Although the fouling factors in the "furnace" volume were forced to be identical in the two RHBP cases, the heat absorption through each tube bank in the convective pass was allowed to self-adjust to meet the RHBP solution and convergence criteria. Therefore, the tube bank heat extractions for the two cases are somewhat different. The tube bank absorption for the Concept-B case is generally lower than (but within 10% of) the tube bank absorption in the Base case.

The above absorptions were specified in the CFD calculation for each tube bank in the form of a sink term to the energy transport equation.

## 3.6 Submodel Parameters and Case Preparation

Calculations of the two Conesville cases were run using FLUENT<sup>™</sup> Version 5.4.8. FLUENT<sup>™</sup> is a general purpose CFD code with a range of physical model capabilities. For these simulations, the important fluid flow, heat transfer, gas and solid phase combustion processes were represented in a steady-state calculation. Submodel selections and their parameter settings are described below.

The SIMPLE pressure-correction algorithm was used with first-order upwind differencing. The turbulence model was the traditional or standard k-ɛ turbulence model. The turbulence-chemistry interaction was modeled using the composite Magnussen eddy-breakup (mixing-limited / fast-chemistry) and Arrhenius rates (kinetically-limited) combustion submodel, in which the smaller of the two rates (eddy-breakup or Arrhenius rates) takes local precedence. The gas-phase chemistry was based on two, irreversible, global steps: (1) volatile combining with oxygen to form carbon monoxide, water, nitrogen, and sulfur dioxide, and (2) carbon monoxide combining with oxygen to form carbon dioxide.

The Discrete Ordinates radiation model was used to calculate the local radiative fluxes. The particle absorption and scattering efficiencies were specified via a proprietary user-defined function (UDF). An implementation inconsistency was found in the weighted-sum-grey-gas (WSGGM) model in the FLUENT<sup>™</sup> code (which ultimately forced the CFD

runs to be repeated and delayed the final report). To circumvent the use of the WSGGM submodel, a gas-phase absorption coefficient, calculated from the Edwards wide-band model, was calculated and utilized instead. Unfortunately, the polynomial prescriptions for the gas-phase absorption coefficient in the FLUENT<sup>TM</sup> input permitted the coefficient to be a function of local temperature only, whereas it should ideally be a dual function of both local concentration and temperature. Consequently, the gas-phase absorption coefficient was input as a linear function of temperature, calculated from a single CO<sub>2</sub> and H<sub>2</sub>O partial pressure that prevailed in the computed upper furnace region. (While the complete wide-band model cannot be incorporated in the time frame required to impact the present CFD runs, a recommendation will subsequently be made to Fluent Inc. to upgrade their gas-phase radiative properties submodel to incorporate a full and reliable wide-band model.)

The particles were modeled as discrete trajectories using the stochastic Lagrangian particle model. Particles were injected from 16 inlet surfaces (8 cells per injection surface), corresponding to each of the primary coal inlets (4 coal elevations), with 10 particle size bins per distribution and 6 stochastic tries, for a total of 7,680 discrete particles that were tracked through the domain. Conesville Unit No. 5 mill classifier or sieve analysis data was available, which were averaged to produce a composite analysis with 98.35% through 50 mesh and 88.55% through 100 mesh. A Rosin-Rammler fit of the data produced a mean particle diameter of 66 microns and a slope/spread parameter of near unity. Maximum and minimum particle sizes were chosen as 200 microns and 1 micron, respectively. This information was utilized to calculate the particle size distribution through the Rosin-Rammler utility in FLUENT<sup>™</sup>.

Each of the particles followed a stochastic particle trajectory, progressing through the sequential stages of heating, devolatilization and char oxidation according to local flame conditions. The mill module, one of the modules within the company proprietary Reheat Boiler Program (RHBP), estimated that the amount of moisture in the as-fired coal would be approximately 4.5% (from an as-received moisture value of 10.1%). However, to simplify the CFD calculations, all of the coal moisture was presumed to have evaporated completely in the mill and was given to the primary transport air. Devolatilization was calculated from the Kobayashi-type two-competing-rates submodel. The high-temperature volatile yield parameter was estimated using the commercially available Niksa Energy Associates (NEA) PC COAL LAB software (i.e., FLASHCHAIN model). The high-temperature volatile yield was specified to be 67.6% on a DAF basis (as calculated for 55 micron particles at 25 °C entrained in nitrogen at 1600 °C in a furnace at 1700 °C and atmospheric pressure). The same high-temperature volatile yield was specified for all particle sizes. Based on the results of an inhouse, proprietary study, the Kobayashi devolatilization parameters were modified somewhat to give accelerated devolatilization rates which more closely approximated the FLASHCHAIN rates.

Parameters for the char oxidation kinetics of the mid-western bituminous coal fired in Conesville Unit No. 5 were set initially through comparison of the proximate and ultimate analyses of the coal with other coals tabulated in an inhouse, drop-tube, kinetics database. Based on a comparison with the database, a reasonable surrogate fuel was found to be Pittsburgh No. 8. Consequently the database kinetics for Pittsburgh No. 8 were used for the Conesville case. The activation energy was not subsequently changed, but the pre-exponential factor was iteratively adjusted as necessary to match the desired unburned carbon in the ash at the exit (of approximately 2%) for the baseline case. The char oxidation submodel in FLUENT<sup>TM</sup> is a composite kinetics/diffusion-limited char combustion model. In the char oxidation submodel, the char is oxidized via heterogeneous reaction to form CO, which is then oxidized further in the gas phase to form CO<sub>2</sub>.

The species (gaseous) properties, such as thermal conductivity, viscosity, and specific heat, were calculated at each cell in the domain based on polynomial functions of temperature. The species specific heats did not account for dissociative effects. The gas mixture properties were based on composition dependent formulations of the properties of the pure species.

The NOx model is run in a post-processor fashion. NOx predictions were performed for a combination of both thermal and fuel NOx submodels. Destruction through the reburn mechanism is permitted only for the presumed probability distribution function (PDF) combustion model, which was not utilized in this case. For thermal NOx, the partial equilibrium assumption was activated for atomic oxygen, and a beta function PDF was utilized for the convolution over temperature. For the fuel NOx model, atomic nitrogen fractions in both the volatile and the char were specified. The char nitrogen was presumed to go to HCN, rather than directly to NO. NOx and CO emissions are typically more difficult to predict than gross flow features or overall heat release because they are more sensitive to accurate calculations of local temperature and require more detailed chemistry. Consequently the NOx predictions were ultimately scaled to the measured Base case value.

Further grid refinement or adaption of the grid was not performed for the two cases. It is not known to what extent numerical diffusion, typically associated with coarse or skewed meshes, has impacted the quantitative accuracy in the present study. Since the focus of the present investigation was to discriminate between the two cases on a relative basis only, the present grid was presumed to be acceptable.

# 3.7 Calculation Results

The baseline case (Case 1) and the Concept-B case (Case 2) will be compared on the basis of the metrics discussed previously in Section 3.3. All of the gas-phase, planar integrated scalars, such as temperature and species, will be reported on a mass-averaged basis.

The calculated residual carbon in the fly ash, as well as the NOx and CO emissions are shown in Table 3.9.

	Base Case (15% Excess Air)	Concept B Case (Oxy-Firing)		
Residual Carbon in Ash (%)	2.4	0.8		
NOx (ppmm, uncorrected, dry) [Note 1]	190	104		
CO (ppmv, dry)	141	82		
Note 1:	Baseline value was scaled to measurement			

Table 3. 9: Comparison of Predicted Residual Carbon and Emissions for Cases 1 and 2

The carbon-in-ash measured in the field was between 2% and 3%; therefore for the baseline case, the pre-exponential factor for the char oxidation kinetics was adjusted until such a representative value was calculated. Relative to the baseline case, the carbon-in-ash value for the Concept-B case was calculated to be significantly lower. The same trend is also exhibited by the emissions calculations. If the calculated NOx value is scaled to the representative measured value of approximately 190 ppm, and assuming that the Concept-B calculated value can be proportionately scaled as well, then the Concept-B NOx value may be expected to decrease by about a factor of two relative to the baseline value. The calculated CO value for Concept-B is also much lower than its baseline counterpart. Since experimental CO values were reported as being "under range", and are therefore not available, and since the inclusion of reliable CO kinetics within the CFD computation is not considered to be practical at present, the CO results, as well as the unburned carbon results, may be taken as an indication of the extent of mixing, the temperature history, and the residence time differences between the two cases.

The planar temperatures at the HFOP, VFOP, and economizer outlet plane constitute implicit boundary conditions or target temperatures, provided by the RHBP, that the CFD calculations attempts to match through modification of its wall heat transfer boundary conditions. The aforementioned planes are depicted in Figure 3.8, to show their relative positioning.

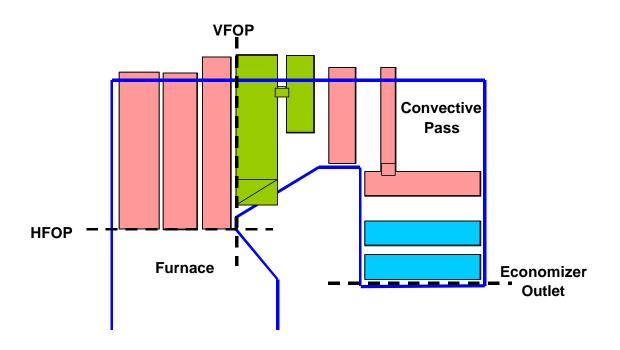


Figure 3.8: Depictions of Specific Planes for Comparisons of Averaged Temperatures

The temperatures at various cross-sections, as well as the integrated wall absorption over various furnace wall sections (largely in accordance with the RHBP partitioning and definitions in Figure 3.7), are shown in Table 3.10. The definition of the "upper furnace" section, prescribed by the RHBP to exclude the superheater platen, is inconvenient for CFD computations. Hence, the term has been modified in the table below, such that the heat extracted in the superheater platen (via a sink term to the energy equation), and its bounding surfaces, is now included in the definition of the "upper furnace" term.

	 Base Case (15% Excess Air)			Concept B Case (Oxy-Firing)		
	 RHBP	FLUENT™		RHBP	FLUENT™	
Average Planar Temperature (°F):						
HFOP VFOP [Note 1]	 2,756 2,185	2,765 2,125		2,729 2,027	2,676 2,040	
Economizer / Domain Outlet	 706	666		683	696	
Furnace Absorption (Btu/hr):						
Firing Zone Region Lower Furnace	5.06E+08 5.28E+08	4.37E+08 5.92E+08		4.83E+08 5.85E+08	4.33E+08 5.88E+08	
Total Absorption Below HFOP Upper Furnace (Note 2)	 1.03E+09 8.95E+08	1.03E+09 8.96E+08		1.07E+09 9.74E+08	1.02E+09 8.88E+08	
Total Furnace Percent Change of Absorption from	1.93E+09	1.93E+09		2.04E+09 +5.8	1.91E+09 -0.8	
Baseline						
Note 1: Note 2:	 Definition of "VFOP" modified to be at the platen outlet Definition of "upper furnace" modified to include platen					
					-	

### Table 3. 10: Comparison of Predicted Gas Temperature and Sectional Wall Absorption Values for Cases 1 and 2

The wall absorption throughout the furnace dictates the resultant temperatures at the HFOP and VFOP. (The domain outlet temperature is a less reliable indicator, since the heat extracted from the tube banks is different for the two cases.) The FLUENT<sup>M</sup> code does not presently permit the user to interrogate the net radiative flux through an arbitrary interior plane, so it is difficult to know to what extent radiation losses through each section, and through the porous media (representing the tube banks), are impacting the above results. Therefore, while it may not be possible to fully ascertain the energy entering and leaving each section in the CFD computation, and thus provide a more detailed explanation as to the magnitudes of the temperatures and fluxes, some general conclusions about the relative trends may be drawn.

In the baseline case, the HFOT and wall absorptions were calibrated to the RHBP values (as shown above in Table 3.10). Although the individual absorptions in the firing zone region and the lower furnace region are not duplicated, the total absorption below the HFOP, as well as the total absorption in the upper furnace are matched to an acceptable degree. The reason that the individual absorptions in the firing zone and lower furnace regions are not matched is because the CFD computation is much more sensitive to the location of the burner-out-of-service (BOOS) than the RHBP (as will be apparent later when the absorption profiles are shown). Since the lowest coal elevation has been dictated to be out of service (OOS), a smaller number of burning particle trajectories traverse the coutant region than would occur if the lowest coal elevation were in service; hence the heat release and wall absorption in the region below the windbox is also commensurately less. Alternatively, the RHBP effectively treats all of the firing zone region (below

the "lower furnace") as a single, well-mixed, global volume (with an allowance for a radiation boundary layer). Since the RHBP has a long history of successful designs that encompass a wide variation in firing system configurations, it is suspected, although not proven, that the CFD computation may be overly sensitive to the location of the BOOS.

When the RHBP run for Case 1 is compared with the RHBP run of Case 2, it is evident from the calculations that the HFOT for Concept-B decreases by 29 °F and the VFOT decreases by 158 °F (for an average decrease of about 94 °F) from the corresponding baseline values. The overall furnace wall absorption for Concept-B is expected to increase over that of the baseline (by 5.8%). This result is in accordance with a literature source (Wilkinson, et al., 2001) for refinery gas fired into a wall-fired boiler, in which a one-dimensional, slice-type model (i.e., RHBP-type model) was used to perform the analysis. The authors found that the oxyfuel concept experienced an increase in the incident radiative heat flux of about 4% to 6%, and a corresponding increase in the furnace heat absorption of approximately 9%, relative to the baseline air concept. This increase was attributed by the authors to "the increase in radiative power of the carbon dioxide and water-rich combustion gases".

The CFD computations exhibited a similar temperature trend to that of the RHBP. Both the HFOT and VFOT for the Concept-B case decreased by 85 and 89 °F, respectively, relative to the baseline results. On the other hand, the CFD cases exhibited a trend in wall absorption which was not as strong as the RHBP results. The wall absorption for the Concept-B case decreased by less than 1% relative to the furnace absorption of the baseline CFD case. Additional CFD runs, in which the fuel was changed from coal to an equivalent gas-only fuel (i.e., volatile), confirmed the trend (i.e., the Concept-B absorption was slightly lower than the baseline absorption). This same CFD trend is partially supported in the literature (Chui, et al., 2001) for coal burned in a cylindrical, down-fired vertical combustor, in which both CFD and experimental data were utilized to assess performance. The authors found that both the CFD calculation and the measured data showed that the oxygen-enriched, recycle-gas case exhibited a significant decrease of about 18% in the incident radiant flux, relative to the baseline case. Chui, et al. attributed this decrease to:

- (a) the change in aerodynamic and temperature patterns due to the lower inlet velocity and penetration of the recycled flue gas (i.e., due to the higher molecular weight of  $CO_2$  relative to  $N_2$ ),
- (b) a decrease in the overall flame temperatures of the recycled flue gas case due to the higher specific heat of  $CO_2$  relative to  $N_2$ , and principally to
- (c) the increase in the absorption coefficient in the recycled flue gas case because of the higher concentrations of the optically absorbing  $CO_2$  and  $H_2O$ , relative to the optically transparent  $N_2$ .

The analysts of both the (1) one-dimensional/slice or global mixing codes (like the RHBP) and the (2) CFD codes rely on the enhanced radiative absorption coefficient associated with  $CO_2$  to partially explain the furnace absorption results, although the calculated trends exhibit different apparent sensitivities for the two types of codes. Apart from differences in the gas-phase radiation properties themselves, a potential explanation for this apparent dichotomy is not readily available. However, in the CFD calculations, the high flame temperatures and patterns are a function of the local aerodynamics and may be effectively isolated from the wall by a significant presence of colder gases. Any  $CO_2$  (and  $H_2O$ ) in the near-wall gases will absorb radiative energy at the higher temperature of the "fireball", but will re-emit at the lower near-wall temperature, thus acting to increase the temperature of the near-wall gases and decreasing the net wall heat absorption. Slice or global-mixing codes will try to mimic this same effect and may, for example, presume a uniform firing zone or slice temperature radiating through a (colder) "radiation boundary layer" adjacent to the wall. The quantitative impact of the near-wall or "radiation boundary layer" gases on the net radiative flux to the wall may be significantly different between the two types of codes. The CFD computations may simply exhibit a greater "insulative" effect to radiation in the near-wall regions than that provided in RHBP-type models due to aerodynamic (case-specific) and submodel differences.

As discussed earlier, due to an implementation inconsistency in the FLUENT<sup>TM</sup> code, the gas-phase radiation absorption coefficient utilized in the CFD computational was a linear function of local temperature only, and not a function of concentration. While it is anticipated that the gas-phase absorption coefficient will be sensitive to the local concentrations of CO<sub>2</sub> and H<sub>2</sub>O, it is not known at this juncture whether the difference in overall wall absorption between the two cases would increase or decrease relative to its present values, and what the difference in magnitude would be. The calculations should be repeated with a gas-phase radiation absorption coefficient submodel that uses the full wide-band model (and that is more reliable than the WSGGM model presently in FLUENT<sup>TM</sup>).

Vertical profiles of the maximum and average net wall heat flux for the baseline case and the Concept-B case are shown in Figures 3.9 and 3.10, respectively. At any given elevation, the net wall heat flux value represents the area-weighted average of all the cells positioned "circumferentially" around the furnace (at that elevation). The maximum local net wall heat flux is simply the maximum value of all of the "circumferential" cells (at a given elevation). The radiative portion of the net wall heat flux, the portion of the net wall heat flux due to conduction, and the incident radiative flux are also shown. A geometry profile is also provided, showing the coutant bendline, the windbox, and the arch bendline. The recessed line in the geometry profile represents the windbox, while the slanted line with the positive slope represents the coutant, and the slanted line with the negative slope represents the arch bendline. The maximum and average values of the net wall heat flux calculated from "idealized" in-house design standards correspond to the base case conditions only (on both Figures 3.9 and 3.10) and are provided simply for comparative reference purposes.

# ENGINEERING FEASIBILITY AND ECONOMICS OF CO2 ON AN EXISTING COAL-FIRED POWER PLANT

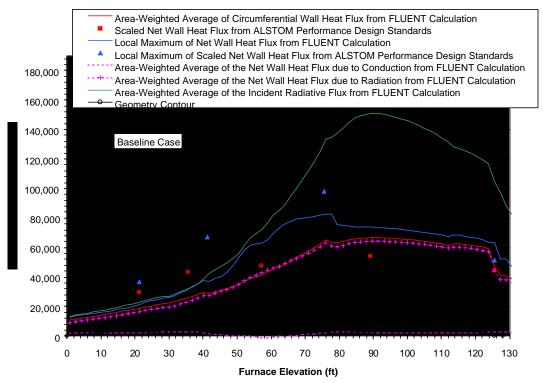


Figure 3.9: Vertical Profiles of the Local Peak and Area-Weighted Net Wall Heat Flux for the Base Case

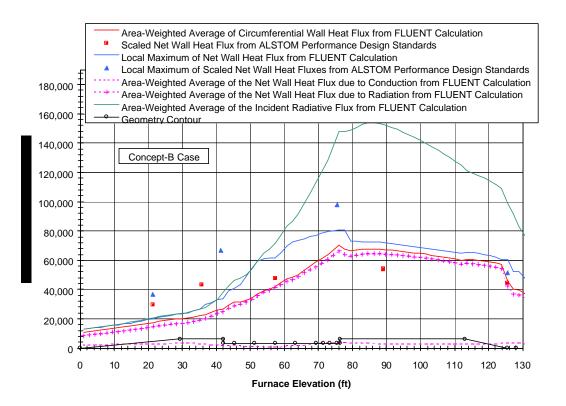


Figure 3. 10: Vertical Profiles of the Local Peak and Area-Weighted Net Wall Heat Flux for the Concept-B Case

ALSTOM Power Inc.

For the Base case (Figure 3.9), it can be seen that the CFD-calculated average net wall heat flux is less than the idealized design standard in the furnace volume below the windbox, and is above the design standard in the furnace volume above the windbox. This is due again to the fact that the lower coal is OOS, which means that fewer particles are carried down toward the bottom of the furnace, and the heat release generated in the coutant region is correspondingly smaller than it otherwise would be. (Computational runs with the lower coal in service show a heat release in the coutant region which is similar in magnitude to the design standard profile.)

In a comparison of Figures 3.9 and 3.10, it can be seen that the Base case has a slightly higher peak and average wall heat flux, over most of the furnace elevation, than the Concept-B case, as has already been established. However, differences in the overall absorption between the two cases are rather small (i.e., less than 1%) and may perhaps be construed to be part of the "noise" in the CFD calculations.

Vertical profiles of the peak, standard deviation, and mass-averaged, planar, gas temperatures are provided in Figures 3.11 and 3.12. The area-averaged interior wall temperature is also shown in both figures. The peak temperatures and standard deviations of the local gas temperature (i.e., a type of unmixedness) for the baseline case are somewhat higher than those of the Concept-B case. The peak temperature differences are higher in the windbox region, with a delta of approximately 200 °F or more for the peak temperature in the mid-windbox region, which then diminishes slightly to about 150 °F as the arch elevation is approached. The standard deviation of the local gas temperature for the baseline case is about 150 °F higher than that of the Concept-B case in the windbox region, although the difference then diminishes and becomes negligibly small as the HFOP is approached. (It is difficult to say whether the difference in standard deviation between the two cases reflects a significant difference in mixing efficiencies or simply a difference in local peak temperature values.) Over most of the furnace height, except in the immediate vicinity of the CCOFA jets, the mean temperature and the interior wall temperature are generally higher in the baseline case than in the Concept-B case. (Table 3.10 shows that the baseline HFOT is approximately 90 °F higher than that of Concept-B.)

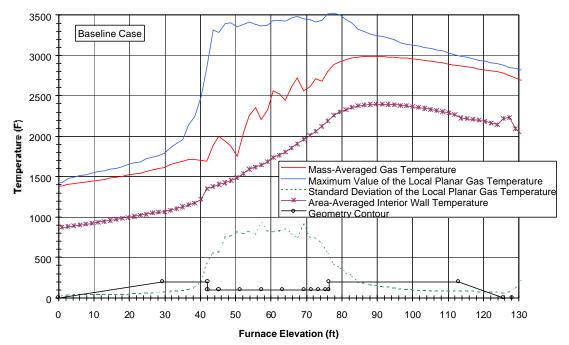
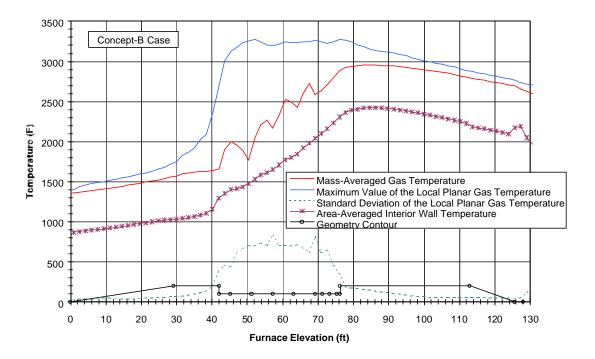


Figure 3.11: Vertical Profiles of the Local Peak and Mass-Averaged Gas Temperatures for the Base Case

The specific heat of  $CO_2$  is about 6% to 7% greater than that of  $N_2$  over the range of 1340 °F (1000 K) to 3140 °F (2000 K). Therefore, for equivalent heat release and wall absorption, the Concept-B case would be expected to have a slightly

lower mean gas temperature. The specific heat of  $H_2O$  (gaseous) is a factor of 2 to 3 times that of  $CO_2$ , but the mass fraction of  $H_2O$  in the inlet mixtures of the Concept-B case is only about a percentage point higher than that in the baseline case; thus its impact on lowering the Concept-B HFOT is minimal. Consequently, it is expected that the specific heat consideration of  $CO_2$  (alone) should be a factor which would ordinarily cause the HFOT for the Concept-B case to decrease relative to that of the baseline case.





## 3.8 Contour Plots

Contour plots of temperature at selected elevations are given in Figure 3.13. The plots show reasonable symmetry of the flowfield, with a relatively cool inner core, surrounded by an annular, high-temperature region. In certain regions, cooler near-wall temperatures may separate the high-temperature annular "ring" from the walls.

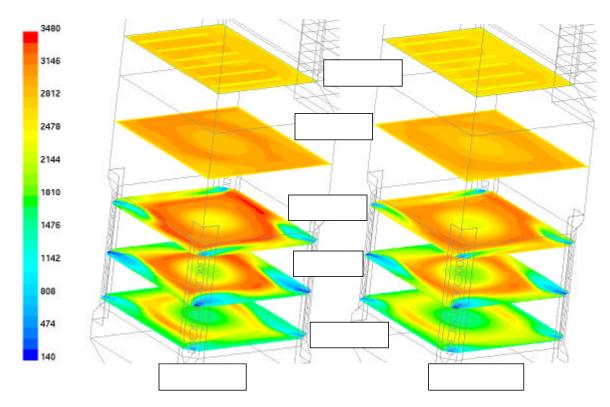
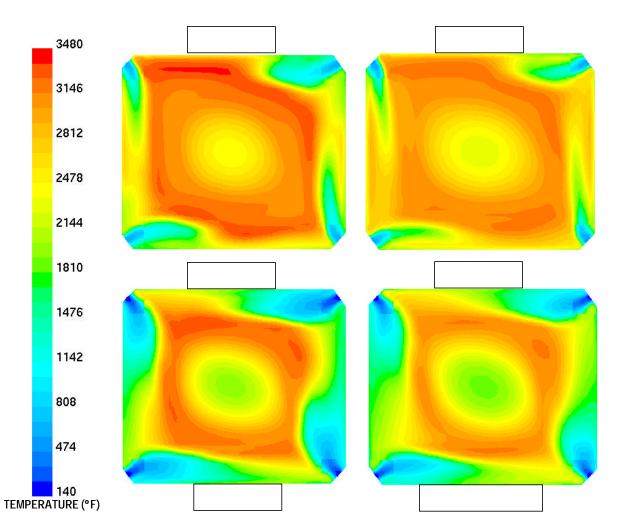


Figure 3. 13: Planar Contour Plots of Temperature at Various Elevations for the Base Case and Concept-B Case



#### A cross-sectional view of the temperature contours at two planes is given in Figure 3.14.

#### Figure 3. 14: Planar Contour Plots of Temperature at two Elevations for the Base Case and Concept-B Case

As can be seen in Figure 3.14, the aerodynamics and flame regions are rather similar in shape and appearance, with minor differences in temperature magnitude. The higher inlet velocities and penetration of the baseline case (see Tables 3.5 and 3.6) are apparent, in that a longer traverse distance is required before the jet is either swept upward out of the plane or mixed out to equivalent temperatures. The swirl is sufficiently strong to prevent the jets from penetrating radially to the core; rather the jets are quickly "bent over" in the direction of the swirl crossflow vectors (in the cross-sectional plane) and any residual jet penetration is in that same direction. It should be noted that although the difference in inlet velocities between the two jets is a factor in the resultant aerodynamic penetration, a perhaps equally influential factor is the velocity acceleration due to combustion. The coal jets, for example, enter the domain at 96.2 ft/s and 60.8 ft/s, for the baseline case and the Concept-B case respectively, but the jets are rapidly accelerated to approximately 170 ft/s (figure not shown) within a few nozzle diameters of the entrance.

The peak temperatures in the annular high-temperature annular "ring" are higher in the baseline case than in the Concept-B case. By the time the CCOFA is reached, the core temperature of the baseline case also appears to be higher than that in the Concept-B case (contributing ultimately to a higher HFOT for the Base case).

Temperature plots at the mid-plane of the x-coordinate direction are shown in Figure 3.15. The plots are again qualitatively very similar in appearance.

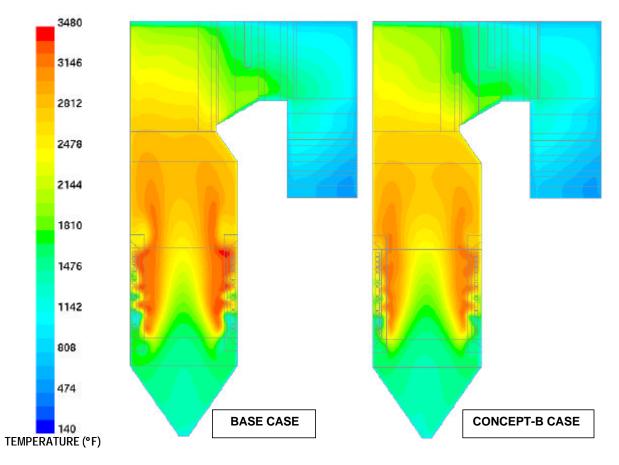
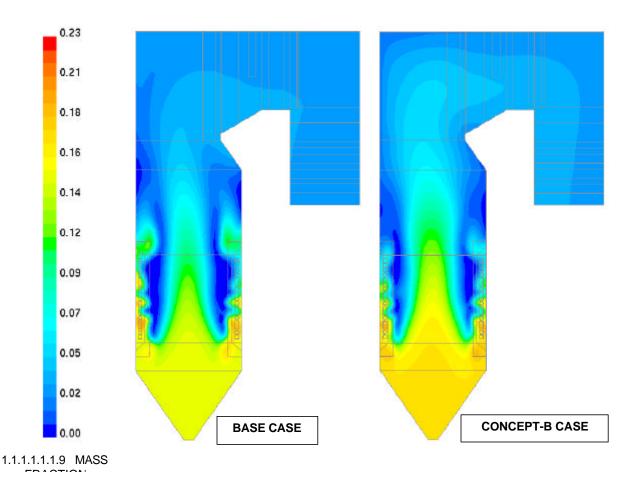


Figure 3. 15: Planar Contour Plots of Temperature at the X-Mid-Plane for the Base Case and Concept-B Case

The corresponding contour plots of the oxygen mass fraction (wet) at the x-mid-plane are shown in Figure 3.16.



#### Figure 3. 16: Contour Plots of O<sub>2</sub> Mass Fraction (Wet) at the X-Mid-Plane for the Base Case and Concept-B Case

The Concept-B case appears to have a slightly greater concentration of oxygen in the coutant region and in the furnace core than the Base case does. The amount of oxygen will be partially controlled by the relative local concentrations of the particles and the gas, as well as the particle burning rates and trajectory history. Assuming complete combustion, the exit  $O_2$  concentrations on a mass fraction basis are almost equivalent (see Table 3.2); on a molar basis, the Concept-B case will have a higher exit mole fraction (3.6%, dry) compared to that of the Base case (2.6%, dry). Since the composite kinetic/diffusion surface reaction rate model for char oxidation in FLUENT<sup>TM</sup> is a direct function of the partial pressure of oxygen, assuming an equivalent particle distribution, the higher oxygen mole fraction in the Concept-B case should help the particles to burn out more completely than the particles in the Base case (as shown in Table 3.9).

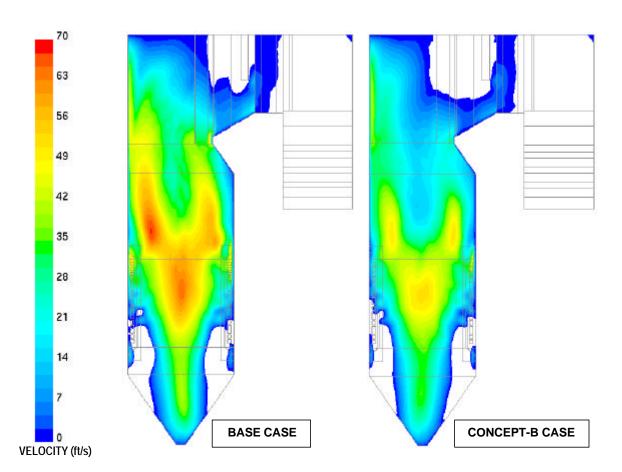


Figure 3.17 shows the z-component (i.e., the upward component) of velocity on the mid-plane.

Figure 3. 17: Contour Plots of the (Upward) Z-Velocity at the X-Mid-Plane for the Base Case and Concept-B Case

In Figure 3.17, only the positive (upward) z-component velocity is shown. The upward velocity appears to be somewhat greater in the core of the furnace for the baseline case than for the Concept-B case. For an equivalent upward mass flow rate, at any cross-section, it would be expected that the baseline case velocity would be higher than that of the Concept-B case due simply to the difference in molecular weights (between  $CO_2$  and  $N_2$ ) and the associated densities. In addition, the baseline case has higher peak temperatures which would also accelerate the local velocity field. However, the presence of a higher velocity does not necessarily mean that the integrated planar flow rates are higher. The CFD results also show that between the bottom of the coutant and the top of the windbox, the planar integrals (not shown) of negative mass flow rate, positive mass flow rate, and absolute mass flow rate are on the order of 10% greater for the Concept-B case than for the baseline case. Above the windbox, the differences in integrated mass flow rate become small (since they simply reflect the nearly equivalent overall inlet flow rates).

Both cases evidence the presence of an adverse pressure gradient (i.e., low velocity region) in the core between the arch-bendline elevation and the top-of-the-windbox elevation. However, the higher upward core velocities associated with the baseline case appear to almost overcome the low-velocity, adverse pressure gradient region. Planar integrals of the swirl number (not shown) indicate that the Concept-B case has a slightly higher swirl magnitude at all elevations except over the upper windbox region. As a result, the Concept-B case appears to be closer to incipient reverse flow zone formation than the baseline case in the upper core region below the arch bendline.

The net wall heat flux is shown in Figure 3.18. (It should be noted that the wall absorption of greatest magnitude is represented by the blue color (i.e., value on the order of -70,000).)

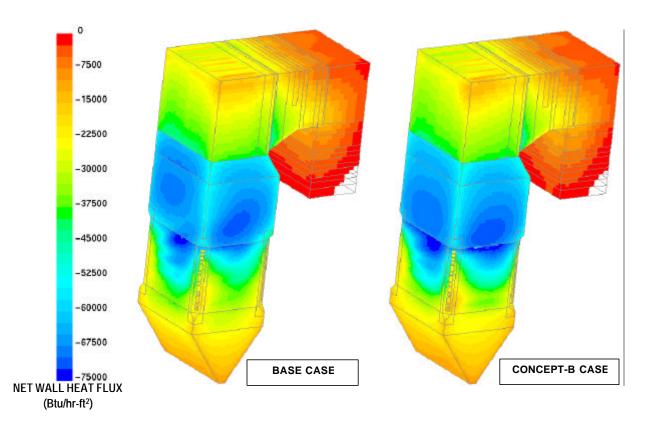


Figure 3. 18: Net Wall Heat Flux for the Base Case and Concept-B Case

As discussed earlier, the wall absorption is very similar for both cases. The peak net wall heat flux is between the top coal nozzle elevation and the arch bendline, in the mid-span region of the waterwall.

# 3.9 Conclusions

Two cases have been compared using the FLUENT<sup>™</sup> CFD code -- a baseline, nominal 15% excess air case (Case 1 or Base case), and a recirculated flue gas, oxy-fired case (Case 2 or Concept-B case). In the Concept-B case, the nitrogen was largely replaced by carbon dioxide. The cases have been compared on the basis of equivalent nozzle/inlet areas, as well as an equivalent coal-to-oxygen feed ratio (by mass). The following computational results have been highlighted:

- The baseline case exhibits higher carbon-in-ash (by 1.6 percentage points), higher outlet NOx emissions (by a factor of 2), and higher outlet CO (by a factor of 2) than the Concept-B case. These same computational trends are also qualitatively exhibited by the bench-scale testing.
- The baseline case exhibits a slightly higher peak gas temperature (maximum difference of about 200 °F), and a correspondingly higher average (cross-sectional) gas temperature (difference of 90 °F at the HFOT), than that of the Concept-B case.
- The net wall absorption in the furnace region for the baseline case is larger (by less than 1%) than that of the Concept-B case. (Conversely, the net wall absorption for the baseline calculation with the RHBP was found to be about 6% lower than the Concept-B case calculated by the RHBP.)

Explanations for the observed trends must rely on physical property differences between the nitrogen, which dominates in the baseline case, and carbon dioxide, which largely supplants the nitrogen in the Concept-B case. The physical species properties and the anticipated consequences are itemized below:

- (1) <u>Higher molecular weight of  $CO_2$  relative to  $N_2$ </u>. For equivalent inlet areas, and as a result of the molecular weight and associated density differences, the baseline case will exhibit larger inlet velocities and a higher penetration capability than the Concept-B case. The inlet velocity differences will further serve to impact the aerodynamic, particle trajectory, mixing, and flame patterns.
- (2) <u>Higher specific heat of CO<sub>2</sub> relative to N<sub>2</sub></u>. For an equivalent local heat release and heat transfer, the higher specific heat of carbon dioxide will serve to decrease the overall flame temperatures of the recycled flue gas mixture in the Concept-B case, relative to the baseline case.
- (3) <u>Higher gas emissivity and absorptance of  $CO_2$  relative to  $N_2$ </u>. For an equivalent local gas temperature, the higher emissivity of  $CO_2$ , relative to the optically transparent  $N_2$ , should serve to increase the absorption coefficient (and the irradiation to the wall) in the recycled flue gas case (Concept-B) relative to the baseline case.

The three physical properties listed above may have compensatory rather than cumulative effects. In the present CFD calculations, the resultant, local gas temperatures are not equivalent in the two cases. The higher specific heat of the carbon dioxide, and the associated lower gas temperatures in the Concept-B case, will tend to offset somewhat or compensate for the expected increase in the wall absorption (i.e., anticipated due to the enhanced emissivity of the  $CO_2$ .) Furthermore, the spatial distribution of the carbon dioxide across the cross-section may be important; it is hypothesized that high concentrations of  $CO_2$  in the cooler gas mixtures between the wall and the flame may actually act to inhibit the net radiative flux to the walls.

The trend calculated by the CFD code, with respect to the furnace temperature at the HFOP, appears to be qualitatively aligned with the trend calculated by the in-house RHBP code. However, the difference in wall absorption for the Concept-B case relative to the baseline case, calculated by FLUENT<sup>M</sup> (change of -1%), does not fully agree with the results of the RHBP (change of +6%). Computed and/or experimental trends that indicate that oxy-firing may induce either an increase in wall absorption (+6%) or a decrease in wall absorption (-18%), relative to the baseline case, are supported in the literature. It is suggested that the absorptive properties of a local CO<sub>2</sub>-containing gas mixture in the vicinity of the wall may either act to enhance or inhibit the incident radiative flux to the wall, depending upon its relative spatial placement and mixture temperature. For example, a low-temperature, CO<sub>2</sub>-rich mixture near the wall would absorb the radiative flux from the interior "fireball" region; a portion of the energy would be re-emitted at the lower gas temperature, and the remainder of the energy would be used to heat up the gas. The result would be a net reduction in the incident radiative flux to the wall. Conversely, a high-temperature, CO<sub>2</sub>-rich mixture near the wall would emit at its local gas temperature, thus enhancing the incident radiative flux to the wall. Therefore, it is suggested that the relative spatial relationships of the cool and hot gas mixtures, the relative composition of the absorbing media, and the proximity of that media to the wall (as induced by the furnace and firing system aerodynamics), may significantly impact the gas-phase irradiation to the wall. Indeed, the aerodynamic and flame patterns that prevail in a given air-fired or oxy-fired furnace may conceivably have as strong an impact on the net wall absorption as the physical property differences themselves (gas-phase emissivity, specific heat, etc.)

The results of computational tools (such as CFD and the RHBP) should be viewed as being qualitative in nature, particularly when they are asked to produce calculations outside of the experience base for which they have been validated. Certainly, the gas-phase and particle-phase radiation property submodels could be enhanced in both codes, and the impact of spatial gradients (caused by the interleaving of hot and cool regions of varying CO<sub>2</sub> composition) on radiative wall flux needs to be investigated more fully. CFD computations have been utilized to gain a more in-depth qualitative understanding of aerodynamic and flame patterns in combustion systems, but have not yet been integrated into routine boiler design procedures. At the present time, the ALSTOM design standards are based upon the experience and expertise built into the RHBP and other design protocols, and those standards must be adhered to in any new design project in order to mitigate risk. Therefore, the results of the RHBP must be regarded as the default standard, both from an engineering experience viewpoint and from a rules-based design viewpoint. However, additional validation work needs to be done in order to confirm the trends for oxy-firing scenarios.

Although differences in physical properties of the transport gases (e.g., air-firing versus oxy-firing) may initially induce undesirable deviations from the performance goals of a field unit, the designer and engineer views such alterations as challenges rather than insurmountable obstacles. Much can be done in the way of operating condition optimization (e.g., spray and nozzle tilt), without major retrofits, to realign steam temperatures and wall absorptions with their desired, target values. Design parameters are often in conflict, and the intelligent designer must work to balance various parameters and operating conditions to achieve the desired outcome. The CFD work performed here was based on

certain constraints to maintain equivalency for comparison purposes, which would not necessarily be the case in the field. For example, a potential decrease in furnace wall absorption of several percentage points could be nullified through manipulation of various operating parameters. If required, firing system retrofits and surface modifications could be performed to handle more severe decreases in absorption; certainly new unit design could easily accommodate any necessary alterations in design philosophy.

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