# Methods of improving CO<sub>2</sub> Sequestration in Saline Aquifer by surface treatment of injected CO<sub>2</sub>

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 Bandar Seri Iskandar 31750 Tronoh Perak Darul Ridzuan

## CERTIFICATION OF APPROVAL

# Methods of improving CO<sub>2</sub> Sequestration in Saline Aquifer by surface treatment of injected CO<sub>2</sub>

By

Mohd Syafiq Firdaus Bin Mohd Nawi

A dissertation submitted to the Petroleum Engineering Department Universiti Teknologi PETRONAS in partial fulfillment of the requirement for the Bachelor of Engineering (Hon.) (Petroleum Engineering)

Approved by,

Manyamu

(Prof. Dr Mariyamni Bt. Awang)

Universiti Teknologi PETRONAS Bandar Seri Iskandar 31750 Tronoh Perak Darul Ridzuan.

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

## **TABLE OF CONTENTS**

CER	TIFICATION	OF AP	PRO	VAL	•	•	•	•	•	i	
CER	TIFICATION	OF OR	IGIN	ALITY	•			•	•	ii	
ABS	FRACT .	•		•	•					iii	
ACK	NOWLEDGEN	MENT.	•	•	٠	•	•	•	•	iv	
LIST	OF FIGURES	•	•	•	•	•	•			vi	
LIST	OF TABLES	•		•	•	•		•	•	vi	
СНА	PTER 1:INTR	ODUC	TION	Ĩ							
1.1.	Background									1	
1.2.	Problem state	ement								3	
1.3.	Objective									3	
1.4	Scope of Stud	lies								4	
СНА	PTER 2: LITE	RATU	RE R	EVIEW	AND	/OR TI	HEORY	ľ			
2.1.	General and	specific	: aspe	ects of sto	orage	option				5	
2.2	Mechanism o	f CO <sub>2</sub> s	seque	stration						5	
2.3	CO2 dissoluti	on in S	aline	Fluid						7	
2.4	Strategy/Met	hod foi	• <b>CO</b> 2	2 dissolut	ion					8	
2.5	Time scales	for C(	) <sub>2</sub> sto	orage in	Salin	e Aqu	ifers by	y stand	ard m	ethod of	F
	injecting CO <sub>2</sub>	into tl	ie aq	uifer.						10	
2.6	Injection che	mical								11	
2.7	Aquifer wate	r (Brin	e)							14	

.

## **CHAPTER 3: METHODOLOGY**

3.1.	Procedure Identification	15
3.2.	Gantt Chart	15
3.3.	Tools Required	16
3.4.	Flow Chart	18
3.5.	Detail Methodology	19
СНА	PTER 4: RESULTS AND DISCUSSION	
4.1.	Results and discussion	21
СНА	PTER 5: RECOMMENDATION AND CONCLUSION	
5.1.	Recommendations	24
5.2.	Conclusion	24
REF	ERENCES	26
GAN	T CHART	28
APPI	ENDICES	29

## LIST OF FIGURES

Figure 1 Figure shows the 2D cross –section of distribution of CO <sub>2</sub> mobile phase
saturation and CO <sub>2</sub> dissolved in formation brine for different times and for two cases of
without (left plates) and with (right plates) brine injection and production. [8]
Figure 2 Time scales for CO <sub>2</sub> storage in Saline Aquifers
Figure 3 Potential trapping mechanisms
Figure 4 Example of flow scheme for cases generated
Figure 5 Illustration of expected behavior of CO2-chemical injected in saline Aquifer 21
Figure 7 Gant Chart 1st semester
Figure 8 Gant Chart 2nd Semester
Figure 9 Solubility of CO <sub>2</sub> versus Pressure with different temperature
Figure 10 Solubility of Co <sub>2</sub> versus Depth with different salinity
Figure 11 Full Report Of Simulation Case By Case

## LIST OF TABLES

Table 1 Properties of Amine	12
Table 2 Properties of Potassium Carbonate	12
Table 3 Properties of Propylene Carbonate	13
Table 4Physico-Chemical Properties of Brine at 353K 257.5 bar	14

# CHAPTER 1 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<sub>2</sub>, 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<sub>2</sub> appears to be contained within the sand in which the CO<sub>2</sub> is injected, although there is evidence of vertical migration within the aquifer [15]. Injected CO<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub>) 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<sub>2</sub> 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<sub>2</sub> 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<sub>2</sub> planned.
- 3) Porosity and permeability: Must be sufficiently high to provide sufficient volume and to allow the injection of CO<sub>2</sub>.
- 4) Suitable geological characteristic: Should have the characteristic such as the cap rock to prevent vertical migration of the CO<sub>2</sub> because CO<sub>2</sub> is less dense than the saline fluid, the CO<sub>2</sub> tend to rise to the top of the aquifer.

#### 2.2 Mechanism of CO<sub>2</sub> 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]:

 The physical trapping of CO<sub>2</sub> 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<sub>2 (aqueous)</sub> + H<sub>2</sub>O → H<sub>2</sub>CO<sub>3 (aqueous)</sub> H<sub>2</sub>CO<sub>3 (aqueous)</sub> + OH<sup>-</sup> → HCO<sub>3</sub><sup>-</sup> (aqueous) + H<sub>2</sub>O HCO<sub>3</sub><sup>-</sup> (aqueous) + OH<sup>-</sup> → CO<sub>3</sub><sup>=</sup> (aqueous) + H<sub>2</sub>O  Hydrodynamic trapping, which is the residual saturation of disconnected CO<sub>2</sub> 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<sub>2</sub> and the host rock and formation waters.

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

#### 2.3 CO<sub>2</sub> 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<sup>-3</sup> (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 CO2 sequestration by dissolving CO2

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<sub>2</sub> 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<sub>2</sub>-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<sub>2</sub> in brine, a large volume of brine is necessary to dissolve a given amount of CO<sub>2</sub>.
  - e. CO<sub>2</sub> 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<sub>2</sub>.
- 3) CO<sub>2</sub>-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<sub>2</sub> alternating brine (CAB) injecting strategy
  - a. Operation strategy that alternates supercritical CO<sub>2</sub> with brine injection. The supercritical CO<sub>2</sub> and Brine are alternately injected.
  - b. Expected to reduce CO<sub>2</sub> buoyancy migration and immobilize CO<sub>2</sub> in the formation.

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

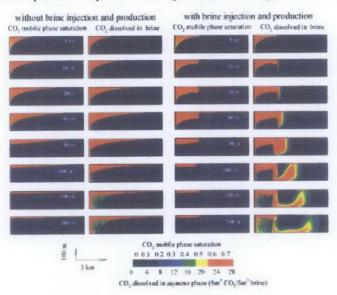


Figure 1 Figure shows the 2D cross –section of distribution of  $CO_2$  mobile phase saturation and  $CO_2$  dissolved in formation brine for different times and for two cases of without (left plates) and with (right plates) brine injection and production. [8]

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<sub>2</sub> storage in Saline Aquifers by standard method of injecting CO<sub>2</sub> into the aquifer.

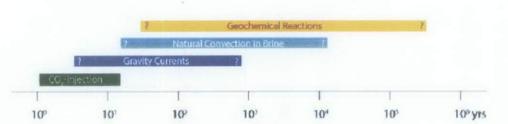


Figure 2 Time scales for CO<sub>2</sub> storage in Saline Aquifers

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<sub>2</sub> migration
- Dissolution of CO<sub>2</sub> in the brine
- Downward buoyancy driven fingering
- Precipitation and dissolution of carbonate and silicate minerals

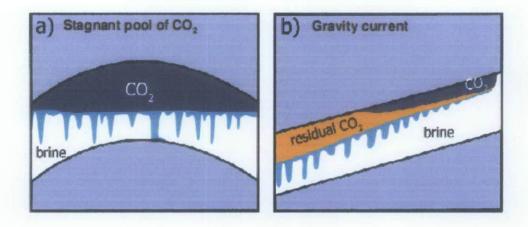


Figure 3 Potential trapping mechanisms.

#### **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<sub>2</sub> and H<sub>2</sub>S 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  $CO_2$ :

	Properties	
Molecular formula	C <sub>2</sub> H <sub>7</sub> NO	C <sub>4</sub> H <sub>11</sub> NO <sub>2</sub>
Molar mass	61.08 g/mol	105.14 g/mol
Density	1.012 g/cm <sup>3</sup>	1.090 g/cm <sup>3</sup>
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)

 $2 (R_2 NH) + CO_2 \rightarrow R_2 NCOONH_2 R_2$ 

**Table 1 Properties of Amine** 

## 2.6.2 Potassium Carbonate

Potassium Carbonate [11] is used to remove CO<sub>2</sub>. Reactions involved:  $K_2CO_3 + CO_2 + H_2O \rightarrow 2KHCO_3$ 

P	roperties
Molecular formula	K <sub>2</sub> CO <sub>3</sub>
Molar mass	138.205 g/mol
Density	$2.29 \text{ g/cm}^3$
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.

Pro	operties
Molecular formula	C <sub>4</sub> H <sub>6</sub> O <sub>3</sub>
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<sub>2</sub> 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<sub>2</sub>. In process design stage, the aim is to determine the properties of the treated CO<sub>2</sub>-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.

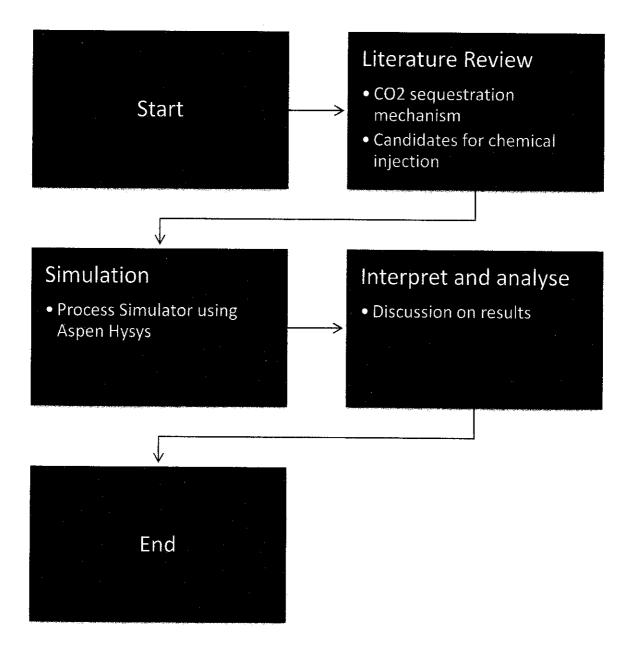
In HYSYS, fluid package have to be determined. Bad selection of fluid package to use with the define cases will yield different results since different type of equation of state have different approaches depending on cases defined. The software suggest the users based on the define fluids used on what 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<sub>2</sub>-chemical injection strategy.
  - a. 4 cases were created :
    - i.  $CO_2$  mix with MEA
    - ii. CO<sub>2</sub> mix with DEA
    - iii. CO<sub>2</sub> mix with potassium carbonate
    - iv. CO<sub>2</sub> 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<sub>2</sub> : 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.

emperature	25.00	C					
ressure	151.3	153					
Actar Flow	92.62	ignoien					
kerage Liquid Density	47.05	kgmole:m3					
				vapour			
			-				
	002					Mitago	
co2 Temperature	\$02		20 C		Temperature	Mbup 42.25	<b>1</b> 0
	502				Temperature Pressure		C 673
Temperature	302	25	3 693			42.25	10°3
Temperature Pressure		25 10 49	3 693		Pressure	42.25 101.3	1073

Figure 4 Example of flow scheme for cases generated.

## **CHAPTER 4**

## **RESULTS AND DISCUSSION**

## 4.1 RESULTS AND DISCUSSION

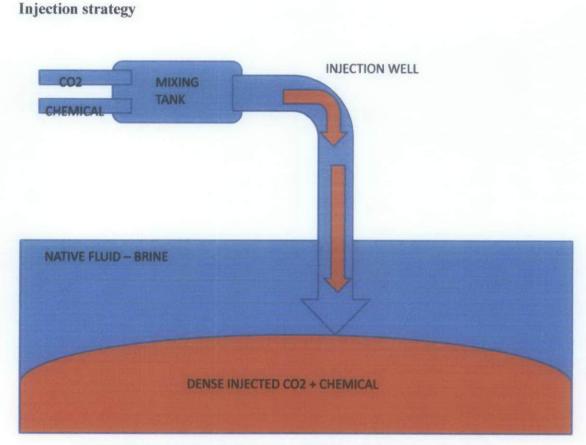


Figure 5 Illustration of expected behavior of CO2-chemical injected in saline Aquifer

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<sub>2</sub> : 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 <sub>2</sub> saturated with MEA	1055	1.006	0.96
CO <sub>2</sub> saturated with DEA	1029	0.086	0.93
CO <sub>2</sub> saturated with Potassium Carbonate	743.6	0.512	0.67
CO <sub>2</sub> 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<sub>2</sub> 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.

.

#### REFERENCES

- [1] Glossary of United Nations Framework Convention on Climate Change
- [2] Amornvadee Veawab, Adisorn Aroonwilas, Amit Chakma, Paitoon Tontiwachwuthikul Solvent Formulation for CO<sub>2</sub> Separation from Flue Gas Streams. Faculty of Engineering University of Regina
- [3] M Bentham and G Kirby. CO<sub>2</sub> Storage in Saline Aquifers. Oil & Gas Science and Technology – Rev. IFP. Vol. 60 (2005), No 3, pp. 559-567 2005
- [4] Chadwick et al. The Case for Underground CO<sub>2</sub> sequestration in Northern Europe, 2002)
- [5] Pentland, William. "The Carbon Conundrum." Forbes.com. 6 October 2008.
- [6] Paul Emeka, SPE, Mark Naylor, Stuart Haszeldine and Andrew Curtis, Scottish Center for Carbon Storage, CO<sub>2</sub>-Brine Surface Dissolution and Injection: CO<sub>2</sub> Storage Enhancement. SPE 124711, Prepared for 2009 SPE Offshore Europe and Gas Conference & Exhibition.
- [7] Hassan Hassanzadeh, Mehran Pooladi-Darvish and David W Keith, Accelerating CO<sub>2</sub> Dissolution in Saline Aquifers for Geological Storage – Mechanistic and Sensitivity Studies. American Chemical Society Publication, 2009.
- [8] Lindeberg E (1996) Phase properties of CO<sub>2</sub>/water systems. In: Holloway S.
   (Ed) Final report of the Joule II project no. CT92-0031
- [9] F.M. Orr, Jr., A. Kovscek, K. Jessen, T. Tang, C. Seto, M. Hesse, T. Ide, W. Lin, and T. Chaturvedi. CO<sub>2</sub> sequestration in oil/gas reservoirs, saline aquifers and coal beds; Energy Research in Stanford 2005
- [10] Anusha Kothandaraman, Carbon Dioxide Capture by Chemical Absorption: Solvent Comparison Study Department of Chemical Engineering Massachusetts Institute of Technology.
- [11] Ken Arnold, Maurice Stewart Surface Production Operations : Design of Gas-Handling Systems and Facilities Vol. 2, Published by Butterword-Heinemann

- [12] Michael C. Trachtenberg, Lihong Bao Carbozyme, Inc CO<sub>2</sub> Capture: Enzyme vs. Amine. Fourth Annual Conference On Carbon Capture And Sequestration DOE/NETL May 2-5, 2005
- [13] Walter Vogel Stuttgart, CO<sub>2</sub> Sequestration Simulations: A Comparison Study Between Dumux and Eclipse, July 2nd, 2009 Universitat Stuttgart.
- [14] Ennis King, J. Geodisc Resources for Code Comparison Project http://wwwold.dpr.csiro.au/people/jonathan/codecomp/, 2001.
- [15] Torp, T.A and Gale, J.: Demonstrating Storage of CO<sub>2</sub> in Geological Reservoirs; the Sleipner and SACS Projects, in Greenhouse Gas Control Technologies, Vol. 1. J. Gale and Y. Kay, Kaya (eds.), Elsevier, Amsterdam (2003) 311-316
- [16] Franklin M. Orr Jr. SPE, Stanford U. Storage of Carbon Dioxide in Geologic Formations, Distinguished Author Series, SPE 88842, September 2004
- [17] Perrot, Pierre (1998). A to Z of Thermodynamics. Oxford University Press. ISBN 0-19-856552-6.
- [18] Peng, DY, and Robinson, DB (1976). "A New Two-Constant Equation of State". Industrial and Engineering Chemistry: Fundamentals 15:59-64. doi:10.1021/i160057a011

GANT CHART

2	No Details							Γ	Week						
		-	- 1	-,	9 × 1 × 2	-	-	<u> </u>	8	<u>م</u>	8 9 10 11 12 13	E	Ξ.	=	3
	Selection of Project Topic		$\vdash$	<b>†</b>	┢─		-		-						
r)	Fust meeting with supervisor			-	-	ŀ		r							L
~,	Preliminary Research work			al. Ni				1.00		Ļ			<u> </u>		<u> </u>
ŀ.	Preliminary Report preparation	1						MUE		L					
ŀ	Submission of Preliminary Report (1 Sept 2010)	1	1	Ê	6	+	-	D SU	L						
v	Seminar 1 (optional)	$\square$	┢	┢				ME	I	ļ	<u> </u>				
~	Progress report preparation		┢─	$\vdash$		-		STE	L	Ĺ			ļ		
ø	Submission of Progress Report		<b> </b>	┢				R BF	I	0					
<b>#</b>	Discussion and Project Alteration	T	┢	╞		+	$\vdash$	(EAJ	1						
÷:	Submission of Interim Report Final Draft			-	┨	<u> </u>	┟	к Т	L					ø	
18	Oral Presentation preparation		<b> </b>	┼	┼──	┢╌	┢	<del>7</del>	L				4.E.		
11	17 Oral Presentation (Week 14)						<u> </u>	+ ·	l						6

Figure 6 Gant Chart 1st semester

?	Cetalis	Weeks											
		1 2 3	4	5 6	~	5	910	H	10 11 12 13 14	13	14	15	16
ا ـــ	Literature Review								<u> </u>	<u> </u>	ļ		
N	Aspen Hysys simulation and interpretation								-	_			
n	Ecilpse simulator			_						<u> </u>			
4	Submission of Progress Report			-				-		-			
ы	Finalization of project		<u> </u>	-						1			
9	PRE-EDX combined with seminar/ Poster Exhibition/ Submission of Final Report (CD		1-	-									
	Softcapy & Softbound)							,					
~	EDX												
20	Final Oral Presentation		+		<u> </u>	+-	+	$\downarrow$	ļ.				
5	Delivery of Final Report to External Examiner / Marking by External Examiner					+-			-				
2	Submission of hardbound copies		+-	+	1	+	+		-				

Figure 7 Gant Chart 2nd Semester

28

e

## APPENDICES

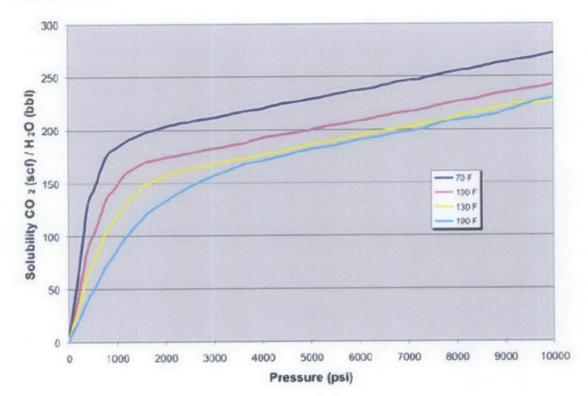
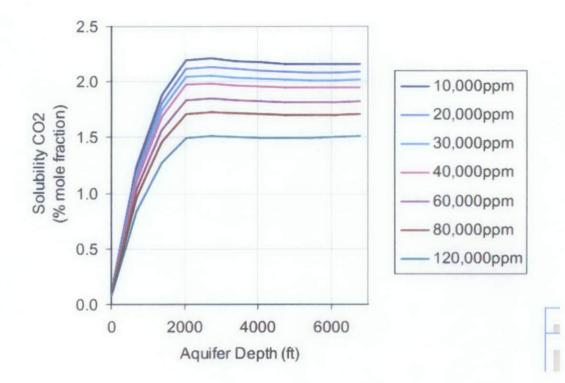


Figure 8 Solubility of CO<sub>2</sub> versus Pressure with different temperature





## RESULTS

## CASE 1 : CO2 with MONOETHANOLAMINE (MEA)

LEGEI	NDS	Case Name:	U: 19 Togram Files VA	spenTechVAspen HYSYS	o zuuovuasesttanik CO2
aspen Calgar	y, Alberta DA	Unit Set:	Field 1		
		Date/Time:	Sun May 15 01:11:	19 2011	
Mate	rial Stream: co	)2		Fluid Package:	Basis-1
in an	n - Anna Anna Anna Anna Anna Anna Anna Anna	CONDITIONS		Property Package:	Amine Pkg - KE
				· · · · · · · · · · · · · · · · · · ·	
Vapour / Phase Fraction	Overall 1.0000	Vapour Phase 1.0000	<u> </u>		
Temperature: (F		77,00		· · · · ·	
Pressure: (psia	·	11.60			
Molar Flow (Ibmole/hr		14.09			
Mass Flow (IbholeAu	<u> </u>				
		4832			
		400.9			
		4027		<b>.</b>	
		50.37			-
	· · · · · · · · · · · · · · · · · · ·	4.422e+005			
Liq Vol Flow @Std Cond (barrel/day	<u> </u>				
		PROPERTIES			
	Overali	Vapour Phase			
Molecular Weight	44.01	44.01			
Molar Density (Ibmole/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/b)	91.50	91.50			· ·· ··· · · · · · · · · · · · · · · ·
Mass Entropy (Btu/Ib-F)	1.144	1.144			······································
Heat Capacity (Btu/ibmole-F)	9.126	9.126	· · · · · · · · · · · · · · · · · · ·		
Mass Heat Capacity (Btu/b-F)		0.2074			
Lower Heating Value (Btu/bmole)		0.0000			
Mass Lower Heating Value (Btu/ib)					· · · · · · · · · · · · · · · · · · ·
Phase Fraction [Vol. Basis]		1.000			
Phase Fraction [Mass Basis]	4.941e-324	1.000			
Partial Pressure of CO2 (psia)					
Cost Based on Flow (Cost/s)		0.0000			
Act. Gas Flow (ACFM)		713.4			·····
Avg Liq. Density (Ibmole/ft3)	···	1.171			
Specific Heat (Btu/bmole-F)					
Std. Gas Flow (MMSCFD)		9.126			
Std. Ideal Liq. Mass Density (fb/ft3)				··	
Act. Liq. Flow (USGPM)		51.52			
Z Factor	0.9945	0.0045	····		<b>}</b>
Watson K	8.524	0.9945			
Jser Property	0.024	8.524			<u></u> .
Partial Pressure of H2S (psia)	0.0000		· · · ·	·······	··· - ···
Cp/(Cp - R)	1.278	4 070			
ар(ор - к.) Эр/Оv	1.286	1.278		· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·
teat of Vap. (Btu/iomole)		1.286		· · ·	}
Gnematic Viscosity (CSt)	8.348				
iq. Mass Density (Std. Cond) (Ib/ft3)	0.340	8.348			
iq. Vol. Flow (Std. Cond) (barrel/day)					·····
iquid Fraction	0.0000	0.0000	·		
fotar Volume (ft3/bmole)	389.8	389.8			
Mass Heat of Vap. (Btu/b)	1 _ 1	_		1	

Phase Fraction [Molar Basis] Surface Tension (dyne/ Thermal Conductivity (Btu/hr-f Viscosity ( Cv (Semi-Ideal) (Btu/tomole Mass Cv (Semi-Ideal) (Btu/tomole Mass Cv (Btu/tomole Mass Cv (Ent. Method) (Btu/tomole Mass Cv (Ent. Method) (Btu/tomole	2m) -F) -F) -F) -F) -F) -F)	Overall 1.0000 9.5256-003 1.5106-002 7.141 0.1623 7.095 0.1612	Unit Set Date/Time: Date/Time: D2 (continue PROPERTIES Vapour Phase 1.0000 — 9.525e-003 1.510e-002 7.141 0.1623 7.095	ed)	) 2011 Iúld Package: roperty Package:	Basis-1 Amine Pkg - KE
Phase Fraction [Molar Basis]         Surface Tension         Surface Tension         (dyne/         Thermal Conductivity         (Btu/brnole         Mass Cv (Semi-Ideal)         (Btu/brnole         Mass Cv (Semi-Ideal)         Cv         (Btu/brnole         Mass Cv (Semi-Ideal)         (Btu/brnole         Mass Cv (Ent. Method)         (Btu/brnole	erial S1 m) -F) -F) -F) -F) -F) -F) -F)	Overall 1.0000 9.525e-003 1.510e-002 7.141 0.1623 7.095	D2 (continue PROPERTIES Vapour Phase 1.0000 	<b>⊧d)</b> P	uid Package: roperty Package:	
Phase Fraction [Molar Basis]         Surface Tension       (dyne/         Thermal Conductivity       (Btu/brnd/         Viscosity       (         Cv (Semi-Ideal)       (Btu/brnd/         Mass Cv (Semi-Ideal)       (Btu/brnd/         Cv       (Btu/brnd/         Mass Cv       (Btu/brnd/         Mass Cv (Ent. Method)       (Btu/brnd/         Cy (Ent. Method)       (Btu/brnd/	2m) -F) -F) -F) -F) -F) -F)	Overall 1.0000 9.525e-003 1.510e-002 7.141 0.1623 7.095	PROPERTIES Vapour Phase 1.0000 9.525e-003 1.510e-002 7.141 0.1623	e <b>d)</b> P	roperty Package.	
Phase Fraction [Molar Basis]         Surface Tension       (dyne/         Thermal Conductivity       (Btu/brnd/         Viscosity       (         Cv (Semi-Ideal)       (Btu/brnd/         Mass Cv (Semi-Ideal)       (Btu/brnd/         Cv       (Btu/brnd/         Mass Cv       (Btu/brnd/         Mass Cv (Ent. Method)       (Btu/brnd/         Cy (Ent. Method)       (Btu/brnd/	2m) -F) -F) -F) -F) -F) -F)	Overall 1.0000 9.525e-003 1.510e-002 7.141 0.1623 7.095	PROPERTIES Vapour Phase 1.0000 9.525e-003 1.510e-002 7.141 0.1623		- <u></u>	Amine Pkg - KE
Phase Fraction [Molar Basis]         Surface Tension       (dyne/)         Thermal Conductivity       (Btu/hr-f)         Viscosity       (         Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Ent. Method)       (Btu/brnole         Mass Cv (Ent. Method)       (Btu/brnole	-F) -F) -F) -F) -F) -F)	1.0000 	Vapour Phase. 1.0000 9.525e-003 1.510e-002 7.141 0.1623			
Phase Fraction [Molar Basis]         Surface Tension       (dyne/)         Thermal Conductivity       (Btu/hr-f)         Viscosity       (         Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Semi-Ideal)       (Btu/brnole         Mass Cv (Ent. Method)       (Btu/brnole         Mass Cv (Ent. Method)       (Btu/brnole	-F) -F) -F) -F) -F) -F)	1.0000 	1.0000 — 9.525e-003 1.510e-002 7.141 0.1623			
Surface Tension     (dyne/i       Thermal Conductivity     (Btu/hr-f       Viscosity     (       Cv (Semi-Ideal)     (Btu/brnole       Mass Cv (Semi-Ideal)     (Btu/brnole       Mass Cv (Semi-Ideal)     (Btu/brnole       Mass Cv (Semi-Ideal)     (Btu/brnole       Mass Cv (Cent. Method)     (Btu/brnole       Mass Cv (Ent. Method)     (Btu/brnole	-F) -F) -F) -F) -F) -F)	9.5250-003 1.5100-002 7.141 0.1623 7.095	9.525e-003 1.510e-002 7.141 0.1623			
Thermal Conductivity     (Btu/hr-f       Viscosity     (       CV (Semi-Ideal)     (Btu/brnole       Mass Cv (Semi-Ideal)     (Btu/brnole       Cv     (Btu/brnole       Mass Cv     (Btu/brnole       Mass Cv     (Btu/brnole       Mass Cv     (Btu/brnole       Mass Cv (Ent. Method)     (Btu/brnole       Cp/Cv (Ent. Method)     (Btu/brnole	-F) -F) -F) -F) -F) -F)	1.510e-002 7.141 0.1623 7.095	1.510e-002 7.141 0.1623			
Viscosity ( Cv (Semi-Ideal) (Btu/bmole Mass Cv (Semi-Ideal) (Btu/b Cv (Btu/bmole Mass Cv (Btu/bmole Mass Cv (Ent. Method) (Btu/bmole Mass Cv (Ent. Method) (Btu/k Cp/Cv (Ent. Method)	-F) -F) -F) -F) -F)	1.510e-002 7.141 0.1623 7.095	1.510e-002 7.141 0.1623			
Cv (Semi-Ideal)     (Btu/tomole       Mass Cv (Semi-Ideal)     (Btu/tomole       Cv     (Btu/tomole       Mass Cv     (Btu/tomole       Cv (Ent. Method)     (Btu/tomole       Cp/Cv (Ent. Method)     (Btu/tomole	-F) -F) -F) -F)	7.141 0.1623 7.095	7.141 0.1623			
Mass Cv (Semi-Ideal) (Btu/t Cv (Btu/tsmole Mass Cv (Btu/t Cv (Ent. Method) (Btu/tsmole Mass Cv (Ent. Method) (Btu/ts Cp/Cv (Ent. Method)	-F) -F) -F)	0.1623 7.095	0.1623			
Cv (Btu/Brnole Mass Cv (Btu/B Cv (Ent. Method) (Btu/Brnole Mass Cv (Ent. Method) (Btu/B Cp/Cv (Ent. Method)	-F) -F)	7.095				
Cv (Btu/Brnole Mass Cv (Btu/B Cv (Ent. Method) (Btu/Brnole Mass Cv (Ent. Method) (Btu/B Cp/Cv (Ent. Method)	-F) -F)		7.095			
Mass Cv (Btu/t Cv (Ent. Method) (Btu/tbrnole Mass Cv (Ent. Method) (Btu/tb Cp/Cv (Ent. Method)	-F) -F)	0.1612				
Cv (Ent. Method) (Btu/Ibmole Mass Cv (Ent. Method) (Btu/It Cp/Cv (Ent. Method)	-F)		0.1612			
Mass Cv (Ent. Method) (Btu/k Cp/Cv (Ent. Method)			_			
Cp/Cv (Ent. Method)		_			· · · · · · · · · · · · · · · · · · ·	
					·····	
	sia)					
	sia)					
Liq. Vol. Flow - Sum(Std. Cond)arrel/d		0.0000	0.0000			
		-		verall Phase	Vapour Fra	action 1.0090
	AR FLOW	MOLE FRACTIC		MASS FRACTION	LIQUID VOLUME	LIQUID VOLUME
	nole/hr)		(lb/hr)		FLOW (barrel/day)	FRACTION
CO2	109.8047 *	1.004	an in the second second			1.0000
H2O	0.0000 *	0.000			* 0.000.*	0.0000
MEAmine	0.0000 *	0.000				0.0000
Total	109.8047	1.000	0 4832.471	7 1.0000		1 0000
					400.9196	1.0000
				apour Phase	Phase Fra	ction 1.000
[28] Bethinson, March 2011. Phys. Rev. B 101 (1994).	AR FLOW	MOLE FRACTIC	MASS FLOW		Phase Fra	ction 1.000
d)	AR FLOW mole/hr)		N MASS FLOW (b/hr)	Apour Phase	Phase Fra LIQUID VOLUME FLOW (barrel/day)	ction 1.000 LIQUID VOLUME FRACTION
(њ	AR FLOW note/hr) 109.8047	1.000	MASS FLOW (10/hr) 00 4832.471	Apour Phase MASS FRACTION 7 1.0000	Phase Fra LIQUID VOLUME FLOW (barrel/day) 400.9196	ction 1.000 LIQUID VOLUME FRACTION 1.0000
dh)	AR FLOW mole/hr)		MASS FLOW (10/hr) 00 4832.471 00 0.000	MASS FRACTION           7         1.0000           0         0.0000	Phase Fra LIQUID VOLUME FLOW (barrel/day)	ction 1.000 LIQUID VOLUME FRACTION

LEGEND		Case Name:	<u>an an a</u>	AspenTech/Aspen HYSYS	
aspen calgary, calgary,		Unit Set:	Field1		
		Date/Time:	Sun May 15 01:11	1;19 2011	
Materi	al Stream: M	EA		Fluid Package:	Basis-1
<u>na kodu (na kodu kodu kodu kodu kodu kodu kodu kodu</u>	, 44, 5, 57, 54, 54, 57, 57, 57, 57, 57, 57, 57, 57, 57, 57	CONDITIONS	<u>l as entre en</u> t	Property Package:	Amine Pkg - KE
	Overall	Aqueous Phase			-
Vapour / Phase Fraction	0.0000	1.0000		· · · · · · · · · · · · · · · · · · ·	
Temperature: (F)	77.00 *	77.00			
Pressure: (psia)	14.69 *	14.69			
Molar Flow (Ibmole/hr)	210.2	210.2			
Mass Flow (ib/hr)	4409 *	4409			-
Stol Ideal Liq Vol Flow (barrel/day)	301.4	301.4			
Molar Enthalpy (Btu/Eomole)	-1.302e+004	-1.302e+004			
Motar Entropy (Btu/Ibmole-F)	19.40	19.40			
Heat Flow (Btu/hr)	-2.737c+006	-2.737c+006		1	
Liq Vol Flow @Std Cond (barrel/day)	300.6 *	300.6		1	
		PROPERTIES			
en en la compañía de	Overail	Aqueous Phase			1
Molecular Weight	20.97		·····		
	· · · · · · · · · · · · · · · · · · ·	20.97	······		
Molar Density (Ibmole/ft3)	2.985	2.985			
Mass Density (1b/fi3)	62.61	62.61			
Act. Volume Flow (barrel/day)	301.0	301.0			
Mass Enthalpy (Btulls)	-620.8	-620.8		-	
Mass Entropy (Btulb-F)	0.9249	0.9249			
Heat Capacity (Btu/ibmole-F)	19.40	19.40			
Mass Heat Capacity (Btu/tb-F)	0.9249	0.9249			
Lower Heating Value (Btu/Ibmole)	4.024e+004	4.024e+004			
Mass Lower Heating Value (Btu/b)	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)	0.000	0.000			
Act. Gas Flow (ACFM)					
Avg. Liq. Density (10mole/ft3)	2.982	2.982			
Specific Heat (Btu/bmole-F)	19.40	19.40			
Std. Gas Flow (MMSCFD)	1.911	1.911			
Std. Ideal Liq. Mass Density (Ib/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		· · · · · · · · · · · · · · · · · · ·	
Jser Property					
Partial Pressure of H2S (psia)	0.0000				
⊅/(Cp - ℝ)	1.114	1.114			
Cp/Cv	1.114	1.114			
leat of Vap. (Btu/Iomole)	1.817e+004				
Gnematic Viscosity (cSt)	1.357	1.357			
iq. Mass Density (Std. Cond) (Ib/ft3)	62.69	62.69			
iq. Vol. Flow (Std. Cond) (barrel/day)	300.6	300.6			
iquid Fraction	1.000	· · · · · · · · · · · · · · · · · · ·			<u> -</u>
	·····	1.000		· · · · · · · · · · · · · · · · · · ·	
	0.3350	0.3350			
ass Heat of Vap. (Btu/b)	866.4				1

aspen	CANADA					
			Dete/Time:	Sun May 15 01:11:19:	2011	*
	Material S	tream: ME	A (continue	d) () () () ()	id Package: xperty Package:	Basis-1 Amine Pkg - KE
			PROPERTIES		<u></u>	
		Overall /	Aqueous Phase			
Phase Fraction [Molar Basi	s]	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			·····
	(Btu/Ibmole-F)	17.41	17.41			
Mass Cv (Semi-Ideal)	(Btu/b-F)	0.8302	0.8302			
	(Btu/fornole-F)	17.41	17.41			
Mass Cv	(Btu/to-F)	0.8302	0.8302			······ ··· ··· ··· ···
	Btu/bmole-F)					
Mass Cv (Ent. Method)	(Btu/b-F)					
Cp/Cv (Ent. Method)						····-
Reid VP at 37.8 C	(psía)					
Frue VP at 37.8 C	(psia)	0.8862	0.8862			
Liq. Vol. Flow - Sum(Std. Co	n <b>@</b> arrei/day)	300.6	300.6			
			Ove	rall Phase	Vapour Fr	action 0.0000
COMPONENTS	MOLAR FLOW	MOLE FRACTION	MASS FLOW	Tall Phase MASS FRACTION		
	(lbmole/hr)		MASS FLOW (B/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
CO2	(Ibmole/for) 0.0000 *	0.0000 *	MASS FLOW (Buhr) 0.0000 *	MASS FRACTION 0.0000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 *	LIQUID VOLUME FRACTION 0.0000
CO2 120	(lbmole/hr) 0.0000 * 195.8002 *	0.0000 * 0.9313 *	MASS FLOW (b/hr) 0.0000 * 3527.3600 *	MASS FRACTION 0.0000 * 0.8000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 *	LIQUID VOLUME FRACTION 0.0000 0.8030
202 120 MEAmine	(lbmole/hr) 0.0000 * 195.8002 * 14.4365 *	0.0000 * 0.9313 * 0.0687 *	MASS FLOW (b/hr) 0.0000 * 3527.3600 * 881.8400 *	MASS FRACTION 0.0000 * 0.8000 * 0.2000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 ° 242.0157 ° 59.3745 °	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970
CO2 120	(lbmole/hr) 0.0000 * 195.8002 *	0.0000 * 0.9313 *	MASS FLOW (b/hr) 0.0000 * 3527.3600 * 881.8400 * 4409.2000	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 59.3745 * 301.3902	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970 1.0000
CO2 12O MEAmine Total	(lbmoke/hr) 0.0000 * 195.8002 * 14.4365 * 210.2367	0.0000 * 0.9313 * 0.0687 * 1.0000	MASS FLOW (b/m) 0.0000 * 3527.3600 * 881.8400 * 4409.2000 Aque	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 ous Phase	LIQUID VOLUME FLOW (barrel/day) 0.0000 ° 242.0157 ° 59.3745 °	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970 1.0000 ction 1.000
202 120 #EAmine	(lbmole/hr) 0.0000 * 195.8002 * 14.4365 *	0.0000 * 0.9313 * 0.0687 *	MASS FLOW (b/hr) 0.0000 * 3527.3600 * 881.8400 * 4409.2000	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 59.3745 * 301.3902	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970 1.0000 ction 1.000
CO2 IZO IEAmine Total COMPONENTS	(lbmoke/hr) 0.0000 * 195.8002 * 14.4365 * 210.2367 MOLAR FLOW	0.0000 * 0.9313 * 0.0687 * 1.0000	MASS FLOW (b/m) 0.0000 * 3527.3600 * 881.8400 * 4409.2000 Aque MASS FLOW	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 ous Phase	LIQUID VOLUME FLOW (barrel/day) 0.0000 ° 242.0157 ° 59.3745 ° 301.3902 Phase Fra	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970 1.0000 ction 1.000 LIQUID VOLUME FRACTION
CO2 IZO IEAmine Total COMPONENTS ICO2	(Ibmole/hr) 0.0000 * 195.8002 * 14.4365 * 210.2367 MOLAR FLOW (Ibmole/hr)	0.0000 * 0.9313 * 0.0687 * 1.0000 MOLE FRACTION	MASS FLOW (b/hr) 0.0000 * 3527.3600 * 881.8400 * 4409.2000 Aque MASS FLOW (b/hr)	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 ous Phase MASS FRACTION	LIQUID VOLUME FLOW (barreVday) 0.0000 • 242.0157 • 59.3745 • 301.3902 Phase Fra LIQUID VOLUME FLOW (barreVday)	LIQUID VOLUME FRACTION 0.0000 0.8030 0.1970 1.0000 ction 1.000 LIQUID VOLUME FRACTION 0.0000
202 120 IEAmine Total	(Ibmole/hr) 0.0000 * 195.8002 * 14.4365 * 210.2367 MOLAR FLOW (Ibmole/hr) 0.0000	0.0000 * 0.9313 * 0.0687 * 1.0000 MOLE FRACTION 0.0000	MASS FLOW (b/hr) 0.0000 * 3527.3600 * 881.8400 * 4409.2000 Aque MASS FLOW (b/hr) 0.0000	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 OUS Phase MASS FRACTION 0.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 ° 242.0157 ° 59.3745 ° 301.3902 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000	LIQUID VOLUME FRACTION 0.8030 0.1970 1.0000 ction 1.000 LIQUID VOLUME

· 14	EGENDS		Case Name:	C:\Program Files\A	spenTechiAspen HYSYS 2006 Cases tank CO2 a			
asnen <sup>c</sup>	algary, Alberta		Unit Set.	Field1				
	ANADA		Date/Time: Sun May 15 01:11:19 2011					
					Fluid Package: Basis-1			
Ma	terial Stre	am: M	ixup	e gran de la composition de la composit La composition de la c	Property Package: Amine Pkg - KE			
- <u>1996 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997</u>			CONDITIONS	<u> </u>	<u></u>			
	04	erali	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				
	oke/hr)	211.9	0.0000	211.9				
	(ib/hr)	4676	0.0000	4676				
	l/day)	325.5	0.0000	325.5				
Molar Enthalpy (Btu/to		303e+004	4298	-1.303e+004	<u> </u>			
Molar Entropy (Btu/tom	ole-F)	16.18	51.35	16.18				
Heat Flow (E	sturhr) -2.	760e+006	0.0000	-2.760e+006				
Liq Vol Flow @Std Cond (barre	l/day)	301.9 *	0.0000	301.9				
			PROPERTIES					
in the second second	0*	erall	Vapour Phase	Aqueous Phase				
Molecular Weight		22.07	42.20	22.07				
	le/ft3)	2.984	2.438e-003	2.984				
	16/ft3)	65,86	0.1029	65.86				
Act. Volume Flow (barre	and the second second second	303.5	0.0000	303.5				
	Btuvfb)	-590.3	101.9	-590.3				
		0.7329		0.7329	· · · · · · · · · · · · · · · · · · ·			
	и́ю-F}	19.40	1.217					
	ињ-г)	0.8790	9.151	19.40				
Lower Heating Value (Blu/b		990e+004	0.2168	0.8790 3.990e+004				
	Sturib)	1808	1.689	1808				
Phase Fraction [Vol. Basis]		1000		1.000				
			0.0000	1.000	· ···· · · ····· ····· ····· ···· ···· ····			
Phase Fraction [Mass Basis] Partial Pressure of CO2		0.0000	0.0000	1.000	· ····· · ····· · · · · · · · · · · ·			
	(psia)	0.0000						
	OST/S)	0.0000	0.0000	0.0000	· · · · · · · · · · · · · · · · · · ·			
	CFM)	0.790	4 007					
	le/ft3)	2.782	1.227	2.782				
Specific Heat (Btu/bm Std. Gas Flow (MMS		19.40	9,151	19.40				
		1.926	0.0000	1.926				
	b/ft3)	61.41	51.79	61.41	· · · · · · · · · · · · · · · · ·			
Act. Liq. Flow (US) Z Factor	GPM)	8.851	0.0050	8.851				
		9.000	0.9950	8.130e-004				
Watson K		8.960	8.524	8,960	· · · · · · · · · · · · · · · · · · ·			
User Property Partial Pressure of H2S	(ogia)	0.0000		·····	··· ··· ··· ··· ··· ··· ··· ··· ··· ··			
	(psia)		4 177		······································			
Cp/(Cp - R) Cp/Cv		1.114	1.277	1.114	· · · · · · · · · · · · · · · · · · ·			
			1.285	1.114	· · · ·			
		0.9533			······			
Kinematic Viscosity	(cSt)	0.9533	9.477	0.9533	······			
and the second	b/ft3)	66.20	65.85	66.20				
Liq. Vol. Flow (Std. Cond) (barre	voay)	301.9	0.0000	301.9				
iquid Fraction		1.000	0.0000	1.000				
Violar Volume (f13/lb	<b>i</b>	0.3351	410.1	0.3351	· · · · · · · · · · · · · · · · · · ·			
Mass Heat of Vap. (8	Sturib)	862.0						

aspen	Calgary, Alberta CANADA		Unit Set	Field1	the second second second second	
			Deto/Times	Sun May 15 01:11:19	2011	
	1		Date/Time:			<u>den ferse en s</u> Transformentes
and the second	Material S	Stream: Mix	kup (contin	ued)	ud Package:	Basis-1
				Pn	operty Package:	Amine Pkg - KE
			PROPERTIES			
		Overall	Vapour Phase	Aqueous Phase		
hase Fraction [Molar Bas		0.0000	0.0000	1.0000 64.89		
Surface Tension	(dyne/cm)	64.89	1.046e-002	0.3122	+	
Thermal Conductivity	(Btu/hr-ft-F)	0.3122	1.562e-002	1.006		
/iscosity	(CP)	17.41	7.165	17.41		
V (Semi-Ideal)	(Btu/bmole-F)	0.7890	0.1698	0.7890		···· ··· · · · ·
Mass Cv (Semi-Ideal) ≫	(Btu/b-F) (Btu/bmole-F)	17.41	7.120	17,41		
Aass Cv	(Btu/to-F)	0.7890	0.1687	0.7890	.,	
Cv (Ent. Method)	(Btu/ibmole-F)		34.98			
Aass Cv (Ent. Method)	(BtuAb-F)		0.8289			
Cp/Cv (Ent. Method)	10000 ( )	· · · · · · · · · · · · · · · · · · ·	0.2616		+	
Reid VP at 37.8 C	(psia)	721.6		721.6		
frue VP at 37.8 C	(psia)	13.08	1243	13.08		
.iq. Vol. Flow - Sum(Std. C	· · · · · · · · · · · · · · · · · · ·	301.9	0.0000	301.9	· · · · · · · · · · · · · · · · · · ·	
······································			COMPOSITION	verali Phase	Vapour Fr	action 0.000
			0		1	
COMPONENTS	MOLAR FLOW	MOLE FRACTION	O MASS FLOW	verall Phase Mass Fraction	LIQUID VOLUME	LIQUID VOLUM
COMPONENTS	MOLAR FLOW (Romoke/hr)		O MASS FLOW (bhr)	MASS FRACTION	1	LIQUID VOLUM FRACTION
COMPONENTS	MOLAR FLOW	0.0432	0 MASS FLOW (Ib/tr) 403.095/	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.102
COMPONENTS	MOLAR FLOW (Bmole/hr) 9.1592	0.0432	O MASS FLOW (b/tr) 403.095/ 3391.672/	MASS FRACTION 0.0862 0.7254	LIQUID VOLUME FLOW (barrel/day) 33.4423	LIQUID VOLUM FRACTION 0.102 0.715
COMPONENTS 202 120 JEAmine	MOLAR FLOW (Ibmole/hr) 9.1592 188.2683	0.0432	O MASS FLOW (b/tr) 403.095/ 3391.672/ 881.036/	MASS FRACTION 0.0862 0.7254 0.1884	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061	LIQUID VOLUM FRACTION 0.102 0.715 0.182
COMPONENTS 202 120 MEAmine	MOLAR FLOW (Ibmole/hr) 9.1592 188.2683 14.4234	0.0432	O MASS FLOW (Ib/ir) 403.095/ 3391.672/ 881.036/ 4675.803/	MASS FRACTION 0.0862 0.7254 0.1884	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000
COMPONENTS 202 120	MOLAR FLOW (Ibmole/hr) 9.1592 188.2683 14.4234	0.0432	O MASS FLOW (b/tr) 403.095 3391.672 881.036 4675.803 V	MASS FRACTION 0.0862 0.7254 0.1884 1.0000	LIQUID VOLUME FLOW (barrel/day) 33,4423 232,7061 59,3204 325,4687	LIQUID VOLUM FRACTION 0.102 0.716 0.182 1.000 action 0.000
COMPONENTS 202 120 MEAmine Fotal	MOLAR FLOW (Ipmole/hr) 9.159/ 188.268: 14.423/ 211.8509	0.0432 0.8887 0.0681 1.0000	O MASS FLOW (b/tr) 403.095 3391.672 881.036 4675.803 V	MASS FRACTION 0.0862 0.7254 0.1884 1.0000 apour Phase	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 326.4687 Phase Fre	LIQUID VOLUM FRACTION 0.102 0.716 0.182 1.000 action 0.000
COMPONENTS 202 120 MEAmine Total COMPONENTS	MOLAR FLOW (IbmoleAr) 9.159/ 188.268: 14.423/ 211.8509 MOLAR FLOW	0.0432 0.8887 0.0681 1.0000 MOLE FRACTION	O MASS FLOW (b/tr) 403.095/ 3391.672/ 881.0363 4675.8037 V MASS FLOW (b/tr)	MASS FRACTION 0.0862 0.7254 0.1884 1.0000 apour Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 325.4687 Phase Fra LIQUID VOLUME	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 action 0.000 LIQUID VOLUM FRACTION
COMPONENTS 202 120 MEAmine Total COMPONENTS 202	MOLAR FLOW (Ibmole/hr) 9.1592 188.2683 14.4234 211.8505 MOLAR FLOW (Ibmole/hr)	0.0432 0.8887 0.0681 1.0000 MOLE FRACTION 0.9303	C MASS FLOW (b/tr) 403.095/ 3391.672/ 881.036/ 4675.803/ V MASS FLOW (b/tr) 0.000/	MASS FRACTION           0.0862           0.7254           0.7254           0.1884           1.0000           apour Phase           MASS FRACTION           0.9701	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 325.4687 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 action 0.000 LIQUID VOLUM FRACTION 0.975
COMPONENTS 202 120 MEAmine Total COMPONENTS 202 120	MOLAR FLOW (Bomole/hr) 9.1592 188.2683 14.4234 211.8509 MOLAR FLOW (Ibmole/hr) 0.0000	0.0432 0.8887 0.0681 1.0000 MOLE FRACTION 0.9303 0.0696	C MASS FLOW (b/tr) 403.095/ 3391.672/ 881.036/ 4675.803/ V MASS FLOW (b/tr) 0.000/ 0.000/	MASS FRACTION           0.0862           0.7254           0.1884           1.0000           apour Phase           MASS FRACTION           0           0.9701           0           0.0297	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 325.4687 Phase Fra Plase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 action 0.000 LIQUID VOLUM FRACTION 0.975 0.024
COMPONENTS 202 120 IEAmine Total COMPONENTS 202 120 IEAmine	MOLAR FLOW (tomole/tr) 9.1592 188.2683 14.4234 211.8508 MOLAR FLOW (tomole/tr) 0.0000 0.0000	MOLE FRACTION 0.0696 0.0001	O MASS FLOW (b/tr) 403.095/ 3391.672/ 881.036/ 4675.803/ V MASS FLOW (b/tr) 0.000/ 0.000/ 0.000/	MASS FRACTION           0.0862           0.7254           0.1884           1.0000           apour Phase           MASS FRACTION           0         0.9701           0         0.9701           0         0.0002	LIQUID VOLUME FLOW (barrel/day) 33,4423 232,7061 59,3204 325,4687 Phase Fra Phase Fra LIQUID VOLUME FLOW (barrel/day) 0,0000 0,0000	LIQUID VOLUM FRACTION 0.102 0.715 1.000 action 0.000 LIQUID VOLUM FRACTION 0.975 0.024
COMPONENTS 202 120 IEAmine Total COMPONENTS 202 120 IEAmine	MOLAR FLOW (komole/hr) 9.1592 188.2683 14.4234 211.8508 MOLAR FLOW (komole/hr) 0.0000 0.0000	MOLE FRACTION 0.0696 0.0001	C MASS FLOW (b/tr) 403.0952 3391.6722 881.0363 4675.8033 V MASS FLOW (b/tr) 0.0000 0.0000 0.0000	MASS FRACTION           0.0862           0.7254           0.1884           1.0000           apour Phase           MASS FRACTION           0         0.9701           0         0.9701           0         0.0002	LIQUID VOLUME FLOW (barrel/day) 33,4423 232,7061 59,3204 325,4687 Phase Fra LIQUED VOLUME FLOW (barrel/day) 0,0000 0,0000 0,0000	LIQUID VOLUM FRACTION 0.102 0.716 0.182 1.000 LIQUID VOLUM FRACTION 0.975 0.024 0.000 1.000
COMPONENTS 202 120 IEAmine Total COMPONENTS 202 120 IEAmine	MOLAR FLOW (Ibmole/hr) 9.1592 188.2683 14.4232 211.8505 MOLAR FLOW (Ibmole/hr) 0.0000 0.0000 0.0000 0.0000	MOLE FRACTION 0.0696 0.0001	C MASS FLOW (b/tr) 403.0952 3391.6722 881.0363 4675.8033 V MASS FLOW (b/tr) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	MASS FRACTION           1         0.0862           0.7254           0         0.1884           1.0000    Appoint Phase  MASS FRACTION  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 325.4687 Phase Fra LIQUED VOLUME FLOW (barrel/day) 0.0000 0.0000 0.0000 Phase Fra LIQUED VOLUME	LIQUID VOLUM FRACTION 0.102 0.716 1.000 action 0.000 LIQUID VOLUM FRACTION 0.024 0.000 1.000 action 1.000
COMPONENTS 202 120 MEAmine Total COMPONENTS 202 120 MEAmine Total 20 COMPONENTS	MOLAR FLOW (BmoleAr) 9.1592 188.2683 14.4234 211.8509 MOLAR FLOW (IbmoleAr) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	O.0432     O.8887     O.0681     O.0681     O.000     MOLE FRACTION     O.9303     O.0696     O.0001     O.0001     O.0001     O.0001     O.0001	C MASS FLOW (b/tr) 403.095 3391.672 881.036 4675.803 V MASS FLOW (b/tr) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	MASS FRACTION           1         0.0862           0.7254           0.1884           1.0000           apour Phase           MASS FRACTION           0         0.9701           0         0.9701           0         0.0297           0         0.0002           0         1.0000           ueous Phase         MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 326.4687 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 0.0000 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 LIQUID VOLUM FRACTION 0.024 0.000 1.000 action 1.00 LIQUID VOLUM FRACTION
COMPONENTS 202 120 MEAmine Total COMPONENTS 202 120 MEAmine Total COMPONENTS 202	MOLAR FLOW (Bmole/hr) 9.1592 188.2683 14.423 211.8505 MOLAR FLOW (Ibmole/hr) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000	O.0432     O.8887     O.0681     O.0681     O.0681     O.0696     O.0001     O.0000     O.0000	C MASS FLOW (b/tr) 403.0952 3391.6722 881.0363 4675.8033 V MASS FLOW (b/tr) 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000	MASS FRACTION           2         0.0862           3         0.7254           4         0.1884           7         1.0000           apour Phase           MASS FRACTION           0         0.9701           0         0.0297           0         0.0002           0         1.0000           HASS FRACTION           0         0.0297           0         0.0002           0         1.0000           HASS FRACTION           0         0.0002           0         0.0002           0         0.0002	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 325.4687 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 0.0000 0.0000 Phase Fra LIQUID VOLUME FLOW (barrel/day) 33.4423	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 action 0.000 LIQUID VOLUM FRACTION 0.975 0.024 0.000 1.000 action 1.00 LIQUID VOLUM FRACTION 0.102
COMPONENTS 202 120 MEAmine Total COMPONENTS 202 120 MEAmine Total 20 COMPONENTS	MOLAR FLOW (BmoleAr) 9.1592 188.2683 14.4234 211.8509 MOLAR FLOW (IbmoleAr) 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000		C MASS FLOW (b/tr) 403.0952 3391.6722 881.0363 4675.8033 V MASS FLOW (b/tr) 0.00000 0.000000	MASS FRACTION           2         0.0862           3         0.1884           4         1.0000           apour Phase         MASS FRACTION           0         0.9701           0         0.9701           0         0.0297           0         0.0002           0         1.0000           ueous Phase         MASS FRACTION           2         0.0862           2         0.7254	LIQUID VOLUME FLOW (barrel/day) 33.4423 232.7061 59.3204 326.4687 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 0.0000 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.102 0.715 0.182 1.000 LIQUID VOLUM FRACTION 0.975 0.024 0.000 1.000 action 1.000

	LEGENDS		Case Name:		spenTech/Aspen HYSYS	
aspen	Calgary, Alberta CANADA		Unit Set	Field1		
			Date/Time:	Sun May 15 01:06	28.2011	
	Motorial 6	Stream: co	<b>.</b> 9	ngen og en er som en som er som e Som er som er	Fluid Package:	Basis-1
	VIALCIIAI	Jucaili. G	<b>//</b>	an shi ka bara i Bala ƙwallon ƙasar ƙ	Property Package:	Amine Pkg - KE
and the second secon			CONDITIONS			<u></u>
		Overall	Vapour Phase			
Vapour / Phase Fraction		1.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(ibmole/hr)	109.8 *	109.8			
Mass Flow	(lb/nr)	4832	4832	· · ·		
Std Ideal Liq Vol Flow (	barrel/day)	400.9	400.9			
Molar Enthalpy (	Btu/bmole)	4027	4027			!
Molar Entropy (Bt	u/tomole-F)	50.37	50.37			
Heat Flow	(Btu/hr)	4.422e+005	4.422e+005			
Liq Vol Flow @Std Cond (	barrel/day}	-	_			
			PROPERTIES			
		Overali	Vapour Phase			
Molecular Weight		44.01	44.01		· · · · · ·	
Molar Density	(ibmole/ft3)	2.565e-003	2.565e-003			
Mass Density	(Ib/ft3)	0.1129	0.1129			
Act. Volume Flow (	barrei/day)	1.830e+005	1.830e+005		· · · · · · · · · · · · · · · · · · ·	
Mass Enthalpy	(Btu/b)	91.50	91.50			
Mass Entropy	(Btu/b-F)	1.144	1.144			
	u/ibmole-F)	9.126	9.126			·····
Mass Heat Capacity	(Btu/tb-F)	0.2074	0.2074		1	
	Btu/Ibmole)	0.0000	0.0000			
Mass Lower Heating Value	(Btu/ib)				1	
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			
	(lbmole/ft3)	1.171	1.171			
	u/ibmole-F)	9.126	9.126		· ·· ··· · · ···· ·	
entre a second and the second s	MMSCFD)	0.9981	0.9981			
Std. Ideal Lig. 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)	<u>* -</u>	1.278	1.278		· ··· · · · · · · · · · · · · · · · ·	
Cp/Cv	· · · · · · · · · · · · · · · · · · ·	1.286	1.286			<b>.</b>
	Btu/ibmole)					
Kinematic Viscosity	(cSt)	8.348	8.348			
Liq. Mass Density (Std. Cond)			_		······································	· · · · · · · · · · · ·
	barrel/day)		·			<b> </b>
Liquid Fraction		0.0000	0.0000			
	(ft3/lbmole)	389.8	389.8			
Mass Heat of Vap.	(Btu/to)					
Hyprotech Ltd.	······································		SYS Version 2006 (		<u> </u>	Page 1 of 7

aspen	LEGENDS		<ul> <li>A set of the set of</li></ul>	C:\Program Files\Aspi		and the second
	Calgary, Albert	ä	Unit Set	Field1		
1972 2996 (1979 1996 1996 1996 1996 1996 1996 1996	CANADA		Date/Time:	Sun May 15 01:06:28	2011	
	Material	Stream: co	2 (continued	<b>i)</b>	uid Package: operty Package:	Basis-1. Amine Pkg - KE
			PROPERTIES			
		Overaš	Vapour Phase			
Phase Fraction (Molar Basi	s]	1.0000	1.0000			
Surface Tension	(dyne/cm)	—				
Thermal Conductivity	(Btu/hr-ft-F)	9.525 <del>0</del> -003	9.525e-003			
Viscosity	(cP)	1.510e-002	1.510e-002			
Cv (Semi-Ideal)	Btu/Ibmole-F)	7.141	7.141			
Mass Cv (Semi-Ideal)	(Btw/b-F)	0.1623	0.1623			
Cv (	(Btu/ibmole-F)	7.095	7.095			
Mass Cv	(Bturtb-F)	0.1612	0.1612			
Cv (Ent. Method) (	Btu/Ibmole-F)	-				
Mass Cv (Ent. Method)	(Btu/b-F)					
		-				
Cp/Cv (Ent. Method)						
	(psia)	_				
Reid VP at 37.8 C	(psia) (psia)	-	-			
Reid VP at 37.8 C True VP at 37.8 C Liq. Voi. Flow - Sum(Std. Co	(psia) on <b>đj</b> arreVday)	0.0000		erall Phase	Vapour Fr	
Reid VP at 37.8 C True VP at 37.8 C	(psia) In <b>đ</b> )arreVday) MOLAR FLOW		COMPOSITION Ove	erall Phase		
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS	(psia) on <b>đj</b> arreVday)	MOLE FRACTION	COMPOSITION Ove MASS FLOW (Juhr)	r	LIQUID VOLUME FLOW (barret/day)	LIQUID VOLUME FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2	(psia) notparrel/day) MOLAR FLOW (tomole/tr)	MOLE FRACTION 7 * 1.0000	COMPOSITION Ove MASS FLOW (#b/hr) 0 * 4832.4717 *	MASS FRACTION		LIQUID VOLUME FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O	(psia) pn@parrel/day) MOLAR FLOW (ibmole/hr) 109.804	MOLE FRACTION 7 * 1.0000 0 * 0.0000	COMPOSITION Ove MASS FLOW (kb/hr) 0 * 4832.4717 * 0 * 0.0000 *	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 400.9196 *	
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine	(psia) monarrel/day) MOLAR FLOW (ibmole/hr) 109.804 0.000	MOLE FRACTION 7 * 1.0000 0 * 0.0000 0 • 0.0000	COMPOSITION Ove N MASS FLOW ((b)trr) 0 * 4832 4717 * 0 * 0.0000 * 0 * 0.0000 *	MASS FRACTION 1.0000 * 0.0000 *	LIQUID VOLUME FLOW (barret/day) 400.9196 * 0.0000 *	LIQUID VOLUME FRACTION 1.0000 0.0000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine	(psia) notparrel/day) MOLAR FLOW (bimole/tir) 109.804 0.000 0.000	MOLE FRACTION 7 * 1.0000 0 * 0.0000 0 • 0.0000	COMPOSITION Ove MASS FLOW (kb/hr) 0 • 4832.4717 • 0 • 0.0000 • 0 • 4832.4717	MASS FRACTION 1.0000 * 0.0000 * 0.0000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 400.9196 * 0.0000 *	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine Total	(psia) m@parrel/day) MOLAR FLOW (timole/hr) 109.804 0.000 0.000	MOLE FRACTION 7 * 1.0000 0 * 0.0000 7 1.0000	COMPOSITION Ove MASS FLOW (#b/hr) 0 * 4832.4717 * 0 * 0.0000 * 0 * 0.0000 * 0 * 4832.4717 Vap	MASS FRACTION 1.0000 * 0.0000 * 1.0000 * 0.0000 * 0.0000 *	LIQUID VOLUME FLOW (bairel/day) 400.9196 * 0.0000 * 400.9196 Phase Fra	LIQUID VOLUME FRACTION 1.0000 0.0000 1,0000 ction 1.000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine	(psia) notparrel/day) MOLAR FLOW (bimole/tir) 109.804 0.000 0.000	MOLE FRACTION 7 * 1.0000 0 * 0.0000 7 1.0000	COMPOSITION Ove MASS FLOW (#b/hr) 0 * 4832.4717 * 0 * 0.0000 * 0 * 0.0000 * 0 * 4832.4717 Vap	MASS FRACTION 1.0000 * 0.0000 * 0.0000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 400.9196 * 0.0000 * 0.0000 * 400.9196	LIQUID VOLUME FRACTION 1.0000 0.0000 1,0000 ction 1.000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine Total COMPONENTS	(psia) motorrel/day) MOLAR FLOW (ibmole/hr) 109.804 0.000 0.000 109.804	MOLE FRACTION 7 * 1.0000 0 * 0.0000 7 0.0000 7 1.0000 MOLE FRACTION	COMPOSITION OV( N MASS FLOW (Bahr) 0 48324717 * 0 0.0000 * 0 48324717 Vap N MASS FLOW (Bar)	MASS FRACTION 1.0000 * 0.0000 * 1.0000 * 0.0000 * 0.0000 *	LIQUID VOLUME FLOW (bairel/day) 400.9196 * 0.0000 * 0.0000 * 400.9196 Phase Fra LIQUID VOLUME	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000 ction 1.000 LIQUID VOLUME FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Voi. Flow - Sum(Std. Co COMPONENTS CO2 H2O DEAmine Total COMPONENTS	(psia) m@arrel/day) MOLAR FLOW (ibmole/hr) 109.804 0.000 0.000 109.804 MOLAR FLOW (ibmole/hr)	MOLE FRACTION 7 * 1.0000 0 * 0.0000 0 * 0.0000 7 1.0000 7 1.0000 7 1.0000	COMPOSITION OV( MASS FLOW (bhr) 0 48324717 * 0 0,0000 * 0 48324717 Vap N MASS FLOW (bhr) 0 48324717	MASS FRACTION 1.0000 * 0.0000 * 0.0000 * 1.0000 BOUR Phase MASS FRACTION	LIQUID VOLUME FLOW (bairrel/day) 400.9196 * 0.0000 * 0.0000 * 400.9196 Phase Fra Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000 ction 1.000 LIQUID VOLUME FRACTION 1.0000
Reid VP at 37.8 C True VP at 37.8 C LIQ. Vol. Flow - Sum(Std. Cc COMPONENTS CO2 H2O DEAmine Total COMPONENTS CO2 CO2	(psia) m@arrel/day) MOLAR FLOW (bimole/hr) 109.804 0.000 0.000 109.804 MOLAR FLOW (bimole/hr) 109.804	MOLE FRACTION 7 * 1.0000 0 * 0.0000 7 1.0000 7 1.0000 7 1.0000 7 1.0000 7 0.0000	COMPOSITION OV( N MASS FLOW (kb/tr) 0 4832.4717 * 0 0.0000 * 0 4832.4717 Vap N MASS FLOW (b/tr) 0 4832.4717 Vap	MÁSS FRACTION 1.0000 * 0.0000 * 0.0000 * 1.0000 NOUR Phase MASS FRACTION 1.0000	LIQUID VOLUME FLOW (barrel/day) 400.9196 * 0.0000 * 0.0000 * 400.9196 Phase Fra LIQUID VOLUME FLOW (barrel/day) 400.9196	LIQUID VOLUME FRACTION 1.0000 0.0000 1,0000 ction 1.000 LIQUID VOLUME

Hyprotech Ltd. Aspen HYSYS Version 2006 (20.0.0.6728)

Page 2 of 7 \* Specified by user.

Licensed to: LEGENDS

•

	LEGENDS		Case Name:	C:\Program Files	VAspenTechVAspen HYSYS	3 200 <b>5\Ca</b> s
aspen	Calgary, Alber	ta	Unit Set:	Field1		
an en	CANADA		Date/Time:	Sun May 15 01:0	5:28 2011	
	Material	Stream: D	EA		Fluid Package: Property Package:	Bas Ame
<u>, en les ser la Alabera.</u>		<u>, anto se la disciplica.</u>	CONDITIONS		Tropary Luxinge.	.,
		Overall	Aqueous Phase			
Vapour / Phase Fraction		0.0000	1.0000		· · ·	
Temperature:	(F)	77.00 *	77.00		•	
Pressure:	(psia)	14.69 *	14.69			1
Molar Flow	(lbmole/hr)	204.2	204.2			1
Mass Flow	(lb/hr)	4409 *	4409			1
Std Ideal Liq Vol Flow	(barrel/day)	297.2	297.2			
Molar Enthalpy	(Btu/Ibmole)	-1.310 <del>e+</del> 004	-1.310e+004		1	· · · · · · · · · · · · · · · · · · ·
Molar Entropy	(Btu/Ibmole-F)	19.63	19.63	· · · · · · · · · · · · · · · · · · ·		
Heat Flow	(Btuthr)	-2.674e+006	-2.674e+006	· · · · · · · · · · · · · · · · · · ·		
Liq Vol Flow @Std Cond	(barrel/day)	295.1 *	295.1			
			PROPERTIES			
		Overail	Aqueous Phase			
Molecular Weight		21.59	21.59			
Molar Density	(ibmole/ft3)	2.951	2.951			
Mass Density	(ib/ft3)	63.73	63.73			
Act. Volume Flow	(barrel/day)	295.8	295.8			-
Mass Enthalpy	(Btu/tb)	-606.5	-605.5		•••	
Mass Entropy	(Btu/tb-F)	0.9093	0.9093			
Heat Capacity	(Btu/fomole-F)	19.63	19.63			
Mass Heat Capacity	(Btu/to-F)	0.9093	0.9093			·
Lower Heating Value	(Btu/ibmole)	0.2053	0.8080		· · · · · · · · · · · · · · · · · · ·	
Mass Lower Heating Value				····		
Phase Fraction [Vol. Basis			+ 000			
Phase Fraction [Mass Bas		0.0000	1.000			
		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	(ibmole/ft3)	2.937	2.937			
	Btu/Ibmole-F)	19.63	19.63			
Std. Gas Flow	(MMSCFD)	1.856	1.856			
Std. Ideal Liq. Mass Densit		63.43	63.43	······	· · · · · · · · · · · · · · · · · · ·	
Act. Liq. Flow	(USGPM)	8.626	8.626			· [
ZFactor		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/ibmole)	1.942e+004				<u> </u>
Kinematic Viscosity	(cSt)	1.548	1.548			
Liq. Mass Density (Std. Col		63.87	63.87			ļ
Liq. Vol. Flow (Std. Cond)	(barrel/day)	295.1	295.1			
Liquid Fraction		1.000	1.000			1
Molar Volume	(ft3/bmoie)	0.3388	0.3388			
Mass Heat of Vap.	(Btu/b)	899.5			1	1

10 m m m	LEGENDS		<u> </u>	C:\Program Files\Asp		
aspen	Calgary, Albe	rta	Unit Set:	Field1		
	CANADA		Date/Time:	Sun May 15 01:06:28	2011	
	Material	Stream: D	EA (continue	d)	ud Päckage: operty Package:	Basis-1 Amine Pkg - KE
			PROPERTIES			
		Overall	Aqueous Phase			
Phase Fraction [Molar Ba	isis)	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/ibmole-F)	17.65	17.65			
Mass Cv (Semi-Ideal)	(BtuAb-F)	0.8173	0.8173			
Cv	(Btu/bmole-F)	17,65	17.65		[	
Mass Cv	(Btu/Ib-F)	0.8173	0.8173			
Cv (Ent. Method)	(Btu/fomole-F)	-				
Mass Cv (Ent. Method)	(Btu/#b-F)					
Cp/Cv (Ent. Method)			-			· ··· ·
Reid VP at 37.8 C	(psia)		_			
	(psia)	0.9113	0.9113			
True VP at 37.8 C						
		295.1	295.1 COMPOSITION	erali Phase	Vapour Fra	action 0.000
True VP at 37.8 C Liq. Vol. Flow - Sum(Std. ( COMPONENTS	MOLAR FLOW	295.1	295.1 COMPOSITION OV/	erall Phase MASS FRACTION		LIQUID VOLUM
Liq. Vol. Flow - Sum(Std. ( COMPONENTS	MOLAR FLOW (Droke/hr)	295.1	295.1 COMPOSITION OVA N MASS FLOW (Ib/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
Liq. Vol. Flow - Sum(Std. ( COMPONENTS	MOLAR FLOW (Broekfir) 0.000	295.1 / MOLE FRACTIO 10 * 0.000	295.1 COMPOSITION OVA MASS FLOW (b/hr) 0 * 0.0000 *	MASS FRACTION 0.0000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 *	LIQUID VOLUME FRACTION 0.0000
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 120	MOLAR FLOW (Bmolefin) 0.000 195.800	295.1 / MOLE FRACTIO 0 * 0.000 2 * 0.958	295.1 COMPOSITION OV (b/hr) 0 * 0.0000 * 9 * 3527.3600 *	MASS FRACTION 0.0000 * 0.8000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 *	LIQUID VOLUM FRACTION 0.0000 0.8144
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 120 DEAmine	MOLAR FLOW (Broekfir) 0.000	295.1 / MOLE FRACTIO 10 * 0.000 12 * 0.958 5 * 0.041	295.1 COMPOSITION OV (b/hr) 0 * 0.0000 * 9 * 3527.3600 * 1 * 881.8400 *	MASS FRACTION 0.0000 * 0.8000 * 0.2000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 *	LIQUID VOLUME FRACTION 0.0000 0.8144 0.1856
Liq, Vol. Flow - Sum(Std. (	MOLAR FLOW (broke/tir) 0,000 195,800 8.387	295.1 / MOLE FRACTIO 0 * 0.000 2 * 0.958 5 * 0.041	295.1 COMPOSITION OV( N MASS FLOW (b)/hr) 0 • 0.0000 • 9 • 3527.3600 • 1 • 881.8400 • 0 • 4409.2000	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592	LIQUID VOLUME FRACTION 0.0000 0.8144 0.1856 1.0000
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 H2O DEAmine	MOLAR FLOW (broke/tir) 0,000 195,800 8.387	295.1 / MOLE FRACTION 0 * 0.000 2 * 0.958 5 * 0.041 6 1.000	295.1 COMPOSITION OV/ N MASS FLOW (lb/hr) 0 * 0.0000 * 9 * 3527.3600 * 1 * 881.8400 * 0 4409.2000 Aque	MASS FRACTION 0.0000 * 0.8000 * 0.2000 *	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592 Phase Fra	LIQUID VOLUME FRACTION 0.0000 0.8144 0.1856 1.0000 ction 1.000
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 H2O DEAmine Fotal	MOLAR FLOW (Broolefir) 0.000 195.800 8.387 204.187	295.1 / MOLE FRACTION 0 * 0.000 2 * 0.958 5 * 0.041 6 1.000	295.1 COMPOSITION OV/ N MASS FLOW (b/hr) 0 * 0.0000 * 9 * 3527.3600 * 1 * 881.8400 * 0 4409.2000 Aqui	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 eous Phase	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592	LIQUID VOLUME FRACTION 0.0000 0.8144 0.1856 1.0000
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 120 JEAmine Total COMPONENTS	MOLAR FLOW (Broolefir) 0.000 195.800 8.387 204.187 MOLAR FLOW	295.1 / MOLE FRACTION 0 * 0.000 12 * 0.958 5 * 0.041 6 1.000 MOLE FRACTION	295.1 COMPOSITION OV/ N MASS FLOW (b/hr) 0 0.0000 * 9 0.0000 * 9 0.0000 * 9 0.0000 * 9 0.0000 * 9 0.0000 * 9 4409.2000 Aque N MASS FLOW (b/hr)	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 eous Phase	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592 Phase Fra LIQUID VOLUME	LIQUID VOLUME FRACTION 0.0000 0.8144 0.1856 1.0000 ction 1.000 LIQUID VOLUME
Liq. Vol. Flow - Sum(Std. ( COMPONENTS CO2 120 DEAmine Total COMPONENTS CO2	MOLAR FLOW (brolefir) 0.000 195.800 8.387 204.187 MOLAR FLOW (brolefir)	295.1 / MOLE FRACTION 0   0   0   0   0   0   0   0   0   0	295.1 COMPOSITION OV/ N MASS FLOW (b/hr) 0 0 0.0000 * 9 3527.3600 * 1 881.8400 * 0 4409.2000 Aque N MASS FLOW (b/hr) 0 0.0000	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0080 EOUS Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.0000 0.8144 0.1856 1.0000 ction 1.000 LIQUID VOLUME FRACTION
Liq. Vol. Flow - Sum(Std. ( COMPONENTS 202 120 DEAmine Fotal	MOLAR FLOW (brolefir) 0.000 195.800 8.387 204.187 MOLAR FLOW (brolefir) 0.000	295.1 / MOLE FRACTIO 0 * 0.000 2 * 0.958 5 * 0.041 6 1.000 MOLE FRACTIO 0 0.0000 2 0.958	295.1 COMPOSITION OV( N MASS FLOW (b/hr) 0 0.0000 * 3527.3600 * 1 881.8400 * 0 4409.2000 Aque N MASS FLOW (b/hr) 0 0.0000 3527.3600	MASS FRACTION 0.0000 * 0.8000 * 0.2000 * 1.0000 EOUS Phase MASS FRACTION 0.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 242.0157 * 55.1435 * 297.1592 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000	LIQUID VOLUM FRACTION 0.0000 0.8144 0.1856 1.0000 ction 1.000 LIQUID VOLUME FRACTION 0.0000

Aspen HYSYS Version 2006 (20.0.0.6728)

Hyprotech Ltd. Licensed to: LEGENDS

Page 4 of 7
\* Specified by user.

LEGENDS		Case Name:		spenTech\Aspen HYSYS 2	006\Cases\lank CO2
Calgary, Albert CANADA	а	Unit Set:	Field1		· · · · · · · · · · · · · · · · · · ·
		Date/Time;	Sun May 15 01:06:	28 2011	
	<b>.</b>			Fluid Package:	Basis-1
Materiał	Stream: M	ixup	na 1949 Angel Tangangan Angel	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	1
Molar Flow (libmole/fvr)	314.0	201.1	112.9	0.0000	I
Mass Flow (b/hr)	9242	4504	4737	0.0000	
Std Ideal Liq Vol Flow (barrel/day)	698.1	307.4	390.7	0.0000	
Molar Enthalpy (Btu/ibmole)	-7109	-1.270 <del>e+0</del> 04	2854	5971	
Molar Entropy (Btu//bmole-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 (barrei/day)	586.3 *	285.6	324.8	0.0000	······································
······································	A	PROPERTIES		1 <u></u>	· · · ·
	Overall	Aqueous Phase	Liquid Phase	Vapour Phase	
Molecular Weight	29.43	22.40	41.95	29.43	
	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/b)	-241,5	-567.1	68.03	202.9	····· ··· ····
Mass Entropy (Btu/b-F)	0.6752	0.8871	0.4737	1.776	
Heat Capacity (Btu/Ibmole-F)	16.31	19.87	9.962	9.003	
Mass Heat Capacity (Btu/b-F)	0.5541	0.8871	0.2375	0.3059	
Lower Heating Value (Btu/ibmole)			0.000		
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 (ibmote/ft3)	1.923	2.796	1.235	1.923	
Specific Heat (Btu/Ibmole-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 (Ib/ft3)	56.59	62.64	51.83	56.59	
Act. Liq. Flow (USGPM)	17.94	8.397	9.545		
	11.34				
Z Factor		8.078e-004	1.635e-003	0.9892	··· ·
Vatson K	8.568	8.847	8.524	8.568	
Jser Property					
Partial Pressure of H2S (psia)	0.0000				
2p/(Cp - R)	1.139	1.111	1.249	1.283	
λρ/Cv	1.139	1.111	1.249	1.299	
leat of Vap. (Btu/bmoke)	1.368e+004				
inematic Viscosity (cSt)	8.325e-002	1.049	1.603e-002	11.09	
iq. Mass Density (Std. Cond) (Ib/ft3)	67.37	67.42	62.34	67.37	
iq. Vol. Flow (Std. Cond) (barrel/day)	586.3	285.6	324.8	0.0000	
iquid Fraction	1.000	1.000	1.000	0.0000	
Iolar Volume (ft3/lbmole)	0.4583	0.3350	0.6779	410.2	

aspen	LEGENDS Calgary, Alberta CANADA		Unit Set			Rank Kara
	CANADA		CTINE CORE	Field1		
			Date/Time:	Sun May 15 01.06:28	2011	
galan ya shekara	Material S	Stream: Mix	kup (continu	ed)	id Package: operty Package:	Basis-1 Amine Pkg - KE
			PROPERTIES			
		Overall	Aqueous Phase	Liquid Phase	Vapour Phase	
Phase Fraction [Molar Basi	is]	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/iomole-F)	14.32	17.89	7_977	7.017	,
Mass Cv (Semi-Ideal)	(Btu/b⊳F)	0.4866	0.7984	0.1901	0.2384	
Cv (	(Btu/tomole-F)	14.32	17.89	7.977	6.930	
Mass Cv	(Btu/Ib-F)	0.4866	0.7984	0.1901	0.2354	
Cv (Ent. Method)	(Btu/fbmole-F)	- [				
Mass Cv (Ent. Method)	(Btu/b-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. Co	on <b>@</b> arrel/day)	610.4	285.6	324.8	0.0000	· · · · · · · · · · · · · · · · · · ·
COMPONENTS	MOLAR FLOW	MOLE FRACTION		MASS FRACTION		action 0.0000
CONFORMENTS	(ismole/hr)	MOLETINACTION	(lb/hr)	MASS FINE HON	FLOW (barrel/day)	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
			Aque	eous Phase	Phase Fra	ction 0.6404
COMPONENTS	MOLAR FLOW	MOLE FRACTION	MASS FLOW	MASS FRACTION		LIQUID VOLUME
	(ibmole/hr)		(b/hr)		FLOW (barrel/day)	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
COMPONENTS	MOLAR FLOW	MOLE FRACTION		uid Phase	Phase Fra	LIQUID VOLUME
	(Ibmole/hr)	INCLUTION ION	(lb/fur)		FLOW (barrel/day)	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	0.000D	0.0000	0.0017	0.0000	0.0001	0.0000
Total	112.9252		4737.3970	1.0000	390.7201	1.0000
<b>3</b> (1) 1 1 <b>3 3 1 1 1</b>				our Phase	Phase Fra	····
COMPONENTS	MOLAR FLOW	MOLE FRACTION	MASS FLOW	MASS FRACTION	LIQUID VOLUME	LIQUID VOLUME
	(Ibmole/inr)		( <b>1</b> 0/11)		FLOW (barrel/day)	FRACTION
	0.0000	0.3497	0.0000	0.5229	0.0000	0.5743
CO2	· · · · · · · · · · · · · · · · · · ·		. <b>.</b>	<ul> <li>A second s</li></ul>	I I I I I I I I I I I I I I I I I I I	

*3. 2° 2° 2° 3°	LEGENDS Calgary, Alberta		Unit Set	Field1		
aspen	CANADA		Date/Time:	Sun May 15 01:06:28	2011	
	Material S	tream: Mix	up (continu	ed)	id Package: operty Package:	Basis-1 Amine Pkg- KE
			COMPOSITION			
			Vapour Ph	ase (continued)	Phase Fra	ction 0.0000
COMPONENTS	MOLAR FLOW (Ibmole/hr)	MOLE FRACTION	MASS FLOW (th/tr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
DEAmine	0.0000	0.0267	0.0000	0.0954	0.0000	0.0790
otal	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
	I					
	7					

LEGENDS Calgary, Alber	ta	Unit Set	Field1		e konstruktivne se
aspen canada		Date/Time:	Sun May 15 00:58:	21-2011	
	n a na kristi s			212011	
Material	Stream: co	<b>52</b>	a an tha an	Fluid Package:	Basis-1
				Property Package:	Peng-Robinson
		CONDITIONS			
	Overali	Vapour Phase			
Vapour / Phase Fraction	1.0000	1.0000			
Temperature: (F)	77.00 *	77.00			
Pressure: (psia)	14.69 *	14.69			1
Molar Flow (ibmole/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/lomole)	-1.693e+005	-1.693e+005			
Molar Entropy (Btu/Ibmole-F)	41.17	41.17			
Heat Flow (Bturhr)	-1.859e+007	-1.859e+007			
Liq Vol Flow @Std Cond (barrel/day)	400.2 *	400.2			
		PROPERTIES			
	Overail	Vapour Phase	n en gewitten det til	ter en el se	1
Molecular Weight	44.01	44.01			
Molar Density (fomole/ft3)	2.565e-003	2.565e-003			
Mass Density (b/ft3)	0.1129	0.1129			
······	1.830e+005				
		1.830e+005			-
Mass Enthalpy (Btu/b)	-3847	-3847			
Mass Entropy (Btu/BD-F)	0.9356	0.9356			
Heat Capacity (Btu/Ibmole-F)	9.195	9.195			
Mass Heat Capacity (Btu/b-F)	0.2089	0.2089			
Lower Heating Value (Btu/Ibmole)	0.0000	0.0000		· · · · · · · · · · · · · · · · · · · ·	
Mass Lower Heating Value (Btu/b)					
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 (Ibmole/ft3)	1.171	1.†71			
Specific Heat (Btu/bmole-F)	9.195	9.195			
Std. Gas Flow (MMSCFD)	0.9981	0.9981			
Std. Ideal Liq. Mass Density (Ib/ft3)	51.52	51.52			
Act. Líq. Flow (USGPM)					
Z Factor	0.9944	0.9944			
Natson K	8.524	8.524			
Jser Property	-	_			
Partial Pressure of H2S (psia)	0.0000				
Cp/(Cp - R)	1.275	1.275		·····	
Cp/Cv	1.284	1.284			1
Heat of Vap. (Btu/bmole)	7396				·]
(inematic Viscosity (cSt)	8.084	8.084		·····	
iq. Mass Density (Std. Cond) (fb/ff3)	51.62	51.62			
ig. Vol. Flow (Std. Cond) (barrel/day)	400.2	400.2		· · · ·	
				• · · · - ·	
iquid Fraction	0.0000	0.0000			
Molar Volume (ft3/fomole)	389.8	389.8			1

	LEGENDS		Case Name:	C:\Program Files\Aspe	en TechlAspen HYSYS 20	06\CasesViank CO2
aspen	Calgary, Alberta		Unit Set:	Field1		
	CANADA		Date/Time:	Sun May 15 00:58:21	2011	
	Material S	tream: co2	? (continued	<b>)</b>	vid Package: operty Package:	Basis-1 Peng-Robinson
			PROPERTIES			
		Overali	Vapour Phase			
Phase Fraction [Molar Bas	is)	1.0000	1.0000			
Surface Tension	(dyrxe/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/Ibmole-F)	7.209	7.209			
Mass Cv (Semi-Ideal)	(Btu/ib-F)	0.1638	0.1638			· · · · · · · · · · · · · · · · · · ·
<u>Cv</u>	(Btu/lbmole-F)	7.163	7.163			
Mass Cv	(Btu/to-F)	0.1628	0.1628			
	(Btu/Ibmole-F)	7.145	7.145			
Mass Cv (Ent. Method)	(Btu/b-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)					
iq. Vol. Flow - Sum(Std. Co	on <b>(ii)</b> arrel/day)	400.2	400.2			
COMPONENTS	MOLAR FLOW (Ibmole/hr)	MOLE FRACTION	MASS FLOW (Ib/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUMI FRACTION
002	109.8047 *	1.0000 *	4832.4717 *	1.0000 *	400.9196 *	1.000
<b></b>	0.0000 *	0.0000 *	0.0000 *	0.0000 *	* 0000.0	0.000
			4832.4717	1.0000		
	109.8047	1.0000	4032.4717	1.0000	400.9196	1.000
Potassium Carbonate*	109.8047	1.0000		our Phase	400.9196 Phase Fra	
	MOLAR FLOW	1.0000 MOLE FRACTION	Vapo MASS FLOW		Phase Fra	ction 1.00
otal COMPONENTS	MOLAR FLOW (tomole/hr)	MOLE FRACTION	Vapo MASS FLOW (b/hr)	DUT Phase MASS FRACTION	Phase Fra LIQUID VOLUME FLOW (barrel/day)	ction 1.00 LIQUID VOLUM FRACTION
CCMPONENTS	MOLAR FLOW (Ibmole/hr) 109.8047	MOLE FRACTION	Vapo MASS FLOW ((b/hr) 4832.4717	Dur Phase MASS FRACTION 1.0000	Phase Fra LIQUID VOLUME FLOW (barrel/day) 400.9196	ction 1.00 LIQUID VOLUM FRACTION 1.000
ota!	MOLAR FLOW (tomole/hr)	MOLE FRACTION	Vapo MASS FLOW (b/hr)	DUT Phase MASS FRACTION	Phase Fra LIQUID VOLUME FLOW (barrel/day)	ction 1.00 LIQUID VOLUM FRACTION

\* Specified by user.

!

<b>20</b> 17.20	LEGENDS Calgary, Albe	ta	Unit Set:	Field1		
aspen	CANADA		Date/Time:	Sun May 15 00:58		entry franciska Statisticka statisticka Stylicka statisticka statisticka statisticka statisticka statisticka statisticka statisticka statisticka statis
e le transferencia de la compañía d	<u></u>			Sull May 15 00.56		
	Material	Stream: Po	otassium Ca	arbonate	Fluid Package: Property Package:	Basis-1 Peng-Robinson
			CONDITIONS			
		Overail	Liquid Phase			
Vapour / Phase Fraction	····	0.0000	1.0000			
Temperature:	(F)	77.00 *	77.00			
Pressure:	(psia)	14.69 *	14.69			
Molar Flow	(Ibmole/hr)	40.74	40.74			ļ
Mass Flow	(lb/hr)	4409 *	4409			
Std Ideal Liq Vol Flow	(barrel/day)	407.6	407.6			
Molar Enthalpy	Btu/ibmole)	-1.007e+005	-1.007e+005	·		
Molar Entropy (B	u/ibmole-F)	38.47	38.47			
Heat Flow	(Btu/hr)	-4.102e+005	-4.102e+006	• • • • • • • • • • • • • • • • • • •		
Liq Vol Flow @Std Cond	(barrei/day)	407.3 *	407.3			}
			PROPERTIES			
		Overall	Liquid Phase			
Molecular Weight		108.2	108.2			
	(Ibmole/ft3)	0.4225	0.4225			
Mass Density	(15/ft3)	45.73	45.73			
	(barrel/day)	412.1	412.1			
Mass Enthalpy	(Btw/b)	-930.3	-930.3			ļ
Mass Entropy	(Btu/b-F)	0.3555	0.3555			
	u/ibmole-F)	50.66	50.66			
Mass Heat Capacity	(Btu/b-F)	0.4680	0.4680			
	Btu/ibmole)					
Mass Lower Heating Value	(Btuño)					
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	Ibmole/ft3)	0,4273	0.4273			
Specific Heat (Bt	/lbmole-F)	50.66	50.66			
Std. Gas Flow (	MMSCFD)	0.3703	0.3703			
Std. Ideal Liq. Mass Density	(ib/ft3)	46.24	46.24	·		· · · · · · · · · · · · · · · · · · ·
Act. Liq. Flow	(USGPM)	12.02	12.02		<b> </b>	
Z Factor	···	6.038e-003	6.038e-003			
Natson K		11.85	11.85			•••••••••••••••••••••••••••••••••••••••
Jser Property						·· ·· ·· ········· · · ···
Partial Pressure of H2S	(psia)	0.0000			· · · · · · · · · · · · · · · · · · ·	
Cp/(Cp - R)		1.041	1.041			
5p/Cv		1.171	1.171	· · · · · · · · · · · · · · · · · · ·		
	Stu/Ibmole)	1.392e+004	LIT3			
·					· · · · · · · · · · · · · · · · · · ·	
Inematic Viscosity	(cSt)	0.6330	0.6330			
iq. Mass Density (Std. Cond)	(Ib/ft3)	46.27	46.27			
	parrel/day)	407.3	407.3			
iquid Fraction		1.000	1.000			
Aolar Volume (	ft3/lbmole)	2.367	2.367			
lass Heat of Vap.	(Btu/b)	128.7				

	CANADA		Unit Set:	Fiela1		
요가지 않는 전체가 가지 않는 것이 전체가 가지 않는 것이			Date/Time:	Sun May 15 00:58:2	21 2011	
	Material S	tream: Po	tassium Cai	bonate (	Fluid Package: Property Package:	Basis-1 Peng-Robinson
			PROPERTIES			
		Overall	Liquid Phase			
Phase Fraction (Molar Bas	is]	0.0000	1.0000			·····
Surface Tension	(dyne/cm)	21.61	21.61			
Thermal Conductivity	(Btu/hr-ft-F)	6.956e-002	6.956e-002			
/iscosity	(cP)	0.4637	0.4637			
≫ (Semi-Ideal)	(Btu/Ibmole-F)	48.67	48.67		······	
lass Cv (Semi-Ideal)	(Btu/to-F)	0.4497	0.4497			
×	(Btu/ibmote-F)	43.26	43.26			
lass Cv	(Btu/lb-F)	0.3997	0.3997			
	(Btu/ibmole-F)					
tass Cv (Ent. Method)	(Btu/tb-F)					
p/Cv (Ent. Method)		<u>-</u>		·····		
Reid VP at 37.8 C	(psia)				· · · · · · · · · · · · · · · · · · ·	
rue VP at 37.8 C	(psia)	1.314	1.314		<u> </u>	·
iq. Vol. Flow - Sum(Std. C	on@arrel/day)	407.3	407.3		İ	
COMPONENTS	MOLARELOW			erall Phase	Vapour Fr	· · · · · · · · · · · · · · · · · · ·
COMPONENTS	MOLAR FLOW	MOLE FRACTION	MASS FLOW	MASS FRACTION	LIQUID VOLUME	LIQUID VOLUI
	MOLAR FLOW (Ibmote/hr) 0.0000 *	MOLE FRACTION	MASS FLOW (lb/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLU FRACTION
02	(ibmole/hr)	an shi da an Aseleta An an Anna Anna Anna Anna Anna Anna An	MASS FLOW (Ib/hr)	<b>1</b>	LIQUID VOLUME FLOW (barrel/day) * 0.0000 *	LIQUID VOLU FRACTION 0.00
COMPONENTS 202 Potassium Cerbonate* Iotal	(Bomote/hr) 0.0000 *	0.0000 *	MASS FLOW (05/hr) * 0.0000 *	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUK
:02 otassium Carbonate*	(ibmote/hr) 0.0000 * 40.7384 *	0.0000 * 1.0000 *	MASS FLOW (b/hr) 0.0000 * 4409.2000 4409.2000	MASS FRACTION 0.0000 1.0000	LIQUID VOLUME FLOW (barrel/day) • 0.0000 • • 407.5724 •	LIQUID VOLU FRACTION 0.09 1.00 1.00
:02 otassium Carbonate*	(ibmote/hr) 0.0000 * 40.7384 *	0.0000 * 1.0000 *	MASS FLOW (b/hr) 0.0000 * 4409.2000 4409.2000	MASS FRACTION 0.0000 1.0000 1.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 407.5724 * 407.5724	LIQUID VOLU FRACTION 0.00 1.00 1.00 ction 1.0
02 otassium Carbonate* otai COMPONENTS	(bmote/hr) 0.0000 * 40.7384 * 40.7384	0.0000 * 1.0000 * 1.0009	MASS FLOW (bihr) 0.0000 * 4409.2000 * 4409.2000 Liq	MASS FRACTION 0.0000 1.0000 1.0000 uid Phase	LIQUID VOLUME FLOW (barrel/day) • 0.0000 • • 407.5724 • 407.5724 Phase Fra	LIQUID VOLU FRACTION 0.00 1.00 1.00 ction 1.0
O2 otassium Carbonate* otai COMPONENTS O2	(ibmole/hr) 0.0000 * 40.7384 * 40.7384 MOLAR FLOW (ibmole/hr) 0.0000	0.0000 * 1.0000 * 1.0009	MASS FLOW ((bihr) 0.0000 * 4409.2000 * 4409.2000 Liq MASS FLOW	MASS FRACTION 0.0000 1.0000 1.0000 uid Phase	LIQUID VOLUME FLOW (barrel/day) • 0.0000 • • 407.5724 • 407.5724 Phase Fra LIQUID VOLUME	LIQUID VOLU FRACTION 0.00 1.00 1.00 ction 1.0 LIQUID VOLUA FRACTION
O2 otassium Carbonate* otal	(bmote/hr) 0.0000 * 40.7384 * 40.7384 MOLAR FLOW (bmote/hr)	0.0000 * 1.0000 * 1.0009 MOLE FRACTION	MASS FLOW ((b/hr) 0.0000 * 4409.2000 4409.2000 Liq MASS FLOW ((b/hr))	MASS FRACTION 0.0000 1.0000 1.0000 uid Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 0.0000 * 407.5724 * 407.5724 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUN FRACTION 0.00 1.00 1.00 ction 1.0 LIQUID VOLUN

\* Specified by user.

.

Licensed to: LEGENDS

LEGENDS		Case Name:		penTech/Aspen HYSYS :	
ASPEN Calgary, A CANADA	berta	Unit Set.	Field1		
		Date/Time:	Sun May 15 00:58:	21 2011	
Motori	al Stream: M	ivun		Fluid Package:	Basis-1
	a Stream. M	ixup		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 (Ibmole/hr)	37.88	0.0000	37.88		
Mass Flow (Ib/hr)	4061	0.0000	4061		
Std Ideal Lig Vol Flow (barrel/day)	375.2	0.0000	375.2		
Molar Enthalpy (Btu/bmole)	-1.027e+005	-1.669e+005	-1.027e+005		
Molar Entropy (Btu/tomole-F)	36.81	41,75	36.81		
Heat Flow (Blufur)	-3.890e+006	0.0000	-3.890e+006		
	373.8 *	0.0000	373.8		
Liq Vol Flow @Std Cond (barrel/day)	373.6				
		PROPERTIES		Philippe 1 and and and	· · · · · · · · · · · · · · · · · · ·
	Overall	Vapour Phase	Liquid Phase		··· ···
Molecular Weight	107.2	45.98	107.2		
Molar Density (Ibmole/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/b)	-957.9	-3630	-957.9		
Mass Entropy (Btu/b-F)	0.3434	0.9080	0.3434		
Heat Capacity (Btu/bmole-F)	49.00	10.04	49.00		
Mass Heat Capacity (Btu/b-F)	0.4571	0.2184	0.4571		
Lower Heating Value (Btu/ibmole)		·····			
Mass Lower Heating Value (Btu/b)			······		
Phase Fraction [Vol. Basis]			1.000	······································	
Phase Fraction [Mass Basis]	2.122e-314	0.0000	1.000		
	0.0000				
Partial Pressure of CO2 (psia)	·······	0.0000	0.0000		
Cost Based on Flow (Cost/s)	0.0000	0.0000	0.0000		
Act. Gas Flow (ACFM)					
Avg. Liq. Density (Ibmole/Tt3)	0,4316	1.111	0.4316		
Specific Heat (Btu/bmole-F)	49.00	10.04	49.00		
Std. Gas Flow (MMSCFD)	0.3443	0.0000	0.3443		
Std. Ideal Liq. Mass Density (Ib/ft3)	46.27	51.10	46.27		
Act. Liq. Flow (USGPM)	10.91		10.91		
Z Factor		0.9930	6.086e-003		<b>.</b>
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/bmole)	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	1	
Liq. Vol. Flow (Std. Cond) (barrel/day)	373.8	0.0000	373.8		1
	1.000	0.0000	1.000		]
Liquid Fraction	j				
Molar Volume (ff3/ibmole)	2.310	376.9	2.310		
Mass Heat of Vap. (Btu/b)	209.6				1

	LEGENDS		Case Name:	C:\Program Files\Asp	penTechVAspen HYSYS 2	005\Cases\tank CO
aspen	Calgary, Albert CANADA	3	Unit Set:	Field1		
-			Date/Time:	Sun May 15 00:58:21	l 2011	
	Material	Stream: Mix	(up (continu	led)	ard Package: roperty Package:	Basis-1 Peng-Robinson
			PROPERTIES			
		Overall	Vapour Phase	Liquid Phase		
Phase Fraction [Molar Bas	is]	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	1.382 <del>0</del> -002	0.5121		
Cv (Semi-Ideal)	(Stu/Ibmole-F)	47.02	8.055	47.02		
Mass Cv (Semi-Ideal)	(Btu/ib-F)	0.4386	0.1752	0.4386		
Cv	(Btu/bmole-F)	41.68	7.999	41.68		
Mass Cv	(Btu/tb-F)	0.3888	0.1740	0.3888		
Cv (Ent. Method)	Btu/Ibmole-F)	45.59	7.503			
Mass Cv (Ent. Method)	(Btu/b-F)	0.4252	0.1632		· · · · · · · · · · · · · · · · · · ·	
Cp/Cv (Ent. Method)		1.075	1.338			
	(peia)	7.945	1067	7.945		
	(psia)		1117	20.60		
Reid VP at 37.8 C	(psia)	20.60				
Reid VP at 37.8 C True VP at 37.8 C	(psia)	373.8	0.0000	373.8 erall Phase	Vapour Fi	raction D.DG
Reid VP at 37.8 C True VP at 37.8 C	(psia) n <b>()</b> arrel/day) MOLAR FLOW	373.8	0.0000 COMPOSITION Ove MASS FLOW	373.8		
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Sid. Co COMPONENTS	(psia) m@parrel/day) MOLAR FLOW (lbmole/ftr)	373.8 MOLE FRACTION	0.0000 COMPOSITION Ove MASS FLOW (b/hr)	373.8 erall Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUN FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2	(psia) m@parrel/day) MOLAR FLOW (lbmole/tir) 0.6014	373.8 MOLE FRACTION 0.0159	0.0000 COMPOSITION Ove (b/tr) 26.4679	373.8 erall Phase MASS FRACTION 0.0065	LIQUID VOLUME FLOW (barrel/day) 2.1959	LIQUID VOLUN FRACTION 0.00
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate*	(psia) m@parrel/day) MOLAR FLOW (bimole/hr) 0.6014 37.2797	373.8 MOLE FRACTION 0.0159 0.9841	0,0000 COMPOSITION Ove (Ib/hr) 26.4679 4034.8586	373.8 erall Phase MASS FRACTION 0.0065 0.9935	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695	LIQUID VOLUM FRACTION 0.00 0.99
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate*	(psia) m@parrel/day) MOLAR FLOW (lbmole/tir) 0.6014	373.8 MOLE FRACTION 0.0159	0,0000 COMPOSITION Ove (b/hr) 26,4679 4034,8586 4061,3265	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653	LIQUID VOLUN FRACTION 0.004 0.994 1.000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total	(psia) m@arrel/day) MOLAR FLOW (lbmole/trr) 0.6014 37.2797 37.8811	373.8 MOLE FRACTION 0.0159 0.9841 1.0000	0,0000 COMPOSITION Ove (b/hr) 26,4679 4034,8586 4061,3265 Vap	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 pour Phase	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fre	LIQUID VOLUK FRACTION 0.00 0.99 1.000 action 0.000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate*	(psia) m@parrel/day) MOLAR FLOW (bimole/hr) 0.6014 37.2797	373.8 MOLE FRACTION 0.0159 0.9841	0,0000 COMPOSITION Ove MASS FLOW (Ib/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME	LIQUID VOLU FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total COMPONENTS	(psia) m@arrel/day) MOLAR FLOW (timole/hir) 0.6014 37.2797 37.8811 MOLAR FLOW (timole/hr)	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION	0,0000 COMPOSITION Ove (b/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr)	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 pour Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total COMPONENTS CO2 202	(psia) m@parrel/day) MOLAR FLOW (Ibmole/hrr) 0.6014 37.2797 37.8811 MOLAR FLOW	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693	0,0000 COMPOSITION Ove (b/hr) 26,4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr) 0,0000	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 our Phase MASS FRACTION 0.9277	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000	LIQUID VOLUM FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM FRACTION 0.92
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* fotal COMPONENTS CO2 Potassium Carbonate*	(psia) m@arrel/day) MOLAR FLOW (lbmole/tir) 0.6014 37.2797 37.8811 MOLAR FLOW (lbmole/tr) 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION	0,0000 COMPOSITION Ove (b/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr)	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 our Phase MASS FRACTION 0.9277 0.0723	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000	LIQUID VOLU FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUA FRACTION 0.924 0.07
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total COMPONENTS CO2 Potassium Carbonate*	(psia) m@parrel/day) MOLAR FLOW (bimole/hir) 0.6014 37.2797 37.8811 MOLAR FLOW (bimole/hir) 0.6000 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693 0.0307	0,0000 COMPOSITION CV( MASS FLOW (b/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr) 0.0000 0.0000 0.0000 0.0000	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 our Phase MASS FRACTION 0.9277 0.0723 1.0000	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000	LIQUID VOLUM FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM FRACTION 0.92/ 0.079 1.000
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total	(psia) m@parrel/day) MOLAR FLOW (bimole/hir) 0.6014 37.2797 37.8811 MOLAR FLOW (bimole/hir) 0.6000 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693 0.0307	0,0000 COMPOSITION CV( MASS FLOW (b/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr) 0.0000 0.0000 0.0000 0.0000	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 OUIT Phase MASS FRACTION 0.9227 0.0723 1.0000 uid Phase	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fre LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 Phase Fre	LIQUID VOLUM FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM FRACTION 0.92( 0.07 1.000 ction 1.00
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total COMPONENTS 202 Potassium Carbonate* Fotal	(psia) m@parrel/day) MOLAR PLOW (bimole/hir) 0.6014 37.2797 37.8811 MOLAR FLOW (lbmole/hr) 0.0000 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693 0.0307 1.0000	0,0000 COMPOSITION Ove MASS FLOW (lb/hr) 26,4679 4034,8586 4061,3265 Vap MASS FLOW (lb/hr) 0,0000 0,0000 0,0000 Liq	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 our Phase MASS FRACTION 0.9277 0.0723 1.0000	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000	LIQUID VOLUM FRACTION 0.00 0.99 1.00 action 0.00 LIQUID VOLUM FRACTION 0.92( 0.07 1.000 ction 1.00
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Total COMPONENTS CO2 Potassium Carbonate* Fotal	(psia) m@parrel/day) MOLAR FLOW (timole/hir) 0.6014 37.2797 37.8811 MOLAR FLOW (tibmole/hir) 0.0000 0.0000 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693 0.0307 1.0000	0,0000 COMPOSITION CV4 MASS FLOW (b/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (b/hr) 0.0000 0.0000 0.0000 Liq	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 OUIT Phase MASS FRACTION 0.9227 0.0723 1.0000 uid Phase	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fre LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 Phase Fre LIQUID VOLUME	LIQUID VOLUN FRACTION 0.00 0.99 1.000 action 0.000 LIQUID VOLUN FRACTION 0.920 0.077 1.000 ction 1.00 LIQUID VOLUM FRACTION
Reid VP at 37.8 C True VP at 37.8 C Liq. Vol. Flow - Sum(Std. Co COMPONENTS CO2 Potassium Carbonate* Fotal COMPONENTS 202 Potassium Carbonate* Total COMPONENTS	(psia) m@parrel/day) MOLAR FLOW (bimole/hr) 0.6014 37.2797 37.8811 MOLAR FLOW (bimole/hr) 0.0000 0.0000 0.0000 0.0000 0.0000	373.8 MOLE FRACTION 0.0159 0.9841 1.0000 MOLE FRACTION 0.9693 0.0307 1.0000 MOLE FRACTION	0,0000 COMPOSITION Ove MASS FLOW (Ib/hr) 26.4679 4034.8586 4061.3265 Vap MASS FLOW (Ib/hr) 0,0000 0,0000 0,0000 Liqi MASS FLOW (Ib/hr)	373.8 erall Phase MASS FRACTION 0.0065 0.9935 1.0000 out Phase MASS FRACTION 0.9277 0.0723 1.0000 uid Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 2.1959 372.9695 375.1653 Phase Fre LIQUID VOLUME FLOW (barrel/day) 0.0000 0.0000 Phase Fre LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION 0.00 0.99 1.000 action 0.000 LIQUID VOLUM FRACTION 0.920 0.075 1.000 ction 1.00

Hyprotech Ltd. Licensed to: LEGENDS Aspen HYSYS Version 2006 (20.0.0.6728)

Page 6 of 6
\* Specified by user.

LE	GENDS	Case Name:	C:\Program FilesV	spenTech/Aspen HYSYS	2006\Cases\tank CO2
asnan <sup>Ca</sup>	gary, Alberta NADA	Unit Set:	Field1		
*		Date/Time:	Sun May 15 00:44	16 2011	
				Fkaid Package:	Basis-1
Mai	erial Stream: c	02		Property Package:	Peng-Robinson
n aga an	in in statistic and a statistic statistic second	CONDITIONS		<u>n dag kin da sepanging sain</u>	:
	Overall	Vapour Phase			
Vapour / Phase Fraction	1.0000	1.0000		, <u>Andrew (1997)</u> , <u>And</u>	·····
Temperature:	(F) 77.00 *	77.00			
Pressure: ()	osia) 14.69 *	14.69			
Molar Flow (tomol	e/hr) 109.8 *	109.8			
Mass Flow (I	b/hr) 4832	4832			
Std Ideal Liq Vol Flow (barrel/	day) 400.9	400.9			
Molar Enthalpy (Btu/lbn	iole) -1.693e+005	~1.693e+005			· · · · · · · · · · · · · · · · · · ·
Molar Entropy (Btu/tumol		41.17			
	uhr) -1.859e+007	-1.859e+007			
Liq Vol Flow @Std Cond (barrel/	day) 400.2 *	400.2	l		
		PROPERTIES			
	Overall	Vapour Phase			
Molecular Weight	44.01	44.01			
Molar Density (ibmole	/ft3) 2.565e-003	2.565e-003			
Mass Density (Ib	<i>f</i> ft3) 0.1129	0.1129			
Act. Volume Flow (barrel/	tay) 1.830e+005	1.830e+005			
Mass Enthalpy (Bt	u⁄lb) –3847	-3847			
Mass Entropy (Btul	b-F) 0.9356	0.9356			
Heat Capacity (Btu/ibmol	9.195 €	9.195			
Mass Heat Capacity (Btu/	b-F) 0.2089	0.2089			
Lower Heating Value (Btu/Ibm	ole) 0.0000	0.0000			
Mass Lower Heating Value (Bt	ufb)				
Phase Fraction [Vol. Basis]		1.000			
Phase Fraction (Mass Basis)	4.941e-324	1.000			
Partial Pressure of CO2 (p	sia) 14.69	· · · · · · · · · · · · · · · · · · ·			
Cost Based on Flow (Cos	st/s) 0.0000	0.0000			
Act. Gas Flow (AC	FM) 713.4	713.4			
Avg. Liq. Density (bmole.	ff3) 1.171	1,171			
Specific Heat (Btu/tomole		9.195			
Std. Gas Flow (MMSC		0.9981			
	113) 51.52	51.52			
Act. Liq. Flow (USG	····				
Z Factor	0.9944	0.9944			
Watson K	8.524	8.524			
User Property					
<u>`</u>	sia) 0.0000				
Cp/(Cp - R)	1.275	1.275	·		
Cp/Cv Heat of Vap (Bt/thm	1.284	1.284			
Heat of Vap. (Btu/bm Kinematic Viscosity (d	••• ••• ••• ••• ••• ••• ••• ••• ••• ••• ••• •••				
	·····	8.084 51.62			
	ft3) 51.62	51.62			
Liq. Vol. Flow (Std. Cond) (barrel/o		400.2	·····		
Liquid Fraction (#3/hm	0.0000	0.0000			· · · · · · · · · · · · · · · · · · ·
Molar Volume (f13/lbm+		389.8			
Mass Heat of Vap. (Bt. Hyprotech Ltd.	and a second	YS Version 2006 (		la at prove	

aspen	Calgary, Alberta		Unit Set	Field1		
	CANADA		Date/Time:	Sun May 15 00:44:16	2011	
					uid Package:	Basis-1
	Material S	Stream: co	2 (continued	I) Pi	roperty Package:	Peng-Robinson
			PROPERTIES			
		Overall	Vapour Phase			
Phase Fraction [Molar Bas Surface Tension	sis) (dyne/cm)	1.0000	1.0000			
Thermal Conductivity	(Btu/hr-ft-F)	9.808e-003	9.808e-003			
Viscosity	(cP)	1.462e-002	1.462e-002	1 and an an add at a 1 m f of the base of an		
Cv (Semi-Ideal)	(Btu/ibmole-F)	7.209	7.209	·····		
Mass Cv (Semi-Ideal)	(BtuAb-F)	0.1638	0.1638			
Cv	(Btu/bmole-F)	7.163	7.163			
Mass Cv	(Btu/to-F)	0.1628	0.1628			
Cv (Ent. Method)	(Btu/lbmole-F)	7.145	7.145			
Mass Cv (Ent. Method)	(Btu/b-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. C	on@arrei/day)	400.2	400.2		, <u>.</u>	·
COMPONENTS	MOLAR FLOW	MOLE FRACTION	Ove MASS FLOW	erall Phase	Vapour Fr	
COMPONENTS		MOLE FRACTION	MASS FLOW	T the second second		LIQUID VOLUMI
	MOLAR FLOW (Ibmole/hr) 0.0000			T the second second		LIQUID VOLUM
COMPONENTS Propylene Carbonate* CO2	(ibmole/hr)	• 0.0000 *	MASS FLOW (Ib/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUMI FRACTION 0.0000
Propylene Carbonate*	(Ibmole/hr) 0.0000	• 0.0000 *	MASS FLOW (10/hr) 0.0000 *	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 0.0000 *	LIQUID VOLUMI FRACTION 0.000 1.000
Propylene Carbonate* CO2	(ibmole/hr) 0.0000 109.8047	• 0.0000 • • 1.0000 •	MASS FLOW (lb/mr) 0.0000 * 4832.4717 * 4832.4717	MASS FRACTION 0.0000 * 1.0000 *	LIQUID VOLUME FLOW (barrs/day) 0.0000 * 400.9196 *	LIQUID VOLUMI FRACTION 0.000 1.000 1.000
Propylene Carbonate* CO2	(ibmole/hr) 0.0000 109.8047	• 0.0000 • • 1.0000 •	MASS FLOW (lb/mr) 0.0000 * 4832.4717 * 4832.4717	MASS FRACTION 0.0000 * 1.0000 * 1.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 • 400.9196 • 400.9196	LIQUID VOLUMI FRACTION 0.000 1.000 1.000 ction 1.00
Propylene Carbonate* CO2 Total	(lbmole/hr) 0.0000 109.8047 109.8047	0.0000     1.0000     1.0000	MASS FLOW (tb/mr) 0.0000 • 4832.4717 • 4832.4717 Vap	MASS FRACTION 0.0000 * 1.0000 * 1.0000 wur Phase	LIQUID VOLUME FLOW (barreviday) 0.0000 • 400.9196 • 400.9196 Phase Fra	LIQUID VOLUMI FRACTION 0.000 1.000 1.000 ction 1.00
Propylene Carbonate* CO2 Total COMPONENTS Propylene Carbonate*	(Ibmole/hr) 0.0000 109.8047 109.8047 MOLAR FLOW (Ibmole/hr) 0.0000	0.0000     1.0000     1.0000     MOLE FRACTION     0.0000	MASS FLOW (Ib/hr) 0.0000 * 4832.4717 4832.4717 Vap MASS FLOW (Ib/hr) 0.0000	MASS FRACTION 0.0000 * 1.0000 1.0000 NOUR Phase MASS FRACTION 0.0000	LIQUID VOLUME FLOW (barrel/day) 0.0000 • 400.9196 • 400.9196 Phase Fra Phase Fra LIQUID VOLUME FLOW (barrel/day) 0.0000	LIQUID VOLUMI FRACTION 0.000 1.000 ctien 1.000 LIQUID VOLUMI FRACTION 0.000
Propylene Carbonate* CO2 Total	(Ibmole/hr) 0.0000 109.8047 109.8047 MOLAR FLOW (Ibmole/hr)	0.0000     1.0000     1.0000     MOLE FRACTION	MASS FLOW (Ib/hr) 0.0000 * 4832.4717 4832.4717 Vap MASS FLOW (Ib/hr)	MASS FRACTION 0.0000 * 1.0000 * 1.0000 NOUR Phase MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 0.0000 • 400.9196 • 400.9196 Phase Fra Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUMI FRACTION 0.0000 1.0000 1.0000 ction 1.000 LIQUID VOLUME

LEGENDS		Case Name;	U.VEI UYRKIR FÜRS	rapenn eun/Aspen mTST	S 2005\Cases\tank CO2
aspen <sup>Calgary, Alb</sup> CANADA	erta	Unit Set:	Field1		*
		Date/Time:	Sun May 15 00:4	4:16 2011	
Materia	Stream: Pr	opylene Ca	arbonate	Fluid Package: Property Package:	Basis-1 Peng-Robinson
	<u></u>	CONDITIONS	<u></u>		····
	Overall	Liquid Phase			a that Alases
Vapour / Phase Fraction	0.0000	1.0000			
Temperature: (F)	77.00 *	77.00			
Pressure: (psia)	14.69 *	14.69			
Molar Flow (Ibmole/hr)	22.48	22.48			
Mass Flow (ib/hr)	4409 *	4409			
Std Ideal Liq Vol Flow (barrel/day)	364.7	364.7			
Molar Enthalpy (Btu/abroole)	-1.806e+005	-1.806e+005			
Molar Entropy (Btu/Ibmole-F)	78.65	78.65			
Heat Flow (Bluftr)	-4.059e+006	-4.059e+006			
Liq Vol Flow @Std Cond (barrel/day)	364.5 *	364.5			
		PROPERTIES			
	Overali	Liquid Phase	la de la A		
Molecular Weight	196.1	196.1			-
Molar Density (Ibmole/ft3)	0.2613	0.2613		•	
Mass Density (15/f13)	51.26	51.26			•••••
Act. Volume Flow (barrel/day)	367.7	367.7		•	
Mass Enthalpy (Btu/b)	-920.6	-920.6			
Mass Entropy (Btu/b-F)	0.4010	0.4010			
Heat Capacity (Btu/fbmole-F)	86.70	86,70	•		
Mass Heat Capacity (Btu/b-F)	0.4420	0.4420	· · · · ······························	· · <b>· · · · · · · · · · · · · · · · · </b>	
Lower Heating Value (Btu/bmole)		0.1120			— - · · · · · - · - · · · · · · · · · ·
Mass Lower Heating Value (Btu/b)					
Phase Fraction [Vol. Basis]		1.000			
Phase Fraction [Mass Basis]	2.1228-314	1.000			
Partial Pressure of CO2 (psia)	0.0600	1.000			
Cost Based on Flow (Cost/s)	0.0000				
	0.0000	0.0000			
Act. Gas Flow (ACFM) Avg. Liq. Density (Ibmole/ft3)	0.2635	0.2635			
Specific Heat (Btu/bmole-F)	86.70				
Std. Gas Flow (MMSCFD)	0.2043	86.70 0.2043			
Std. Ideal Liq. Mass Density (10/ft3)	51.68	51.68			
Act. Liq. Flow (USGPM)	10.72	10.72	<u> </u>		
Z Factor	9.761e-003	9.761e-003			
Watson K	11.74	9.7618-005			
User Property					
	0.0000				
	1.023		,		
Cp/(Cp - R) Cp/Cv		1.023			
Heat of Vap. (Btu/Ibmole)	1.111 1.995e+004	1.111	·		
Kinematic Viscosity (cSt)	3.136	2 126		·	
· · · · · · · · · · · · · · · · · · ·	· ··· ··	3.136		• ]	
Liq. Mass Density (Std. Cond) (Ib/R3)	51.71	51.71		·   · · · · · · · · · · · · · · · · ·	
Liq. Vol. Flow (Std. Cond) (barret/day)	364.5	364.5			
Liquid Fraction	1.000	1.000			
Molar Volume (ff3/lbmole)	3.826	3.826			
Mass Heat of Vap. (Btu/b)	101.8			1	[

aspen	LEGENDS Calgary, Alberta CANADA	i		ほうおち おうちょう うち	and the second second	
	CANADA		Unit Set	Field1		n an tha an tao an t
			Date/Time:	Sun May 15 00:44:16	2011	
		enter en service de la Reservice de la Constante		Ru	id Package:	Basis-1
	Material S	Stream: Pr	ropylene Car	bonate (c	operty Package.	Peng-Robinson
			PROPERTIES			
		Overall	Liquid Phase			
Phase Fraction [Molar Bas	is]	0.0000	1.0000			
Surface Tension	(dyne/cm)	27.10	27.10			
Thermal Conductivity	(Btu/ts-fi-F)	8.656e-002	8.656e-002			
Viscosity	(cP)	2.575	2.575			
	(Btu/lbmole-F)	84.71	84.71			
Mass Cv (Semi-Ideal)	(Btu/lo-F)	0.4319	0.4319			
	(Btu/Ibmole-F)	78.04	78.04			
Mass Cv	(Btu/b-F)	0.3979	0.3979			
	(Btu/lbmole-F)					
Mass Cv (Ent. Method)	(Btu/Ib-F)	· · · · · · · · · · · · · · · · · · ·				
and the second						
Cp/Cv (Ent. Method)	(		···· ··· • ··· • ··· • ··· · ··			
Reid VP at 37.8 C	(psia)					
True VP at 37.8 C	(psia)					
Liq. Vol. Flow - Sum(Std. Ci	on <b>d)</b> arrel/day)	364.5	364.5 COMPOSITION	erali Phase	Vapour Fr	action 0.000
Liq. Vol. Flow - Sum(Std. C			COMPOSITION	erall Phase	Vapour Fr	
Liq. Vol. Flow - Sum(Std. C COMPONENTS	MOLAR FLOW	364.5 MOLE FRACTIO	COMPOSITION	erall Phase	Vapour Fr LIQUID VOLUME FLOW (barrel/day)	action 0.0000 LIQUID VOLUME FRACTION
	MOLAR FLOW	MOLE FRACTIO	COMPOSITION Ov N. MASS FLOW (Buffrr)	La just the s		
COMPONENTS	MOLAR FLOW	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (Buffar) 0 * 4409.2000	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION
COMPONENTS Propylene Carbonate*	MOLAR FLOW (ibriole/hr) 22.4804	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (B)/rr) 0 * 4409.2000 0 * 0.0000	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 364.6647 *	LIQUID VOLUME FRACTION
COMPONENTS Propylene Carbonate* CO2	MOLAR FLOW (biniole/hr) 22.4804 0.0000	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (Buffer) 0 * 4409.2000 0 * 0.0000 0 4409.2000	MASS FRACTION 1.0000 * 0.0000 *	LIQUID VOLUME FLOW (barrel/day) 364.6647 * 0.0000 *	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000
COMPONENTS Propylene Carbonate* CO2	MOLAR FLOW (biniole/hr) 22.4804 0.0000	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (Bb/97) 0 * 4409.2000 0 * 0.0000 0 4409.2000 Lit	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 364.6647 * 0.0000 * 364.6647	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000 ction 1.000
COMPONENTS Propylene Carbonate* CO2 Total	MOLAR FLOW (ibriole/hr) 22.4804 0,0000 22.4804	MOLE FRACTIO • 1.000 • 0.000 1.000	COMPOSITION Ov N MASS FLOW (Bb/97) 0 * 4409.2000 0 * 0.0000 0 4409.2000 Lit	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 364.6647 * 0.0000 * 364.6647 Phase Fra	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000
COMPONENTS Propylene Carbonate* CO2 Total	MOLAR FLOW (ibriole/hr) 22.4804 0,0000 22.4804 MOLAR FLOW	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (Buffer) 0 * 4409.2000 0 * 0.0000 0 4409.2000 Lite N MASS FLOW (Buffer)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 364.6647 * 0.0000 * 364.6647 Phase Fra LIQUID VOLUME	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000 ction 1.000 LIQUID VOLUME FRACTION
COMPONENTS Propylene Carbonate* CO2 Total COMPONENTS	MOLAR FLOW (briole/hr) 22.4804 0.0000 22.4804 MOLAR FLOW (lbriole/hr)	MOLE FRACTIO	COMPOSITION Ov N MASS FLOW (b)/rr) 0 * 4409.2000 0 * 0.0000 0 4409.2000 Lite N MASS FLOW (b)/rr) 0 4409.2000	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day) 364.6647 * 0.0000 * 364.6647 Phase Fra LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUME FRACTION 1.0000 0.0000 1.0000 ction 1.000 LIQUID VOLUME

Hyprotech Ltd.

Aspen HYSYS Version 2006 (20.0.0.6728)

Page 4 of 6 \* Specified by user.

Licensed to: LEGENDS

LEGENDS Calgary, Albe	ta	Unit Set:	Field1		영상 관련적		
aspen canada		Date/Time:	Date/Time: Sun May 15 00:44:16 2011				
				Fluid Package:	Basis-1		
Material	Stream: M	lixup			David Dablary		
				Property Package:	Peng-Robinso		
		CONDITIONS					
	Overali	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 (Ibmole/hr)	22.80	0.0000	22.80				
Mass Flow (ib/hr)	4422	0.0000	4422	ļ			
Std Ideal Liq Vol Flow (barrel/day)	365.7	0.0000	365.7		_ <u>_</u>		
Molar Enthalpy (Btu/Ibmole)	-1,804e+005	-1.693e+005	-1.804e+005				
Molar Entropy (Btu/bmole-F)	78.09	41.19	78.09	<u> </u>			
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 (Ibmole/ft3)	0.2650	2.563e-003	0.2650	]			
Mass Density (1b/ft3)	51.40	0.1128	51.40				
Act. Volume Flow (barrel/day)	367.8	0.0000	367.8	· · · · · · · · · · · · · · · · · · ·			
Mass Enthalpy (Btu/b)	-930,2	-3846	-930.2	-			
Mass Entropy (Btu/b-F)	0.4026	0.9356	0.4026				
Heat Capacity (Btu/bmole-F)	85.73	9.201	85.73				
Mass Heat Capacity (Btu/b-F)	0.4420	0.2090	0.4420				
Lower Heating Value (Btu/bmole)	_				-		
Mass Lower Heating Value (Btu/b)	_		_		1		
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		1		
Act. Gas Flow (ACFM)			_				
Avg. Liq. Density (Ibmole/ft3)	0.2665	1.170	0.2665				
Specific Heat (Btu/Ibmole-F)	85.73	9.201	85.73				
Std. Gas Flow (MMSCFD)	0.2072	0.0000	0.2072				
Std. Ideal Liq. Mass Density (Ib/ft3)	51.68	51.52	51.68				
Act. Lig. Flow (USGPM)	10.73		10.73				
Z Factor		0.9945	9.620e-003				
Watson K	11.72	8.525	t1.72				
User Property				<b>.</b>			
Partial Pressure of H2S (psia)	0.0000						
Cp/(Cp - R)	1.024	1.275	1.024	<b>_</b>			
Cp/Cv	1.113	1.283	1.113	<u> .</u>			
Heat of Vap. (Btu/bmole)	6.091e+004	-			<b></b>		
Kinematic Viscosity (CSt)	3.068	8.096	3.068				
Liq. Mass Density (Std. Cond) (Ib/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		1		

1

ASLET       CAN         Mate       Mate         Phase Fraction [Molar Basis]       Mate         Surface Tension       (dynex)         Thermal Conductivity       (Btu/brncle         Mass Cv (Semi-Ideal)       (Btu/brncle         Mass Cv (Ent. Method)       (Btu/brncle         Cp/Cv (Ent. Method)       (Btu/brncle         Reid VP at 37.8 C       (pater)	Overall           0.00000000000000000000000000000000000	0000 26.72 -002 .526 33.75 4318 77.01 3370 15.34 4400 .005 	Unit Set: Date/Time: Up (Continue PROPERTIES Vapour Phase 0.0000 9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624 1.287 	Jed)	i2011 uid Package: operty Package:	Basis-1 Peng-Robinson
Matu Phase Fraction [Molar Basis] Surface Tension (dynew Thermal Conductivity (Btu/hr-f Viscosity ( Cv (Semi-Ideal) (Btu/bmole Mass Cv (Semi-Ideal) (Btu/b Cv (Btu/bmole Mass Cv (Btu/b Cv (Cv (Cv (Btu/b Cv (Cv (Cv (Cv (Cv (Cv (Cv (Cv (Cv (Cv (	Overall           0.00000000000000000000000000000000000	0000 26.72 -002 .526 33.75 4318 77.01 3370 15.34 4400 .005 	Up (Continue PROPERTIES Vapour Phase 0.0000  9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	Liquid Phase 1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01	uid Package:	
Phase Fraction [Molar Basis]         Surface Tension       (dyneA         Thermal Conductivity       (Btu/brief         Viscosity       (c         Cv (Semi-Ideal)       (Btu/brief         Mass Cv (Semi-Ideal)       (Btu/brief         Cv       (Btu/brinde         Mass Cv (Semi-Ideal)       (Btu/brief         Cv       (Btu/brinde         Mass Cv (Semi-Ideal)       (Btu/brinde         Mass Cv (Ent. Method)       (Btu/brinde         Cp/Cv (Ent. Method)       (Btu/brinde         Reid VP at 37.8 C       (ps	Overall         0.           m)         2           F)         8.551e           P)         2           F)         6           F)         0.           a)         4	0000 26.72 -002 .526 33.75 4318 77.01 3370 15.34 4400 .005 	PROPERTIES Vapour Phase 0.0000 9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	Liquid Phase 1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01		
Phase Fraction [Molar Basis]         Surface Tension       (dyneA         Thermal Conductivity       (Btu/brief         Viscosity       (c         Cv (Semi-Ideal)       (Btu/brief         Mass Cv (Semi-Ideal)       (Btu/brief         Cv       (Btu/brinde         Mass Cv (Semi-Ideal)       (Btu/brief         Cv       (Btu/brinde         Mass Cv (Semi-Ideal)       (Btu/brinde         Mass Cv (Ent. Method)       (Btu/brinde         Cp/Cv (Ent. Method)       (Btu/brinde         Reid VP at 37.8 C       (ps	Overall         0.           m)         2           F)         8.551e           P)         2           F)         6           F)         0.           a)         4	0000 26.72 -002 .526 33.75 4318 77.01 3370 15.34 4400 .005 	PROPERTIES Vapour Phase 0.0000 9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	Pr Liquid Phase 1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01	uperly Package:	Peng-Robinson
Surface Tension         (dyne/n           Thermal Conductivity         (Bauhn-f)           Viscosity         (C           Cv (Semi-Ideal)         (Bauhn-f)           Mass Cv (Semi-Ideal)         (Bauhnole           Mass Cv (Semi-Ideal)         (Bauhnole           Cv         (Bauhnole           Mass Cv (Semi-Ideal)         (Bauhnole           Cv         (Bauhnole           Mass Cv (Semi-Ideal)         (Bauhnole           Cv         (Bauhnole           Mass Cv (Ent. Method)         (Bauhnole           Cp/Cv (Ent. Method)         (Bauhnole           Reid VP at 37.8 C         (pathnole)	O.           m)         2           F)         8.551e           P)         2           F)         6           F)         0.           a)         4	00000 66.72 002 2.526 33.75 4318 77.01 3970 15.34 4400 0.005 1.239 7.32	Vapour Phase 0.0000  9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01		
Surface Tension         (dyne/n           Thermal Conductivity         (Btu/hr-f)           Viscosity         (i)           Cv (Semi-Ideal)         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ib           Cv         (Btu/Ib           Cv (Ent. Method)         (Btu/Ib           Cp/Cv (Ent. Method)         (Btu/Ib           Chourt (Data 37.8 C)         (pathode)	O.           m)         2           F)         8.551e           P)         2           F)         6           F)         0.           a)         4	0000 26.72 2.526 33.75 4318 77.01 33970 25.34 4400 005 	0.0000 — 9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01		
Surface Tension         (dyne/n           Thermal Conductivity         (Btu/hr-f)           Viscosity         (i)           Cv (Semi-Ideal)         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ibmole           Mass Cv (Semi-Ideal)         (Btu/Ib           Cv         (Btu/Ib           Cv         (Btu/Ib           Cv (Ent. Method)         (Btu/Ib           Cp/Cv (Ent. Method)         (Btu/Ib           Chourt (Data 37.8 C)         (pathode)	m) 2 F) 8.551c P) 2 F) 6 F) 0. F)	0000 26.72 2.526 33.75 4318 77.01 33970 25.34 4400 005 	0.0000 — 9.818e-003 1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	1.0000 26.72 8.551e-002 2.526 83.75 0.4318 77.01		
Thermal Conductivity     (Btulhr-f       Viscosity     (C       Viscosity     (Btulbrook       Mass Cv (Semi-Ideal)     (Btulbrook       Mass Cv (Ent. Method)     (Btulbrook       Cp/Cv (Ent. Method)     (Btulbrook       Reid VP at 37.8 C     (ps       True VP at 37.8 C     (ps	F)         8.551c           P)         2           F)         2           F)         0.           F)         0.           F)         0.           F)         0.           F)         0.           F)         0.           I         1           a)         1	•002           2.526           33.75           4318           77.01           3970           15.34           4400           .005           1.239           7.32	1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	8.551e-002 2.526 83.75 0.4318 77.01		
Viscosity ( Cv (Semi-Ideal) (Btu/Ibmole Mass Cv (Semi-Ideal) (Btu/Ib Cv (Btu/Ibmole Mass Cv (Btu/Ib Cv (Ent. Method) (Btu/Ib Cp/Cv (Ent. Method) (Btu/Ib Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps True VP at 37.8 C (ps	P)         2           F)         6           F)         0.           a)         4	2.526 33.75 4318 77.01 3970 5.34 4400 .005 1.239 7.32	1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	8.551e-002 2.526 83.75 0.4318 77.01		
Viscosity ( Cv (Semi-Ideal) (Btu/Ibmole Mass Cv (Semi-Ideal) (Btu/Ib Cv (Btu/Ibmole Mass Cv (Btu/Ib Cv (Ent. Method) (Btu/Ib Cp/Cv (Ent. Method) (Btu/Ib Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps	P)         2           F)         6           F)         0.           a)         4	2.526 33.75 4318 77.01 3970 5.34 4400 .005 1.239 7.32	1.463e-002 7.215 0.1639 7.169 0.1629 7.149 0.1624	2.526 83.75 0.4318 77.01		
Cv (Semi-Ideal)     (Btu/Itmole       Mass Cv (Semi-Ideal)     (Btu/Itmole       Cv     (Btu/Itmole       Mass Cv     (Btu/Itmole       Cv (Ent. Method)     (Btu/Itmole       Mass Cv (Ent. Method)     (Btu/Itmole       Cp/Cv (Ent. Method)     (Btu/Itmole       Reid VP at 37.8 C     (ps       True VP at 37.8 C     (ps	F)         8           F)         0.           F)         0.           F)         0.           F)         0.           F)         0.           F)         0.           A)         4	33.75       4318       77.01       3970       15.34       4400       0.005       1.239       7.32	7.215 0.1639 7.169 0.1629 7.149 0.1624	83.75 0.4318 77.01		
Mass Cv (Semi-Ideal)     (Btulith       Cv     (Btulith       Mass Cv     (Btulith       Mass Cv     (Btulith       Cv (Ent. Method)     (Btulith       Vass Cv (Ent. Method)     (Btulith       Cp/Cv (Ent. Method)     (Btulith)	F)         0.           F)         7           F)         0.           F)         8           F)         0.           a)         4	4318 77.01 3970 15.34 4400 .005 1.239 7.32	0.1639 7.169 0.1629 7.149 0.1624	0.4318 77.01		
Cv (Btulbmole Mass Cv (Btulb Cv (Ent. Method) (Btulb Cv (Ent. Method) (Btulb Cp/Cv (Ent. Method) Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps	F) 7 F) 0. F) 8 F) 0. 1 a) 4 a) 1	77.01 3970 15.34 4400 .005 	7.169 0.1629 7.149 0.1624	77.01	· · · · · · · · · · · · · · · · · · ·	
Mass Cv     (Bitu/b       Cv (Ent. Method)     (Bitu/b       Vass Cv (Ent. Method)     (Bitu/b       Cp/Cv (Ent. Method)     (Bitu/b       Cp/Cv (Ent. Method)     (Bitu/b       Reid VP at 37.8 C     (ps       Irue VP at 37.8 C     (ps	F)         O.           F)         8           F)         0.           f)         0.           a)         1	3970       15.34       4400       .005       1.239       7.32	0,1629 7.149 0,1624			
Cv (Ent. Method) (Btu/brooke Mass Cv (Ent. Method) (Btu/b Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps Irue VP at 37.8 C (ps	F) 8 F) 0, 1 a) 4 a) 1	15.34 4400 1.005 1.239 7.32	7.149 0.1624			
Mass Cv (Ent. Method) (Btu/b Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps Irue VP at 37.8 C (ps	F) 0. 1 a) 4 a) 1	4400 1.005 1.239 7.32	0,1624			
Cp/Cv (Ent. Method) Reid VP at 37.8 C (ps True VP at 37.8 C (ps	a) 4	.005 1.239 7.32		.		
Reid VP at 37.8 C (ps True VP at 37.8 C (ps	a) 4 a) 1	7.32	1.287	ែ		
True VP at 37.8 C (ps	a) 1	7.32		-		
		- ·		4.239		
.iq. Vol. Flow ~ Sum(Std. Con <b>t</b> harrel/d	y) 3		765.0	17.32		
		64.5	0.0000	364.5		
요즘 이 가격에 있는 것이 같이 나는 것같이요.	iole/hr)	FRACTION	MÁSS FLOW (1b/hr)	MASS FRACTION	LIQUID VOLUME FLOW (barrel/day)	LIQUID VOLUM FRACTION
Propylene Carbonate*	22.4719	0.9857	4407.5286	0.9968	364.5265	0.996
02	0.3250	0.0143	14.3017	0.0032	1.1865	0.003
Fotal	22.7968	1.0000	4421.8303	1.0000	365.7130	1.000
			Vaş	our Phase	Phase Fra	ction 0.000
COMPONENTS MOL	R FLOW MOLE	FRACTION	MASS FLOW	MASS FRACTION	LIQUID VOLUME	LIQUID VOLUM
(lbr	ole/hr)		(fb/hr)		FLOW (barrel/day)	FRACTION
Propylene Carbonate*	0.0000	0.0001	0.0000	0.0003	0.0000	0.000
202	0.0000	0.99999	0.0000	0.9997	0.0000	0.999
otal	0.0000	1.0000	0.0000	1.0000	0.0000	1.000
			Líq	uid Phase	Phase Fra	ction 1.00
COMPONENTS MOLA	R FLOW MOLE	RACTION	MASS FLOW	MASS FRACTION		LIQUED VOLUM
	ole/hr)		(lb/hr)		FLOW (barrel/day)	FRACTION
(804)			4407.5286	0.9968	364.5265	·····
Topylene Carbonate*	22.4719	0.9857			, UM,UZOU I	0 996
······································		0.9857	14.3017	0.0032	1.1865	0,996

Case Name: C:\Program Files\AspenTech\Aspen HYSYS 2006\Cases\tank CO2 Pi LEGENDS Calgary, Alberta Unit Set Field1 aspen CANADA Date/Time: Sun May 15 00:44:16 2011 Fluid Package: Basis-1 Material Stream: Mixup (continued) Property Package: Peng-Robinson PROPERTIES Overall Liquid Phase Vapour Phase 0.0000 0.0000 Phase Fraction [Molar Basis] 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 2,526 (cP) 1.463e-002 2,526 Cv (Semi-Ideal) (Btu/lbmote-F) 83 75 7 215 83.75 Mass Cv (Semi-Ideal) 0.4318 (Btu/lb-F) 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/ibmole-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 2 3 9 True VP at 37.8 C (psia) 17.32 765.0 17.32 Liq. Vol. Flow - Sum(Std. Co(manual/day) 364.5 0.0000 364.5 COMPOSITION **Overall Phase** Vapour Fraction 0.0000 COMPONENTS MOLAR FLOW MOLE FRACTION MASS FLOW MASS FRACTION LIQUID VOLUME LIQUID VOLUME (lbmole/hr) FLOW (barrel/day) (ib/hr) 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 MOLE FRACTION MASS FLOW MASS FRACTION LIQUID VOLUME LIQUID VOLUME (ibmole/hr) (lb/hr) FLOW (barrel/day) 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 MOLE FRACTION MASS FLOW MASS FRACTION LIQUID VOLUME LIQUID VOLUME (ibmole/hr) FLOW (barrel/day) (ib/hr) 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 1.0000 22.7968 4421.8303 1.0000 365,7130 1.0000 Hyprotech Ltd. Page 6 of 6

Aspen HYSYS Version 2006 (20.0.0.6728)

Licensed to: LEGENDS