Methods of improving CO_2 Sequestration in Saline Aquifer by surface treatment of injected CO_2

By

Mohd Syafiq Firdaus Bin Mohd Nawi

This dissertation is submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons.)
(Petroleum Engineering)

April 2011

Universiti Teknologi PETRONAS
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Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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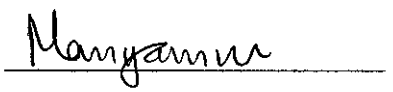
Approved by,



(Prof. Dr Mariyamni Bt. Awang)

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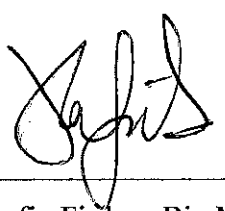
April 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Mohd Syafiq Firdaus Bin Mohd Nawi

ABSTRACT

Sequestration of CO_2 in geologic formations will be part of substantive campaign to mitigate greenhouse gas (CO_2) emissions. The risk of leakage from the target formation due to natural and artificial pathways such as fractures, and fault are important challenges in geological storage of CO_2. The leakage arises mainly from the buoyancy of free-phase mobile CO_2 (gas or supercritical fluid). The best way for CO_2 to be sequestered permanently is by mineralization of CO_2 and solubility trapping of CO_2 naturally in the aquifer. Those two processes take a long period of time estimated to start in 10+ years of time. Alternatives of dissolution of CO_2 prior to injection have been come up to mitigate risk of leakage during period of the CO_2 to permanently naturally sequester.

In this paper, the author investigates a conceptual process in which CO_2 is dissolved with chemical prior to injection into the saline formations. As the CO_2-laden chemical is denser than native brine containing no CO_2, it will eliminate the risk of buoyancy-driven leakage. Several chemicals have been chosen namely Amine solution (Monoethanolamine and Diethanolamine), Potassium Carbonate and Propylene Carbonate. Using Aspen Hysys, products from the mixture of CO_2 and chemicals are evaluated for their properties. The author then investigates and compared the different product properties. Main properties for evaluation of the products are the density. By contrasting the injection strategy, the author chose the best injection strategy. In theory, the injected CO_2 will mineralize with native rocks and sequestered permanently. Native saline density of 1.1g/cm3 is use for comparing the treated chemical.

Although this alternative may result in higher costs compared to standard injection strategy, surface dissolution of CO_2 with chemical may be attractive where the costs of monitoring or insuring against buoyancy-driven CO_2 leakage may exceed the additional cost incurred. The benefit would be to decrease the risk of CO_2 leakage and potential harm of environment and people.

ACKNOWLEDGEMENT

First of all, I would like to say Alhamdulillah, for giving me the strength and health to finally complete this thesis.

I am heartily thankful to my supervisor, Prof Dr Mariyamni Bt. Awang, whose encouragement, guidance and support from the initial stage to the completion enabled me to complete this thesis. I am also grateful for the advice in life.

Lastly, I offer my regards and blessings to all of those who have supported me; my family, friends and those who have indirectly contributed in any respect during the completion of this thesis.

Thank you.

M. Syafiq Firdaus M. Nawi

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INTRODUCTION

1. INTRODUCTION

1. 1 Background

CO_2 **sequestration** is the process of removing excess CO_2 from the atmosphere and depositing it in a reservoir [1].

It is a geo-engineering technique for long term storage of carbon dioxide or other forms of carbon to mitigate/defer global warming. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are commonly released by industrial.

Naturally, Carbon dioxide is captured from the atmosphere through biological, chemical or physical processes. Some anthropogenic sequestration techniques exploit these natural processes.

CO_2 may be captured as a pure by-product in processes related to petroleum refining or from flue gases from power generation. CO_2 sequestration includes the storage part of carbon capture and storage, which refers to large-scale, permanent artificial capture and sequestration of industrially produced CO_2 using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks. [2]

Injected CO_2 remains in the reservoir rock by a combination of three main processes, which under the correct conditions can produce long-term, effectively permanent subsurface storage [4]

1) Immobilization in traps (structural/stratigraphic)
2) Dissolution of CO_2 in the saline water.
3) Geochemical reaction and formation of minerals in the pore spaces.

In 1986 a large leakage of naturally sequestered carbon dioxide rose from Lake Nyos in Cameroon and asphyxiated 1,700 people. While the carbon had been sequestered naturally, some point to the event as evidence for the potentially catastrophic effects of sequestering carbon. [5]. The Lake Nyos disaster resulted from a freak volcanic event one night, which very suddenly released as much as a cubic kilometer of CO_2 gas from a pool of naturally occurring CO_2 under the lake in a deep narrow valley. The location of this pool of CO_2 is not a place where man can inject or store CO_2 and this pool of CO_2 was not known about nor monitored until after the occurrence of the natural disaster.

A large aquifer-storage project is being conducted in the North Sea at the Sleipner gas field. [15]. Approximated 10 millions tones of CO_2, separated from produced natural gas, are injected each year into an overlying aquifer. An extensive time-lapse seismic-monitoring effort accompanies the injection. The injected CO_2 appears to be contained within the sand in which the CO_2 is injected, although there is evidence of vertical migration within the aquifer [15]. Injected CO_2 flowed horizontally under thin shale, migrating upward toward the cap rock at breaks in the shale, behavior that also is common in gas injection projects in oil reservoirs. [16]

Problems identified in this research, are:

1. Injected CO_2 is possible to leak through upward due to injected CO_2 is less dense than the native fluid and create buoyancy effect. If any migration route exist (crack, fracture cap), it will create channel for the CO_2 to escape vertically.
2. As salinity of saline water increased the solubility of CO_2 with water decrease.

This research focused on storing the captured CO_2 in saline aquifers. Saline aquifers are defined as porous and permeable reservoir rocks that contain saline fluid in the pore spaces between the rock grains. Due to high saline proportion and its depth, the water contained cannot be technically and economically exploited for surface uses. Current CO_2 storage site in a saline aquifer is at Sleipner in the North Sea. Due to the geological characteristic of the aquifers, it is possible for it to store CO_2. [3]

The research focused on treating the injected CO_2 on surface and making it stable enough for the reservoir and provide time for mineralization of CO_2 to occur by accelerating the dissolution CO_2 in the saline water.

1.2 Problem Statement

Injected CO_2 may leak from the storage area. The leakage of the CO_2 is environmentally catastrophic and economically wasting as CO_2 sequestration technique is expensive.

1.2.1 Significance of Project

It is significant as means of mitigating the contribution of fossil fuel emissions to global warming, based on capturing carbon dioxide (CO_2) from large point sources such as fossil fuel power plants, and storing it in such a way that it does not enter the atmosphere. It can also be used to describe the scrubbing of CO_2 from ambient air as a geo-engineering technique.

1.3 Objectives

1. To identify CO_2 sequestration mechanisms.
2. To research on suitable candidates of chemical for CO_2 sequestration injection.
3. To determine the best method of treating injected CO_2 for permanent storage by analyzing and simulating various injection chemicals.

1.4 Scope of Study

The scope of the study was to simulate the process at surface for CO_2 sequestration injection in saline aquifer. The author considered the density of the saline aquifer to be 1.1g/cm3 throughout the whole project for the purpose of comparing the CO_2 treated chemical. Parts of the evaluation to obtain the result which to choose will be on study of literature review, then, the design and simulation part will be evaluated using simulation software. This project will utilize the known chemical used in CO_2 capture design which is proven to absorb the large amount of CO_2 namely the amine solutions, potassium carbonate, and propylene carbonate with 20% concentration.

1.4.1 The Relevancy of Project

This project is relevant to the study of carbon sequestration as it focuses the on the method of storing CO_2 permanently in the saline aquifer. Even though the research of CO_2 sequestration has already existed, but improvement can be made thus eliminating certain uncertainties and risks that may occur. This will contribute to level of confidence for this project to be taken widely.

1.4.2 Feasibility of the Project within the Scope and Time frame

The project was conducted starting with the collection of related materials such books, journals and technical papers on relevant subject. Research was done from time to time as to get a better understanding on the subject. Based on the activities stated above, the given 5 months for the researches and studies to be done and for the other 4 months for the finalization of the project, i.e. simulation, the project have been completed within the given time frame but more modification can be done if the time frame is extended.

CHAPTER 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 General and specific aspects of the storage option

Saline aquifer is defined as porous and permeable reservoir rocks that contain saline fluid in the pore spaces between the rock grains. Due to high salinity and depth, water contained cannot be exploited for surface uses.

Basis criteria for all potential storage sites are as follows: [3]

1) Should be in geologically stable area, as tectonic activities could create pathways for the CO_2 to migrate out of the reservoir through the cap rock into the overburden and potentially to surface.
2) Size: The reservoir must be large enough to be able to store the quantities of CO_2 planned.
3) Porosity and permeability: Must be sufficiently high to provide sufficient volume and to allow the injection of CO_2.
4) Suitable geological characteristic: Should have the characteristic such as the cap rock to prevent vertical migration of the CO_2 because CO_2 is less dense than the saline fluid, the CO_2 tend to rise to the top of the aquifer.

2.2 Mechanism of CO_2 sequestration.

CO_2 storage for long timescales relies on the contribution of several CO_2 trapping mechanism. [4]

1) Immobilization in traps
2) Dissolution in the saline waters

3) Geochemical reaction and formation of minerals in the pore spaces.

Details of the mechanism of CO_2 trapping (naturally occurring- will occur at any depth, pressure and temperature in the reservoir.) [6]:

1) The physical trapping of CO_2 in a gaseous, liquid or critical state in a subsurface formation.

   The primary mechanism for trapping CO2 or other fluids in the subsurface is through the existence of confining layers, or cap rocks, such as shale or salt beds, that are impermeable to the CO2 or other fluid. Whereas a suitable reservoir layer for CO2 injection may have a permeability of 10-1,000 miliDarcies, the cap rock will have permeability of at least 1,000 times less, measured in the microDarcies. Such low permeability prevents CO2 migration into the confining layer. When a confining layer exists above as well as to all sides of a reservoir layer, the CO2 will be prevented from migrating both vertically and laterally; it will be confined. Such subsurface orientations of reservoir and confining layers into trapping structures are the source of all the oil and natural gas that has been or will be recovered. Specifically, the geometry of the sub-surface traps takes two dominant forms. The first type of trap, called a structural trap, is shaped as a dome or anticline, while the second called a stratigraphic trap, derives from lateral variations in rock type that result in the reservoir layer grading into adjacent confining layers.

2) Solubility trapping which is the trapping of CO_2 via the dissolution of CO_2 within brine, hydrocarbon, or other subsurface fluid.

$$CO_{2\,(aqueous)} + H_2O \rightarrow H_2CO_{3\,(aqueous)}$$

$$H_2CO_{3\,(aqueous)} + OH^- \rightarrow HCO_3^-{}_{(aqueous)} + H_2O$$

$$HCO_3^-\,(aqueous) + OH^- \rightarrow CO_3^{=}\,(aqueous) + H_2O$$

3) Hydrodynamic trapping, which is the residual saturation of disconnected CO_2 within individual pores.

   As the CO2 migrates through the pores in the reservoir layer, pockets of CO2 will adhere to the rock grains, where they will remain due to surface tension effects; this is called residual or capillary trapping.

4) Mineral trapping – the process of forming in situ, interstitial carbonate minerals from CO_2 and the host rock and formation waters.

   Example: (with Calcium ions)
   $CO_3^{=}$ (aqueous) + $Ca^{2+} \rightarrow CaCO_3$ (solid)

2.3 CO_2 Dissolution in Saline Fluid.

The goal of CO_2 sequestration is to store CO_2 for centuries or thousands of years if not indefinitely. The solubility of CO_2 under typical reservoir conditions at pore water salinity of 3% is about 49 kg m^{-3} (corresponding to a volume of free CO_2 of about 7% of the pore volume.) [7]

Solubility of CO_2 is sensitive to changes in pore water salinity and salinity gradients. The rate of dissolution depends on the amount of mixing of CO_2 and formation water. Diffusion of CO_2 into the water is assisted by accumulations with a high surface area to volume ratio, such as in thin but widespread layers. For many accumulations, dissolution could be slow, in the order of a few thousand years for some injection scenarios, unless there is some form of active mixing induced by fluid flow or convection within the reservoir. [3]

2.4 Strategy/Method for CO_2 sequestration by dissolving CO_2

There are discussions in the literature on how the CO_2 should be injected. Options are as follows [6]:

1) Standard method
    a. Injection of compressed CO_2 in a dense supercritical phase into a saline aquifer for geologic storage
    b. Reliant on the presence of a cap rock with a capillary entry pressure sufficient to hold the CO_2.

2) CO_2-Brine surface mixing strategy
    a. Essential step for the secure storage of CO_2 as it removes buoyant vertical migration in the reservoir.
    b. Once dissolved, it will travel at the same rate as the native formation fluids, which may remain underground for millions of years.
    c. Mixing was done in the surface pressure mixing vessel. It involves dissolving captured dense CO_2 into brine in surface facilities and the CO_2 saturated brine is then injected into the storage formation. Brine required is extracted from same formation used for storage.
    d. Due to low solubility of CO_2 in brine, a large volume of brine is necessary to dissolve a given amount of CO_2.
    e. CO_2 saturated brine is slightly dense than native brine and hence a downward buoyancy drive. Thus this removes the need for a perfect seal and can be injected safely at shallower depths than the pure CO_2.

3) CO_2-water surface mixing.
    a. Dissolving CO_2 in water for carbonic acid, thus CO_2 will be much less buoyant in the subsurface.
    b. Dissolved CO_2 when stored in geological formation may assist transformation into carbonate minerals.

4) CO_2 alternating brine (CAB) injecting strategy

   a. Operation strategy that alternates supercritical CO_2 with brine injection. The supercritical CO_2 and Brine are alternately injected.

   b. Expected to reduce CO_2 buoyancy migration and immobilize CO_2 in the formation.

Effect of option 2 compared to option 1 as represented in Figure below. [8]

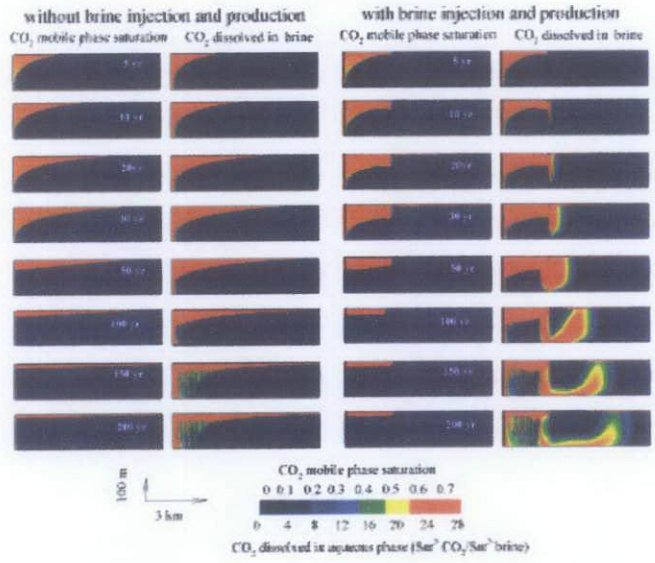


Figure 1 Figure shows the 2D cross –section of distribution of CO_2 mobile phase saturation and CO_2 dissolved in formation brine for different times and for two cases of without (left plates) and with (right plates) brine injection and production. [8]

Results demonstrate that more than 50% of the injected CO_2 dissolves by injecting brine on top of the injected CO_2. Thus based on this figure, improvement was made to the dissolution of CO_2 in the brine. But this would not eliminate the tendency of CO_2 to buoyant upwards.

Hence, the author suggested treating the CO_2 at surface which is the focused of this research. The assumptions was, with the treatment the CO_2 will be more stable for CO_2 sequestration by eliminating the buoyant effect of CO_2.

2.5 Time scales for CO_2 storage in Saline Aquifers by standard method of injecting CO_2 into the aquifer.

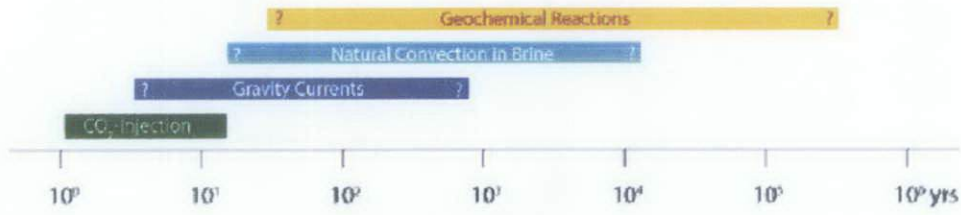


Figure 2 Time scales for CO_2 storage in Saline Aquifers

Referring to figure 2 above [9], the explanations of exhibited mechanisms were describes below:

Injection Period:

During the injection phase, flow rates near the injection well are high. Advection and gravity segregation are the dominant transport mechanisms. Movement of low viscosity CO_2 will be dominated by heterogeneity, and an appropriate representation of heterogeneity is important. Additional effects include capillarity and viscous fingering. Structural trapping and CO_2 immobilized as residual gas are the most important sequestration mechanisms in this phase.

Post Injection Period:

After injection has ended, buoyancy and capillary forces will dominate over viscous forces (Fig. 2). Dissolution and precipitation reactions are likely to become more important as time proceeds. Important physical/chemical processes in the post-injection period are:

- Residual trapping associated with up dip buoyancy-driven CO_2 migration
- Dissolution of CO_2 in the brine
- Downward buoyancy driven fingering
- Precipitation and dissolution of carbonate and silicate minerals

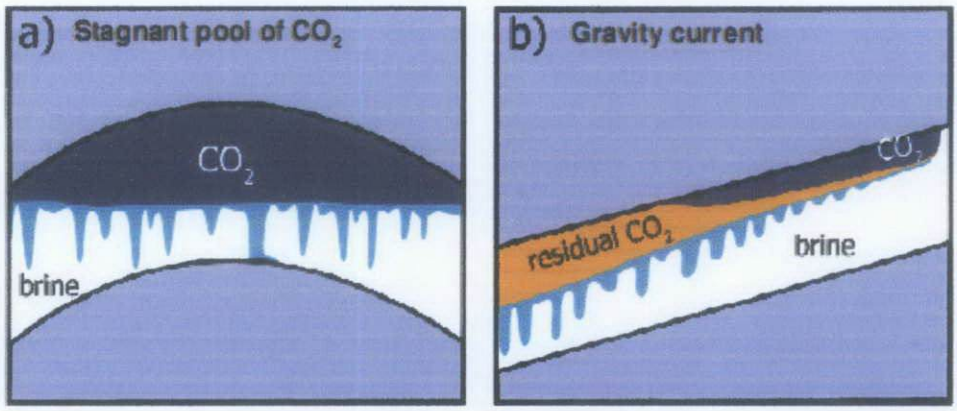


Figure 3 Potential trapping mechanisms.

2.6 Injection Chemicals

As mentioned in the scope of study, the research focused on injection with known chemical used in CO_2 capture system. Options chosen were widely known for its capability to absorb CO_2 in a large scale [11].

Option of chemical to be used:

2.6.1 Amine solution

Amines **[10]** are organic compounds and functional groups that contain a basic nitrogen atom with a lone pair. Primary amines are stronger bases than secondary amines. Amine with stronger base properties will be more reactive towards CO_2 and H_2S gases and will form stronger chemical bonds.

Monoethanolamine (MEA) is a primary amine for removing both H_2S and CO_2. MEA is a stable compound and in the absence of other chemicals suffers no degradation or decomposition at temperatures up to its normal boiling point. It reacts with CO_2 as follows:

$2\,(RNH_2) + CO_2 \rightarrow RNHCOONH_3R$

Diethanolamine (DEA) is a secondary amine. DEA is a weaker base than MEA; DEA systems do not typically suffer the same corrosion problems. DEA has lower vapor loss. Reaction with CO_2:

$2\ (R_2NH) + CO_2 \rightarrow R_2NCOONH_2R_2$

Properties		
Molecular formula	C_2H_7NO	$C_4H_{11}NO_2$
Molar mass	61.08 g/mol	105.14 g/mol
Density	1.012 g/cm^3	1.090 g/cm^3
Melting point	10.3°C	28 °C, 301 K, 82 °F
Boiling point	170°C	217 °C, 490 K, 423 °F
Solubility in water	Miscible	Soluble
Vapor pressure	64 Pa (20°C)	< 0.01 hPa (20 °C)

Table 1 Properties of Amine

2.6.2 Potassium Carbonate

Potassium Carbonate **[11]** is used to remove CO_2. Reactions involved:

$K_2CO_3 + CO_2 + H_2O \rightarrow 2KHCO_3$

Properties	
Molecular formula	K_2CO_3
Molar mass	138.205 g/mol
Density	2.29 g/cm^3
Melting point	891 °C, 1164 K, 1636 °F
Boiling point	decomposes
Solubility in water	112 g/100 mL (20 °C) 156 g/100 mL (100 °C)

Table 2 Properties of Potassium Carbonate

2.6.3 Propylene carbonate

Propylene carbonate [11] is an organic compound, a twofold ester of propylene glycol and carbonic acid. This colorless and odorless liquid is useful as a highly polar but aprotic solvent.

Properties	
Molecular formula	$C_4H_6O_3$
Molar mass	102.09 g/mol
Density	1.205 g/mL
Melting point	**-55 °C, 218 K, -67 °F**
Boiling point	240 °C, 513 K, 464 °F

Table 3 Properties of Propylene Carbonate

Propylene carbonate has the following characteristics, which make it suitable as a solvent:

1. High degree of solubility for CO_2 and other gases
2. Low heat of solution for CO_2
3. Low vapor pressure at operating temperature.
4. Low solubility for light hydrocarbons.
5. Chemically nonreactive toward all natural gas components.
6. Low viscosity.
7. Noncorrosive toward common metal.

2.7 Brine

The pores of the saline aquifer are not empty but filled with brine. This brine will have to be displaced by the injected carbon dioxide. Its physical properties are therefore also of interest, again especially its density, viscosity and its ability to dissolve CO_2.

The density of the water changes not only with temperature and pressure but also with the amount of dissolved salt and ultimately when CO_2 gets dissolved.

Fluid properties **[14]**:

	At Reservoir
Density	1103 kg/m3 or 1.1g/cm3 or 68.9 lb/ft3
Viscosity	1.59 µPas

Table 4Physico-Chemical Properties of Brine at 353K 257.5 bar

CHAPTER 3
METHODOLOGY

3.1 Procedure Identification

Referring the literature review, chemicals to be injected have been identified. The criteria for selection used were absorption of chemical with CO_2. In process design stage, the aim is to determine the properties of the treated CO_2-chemicals. Mass density of the product of the reacted chemicals was determined. The process design stage utilizes Aspen Hysys simulator. Aspen HYSYS is a market-leading process modeling tool for conceptual design, optimization, business planning, asset management, and performance monitoring for oil & gas production, gas processing, petroleum refining, and air separation industries. Aspen HYSYS is a core element of AspenTech's aspenONE® Engineering applications. Aspen HYSYS offers a comprehensive thermodynamics foundation for accurate calculation of physical properties, transport properties, and phase behavior for the oil & gas and refining industries.

The results then were analyzed. Any corrections have been done once the results is obtained and tested.

3.2 Gantt Chart

The Gantt chart is provided together with the report in the Appendices section. It is to be noted that the Gantt chart is a guideline for the project timeline.

3.3 Tools Required

For the accomplishment of the project, items used are as below:

Simulation components:

1. Saline water.

2. CO_2 gas.
3. Amine solution (Monoethanolamine and Diethanolamine)
4. Potassium Carbonate.
5. Propylene Carbonate.

Software to be used:

1. Process design simulator (Aspen Hysys)

Aspen HYSYS utilize the equation of state for solving the cases. In physics and thermodynamics, an equation of state is a relation between state variables [17] .More specifically, an equation of state is a thermodynamic equation describing the state of matter under a given set of physical conditions. It is a constitutive equation which provides a mathematical relationship between two or more state functions associated with the matter, such as its temperature, pressure, volume, or internal energy. Equations of state are useful in describing the properties of fluids, mixtures of fluids, solids.

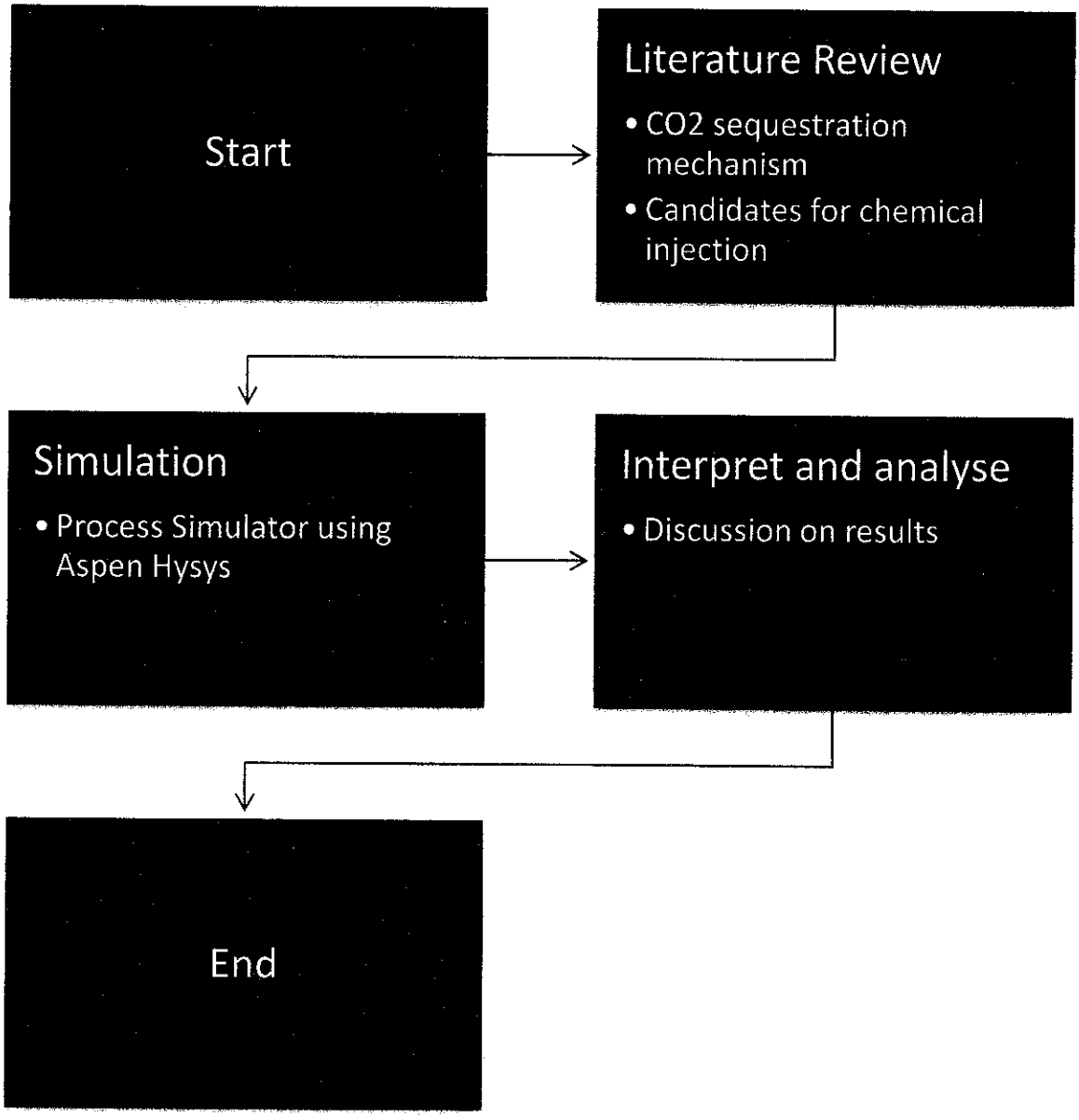
In HYSYS, fluid package have to be determined. Bad selection of fluid package to use with the define cases will yield different results since different type of equation of state have different approaches depending on cases defined. The software suggest the users based on the define fluids used on what type of package to be used. In this research, Peng-Robinson and Amine Fluid Package was used for determination of its physical properties. Amine Fluid Package was used since the fluid selected will fit the package since we are using MEA and DEA. The Peng-Robinson equation [17] was developed in 1976 in order to satisfy the following goals:

1. The parameters should be expressible in terms of the critical properties and the eccentric factor.
2. The model should provide reasonable accuracy near the critical point, particularly for calculations of the compressibility factor and liquid density.

3. The mixing rules should not employ more than a single binary interaction parameter, which should be independent of temperature pressure and composition.
4. The equation should be applicable to all calculations of all fluid properties in natural gas processes.

For the most part the Peng-Robinson is generally superior in predicting the liquid densities of many materials, especially non-polar ones.

3.4 Flowchart



3.4 Methodology

Using process simulator Aspen HYSYS, the author simulate the properties of CO_2 by mixing the chemical in a pressurized vessel (pressurized tank). In the flow scheme, the most important unit operation is the pressurized tank because at this unit the material streams are combined. A detailed process pressure vessel is normally designed in accordance with ASME Boiler and Pressure Vessel Code [6] but is beyond the scope of the paper. This design is a first theoretical stage of analyzing the surface mixing vessel and much more detailed work on the physical equipment and the costing still needs to be undertaken.

The process flow as below:

1. Using Aspen HYSYS create cases for CO_2-chemical injection strategy.
    a. 4 cases were created :
        i. CO_2 mix with MEA
        ii. CO_2 mix with DEA
        iii. CO_2 mix with potassium carbonate
        iv. CO_2 mix with propylene carbonate
2. Create flow scheme of streams to operating unit which is the pressurized vessel.
3. To standardize the results, operating pressure and temperature for each stream is set to :
    a. Operating pressure : 101.3 Kpa
    b. Operating temperature : 25 C
    c. Molar Flow rate for CO_2 : 1MMscf/day
    d. Mass flow rate for injection chemical : 2000 kg/h
    e. Concentration of chemical : 20%
4. Results are displayed and density is obtained.
5. Compared with native saline fluid.

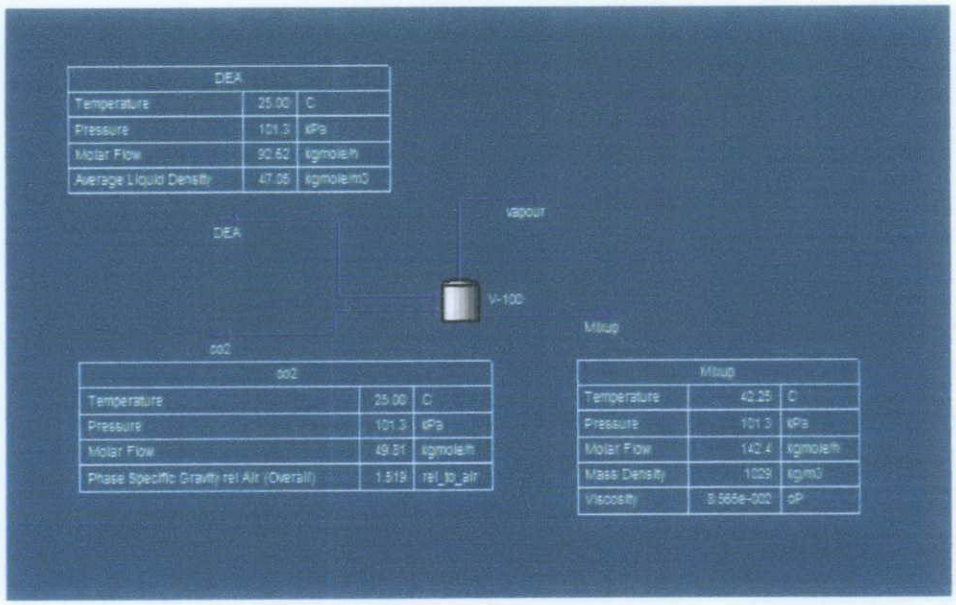


Figure 4 Example of flow scheme for cases generated.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS AND DISCUSSION

Injection strategy

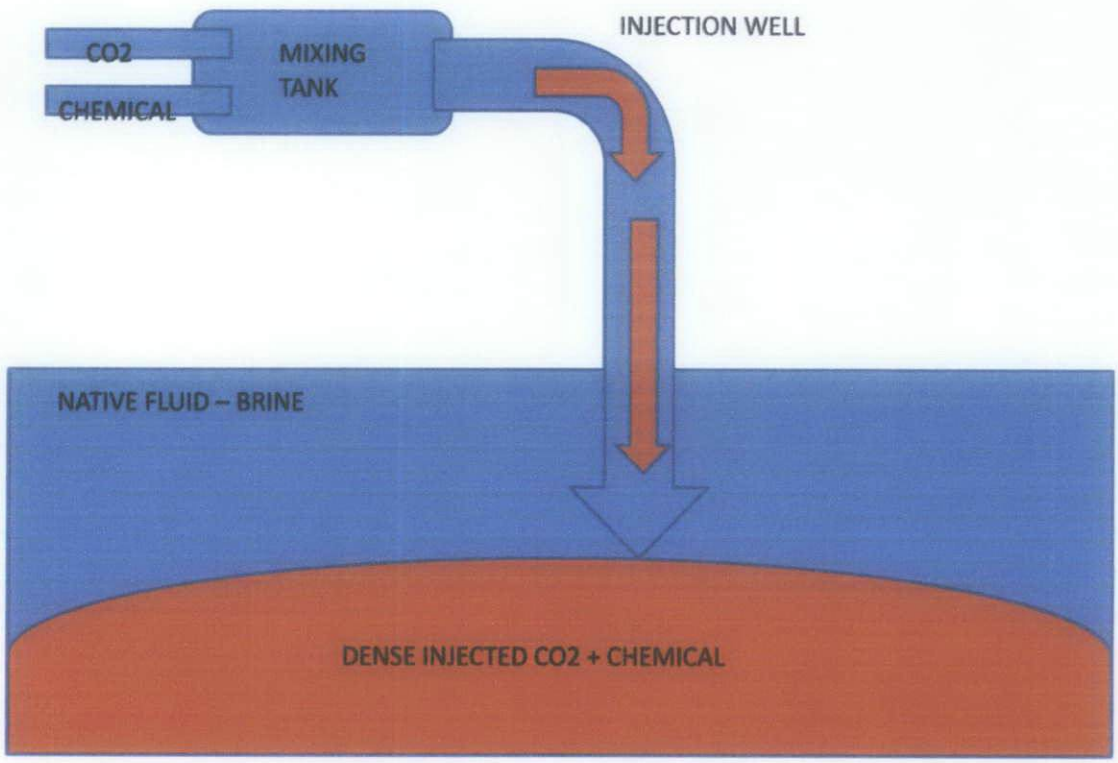


Figure 5 Illustration of expected behavior of CO_2-chemical injected in saline Aquifer

Conceptual idea of using chemically treated injection strategy to improve security of sequestrating permanently the CO_2 by eliminating CO_2 upward buoyancy.

If not treated, the injected CO_2 will move upward due to its buoyancy and migrate through the channel. By treating the CO_2, the author can control the density and making sure the injected CO_2 will lies below the native fluid and mitigate the movement of CO_2 upwards.

Process simulator results

Refer to attachment (Figure 11) for table of results of properties:

Summary of results

At standard condition as below:

a. Operating pressure : 101.3 Kpa
b. Operating temperature : 25 C
c. Molar Flow rate for CO_2 : 1MMscf/day
d. Mass flow rate for injection chemical : 2000 kg/h
e. Concentration of chemical : 20-30%

The author used the operating temperature and pressure for preliminary evaluation of selected chemical. Since the reservoir temperature is higher, the phase is most likely to change to gas phase which would yield lighter mass density. After comparing those mixture components, it did not satisfy the requirement at standard condition which would suggest at higher temperature in the reservoir the mass density will be lower.

Component	Average Mass Density (kg/m3)	Viscosity (cP)	Density relative to native brine (1103 kg/m3)
CO_2 saturated with MEA	1055	1.006	0.96
CO_2 saturated with DEA	1029	0.086	0.93
CO_2 saturated with Potassium Carbonate	743.6	0.512	0.67
CO_2 saturated with Propylene Carbonate	823.3	2.526	0.75

Based on the table above, the relative density of treated CO_2 with native brine are not higher thus conclude that CO_2 injected will not sink below the native brine. Thus this proves that the selected chemicals cannot be use for injection as our aim for preventing upward buoyancy cannot be achieved.

Therefore, based on results, another candidate should be chosen for treatment purposes. The scope for chemical selection should widen. Chemicals with higher molecular weight should be chosen as demonstrated, the higher the molecular weight of chemical the higher the relative mass density it will yield.

CHAPTER 5

RECOMMENDATION AND CONCLUSION

5.1 Recommendation

For security concern, CO_2 sequestration monitoring is important during the life cycle of CO_2. This is because since CO_2 sequestration required a long time for the result to actually being validate, the risk of leakage still occurred. A few methods for monitoring to be recommended as follow:

1. Formation fluid sampling to be within a period of time required.
2. Introduce tracer for purpose of tracing CO_2 migration.
3. 2D and 3D seismic survey.
4. Logging

The purpose is to evaluate if the performance as predicted during the conceptual process and mitigate the risk of leakage.

5.2 Conclusion

Based on the result obtained, the author can conclude that treating CO_2 with said chemical did not improve the properties of the CO_2. The prospect of using chemicals to enhance CO_2 sequestration is bright but further research must be done to select the best chemicals for CO_2 sequestration.

The author has demonstrated effect of molecular weight on mixture mass density. Further research should consider the use of higher molecular weight chemical to increase the injected chemical mass density relative to brine.

The research has demonstrated that to have the CO_2 stored permanently a mechanism is to be devised to ensure that upward buoyancy will be eliminated. Fracture or existing migration route at aquifer cap may lead to CO_2 leakage.

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GANT CHART

No	Details	Week													
		1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of Project Topic								MID SEMESTER BREAK							
2	First meeting with supervisor															
3	Preliminary Research work															
4	Preliminary Report preparation															
5	Submission of Preliminary Report (1 Sept 2010)				●											
6	Seminar 1 (optional)															
7	Progress report preparation															
8	Submission of Progress Report										●					
13	Discussion and Project Alteration															
15	Submission of Interim Report Final Draft														●	
16	Oral Presentation preparation															
17	Oral Presentation (Week 14)															●

Figure 6 Gant Chart 1st semester

No	Details	Weeks														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Literature Review																
2	Aspen Hysys simulation and interpretation																
3	Eclipse simulator																
4	Submission of Progress Report																
5	Finalization of project																
6	PRE-EDX combined with seminar/ Poster Exhibition/ Submission of Final Report (CD Softcopy & Softbound)																
7	EDX																
8	Final Oral Presentation																
9	Delivery of Final Report to External Examiner / Marking by External Examiner																
10	Submission of hardbound copies																

Figure 7 Gant Chart 2nd Semester

APPENDICES

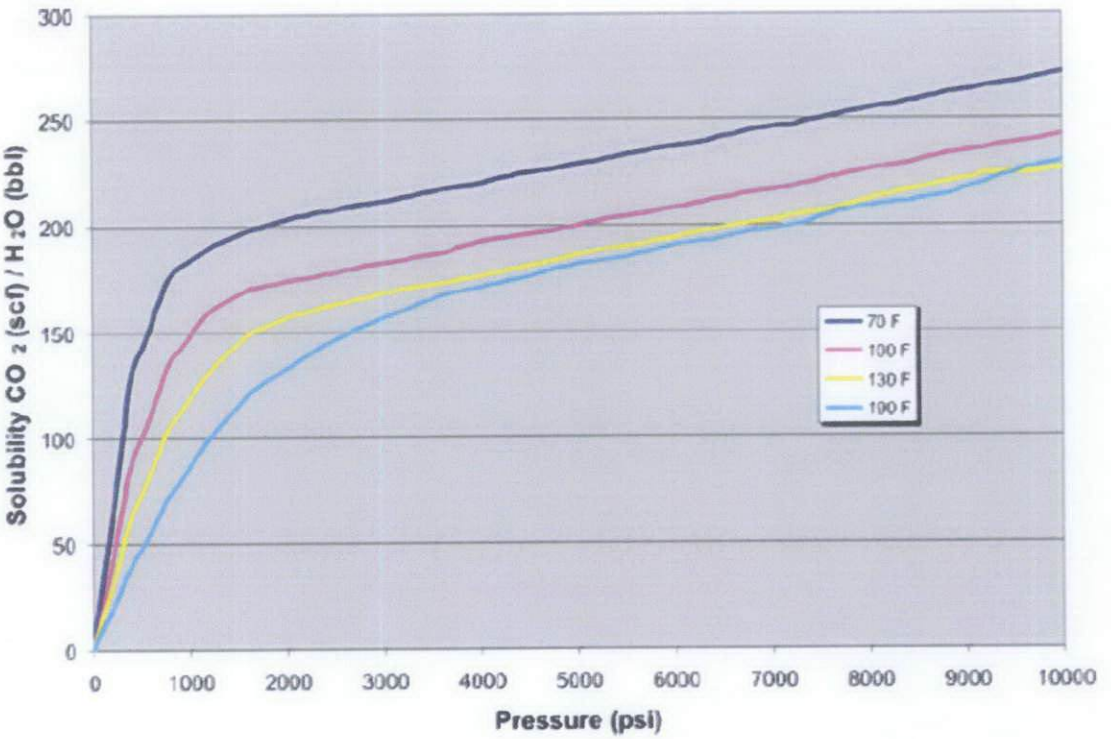

Figure 8 Solubility of CO_2 versus Pressure with different temperature

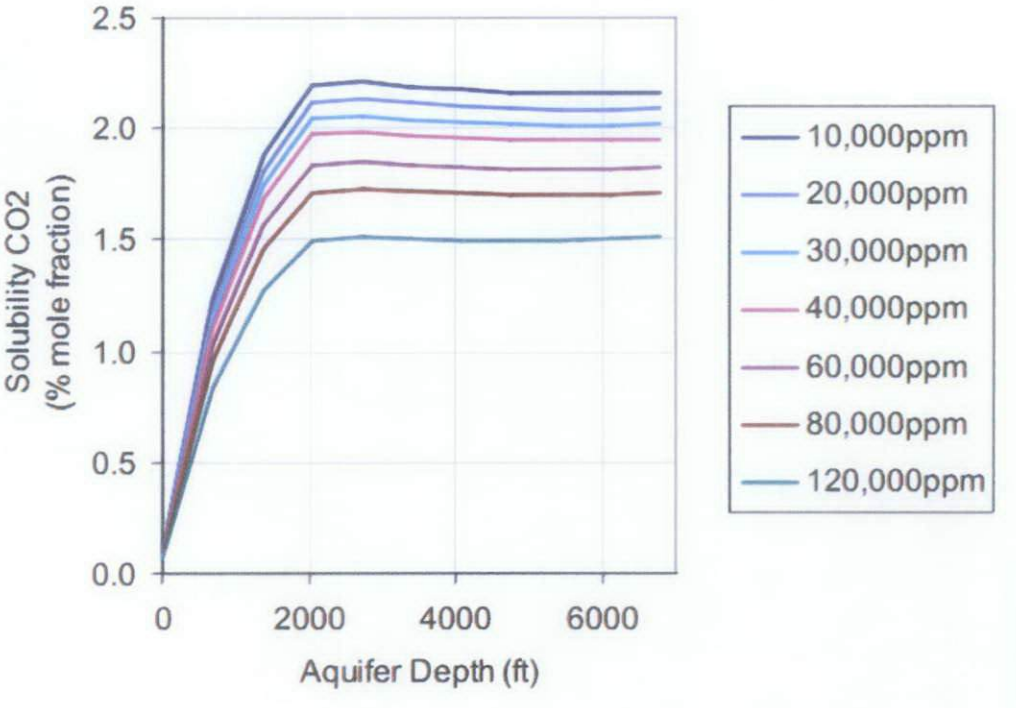

Figure 9 Solubility of CO_2 versus Depth with different salinity

RESULTS

CASE 1 : CO2 with MONOETHANOLAMINE (MEA)

Material Stream: co2

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Vapour Phase			
Vapour / Phase Fraction		1.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	109.8 *	109.8			
Mass Flow	(lb/hr)	4832	4832			
Std Ideal Liq Vol Flow	(barrel/day)	400.9	400.9			
Molar Enthalpy	(Btu/lbmole)	4027	4027			
Molar Entropy	(Btu/lbmole-F)	50.37	50.37			
Heat Flow	(Btu/hr)	4.422e+005	4.422e+005			
Liq Vol Flow @Std Cond	(barrel/day)	—	—			

PROPERTIES

		Overall	Vapour Phase			
Molecular Weight		44.01	44.01			
Molar Density	(lbmole/ft3)	2.565e-003	2.565e-003			
Mass Density	(lb/ft3)	0.1129	0.1129			
Act. Volume Flow	(barrel/day)	1.830e+005	1.830e+005			
Mass Enthalpy	(Btu/lb)	91.50	91.50			
Mass Entropy	(Btu/lb-F)	1.144	1.144			
Heat Capacity	(Btu/lbmole-F)	9.126	9.126			
Mass Heat Capacity	(Btu/lb-F)	0.2074	0.2074			
Lower Heating Value	(Btu/lbmole)	0.0000	0.0000			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		4.941e-324	1.000			
Partial Pressure of CO2	(psia)	14.69	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	713.4	713.4			
Avg. Liq. Density	(lbmole/ft3)	1.171	1.171			
Specific Heat	(Btu/lbmole-F)	9.126	9.126			
Std. Gas Flow	(MMSCFD)	0.9981	0.9981			
Std. Ideal Liq. Mass Density	(lb/ft3)	51.52	51.52			
Act. Liq. Flow	(USGPM)	—	—			
Z Factor		0.9945	0.9945			
Watson K		8.524	8.524			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.278	1.278			
Cp/Cv		1.286	1.286			
Heat of Vap.	(Btu/lbmole)	—	—			
Kinematic Viscosity	(cSt)	8.348	8.348			
Liq. Mass Density (Std. Cond)	(lb/ft3)	—	—			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	—	—			
Liquid Fraction		0.0000	0.0000			
Molar Volume	(ft3/lbmole)	389.8	389.8			
Mass Heat of Vap.	(Btu/lb)	—	—			

* Specified by user.

Material Stream: co2 (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Vapour Phase			
Phase Fraction [Molar Basis]		1.0000	1.0000			
Surface Tension	(dyne/cm)	—	—			
Thermal Conductivity	(Btu/hr-ft-F)	9.525e-003	9.525e-003			
Viscosity	(cP)	1.510e-002	1.510e-002			
Cv (Semi-Ideal)	(Btu/lbmole-F)	7.141	7.141			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.1623	0.1623			
Cv	(Btu/lbmole-F)	7.095	7.095			
Mass Cv	(Btu/lb-F)	0.1612	0.1612			
Cv (Ent. Method)	(Btu/lbmole-F)	—	—			
Mass Cv (Ent. Method)	(Btu/lb-F)	—	—			
Cp/Cv (Ent. Method)		—	—			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	—	—			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	0.0000	0.0000			

COMPOSITION

Overall Phase

Vapour Fraction 1.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047 *	1.0000 *	4832.4717 *	1.0000 *	400.9196 *	1.0000 *
H2O	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
MEAmine	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

Vapour Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000
H2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MEAmine	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

* Specified by user.

Material Stream: MEA

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Aqueous Phase			
Vapour / Phase Fraction		0.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	210.2	210.2			
Mass Flow	(lb/hr)	4409 *	4409			
Std Ideal Liq Vol Flow	(barrel/day)	301.4	301.4			
Molar Enthalpy	(Btu/lbmole)	-1.302e+004	-1.302e+004			
Molar Entropy	(Btu/lbmole-F)	19.40	19.40			
Heat Flow	(Btu/hr)	-2.737e+006	-2.737e+006			
Liq Vol Flow @Std Cond	(barrel/day)	300.6 *	300.6			

PROPERTIES

		Overall	Aqueous Phase			
Molecular Weight		20.97	20.97			
Molar Density	(lbmole/ft3)	2.985	2.985			
Mass Density	(lb/ft3)	62.61	62.61			
Act. Volume Flow	(barrel/day)	301.0	301.0			
Mass Enthalpy	(Btu/lb)	-620.8	-620.8			
Mass Entropy	(Btu/lb-F)	0.9249	0.9249			
Heat Capacity	(Btu/lbmole-F)	19.40	19.40			
Mass Heat Capacity	(Btu/lb-F)	0.9249	0.9249			
Lower Heating Value	(Btu/lbmole)	4.024e+004	4.024e+004			
Mass Lower Heating Value	(Btu/lb)	1919	1919			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		0.0000	1.000			
Partial Pressure of CO2	(psia)	0.0000	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	—	—			
Avg. Liq. Density	(lbmole/ft3)	2.982	2.982			
Specific Heat	(Btu/lbmole-F)	19.40	19.40			
Std. Gas Flow	(MMSCFD)	1.911	1.911			
Std. Ideal Liq. Mass Density	(lb/ft3)	62.54	62.54			
Act. Liq. Flow	(USGPM)	8.780	8.780			
Z Factor		8.546e-004	8.546e-004			
Watson K		9.103	9.103			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.114	1.114			
Cp/Cv		1.114	1.114			
Heat of Vap.	(Btu/lbmole)	1.817e+004	—			
Kinematic Viscosity	(cSt)	1.357	1.357			
Liq. Mass Density (Std. Cond)	(lb/ft3)	62.69	62.69			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	300.6	300.6			
Liquid Fraction		1.000	1.000			
Molar Volume	(ft3/lbmole)	0.3350	0.3350			
Mass Heat of Vap.	(Btu/lb)	866.4	—			

* Specified by user.

Material Stream: MEA (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Aqueous Phase			
Phase Fraction [Molar Basis]		0.0000	1.0000			
Surface Tension	(dyne/cm)	67.24	67.24			
Thermal Conductivity	(Btu/hr-ft-F)	0.3041	0.3041			
Viscosity	(cP)	1.360	1.360			
Cv (Semi-Ideal)	(Btu/lbmole-F)	17.41	17.41			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.8302	0.8302			
Cv	(Btu/lbmole-F)	17.41	17.41			
Mass Cv	(Btu/lb-F)	0.8302	0.8302			
Cv (Ent. Method)	(Btu/lbmole-F)	—	—			
Mass Cv (Ent. Method)	(Btu/lb-F)	—	—			
Cp/Cv (Ent. Method)		—	—			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	0.8862	0.8862			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	300.6	300.6			

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
H2O	195.8002 *	0.9313 *	3527.3600 *	0.8000 *	242.0157 *	0.8030 *
MEAmine	14.4365 *	0.0687 *	881.8400 *	0.2000 *	59.3745 *	0.1970 *
Total	210.2367	1.0000	4409.2000	1.0000	301.3902	1.0000

Aqueous Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2O	195.8002	0.9313	3527.3600	0.8000	242.0157	0.8030
MEAmine	14.4365	0.0687	881.8400	0.2000	59.3745	0.1970
Total	210.2367	1.0000	4409.2000	1.0000	301.3902	1.0000

* Specified by user.

Material Stream: Mixup

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Vapour Phase	Aqueous Phase		
Vapour / Phase Fraction		0.0000	0.0000	1.0000		
Temperature:	(F)	104.7	104.7	104.7		
Pressure:	(psia)	14.69	14.69	14.69		
Molar Flow	(lbmole/hr)	211.9	0.0000	211.9		
Mass Flow	(lb/hr)	4676	0.0000	4676		
Std Ideal Liq Vol Flow	(barrel/day)	325.5	0.0000	325.5		
Molar Enthalpy	(Btu/lbmole)	-1.303e+004	4298	-1.303e+004		
Molar Entropy	(Btu/lbmole-F)	16.18	51.35	16.18		
Heat Flow	(Btu/hr)	-2.760e+006	0.0000	-2.760e+006		
Liq Vol Flow @Std Cond	(barrel/day)	301.9 *	0.0000	301.9		

PROPERTIES

		Overall	Vapour Phase	Aqueous Phase		
Molecular Weight		22.07	42.20	22.07		
Molar Density	(lbmole/ft3)	2.984	2.438e-003	2.984		
Mass Density	(lb/ft3)	65.86	0.1029	65.86		
Act. Volume Flow	(barrel/day)	303.5	0.0000	303.5		
Mass Enthalpy	(Btu/lb)	-590.3	101.9	-590.3		
Mass Entropy	(Btu/lb-F)	0.7329	1.217	0.7329		
Heat Capacity	(Btu/lbmole-F)	19.40	9.151	19.40		
Mass Heat Capacity	(Btu/lb-F)	0.8790	0.2168	0.8790		
Lower Heating Value	(Btu/lbmole)	3.990e+004	71.27	3.990e+004		
Mass Lower Heating Value	(Btu/lb)	1808	1.689	1808		
Phase Fraction [Vol. Basis]		—	—	1.000		
Phase Fraction [Mass Basis]		4.941e-324	0.0000	1.000		
Partial Pressure of CO2	(psia)	0.0000	—	—		
Cost Based on Flow	(Cost/s)	0.0000	0.0000	0.0000		
Act. Gas Flow	(ACFM)	—	—	—		
Avg. Liq. Density	(lbmole/ft3)	2.782	1.227	2.782		
Specific Heat	(Btu/lbmole-F)	19.40	9.151	19.40		
Std. Gas Flow	(MMSCFD)	1.926	0.0000	1.926		
Std. Ideal Liq. Mass Density	(lb/ft3)	61.41	51.79	61.41		
Act. Liq. Flow	(USGPM)	8.851	—	8.851		
Z Factor		—	0.9950	8.130e-004		
Watson K		8.960	8.524	8.960		
User Property		—	—	—		
Partial Pressure of H2S	(psia)	0.0000	—	—		
Cp/(Cp - R)		1.114	1.277	1.114		
Cp/Cv		1.114	1.285	1.114		
Heat of Vap.	(Btu/lbmole)	1.903e+004	—	—		
Kinematic Viscosity	(cSt)	0.9533	9.477	0.9533		
Liq. Mass Density (Std. Cond)	(lb/ft3)	66.20	65.85	66.20		
Liq. Vol. Flow (Std. Cond)	(barrel/day)	301.9	0.0000	301.9		
Liquid Fraction		1.000	0.0000	1.000		
Molar Volume	(ft3/lbmole)	0.3351	410.1	0.3351		
Mass Heat of Vap.	(Btu/lb)	862.0	—	—		

* Specified by user.

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Vapour Phase	Aqueous Phase		
Phase Fraction [Molar Basis]		0.0000	0.0000	1.0000		
Surface Tension	(dyne/cm)	64.89	—	64.89		
Thermal Conductivity	(Btu/hr-ft-F)	0.3122	1.046e-002	0.3122		
Viscosity	(cP)	1.006	1.562e-002	1.006		
Cv (Semi-Ideal)	(Btu/lbmole-F)	17.41	7.165	17.41		
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.7890	0.1698	0.7890		
Cv	(Btu/lbmole-F)	17.41	7.120	17.41		
Mass Cv	(Btu/lb-F)	0.7890	0.1687	0.7890		
Cv (Ent. Method)	(Btu/lbmole-F)	—	34.98	—		
Mass Cv (Ent. Method)	(Btu/lb-F)	—	0.8289	—		
Cp/Cv (Ent. Method)		—	0.2616	—		
Reid VP at 37.8 C	(psia)	721.6	—	721.6		
True VP at 37.8 C	(psia)	13.08	1243	13.08		
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	301.9	0.0000	301.9		

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	9.1592	0.0432	403.0952	0.0862	33.4423	0.1028
H2O	188.2683	0.8887	3391.6722	0.7254	232.7061	0.7150
MEAmine	14.4234	0.0681	881.0363	0.1884	59.3204	0.1823
Total	211.8509	1.0000	4675.8037	1.0000	325.4687	1.0000

Vapour Phase

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.9303	0.0000	0.9701	0.0000	0.9752
H2O	0.0000	0.0696	0.0000	0.0297	0.0000	0.0247
MEAmine	0.0000	0.0001	0.0000	0.0002	0.0000	0.0001
Total	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Aqueous Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	9.1592	0.0432	403.0952	0.0862	33.4423	0.1028
H2O	188.2683	0.8887	3391.6722	0.7254	232.7061	0.7150
MEAmine	14.4234	0.0681	881.0363	0.1884	59.3204	0.1823
Total	211.8509	1.0000	4675.8037	1.0000	325.4687	1.0000

Material Stream: co2

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Vapour Phase			
Vapour / Phase Fraction		1.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	109.8 *	109.8			
Mass Flow	(lb/hr)	4832	4832			
Std Ideal Liq Vol Flow	(barrel/day)	400.9	400.9			
Molar Enthalpy	(Btu/lbmole)	4027	4027			
Molar Entropy	(Btu/lbmole-F)	50.37	50.37			
Heat Flow	(Btu/hr)	4.422e+005	4.422e+005			
Liq Vol Flow @Std Cond	(barrel/day)	—	—			

PROPERTIES

		Overall	Vapour Phase			
Molecular Weight		44.01	44.01			
Molar Density	(lbmole/ft3)	2.565e-003	2.565e-003			
Mass Density	(lb/ft3)	0.1129	0.1129			
Act. Volume Flow	(barrel/day)	1.830e+005	1.830e+005			
Mass Enthalpy	(Btu/lb)	91.50	91.50			
Mass Entropy	(Btu/lb-F)	1.144	1.144			
Heat Capacity	(Btu/lbmole-F)	9.126	9.126			
Mass Heat Capacity	(Btu/lb-F)	0.2074	0.2074			
Lower Heating Value	(Btu/lbmole)	0.0000	0.0000			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		4.941e-324	1.000			
Partial Pressure of CO2	(psia)	14.69	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	713.4	713.4			
Avg. Liq. Density	(lbmole/ft3)	1.171	1.171			
Specific Heat	(Btu/lbmole-F)	9.126	9.126			
Std. Gas Flow	(MMSCFD)	0.9981	0.9981			
Std. Ideal Liq. Mass Density	(lb/ft3)	51.52	51.52			
Act. Liq. Flow	(USGPM)	—	—			
Z Factor		0.9945	0.9945			
Watson K		8.524	8.524			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.278	1.278			
Cp/Cv		1.286	1.286			
Heat of Vap.	(Btu/lbmole)	—	—			
Kinematic Viscosity	(cSt)	8.348	8.348			
Liq. Mass Density (Std. Cond)	(lb/ft3)	—	—			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	—	—			
Liquid Fraction		0.0000	0.0000			
Molar Volume	(ft3/lbmole)	389.8	389.8			
Mass Heat of Vap.	(Btu/lb)	—	—			

* Specified by user.

Material Stream: co2 (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Vapour Phase			
Phase Fraction [Molar Basis]		1.0000	1.0000			
Surface Tension	(dyne/cm)	—	—			
Thermal Conductivity	(Btu/hr-ft-F)	9.525e-003	9.525e-003			
Viscosity	(cP)	1.510e-002	1.510e-002			
Cv (Semi-Ideal)	(Btu/lbmole-F)	7.141	7.141			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.1623	0.1623			
Cv	(Btu/lbmole-F)	7.095	7.095			
Mass Cv	(Btu/lb-F)	0.1612	0.1612			
Cv (Ent. Method)	(Btu/lbmole-F)	—	—			
Mass Cv (Ent. Method)	(Btu/lb-F)	—	—			
Cp/Cv (Ent. Method)		—	—			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	—	—			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	0.0000	0.0000			

COMPOSITION

Overall Phase Vapour Fraction 1.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047 *	1.0000 *	4832.4717 *	1.0000 *	400.9196 *	1.0000 *
H2O	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
DEAmine	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

Vapour Phase Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000
H2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DEAmine	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

* Specified by user.

Material Stream: DEA

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Aqueous Phase			
Vapour / Phase Fraction		0.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	204.2	204.2			
Mass Flow	(lb/hr)	4409 *	4409			
Std Ideal Liq Vol Flow	(barrel/day)	297.2	297.2			
Molar Enthalpy	(Btu/lbmole)	-1.310e+004	-1.310e+004			
Molar Entropy	(Btu/lbmole-F)	19.63	19.63			
Heat Flow	(Btu/hr)	-2.674e+006	-2.674e+006			
Liq Vol Flow @Std Cond	(barrel/day)	295.1 *	295.1			

PROPERTIES

		Overall	Aqueous Phase			
Molecular Weight		21.59	21.59			
Molar Density	(lbmole/ft3)	2.951	2.951			
Mass Density	(lb/ft3)	63.73	63.73			
Act. Volume Flow	(barrel/day)	295.8	295.8			
Mass Enthalpy	(Btu/lb)	-606.5	-606.5			
Mass Entropy	(Btu/lb-F)	0.9093	0.9093			
Heat Capacity	(Btu/lbmole-F)	19.63	19.63			
Mass Heat Capacity	(Btu/lb-F)	0.9093	0.9093			
Lower Heating Value	(Btu/lbmole)	—	—			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		0.0000	1.000			
Partial Pressure of CO2	(psia)	0.0000	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	—	—			
Avg. Liq. Density	(lbmole/ft3)	2.937	2.937			
Specific Heat	(Btu/lbmole-F)	19.63	19.63			
Std. Gas Flow	(MMSCFD)	1.856	1.856			
Std. Ideal Liq. Mass Density	(lb/ft3)	63.43	63.43			
Act. Liq. Flow	(USGPM)	8.626	8.626			
Z Factor		8.644e-004	8.644e-004			
Watson K		9.040	9.040			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.113	1.113			
Cp/Cv		1.113	1.113			
Heat of Vap.	(Btu/lbmole)	1.942e+004	—			
Kinematic Viscosity	(cSt)	1.548	1.548			
Liq. Mass Density (Std. Cond)	(lb/ft3)	63.87	63.87			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	295.1	295.1			
Liquid Fraction		1.000	1.000			
Molar Volume	(ft3/lbmole)	0.3388	0.3388			
Mass Heat of Vap.	(Btu/lb)	899.5	—			

* Specified by user.

Material Stream: DEA (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Aqueous Phase			
Phase Fraction [Molar Basis]		0.0000	1.0000			
Surface Tension	(dyne/cm)	65.23	65.23			
Thermal Conductivity	(Btu/hr-ft-F)	0.2940	0.2940			
Viscosity	(cP)	1.581	1.581			
Cv (Semi-Ideal)	(Btu/lbmole-F)	17.65	17.65			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.8173	0.8173			
Cv	(Btu/lbmole-F)	17.65	17.65			
Mass Cv	(Btu/lb-F)	0.8173	0.8173			
Cv (Ent. Method)	(Btu/lbmole-F)	—	—			
Mass Cv (Ent. Method)	(Btu/lb-F)	—	—			
Cp/Cv (Ent. Method)		—	—			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	0.9113	0.9113			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	295.1	295.1			

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
H2O	195.8002 *	0.9589 *	3527.3600 *	0.8000 *	242.0157 *	0.8144 *
DEAmine	8.3875 *	0.0411 *	881.8400 *	0.2000 *	55.1435 *	0.1856 *
Total	204.1876	1.0000	4409.2000	1.0000	297.1592	1.0000

Aqueous Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
H2O	195.8002	0.9589	3527.3600	0.8000	242.0157	0.8144
DEAmine	8.3875	0.0411	881.8400	0.2000	55.1435	0.1856
Total	204.1876	1.0000	4409.2000	1.0000	297.1592	1.0000

* Specified by user.

Material Stream: Mixup

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

CONDITIONS

		Overall	Aqueous Phase	Liquid Phase	Vapour Phase
Vapour / Phase Fraction		0.0000	0.6404	0.3596	0.0000
Temperature:	(F)	108.0	108.0	108.0	108.0
Pressure:	(psia)	14.69	14.69	14.69	14.69
Molar Flow	(lbmole/hr)	314.0	201.1	112.9	0.0000
Mass Flow	(lb/hr)	9242	4504	4737	0.0000
Std Ideal Liq Vol Flow	(barrel/day)	698.1	307.4	390.7	0.0000
Molar Enthalpy	(Btu/lbmole)	-7109	-1.270e+004	2854	5971
Molar Entropy	(Btu/lbmole-F)	19.87	19.87	19.87	52.28
Heat Flow	(Btu/hr)	-2.232e+006	-2.554e+006	3.223e+005	0.0000
Liq Vol Flow @Std Cond	(barrel/day)	586.3 *	285.6	324.8	0.0000

PROPERTIES

		Overall	Aqueous Phase	Liquid Phase	Vapour Phase
Molecular Weight		29.43	22.40	41.95	29.43
Molar Density	(lbmole/ft3)	2.182	2.986	1.475	2.438e-003
Mass Density	(lb/ft3)	64.22	66.88	61.88	7.176e-002
Act. Volume Flow	(barrel/day)	615.1	287.9	327.2	0.0000
Mass Enthalpy	(Btu/lb)	-241.5	-567.1	68.03	202.9
Mass Entropy	(Btu/lb-F)	0.6752	0.8871	0.4737	1.776
Heat Capacity	(Btu/lbmole-F)	16.31	19.87	9.962	9.003
Mass Heat Capacity	(Btu/lb-F)	0.5541	0.8871	0.2375	0.3059
Lower Heating Value	(Btu/lbmole)	---	---	0.0000	---
Mass Lower Heating Value	(Btu/lb)	---	---	---	---
Phase Fraction [Vol. Basis]		---	0.4403	0.5597	---
Phase Fraction [Mass Basis]		2.122e-314	0.4874	0.5126	0.0000
Partial Pressure of CO2	(psia)	0.0000	---	---	---
Cost Based on Flow	(Cost/s)	0.0000	0.0000	0.0000	0.0000
Act. Gas Flow	(ACFM)	---	---	---	---
Avg. Liq. Density	(lbmole/ft3)	1.923	2.796	1.235	1.923
Specific Heat	(Btu/lbmole-F)	16.31	19.87	9.962	9.003
Std. Gas Flow	(MMSCFD)	2.854	1.828	1.026	0.0000
Std. Ideal Liq. Mass Density	(lb/ft3)	56.59	62.64	51.83	56.59
Act. Liq. Flow	(USGPM)	17.94	8.397	9.545	---
Z Factor		---	8.078e-004	1.635e-003	0.9892
Watson K		8.568	8.847	8.524	8.568
User Property		---	---	---	---
Partial Pressure of H2S	(psia)	0.0000	---	---	---
Cp/(Cp - R)		1.139	1.111	1.249	1.283
Cp/Cv		1.139	1.111	1.249	1.299
Heat of Vap.	(Btu/lbmole)	1.368e+004	---	---	---
Kinematic Viscosity	(cSt)	8.325e-002	1.049	1.603e-002	11.09
Liq. Mass Density (Std. Cond)	(lb/ft3)	67.37	67.42	62.34	67.37
Liq. Vol. Flow (Std. Cond)	(barrel/day)	586.3	285.6	324.8	0.0000
Liquid Fraction		1.000	1.000	1.000	0.0000
Molar Volume	(ft3/lbmole)	0.4583	0.3350	0.6779	410.2
Mass Heat of Vap.	(Btu/lb)	464.8	---	---	---

* Specified by user.

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

PROPERTIES

		Overall	Aqueous Phase	Liquid Phase	Vapour Phase	
Phase Fraction [Molar Basis]		0.0000	0.6404	0.3596	0.0000	
Surface Tension	(dyne/cm)	—	62.18	3.690e-010	—	
Thermal Conductivity	(Btu/hr-ft-F)	0.3375	0.3030	0.3712	1.295e-002	
Viscosity	(cP)	8.565e-002	1.124	1.589e-002	1.275e-002	
Cv (Semi-Ideal)	(Btu/lbmole-F)	14.32	17.89	7.977	7.017	
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4866	0.7984	0.1901	0.2384	
Cv	(Btu/lbmole-F)	14.32	17.89	7.977	6.930	
Mass Cv	(Btu/lb-F)	0.4866	0.7984	0.1901	0.2354	
Cv (Ent. Method)	(Btu/lbmole-F)	—	—	—	—	
Mass Cv (Ent. Method)	(Btu/lb-F)	—	—	—	—	
Cp/Cv (Ent. Method)		—	—	—	—	
Reid VP at 37.8 C	(psia)	—	—	—	—	
True VP at 37.8 C	(psia)	318.3	11.56	1243	318.3	
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	610.4	285.6	324.8	0.0000	

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047	0.3497	4832.4717	0.5229	400.9196	0.5743
H2O	195.8002	0.6236	3527.3600	0.3817	242.0157	0.3467
DEAmine	8.3875	0.0267	881.8400	0.0954	55.1435	0.0790
Total	313.9923	1.0000	9241.6717	1.0000	698.0788	1.0000

Aqueous Phase

Phase Fraction 0.6404

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	5.8201	0.0289	256.1427	0.0569	21.2505	0.0691
H2O	186.8596	0.9293	3366.2938	0.7474	230.9648	0.7515
DEAmine	8.3874	0.0417	881.8383	0.1958	55.1433	0.1794
Total	201.0671	1.0000	4504.2747	1.0000	307.3587	1.0000

Liquid Phase

Phase Fraction 0.3596

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	103.9846	0.9208	4576.3290	0.9660	379.6691	0.9717
H2O	8.9406	0.0792	161.0662	0.0340	11.0509	0.0283
DEAmine	0.0000	0.0000	0.0017	0.0000	0.0001	0.0000
Total	112.9252	1.0000	4737.3970	1.0000	390.7201	1.0000

Vapour Phase

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.3497	0.0000	0.5229	0.0000	0.5743
H2O	0.0000	0.6236	0.0000	0.3817	0.0000	0.3467

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Amine Pkg - KE

COMPOSITION

Vapour Phase (continued)

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
DEAmine	0.0000	0.0267	0.0000	0.0954	0.0000	0.0790
Total	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Material Stream: co2

Fluid Package: Basis-1
Property Package: Peng-Robinson

CONDITIONS

		Overall	Vapour Phase			
Vapour / Phase Fraction		1.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	109.8 *	109.8			
Mass Flow	(lb/hr)	4832	4832			
Std Ideal Liq Vol Flow	(barrel/day)	400.9	400.9			
Molar Enthalpy	(Btu/lbmole)	-1.693e+005	-1.693e+005			
Molar Entropy	(Btu/lbmole-F)	41.17	41.17			
Heat Flow	(Btu/hr)	-1.859e+007	-1.859e+007			
Liq Vol Flow @Std Cond	(barrel/day)	400.2 *	400.2			

PROPERTIES

		Overall	Vapour Phase			
Molecular Weight		44.01	44.01			
Molar Density	(lbmole/ft3)	2.565e-003	2.565e-003			
Mass Density	(lb/ft3)	0.1129	0.1129			
Act. Volume Flow	(barrel/day)	1.830e+005	1.830e+005			
Mass Enthalpy	(Btu/lb)	-3847	-3847			
Mass Entropy	(Btu/lb-F)	0.9356	0.9356			
Heat Capacity	(Btu/lbmole-F)	9.195	9.195			
Mass Heat Capacity	(Btu/lb-F)	0.2089	0.2089			
Lower Heating Value	(Btu/lbmole)	0.0000	0.0000			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		4.941e-324	1.000			
Partial Pressure of CO2	(psia)	14.69	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	713.4	713.4			
Avg. Liq. Density	(lbmole/ft3)	1.171	1.171			
Specific Heat	(Btu/lbmole-F)	9.195	9.195			
Std. Gas Flow	(MMSCFD)	0.9981	0.9981			
Std. Ideal Liq. Mass Density	(lb/ft3)	51.52	51.52			
Act. Liq. Flow	(USGPM)	—	—			
Z Factor		0.9944	0.9944			
Watson K		8.524	8.524			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.275	1.275			
Cp/Cv		1.284	1.284			
Heat of Vap.	(Btu/lbmole)	7396	—			
Kinematic Viscosity	(cSt)	8.084	8.084			
Liq. Mass Density (Std. Cond)	(lb/ft3)	51.62	51.62			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	400.2	400.2			
Liquid Fraction		0.0000	0.0000			
Molar Volume	(ft3/lbmole)	389.8	389.8			
Mass Heat of Vap.	(Btu/lb)	168.1	—			

* Specified by user.

Material Stream: co2 (continued)

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Vapour Phase			
Phase Fraction [Molar Basis]		1.0000	1.0000			
Surface Tension	(dyne/cm)	—	—			
Thermal Conductivity	(Btu/hr-ft-F)	9.808e-003	9.808e-003			
Viscosity	(cP)	1.462e-002	1.462e-002			
Cv (Semi-Ideal)	(Btu/lbmole-F)	7.209	7.209			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.1638	0.1638			
Cv	(Btu/lbmole-F)	7.163	7.163			
Mass Cv	(Btu/lb-F)	0.1628	0.1628			
Cv (Ent. Method)	(Btu/lbmole-F)	7.145	7.145			
Mass Cv (Ent. Method)	(Btu/lb-F)	0.1624	0.1624			
Cp/Cv (Ent. Method)		1.287	1.287			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	—	—			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	400.2	400.2			

COMPOSITION

Overall Phase

Vapour Fraction 1.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047 *	1.0000 *	4832.4717 *	1.0000 *	400.9196 *	1.0000 *
Potassium Carbonate*	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

Vapour Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000
Potassium Carbonate*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

* Specified by user.

Material Stream: Potassium Carbonate

Fluid Package: Basis-1
Property Package: Peng-Robinson

CONDITIONS

		Overall	Liquid Phase			
Vapour / Phase Fraction		0.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	40.74	40.74			
Mass Flow	(lb/hr)	4409 *	4409			
Std Ideal Liq Vol Flow	(barrel/day)	407.6	407.6			
Molar Enthalpy	(Btu/lbmole)	-1.007e+005	-1.007e+005			
Molar Entropy	(Btu/lbmole-F)	38.47	38.47			
Heat Flow	(Btu/hr)	-4.102e+006	-4.102e+006			
Liq Vol Flow @Std Cond	(barrel/day)	407.3 *	407.3			

PROPERTIES

		Overall	Liquid Phase			
Molecular Weight		108.2	108.2			
Molar Density	(lbmole/ft3)	0.4225	0.4225			
Mass Density	(lb/ft3)	45.73	45.73			
Act. Volume Flow	(barrel/day)	412.1	412.1			
Mass Enthalpy	(Btu/lb)	-930.3	-930.3			
Mass Entropy	(Btu/lb-F)	0.3555	0.3555			
Heat Capacity	(Btu/lbmole-F)	50.66	50.66			
Mass Heat Capacity	(Btu/lb-F)	0.4680	0.4680			
Lower Heating Value	(Btu/lbmole)	—	—			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		2.122e-314	1.000			
Partial Pressure of CO2	(psia)	0.0000	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	—	—			
Avg. Liq. Density	(lbmole/ft3)	0.4273	0.4273			
Specific Heat	(Btu/lbmole-F)	50.66	50.66			
Std. Gas Flow	(MMSCFD)	0.3703	0.3703			
Std. Ideal Liq. Mass Density	(lb/ft3)	46.24	46.24			
Act. Liq. Flow	(USGPM)	12.02	12.02			
Z Factor		6.038e-003	6.038e-003			
Watson K		11.85	11.85			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.041	1.041			
Cp/Cv		1.171	1.171			
Heat of Vap.	(Btu/lbmole)	1.392e+004	—			
Kinematic Viscosity	(cSt)	0.6330	0.6330			
Liq. Mass Density (Std. Cond)	(lb/ft3)	46.27	46.27			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	407.3	407.3			
Liquid Fraction		1.000	1.000			
Molar Volume	(ft3/lbmole)	2.367	2.367			
Mass Heat of Vap.	(Btu/lb)	128.7	—			

* Specified by user.

Material Stream: Potassium Carbonate (

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Liquid Phase			
Phase Fraction [Molar Basis]		0.0000	1.0000			
Surface Tension	(dyne/cm)	21.61	21.61			
Thermal Conductivity	(Btu/hr-ft-F)	6.956e-002	6.956e-002			
Viscosity	(cP)	0.4637	0.4637			
Cv (Semi-Ideal)	(Btu/lbmole-F)	48.67	48.67			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4497	0.4497			
Cv	(Btu/lbmole-F)	43.26	43.26			
Mass Cv	(Btu/lb-F)	0.3997	0.3997			
Cv (Ent. Method)	(Btu/lbmole-F)	---	---			
Mass Cv (Ent. Method)	(Btu/lb-F)	---	---			
Cp/Cv (Ent. Method)		---	---			
Reid VP at 37.8 C	(psia)	---	---			
True VP at 37.8 C	(psia)	1.314	1.314			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	407.3	407.3			

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
Potassium Carbonate*	40.7384 *	1.0000 *	4409.2000 *	1.0000 *	407.5724 *	1.0000 *
Total	40.7384	1.0000	4409.2000	1.0000	407.5724	1.0000

Liquid Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Potassium Carbonate*	40.7384	1.0000	4409.2000	1.0000	407.5724	1.0000
Total	40.7384	1.0000	4409.2000	1.0000	407.5724	1.0000

* Specified by user.

Material Stream: Mixup

Fluid Package: Basis-1
Property Package: Peng-Robinson

CONDITIONS

	Overall	Vapour Phase	Liquid Phase		
Vapour / Phase Fraction	0.0000	0.0000	1.0000		
Temperature: (F)	59.93	59.93	59.93		
Pressure: (psia)	14.69	14.69	14.69		
Molar Flow (lbmole/hr)	37.88	0.0000	37.88		
Mass Flow (lb/hr)	4061	0.0000	4061		
Std Ideal Liq Vol Flow (barrel/day)	375.2	0.0000	375.2		
Molar Enthalpy (Btu/lbmole)	-1.027e+005	-1.669e+005	-1.027e+005		
Molar Entropy (Btu/lbmole-F)	36.81	41.75	36.81		
Heat Flow (Btu/hr)	-3.890e+006	0.0000	-3.890e+006		
Liq Vol Flow @Std Cond (barrel/day)	373.8 *	0.0000	373.8		

PROPERTIES

	Overall	Vapour Phase	Liquid Phase		
Molecular Weight	107.2	45.98	107.2		
Molar Density (lbmole/ft3)	0.4330	2.653e-003	0.4330		
Mass Density (lb/ft3)	46.42	0.1220	46.42		
Act. Volume Flow (barrel/day)	374.0	0.0000	374.0		
Mass Enthalpy (Btu/lb)	-957.9	-3630	-957.9		
Mass Entropy (Btu/lb-F)	0.3434	0.9080	0.3434		
Heat Capacity (Btu/lbmole-F)	49.00	10.04	49.00		
Mass Heat Capacity (Btu/lb-F)	0.4571	0.2184	0.4571		
Lower Heating Value (Btu/lbmole)	---	---	---		
Mass Lower Heating Value (Btu/lb)	---	---	---		
Phase Fraction [Vol. Basis]	---	---	1.000		
Phase Fraction [Mass Basis]	2.122e-314	0.0000	1.000		
Partial Pressure of CO2 (psia)	0.0000	---	---		
Cost Based on Flow (Cost/s)	0.0000	0.0000	0.0000		
Act. Gas Flow (ACFM)	---	---	---		
Avg. Liq. Density (lbmole/ft3)	0.4316	1.111	0.4316		
Specific Heat (Btu/lbmole-F)	49.00	10.04	49.00		
Std. Gas Flow (MMSCFD)	0.3443	0.0000	0.3443		
Std. Ideal Liq. Mass Density (lb/ft3)	46.27	51.10	46.27		
Act. Liq. Flow (USGPM)	10.91	---	10.91		
Z Factor	---	0.9930	6.086e-003		
Watson K	11.82	8.720	11.82		
User Property	---	---	---		
Partial Pressure of H2S (psia)	0.0000	---	---		
Cp/(Cp - R)	1.042	1.247	1.042		
Cp/Cv	1.176	1.255	1.176		
Heat of Vap. (Btu/lbmole)	2.248e+004	---	---		
Kinematic Viscosity (cSt)	0.6887	7.073	0.6887		
Liq. Mass Density (Std. Cond) (lb/ft3)	46.45	53.83	46.45		
Liq. Vol. Flow (Std. Cond) (barrel/day)	373.8	0.0000	373.8		
Liquid Fraction	1.000	0.0000	1.000		
Molar Volume (ft3/lbmole)	2.310	376.9	2.310		
Mass Heat of Vap. (Btu/lb)	209.6	---	---		

* Specified by user.

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Vapour Phase	Liquid Phase		
Phase Fraction [Molar Basis]		0.0000	0.0000	1.0000		
Surface Tension	(dyne/cm)	22.28	---	22.28		
Thermal Conductivity	(Btu/hr-ft-F)	7.036e-002	9.244e-003	7.036e-002		
Viscosity	(cP)	0.5121	1.382e-002	0.5121		
Cv (Semi-Ideal)	(Btu/lbmole-F)	47.02	8.055	47.02		
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4386	0.1752	0.4386		
Cv	(Btu/lbmole-F)	41.68	7.999	41.68		
Mass Cv	(Btu/lb-F)	0.3888	0.1740	0.3888		
Cv (Ent. Method)	(Btu/lbmole-F)	45.59	7.503	---		
Mass Cv (Ent. Method)	(Btu/lb-F)	0.4252	0.1632	---		
Cp/Cv (Ent. Method)		1.075	1.338	---		
Reid VP at 37.8 C	(psia)	7.945	1067	7.945		
True VP at 37.8 C	(psia)	20.60	1117	20.60		
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	373.8	0.0000	373.8		

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.6014	0.0159	26.4679	0.0065	2.1959	0.0059
Potassium Carbonate*	37.2797	0.9841	4034.8586	0.9935	372.9695	0.9941
Total	37.8811	1.0000	4061.3265	1.0000	375.1653	1.0000

Vapour Phase

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.0000	0.9693	0.0000	0.9277	0.0000	0.9201
Potassium Carbonate*	0.0000	0.0307	0.0000	0.0723	0.0000	0.0799
Total	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Liquid Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	0.6014	0.0159	26.4679	0.0065	2.1959	0.0059
Potassium Carbonate*	37.2797	0.9841	4034.8586	0.9935	372.9695	0.9941
Total	37.8811	1.0000	4061.3265	1.0000	375.1653	1.0000

* Specified by user.

aspen	LEGENDS Calgary, Alberta CANADA	Case Name:	C:\Program Files\AspenTech\Aspen HYSYS 2006\Cases\tank CO2 Pro
		Unit Set:	Field1
		Date/Time:	Sun May 15 00:44:16 2011

Material Stream: co2

Fluid Package: Basis-1

Property Package: Peng-Robinson

CONDITIONS

		Overall	Vapour Phase			
Vapour / Phase Fraction		1.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	109.8 *	109.8			
Mass Flow	(lb/hr)	4832	4832			
Std Ideal Liq Vol Flow	(barrel/day)	400.9	400.9			
Molar Enthalpy	(Btu/lbmole)	-1.693e+005	-1.693e+005			
Molar Entropy	(Btu/lbmole-F)	41.17	41.17			
Heat Flow	(Btu/hr)	-1.859e+007	-1.859e+007			
Liq Vol Flow @Std Cond	(barrel/day)	400.2 *	400.2			

PROPERTIES

		Overall	Vapour Phase			
Molecular Weight		44.01	44.01			
Molar Density	(lbmole/ft3)	2.565e-003	2.565e-003			
Mass Density	(lb/ft3)	0.1129	0.1129			
Act. Volume Flow	(barrel/day)	1.830e+005	1.830e+005			
Mass Enthalpy	(Btu/lb)	-3847	-3847			
Mass Entropy	(Btu/lb-F)	0.9356	0.9356			
Heat Capacity	(Btu/lbmole-F)	9.195	9.195			
Mass Heat Capacity	(Btu/lb-F)	0.2089	0.2089			
Lower Heating Value	(Btu/lbmole)	0.0000	0.0000			
Mass Lower Heating Value	(Btu/lb)	—	—			
Phase Fraction [Vol. Basis]		—	1.000			
Phase Fraction [Mass Basis]		4.941e-324	1.000			
Partial Pressure of CO2	(psia)	14.69	—			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	713.4	713.4			
Avg. Liq. Density	(lbmole/ft3)	1.171	1.171			
Specific Heat	(Btu/lbmole-F)	9.195	9.195			
Std. Gas Flow	(MMSCFD)	0.9981	0.9981			
Std. Ideal Liq. Mass Density	(lb/ft3)	51.52	51.52			
Act. Liq. Flow	(USGPM)	—	—			
Z Factor		0.9944	0.9944			
Watson K		8.524	8.524			
User Property		—	—			
Partial Pressure of H2S	(psia)	0.0000	—			
Cp/(Cp - R)		1.275	1.275			
Cp/Cv		1.284	1.284			
Heat of Vap.	(Btu/lbmole)	7396	—			
Kinematic Viscosity	(cSt)	8.084	8.084			
Liq. Mass Density (Std. Cond)	(lb/ft3)	51.62	51.62			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	400.2	400.2			
Liquid Fraction		0.0000	0.0000			
Molar Volume	(ft3/lbmole)	389.8	389.8			
Mass Heat of Vap.	(Btu/lb)	168.1	—			

* Specified by user.

Material Stream: co2 (continued)

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Vapour Phase			
Phase Fraction [Molar Basis]		1.0000	1.0000			
Surface Tension	(dyne/cm)	—	—			
Thermal Conductivity	(Btu/hr-ft-F)	9.808e-003	9.808e-003			
Viscosity	(cP)	1.462e-002	1.462e-002			
Cv (Semi-Ideal)	(Btu/lbmole-F)	7.209	7.209			
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.1638	0.1638			
Cv	(Btu/lbmole-F)	7.163	7.163			
Mass Cv	(Btu/lb-F)	0.1628	0.1628			
Cv (Ent. Method)	(Btu/lbmole-F)	7.145	7.145			
Mass Cv (Ent. Method)	(Btu/lb-F)	0.1624	0.1624			
Cp/Cv (Ent. Method)		1.287	1.287			
Reid VP at 37.8 C	(psia)	—	—			
True VP at 37.8 C	(psia)	—	—			
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	400.2	400.2			

COMPOSITION

Overall Phase Vapour Fraction 1.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
CO2	109.8047 *	1.0000 *	4832.4717 *	1.0000 *	400.9196 *	1.0000 *
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

Vapour Phase Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
CO2	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000
Total	109.8047	1.0000	4832.4717	1.0000	400.9196	1.0000

Material Stream: Propylene Carbonate

Fluid Package: Basis-1
Property Package: Peng-Robinson

CONDITIONS

		Overall	Liquid Phase			
Vapour / Phase Fraction		0.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(lbmole/hr)	22.48	22.48			
Mass Flow	(lb/hr)	4409 *	4409			
Std Ideal Liq Vol Flow	(barrel/day)	364.7	364.7			
Molar Enthalpy	(Btu/lbmole)	-1.806e+005	-1.806e+005			
Molar Entropy	(Btu/lbmole-F)	78.65	78.65			
Heat Flow	(Btu/hr)	-4.059e+006	-4.059e+006			
Liq Vol Flow @Std Cond	(barrel/day)	364.5 *	364.5			

PROPERTIES

		Overall	Liquid Phase			
Molecular Weight		196.1	196.1			
Molar Density	(lbmole/ft3)	0.2613	0.2613			
Mass Density	(lb/ft3)	51.26	51.26			
Act. Volume Flow	(barrel/day)	367.7	367.7			
Mass Enthalpy	(Btu/lb)	-920.6	-920.6			
Mass Entropy	(Btu/lb-F)	0.4010	0.4010			
Heat Capacity	(Btu/lbmole-F)	86.70	86.70			
Mass Heat Capacity	(Btu/lb-F)	0.4420	0.4420			
Lower Heating Value	(Btu/lbmole)	---	---			
Mass Lower Heating Value	(Btu/lb)	---	---			
Phase Fraction [Vol. Basis]		---	1.000			
Phase Fraction [Mass Basis]		2.122e-314	1.000			
Partial Pressure of CO2	(psia)	0.0000	---			
Cost Based on Flow	(Cost/s)	0.0000	0.0000			
Act. Gas Flow	(ACFM)	---	---			
Avg. Liq. Density	(lbmole/ft3)	0.2635	0.2635			
Specific Heat	(Btu/lbmole-F)	86.70	86.70			
Std. Gas Flow	(MMSCFD)	0.2043	0.2043			
Std. Ideal Liq. Mass Density	(lb/ft3)	51.68	51.68			
Act. Liq. Flow	(USGPM)	10.72	10.72			
Z Factor		9.761e-003	9.761e-003			
Watson K		11.74	11.74			
User Property		---	---			
Partial Pressure of H2S	(psia)	0.0000	---			
Cp/(Cp - R)		1.023	1.023			
Cp/Cv		1.111	1.111			
Heat of Vap.	(Btu/lbmole)	1.996e+004	---			
Kinematic Viscosity	(cSt)	3.136	3.136			
Liq. Mass Density (Std. Cond)	(lb/ft3)	51.71	51.71			
Liq. Vol. Flow (Std. Cond)	(barrel/day)	364.5	364.5			
Liquid Fraction		1.000	1.000			
Molar Volume	(ft3/lbmole)	3.826	3.826			
Mass Heat of Vap.	(Btu/lb)	101.8	---			

* Specified by user.

Material Stream: Propylene Carbonate (c

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Liquid Phase
Phase Fraction [Molar Basis]		0.0000	1.0000
Surface Tension	(dyne/cm)	27.10	27.10
Thermal Conductivity	(Btu/hr-ft-F)	8.656e-002	8.656e-002
Viscosity	(cP)	2.575	2.575
Cv (Semi-Ideal)	(Btu/lbmole-F)	84.71	84.71
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4319	0.4319
Cv	(Btu/lbmole-F)	78.04	78.04
Mass Cv	(Btu/lb-F)	0.3979	0.3979
Cv (Ent. Method)	(Btu/lbmole-F)	---	---
Mass Cv (Ent. Method)	(Btu/lb-F)	---	---
Cp/Cv (Ent. Method)		---	---
Reid VP at 37.8 C	(psia)	---	---
True VP at 37.8 C	(psia)	---	---
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	364.5	364.5

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4804 *	1.0000 *	4409.2000 *	1.0000 *	364.6647 *	1.0000 *
CO2	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *	0.0000 *
Total	22.4804	1.0000	4409.2000	1.0000	364.6647	1.0000

Liquid Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4804	1.0000	4409.2000	1.0000	364.6647	1.0000
CO2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	22.4804	1.0000	4409.2000	1.0000	364.6647	1.0000

Material Stream: Mixup

Fluid Package: Basis-1
Property Package: Peng-Robinson

CONDITIONS

		Overall	Vapour Phase	Liquid Phase		
Vapour / Phase Fraction		0.0000	0.0000	1.0000		
Temperature:	(F)	77.41	77.41	77.41		
Pressure:	(psia)	14.69	14.69	14.69		
Molar Flow	(lbmole/hr)	22.80	0.0000	22.80		
Mass Flow	(lb/hr)	4422	0.0000	4422		
Std Ideal Liq Vol Flow	(barrel/day)	365.7	0.0000	365.7		
Molar Enthalpy	(Btu/lbmole)	-1.804e+005	-1.693e+005	-1.804e+005		
Molar Entropy	(Btu/lbmole-F)	78.09	41.19	78.09		
Heat Flow	(Btu/hr)	-4.113e+006	0.0000	-4.113e+006		
Liq Vol Flow @Std Cond	(barrel/day)	364.5 *	0.0000	364.5		

PROPERTIES

		Overall	Vapour Phase	Liquid Phase		
Molecular Weight		194.0	44.02	194.0		
Molar Density	(lbmole/ft3)	0.2650	2.563e-003	0.2650		
Mass Density	(lb/ft3)	51.40	0.1128	51.40		
Act. Volume Flow	(barrel/day)	367.8	0.0000	367.8		
Mass Enthalpy	(Btu/lb)	-930.2	-3846	-930.2		
Mass Entropy	(Btu/lb-F)	0.4026	0.9356	0.4026		
Heat Capacity	(Btu/lbmole-F)	85.73	9.201	85.73		
Mass Heat Capacity	(Btu/lb-F)	0.4420	0.2090	0.4420		
Lower Heating Value	(Btu/lbmole)	—	—	—		
Mass Lower Heating Value	(Btu/lb)	—	—	—		
Phase Fraction [Vol. Basis]		—	—	1.000		
Phase Fraction [Mass Basis]		2.122e-314	0.0000	1.000		
Partial Pressure of CO2	(psia)	0.0000	—	—		
Cost Based on Flow	(Cost/s)	0.0000	0.0000	0.0000		
Act. Gas Flow	(ACFM)	—	—	—		
Avg. Liq. Density	(lbmole/ft3)	0.2665	1.170	0.2665		
Specific Heat	(Btu/lbmole-F)	85.73	9.201	85.73		
Std. Gas Flow	(MMSCFD)	0.2072	0.0000	0.2072		
Std. Ideal Liq. Mass Density	(lb/ft3)	51.68	51.52	51.68		
Act. Liq. Flow	(USGPM)	10.73	—	10.73		
Z Factor		—	0.9945	9.620e-003		
Watson K		11.72	8.525	11.72		
User Property		—	—	—		
Partial Pressure of H2S	(psia)	0.0000	—	—		
Cp/(Cp - R)		1.024	1.275	1.024		
Cp/Cv		1.113	1.283	1.113		
Heat of Vap.	(Btu/lbmole)	6.091e+004	—	—		
Kinematic Viscosity	(cSt)	3.068	8.096	3.068		
Liq. Mass Density (Std. Cond)	(lb/ft3)	51.86	51.63	51.86		
Liq. Vol. Flow (Std. Cond)	(barrel/day)	364.5	0.0000	364.5		
Liquid Fraction		1.000	0.0000	1.000		
Molar Volume	(ft3/lbmole)	3.774	390.1	3.774		
Mass Heat of Vap.	(Btu/lb)	314.0	—	—		

* Specified by user.

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Vapour Phase	Liquid Phase		
Phase Fraction [Molar Basis]		0.0000	0.0000	1.0000		
Surface Tension	(dyne/cm)	26.72	—	26.72		
Thermal Conductivity	(Btu/hr-ft-F)	8.551e-002	9.818e-003	8.551e-002		
Viscosity	(cP)	2.526	1.463e-002	2.526		
Cv (Semi-Ideal)	(Btu/lbmole-F)	83.75	7.215	83.75		
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4318	0.1639	0.4318		
Cv	(Btu/lbmole-F)	77.01	7.169	77.01		
Mass Cv	(Btu/lb-F)	0.3970	0.1629	0.3970		
Cv (Ent. Method)	(Btu/lbmole-F)	85.34	7.149	—		
Mass Cv (Ent. Method)	(Btu/lb-F)	0.4400	0.1624	—		
Cp/Cv (Ent. Method)		1.005	1.287	—		
Reid VP at 37.8 C	(psia)	4.239	—	4.239		
True VP at 37.8 C	(psia)	17.32	765.0	17.32		
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	364.5	0.0000	364.5		

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4719	0.9857	4407.5286	0.9968	364.5265	0.9968
CO2	0.3250	0.0143	14.3017	0.0032	1.1865	0.0032
Total	22.7968	1.0000	4421.8303	1.0000	365.7130	1.0000

Vapour Phase

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	0.0000	0.0001	0.0000	0.0003	0.0000	0.0003
CO2	0.0000	0.9999	0.0000	0.9997	0.0000	0.9997
Total	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Liquid Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4719	0.9857	4407.5286	0.9968	364.5265	0.9968
CO2	0.3250	0.0143	14.3017	0.0032	1.1865	0.0032
Total	22.7968	1.0000	4421.8303	1.0000	365.7130	1.0000

* Specified by user.

Material Stream: Mixup (continued)

Fluid Package: Basis-1
Property Package: Peng-Robinson

PROPERTIES

		Overall	Vapour Phase	Liquid Phase		
Phase Fraction [Molar Basis]		0.0000	0.0000	1.0000		
Surface Tension	(dyne/cm)	26.72	—	26.72		
Thermal Conductivity	(Btu/hr-ft-F)	8.551e-002	9.818e-003	8.551e-002		
Viscosity	(cP)	2.526	1.463e-002	2.526		
Cv (Semi-Ideal)	(Btu/lbmole-F)	83.75	7.215	83.75		
Mass Cv (Semi-Ideal)	(Btu/lb-F)	0.4318	0.1639	0.4318		
Cv	(Btu/lbmole-F)	77.01	7.169	77.01		
Mass Cv	(Btu/lb-F)	0.3970	0.1629	0.3970		
Cv (Ent. Method)	(Btu/lbmole-F)	85.34	7.149	—		
Mass Cv (Ent. Method)	(Btu/lb-F)	0.4400	0.1624	—		
Cp/Cv (Ent. Method)		1.005	1.287	—		
Reid VP at 37.8 C	(psia)	4.239	—	4.239		
True VP at 37.8 C	(psia)	17.32	765.0	17.32		
Liq. Vol. Flow - Sum(Std. Cond)	(barrel/day)	364.5	0.0000	364.5		

COMPOSITION

Overall Phase

Vapour Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4719	0.9857	4407.5286	0.9968	364.5265	0.9968
CO2	0.3250	0.0143	14.3017	0.0032	1.1865	0.0032
Total	22.7968	1.0000	4421.8303	1.0000	365.7130	1.0000

Vapour Phase

Phase Fraction 0.0000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	0.0000	0.0001	0.0000	0.0003	0.0000	0.0003
CO2	0.0000	0.9999	0.0000	0.9997	0.0000	0.9997
Total	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000

Liquid Phase

Phase Fraction 1.000

COMPONENTS	MOLAR FLOW (lbmole/hr)	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Propylene Carbonate*	22.4719	0.9857	4407.5286	0.9968	364.5265	0.9968
CO2	0.3250	0.0143	14.3017	0.0032	1.1865	0.0032
Total	22.7968	1.0000	4421.8303	1.0000	365.7130	1.0000

* Specified by user.