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Effect of Concentration, Circulation Rate, Stages, Pressure and Temperature of Pure Glycols on Natural Gas Dehydration Performance and Sales Gas Characteristics

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Abstract

This study investigated natural gas dehydration performance of selected glycols and sales gas characteristics of dehydrated gases with Aspen Hysys. In this study, all the relevant simulations with the selected glycols were conducted with the same scale and parameters, so that their dehydration performance and sales gas characteristics could be compared effectively. In case of circulation rate, lowest water composition was achieved by 99% ethylene-glycol (EG), highest methane composition was obtained by 90% triethylene-glycol (TEG), the highest amount of sales gas obtained by 90% tetraethylene-glycol (TREG), highest LHV (lower heating value) was achieved by 99% diethylene-glycol (DEG), highest HHV (higher heating value) was achieved by 99% DEG, highest total LHV was obtained by 95% TEG and highest total HHV was obtained by 95%-TEG. In case of both contractor pressure and stage number, lowest water composition was achieved by 95% TEG, highest methane composition was obtained by 95% TEG, the highest amount of sales gas obtained by 90% TREG, highest LHV was achieved by 95% TEG, highest HHV was achieved by 99% DEG, highest total LHV was obtained from 95% EG and highest total HHV was obtained by 90% TREG. The pressure and temperature of glycol did not show any effect on any parameter of sales gas. With glycol circulation rate, a similar changing trend of H_2O and CH_4 composition and amount of sales gas was found for all TEG and TREG components and higher concentration DEG and EG components, although different patterns found for lower concentration DEG and EG. Change of H_2O and CH_4 composition and amount of sales gas with stage number DEG and EG showed more sensitivity, and for heating values, TREG showed higher sensitivity. EG showed more sensitivity to the parameters with the change of contractor pressure. Although TEG was found as an overall better dehydrator, but its high circulation rate made EG an alternate.

Keywords: *Natural gas; DEG; EG; TEG; TREG; Dehydration.*

1. Introduction

Natural gas (NG) is considered the cleanest and the most hydrogen-rich fuel among all fossil energy sources [1]. NG requires to go through the treatment process to meet sales gas specifications and to be suitable for specific transport systems. Dehydration is one of these essential treatment steps where water vapor composition in NG is reduced to ensure trouble-free operation in the natural gas transmission systems. Presence of water vapor in NG may cause hydrate formation in transporting pipelines, which may cause pipeline plugging and/or corrosion, reduce the natural gas combustion efficiency and volumetric capacity of the system, induce blockage of valve fittings, compression system, process equipment, and instrumentation, and cause potential damage to equipment due to liquid carryover, especially when the natural gas composition is rich in CO_2 and H_2S [2]. Most of the natural gas transmission companies impose regulations and restrictions on the quality of natural gas acceptable for transport, such as water and hydrocarbon dew point limits or limit of CO_2 and H_2S composition to reduce operational problems [3-4]. This limitation depends on environmental conditions, varies from country to country, i.e., maximum permissible pipeline specification water content

is 7 lb/MMscf (million of standard cubic feet) in US pipeline systems, 4 lb/MMscf in Canada and 1-2 lb/MMscf in the Alaskan environment [5].

NG dehydration can be achieved by several ways, i.e., refrigeration [2], using liquid desiccants such as glycol absorption [6], polymer membranes [7], composite membranes [8], molecular sieves [9] and isenthalpic gas cooling with controlled hydrate formation [10]. Several liquids were found capable of absorbing water from the gas stream; few of them are suitable for commercial use. Highly hygroscopic, the low solubility of hydrocarbons in the solvent, easy regeneration to higher concentration for reuse, low vapor pressure, thermal stability, noncorrosive nature, chemical inertness to any of the NG constituents, etc. are the criteria of commercial liquid desiccants [11]. Glycol absorption method is used in most of the existing NG treatment plants and facilities because of its higher boiling point than water and low vapor pressure [12–14]. EG, DEG, TEG, and TREG are the most used glycols for dehydration applications. A simplified process flow chart of the glycol dehydration process is given in Figure 1.

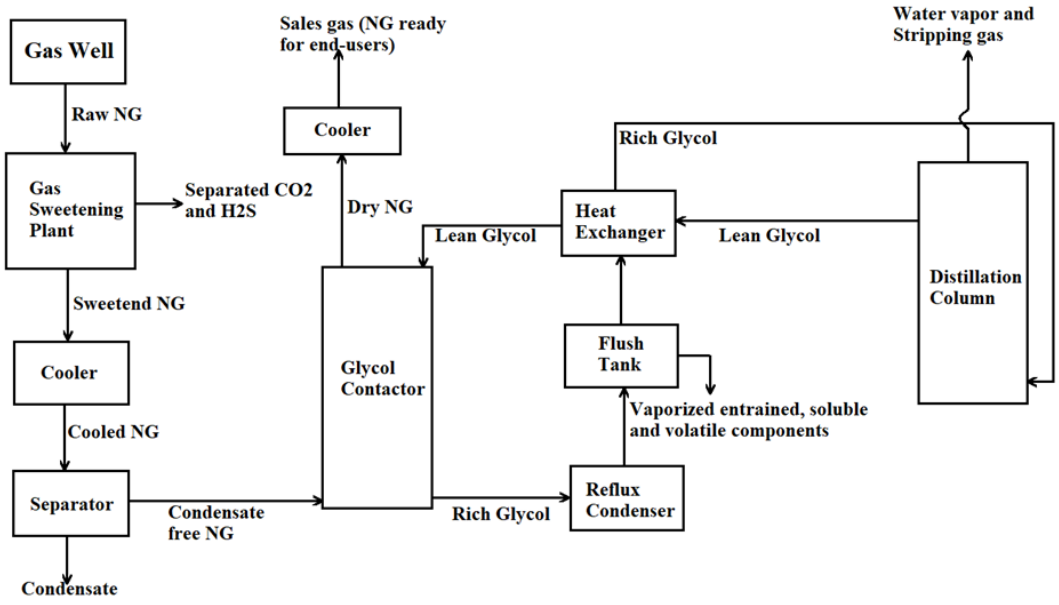

Figure 1. Process flow chart of glycol dehydration process of NG

The main objective of this study was to investigate the effects of concentration, circulation rate, number of stages, pressure and temperature of pure DEG, EG, TEG, and TREG components on natural gas dehydration performance by conducting simulation with Aspen Hysys software. Water removal efficiency from NG was given the most priority, as well as methane and CO2 composition in sales gas, sales gas amount, lower heating value (LHV, kJ/kmole), higher heating value (HHV, kJ/kmole), total LHV (kJ) and total HHV (kJ) of sales gas from every glycol component, was measured and compared to find the degree of performance and sensitivity of the glycol components. Although this study is in the dehydration unit, the amount of sales gas and total heating value were also included. The amount of sales gas is an essential factor for transportation pipeline design, and total heating value is vital at the end-user level for commercial purposes. In all simulations, pure glycol components (only glycol and water, no other component) were used as the purpose was to investigate the performance of the components at their pure phase.

2. Methodology

At first, a simulation was conducted on gas sweetening. Then, the sweetened gas was delivered to the dehydration unit. 55 MMscfd (MMscf/day) (2739 kmole/hr) raw NG went through the gas sweetening process, and 2550 kmole/hr sweetened gas was discharged at 39.55°C temperature, and 2413 kPa pressure which was forwarded to cooler afterward where

it was cooled to 25°C and pressure dropped to 2300 kPa. After that, the cooled sweetened gas was sent to the separator where condensate was separated from gas, which was mostly water (99.93%). Then the condensate-free gas was introduced in the absorber/glycol contractor from the bottom, and glycol was introduced in the glycol contractor from the top so that they met in counter-direction. Glycol absorbed H_2O, CH_4, C_2H_6, C_3H_8, etc. and glycol enriched with these components discharged from the bottom of contractor and sales gas with less water composition released from the top of the contractor. The whole process was simulated with Aspen Hysys software. "Glycol Package" fluid package for glycol stream and "Acid Gas – Chemical Solvents" fluid package for other streams were applied.

Four glycols, i.e., DEG, EG, TEG, and TREG at 90% (wt), 95% (wt), and 99% (wt) concentration, were introduced in the contractor from very low to very high circulation rate. When the circulation rate was changed for any glycol component at a certain concentration, all other parameters were kept constant, i.e., stage number was 15, contractor pressure was 60 bar, glycol temperature and the pressure were 30°C and 60 bar, respectively.

The concentration and circulation rate of glycol components used to assess the effects of contractor pressure, stage number, glycol temperature and glycol pressure were for DEG (90% + 50 kg/hr), (95% + 30 kg/hr) and (99% + 20 kg/hr), for EG (90% + 30 kg/hr), (95% + 30 kg/hr) and (99% + 20 kg/hr), for TEG (90% + 200 kg/hr), (95% + 150 kg/hr) and (99% + 100 kg/hr), and for TREG all three concentrations at 30 kg/hr. Contractor pressure was changed from 40 to 80 bar; stage number was changed from 3 to 25, glycol temperature was changed from 20°C to 40°C and glycol pressure was changed from 40 to 80 bar to evaluate the effect of contractor pressure, stage number, glycol temperature, and glycol pressure, respectively on dehydrated gas released from glycol contractor. When one parameter was changed, all other parameters were kept constant. For example, to evaluate the effect of stage number simulations were conducted with stage number from 3 to 25 with 90% DEG at a fixed circulation rate of 50kg/hr, fixed contractor pressure of 60 bar, fixed glycol temperature of 30°C and fixed pressure of 60 bar.

The composition of raw NG collected from Kailashtilla Gas Field, Bangladesh, was used in this study. This raw NG composition, along with gas composition after the sweetening process reported in Table 1. The methane composition in raw NG of Bangladesh is usually high. After dehydration, there was only 0.35% water in NG. To examine the effect of several parameters used in this study on water, methane and CO_2 composition in sales gas, relevant data of compositions were tabulated up to 5th decimal (provided in the supplementary file), and for sales gas amount the amounts were tabulated up to 3rd decimal (provided in the supplementary file).

Table 1. NG composition before and after gas sweetening process

Name of the component	Composition of raw NG (Before NG sweetening)	Composition after NG sweetening (Before NG dehydration)
Methane	86.34%	92.72%
Ethane	3.92%	4.21%
Propane	0.88%	0.95%
i-Butane	0.07%	0.08%
n-Butane	0.05%	0.05%
n-Pentane	0.05%	0.05%
n-Hexane	0.03%	0.03%
H_2O	4.67%	0.35%
N_2	0.18%	0.19%
CO_2	2.04%	1.37%
H_2S	1.77%	0.00%

3. Data and results

Effect of different circulation rates of 90%, 95%, and 99% DEG, EG, TEG, and TREG on amount of sales gas, the composition of CH_4 and H_2O and heating values, i.e., LHV, HHV, total LHV, and total HHV is reported in Table 2 to Table 13 provided in the supplementary file. The effect of contactor pressure and the stage number of the contactor on all these parameters is reported in Table 14 and Table 15, respectively.

3.1. Effect of glycol circulation rate

3.1.1. H_2O composition

Overall lowest water composition in sales gas was found when 99% EG was circulated at 1000 kg/hr, followed by 99% TEG (100000 kg/hr), 99% TREG (250000 kg/hr), 99% DEG (1500 kg/hr), 95% EG (450 kg/hr), 95% TREG (60000 kg/hr), 95% DEG (600 kg/hr), 95% TEG (150000 kg/hr), 90% TEG (100000 kg/hr), 90% EG (350 kg/hr), 90% TREG (150000 kg/hr) and 90% DEG (450 kg/hr).

The change of water composition with glycol flow rate mainly followed two trends described in Figure 2. In Figure 2(a), at first, water composition dropped rapidly (AB) with glycol flow rate, and reached the lowest percentage (B), then started increasing up to C. After that, water composition kept increasing slowly (CD). In Figure 2(b), at first, water composition dropped rapidly (up to B), then again dropped slowly (BC). 90% and 95% DEG and EG followed the pattern described in Figure 2(a), 95% TEG did not follow any of the two trends, and the rest of the glycols followed the pattern of Figure 2(b).

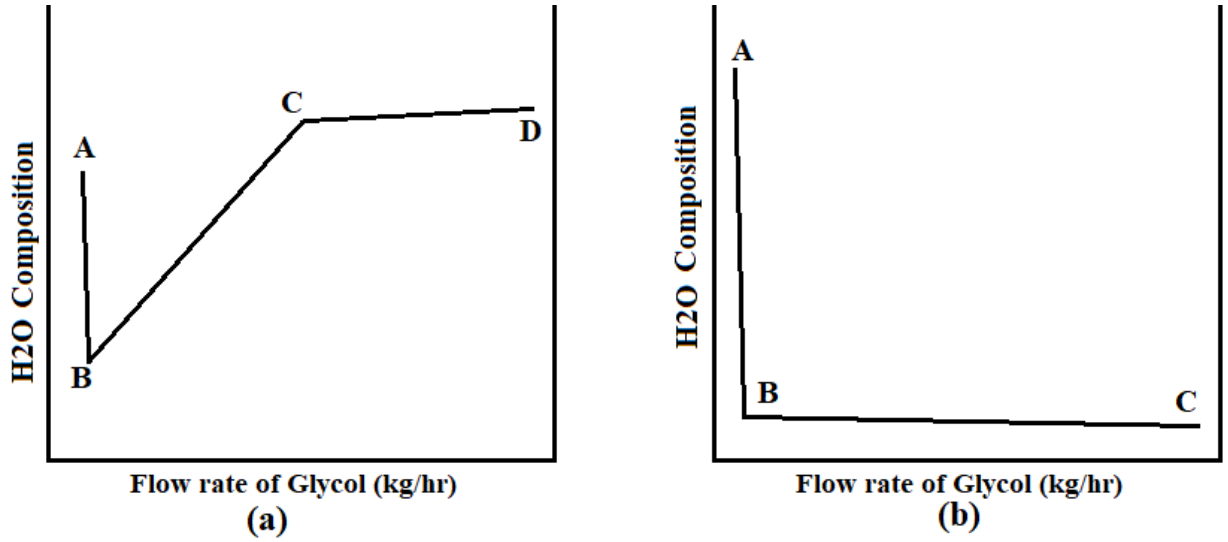

Figure 2. Change of H_2O composition in sales gas with the increase of glycol circulation rate

3.1.2. CH_4 composition and sales gas

Overall highest methane percentage in sales gas was found when 90% TEG was circulated followed by 99% TREG, 99% TEG, 99% EG, 99% DEG, 95% TREG, 95% TEG, 90% TREG, 95% EG, 90% EG, 95% DEG and 90% DEG. Individually highest CH_4 composition for every glycol was found at the circulation rate of 15000 kg/hr or more, except for 90% DEG where the circulation rate was 450 kg/hr.

Change of CH_4 composition followed mainly two trends. One trend is reported in Figure 3(a), where at first CH_4 composition increased fast with glycol flow rate (AB), after B increased slowly up to C, then decreased up to D. All TEG and TREG components, 99% DEG and 99% EG followed this trend. CH_4 composition always increased in the trend reported in Figure 3(b); however, the rate of increase dropped at B and again dropped at C. Among the rest of the four components, except 90% DEG other three components followed figure 3(b). Change of

sales gas with glycol flow rate was the exact opposite of trend followed by the change of CH_4 composition like vertical flip, except 90% DEG. Two examples are given in Figure 4.

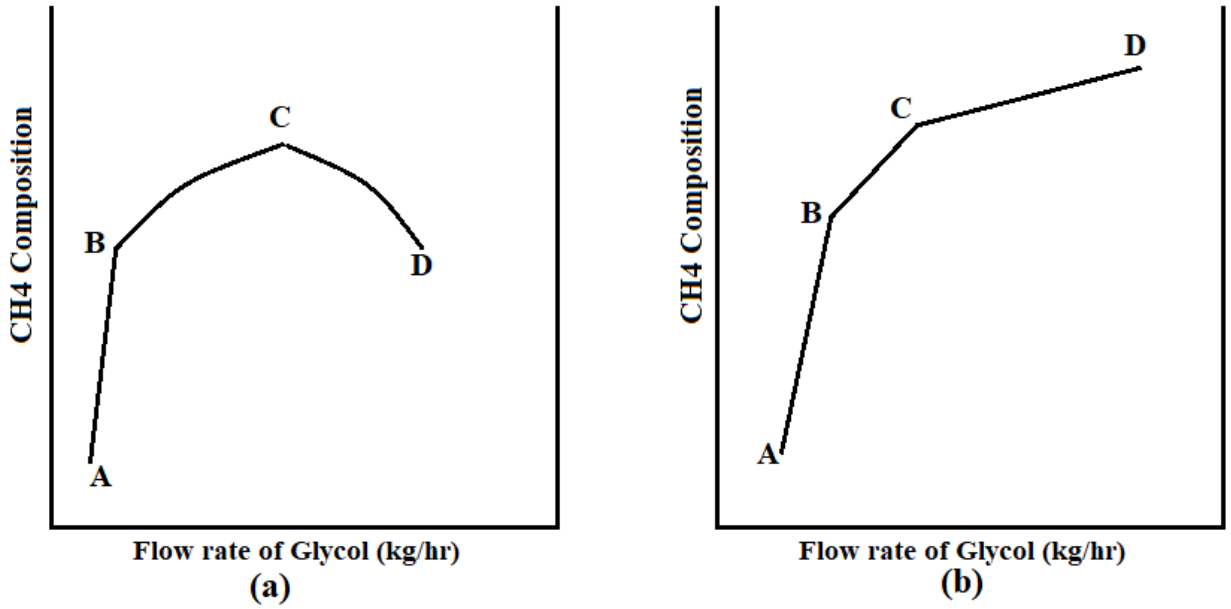

Figure 3. Change of CH_4 composition in sales gas with increasing glycol circulation rate. Amount of sales gas also followed opposite trends

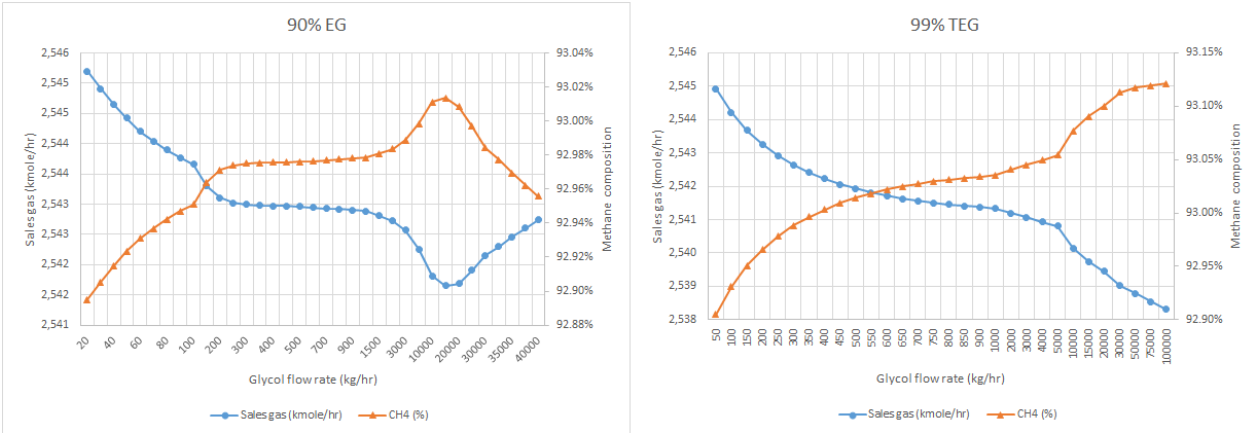

Figure 4. Change of CH_4 composition and sales gas with glycol circulation rate; 3(a) 90% EG, 3(b) 99% TEG

3.1.3. LHV, HHV, total LHV, total HHV

Overall highest LHV and HHV in sales gas was found when 99% DEG was circulated at 800 kg/hr, followed by 99% EG (400 kg/hr), 99% TEG (1000 kg/hr), 99% TREG (1400 kg/hr), 95% EG (350 kg/hr), 95% DEG (500 kg/hr), 90% EG (250 kg/hr), 95% TEG (600), 95% TREG (800 kg/hr), 90% DEG (350 kg/hr), 90% TEG (500 kg/hr) and 90% TREG (2000 kg/hr), respectively. Highest total LHV and total HHV for every glycol component were found at their respective lowest circulation rate or below 100 kg/hr circulation rate, except 95% TEG (overall highest total LHV and HHV at 600 kg/hr) and 90% TREG (overall 3rd highest total LHV and HHV at 200 kg/hr). Unlike LHV and HHV, the maximum total LHV and total HHV for some components were found at different circulation rates.

Changing trends of HHV, LHV, total HHV, and total LHV for DEG, EG, TEG, and TREG components mostly followed three patterns. Schematic diagrams of the patterns are given as

reported in Figure 5. In figure 5(a), the heating values increased fast with a circulation rate of glycol and reached to B, the highest point and then drops rapidly up to C. The heating values continued dropping but at a slower rate beyond C. Up to point C Figure 5(b) is similar of Figure 5(a), but after that heating value increased slowly (CD). The heating values always dropped in the trend described in Figure 5(c); it is similar to figure 5(a) except that the AB section does not exist here. In case of change of the value of LHV and HHV with glycol flowrate, all TEG components, 99% EG and 95%, and 99% TREG showed a similar trend of Figure 5(b), other components followed the trend of figure 5(a).

In case of change of the value of total HHV and total LHV, 95% TEG followed the pattern of 5(a), except EG all other glycols with all concentrations followed the pattern of 5(c). Total LHV and total HHV of EG followed Figure 5(a) and Figure 5(c), respectively. EG was the only glycol where total LHV and total HHV followed different trends. Unlike the highest HHV and LHV, sequential orders of the highest total HHV and total LHV for glycol components were different. Figure 5(a) was followed by HHV, LHV, total HHV and total LHV for some glycol components, figure 5(b) was followed by only HHV, and LHV for some glycol components and Figure 5(c) was followed by only total HHV and total LHV for some glycol components. Considering only 90% concentration, TEG displayed maximum sensitivity, followed by EG, DEG, and TREG. Considering 95% and 99% concentration, EG exhibited maximum sensitivity, followed by DEG, TEG, and TREG. After C, except 90% TEG, for all other glycols, slopes of CD were small.

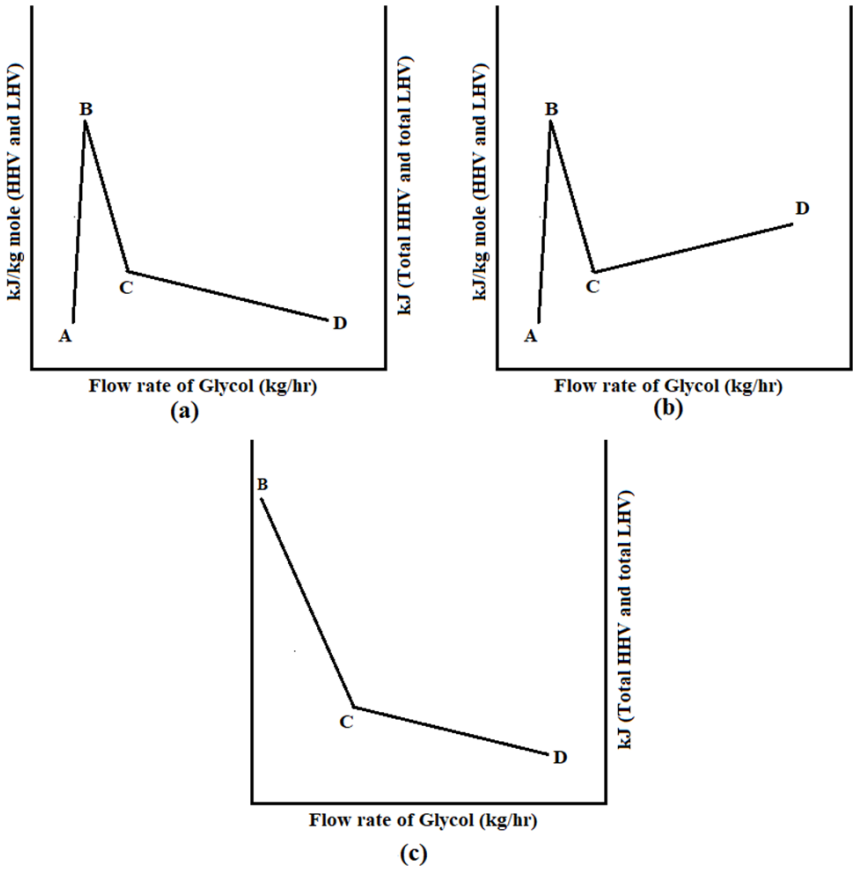

Figure 5. Change of LHV, HHV, total LHV, and total HHV with a glycol circulation rate

3.2. Stage numbers

The overall highest amount of sales gas, total HHV, and the lowest percentage of CO_2 were found at 3rd stage for every component. Overall lowest H_2O and highest CH_4 composition, highest LHV and HHV was obtained at 25th stage when 95% TEG was circulated followed by

99% TEG at 25th stage, 90% TEG at 25th stage, 95% EG at 22nd stage, 90% EG at 18th stage, 90% DEG at 20th stage, 99% EG at 22nd stage, 95% DEG at 18th stage, 99% DEG at 22nd stage, 99% TREG at 22nd stage, 95% TREG at 22nd stage and 90% TREG at 25th stage.

Overall highest sales gas amount and lowest CO_2 composition was obtained when 90% TREG was circulated followed by 95% TREG, 99% TREG, 99% DEG, 95% DEG, 99% EG, 90% DEG, 90% EG, 95% EG, 90% TEG, 99% TEG and 95% TEG. Highest total LHV was obtained by 95% EG at 22nd stage followed by 90% EG (20th stage), 99% EG (22nd stage), 99% DEG (15th stage), 95% DEG (22nd stage), 90% DEG (20th stage), 90% TREG, (3rd stage), 95% TREG (3rd stage), 99% TREG (3rd stage), 99% TEG (25th stage), 95% TEG (25th stage) and 90% TEG (25th stage). Highest total HHV was obtained by 90% TREG followed by 95% TREG, 99% TREG, 99% EG, 90% EG, 95% EG, 99% DEG, 95% DEG, 90% DEG, 90% TEG, 99% TEG and 95% TEG.

The rate of change of sales gas and composition of CH_4 and H_2O increased with concentration for DEG and EG components but remained almost the same for TEG and TREG components. Every glycol component exhibited a one-directional change up to the 15th stage, and then some components showed fluctuation. Both LHV and HHV of all glycol components showed an increasing trend with stage number with small fluctuation from 18th to 25th stages for some glycol components. The increasing rate of all components decreased with the number of stages. TREG components showed the maximum rate of increase followed by TEG, EG, and DEG. 90% DEG and all TEG components showed a continuously increasing trend of total LHV. Other DEG components and all EG components showed an increasing trend of total LHV up to 18th then showed fluctuating behavior; however, TREG showed a decreasing trend. The rate of change of total LHV decreased with stage number, and the maximum changing rate was exhibited by TREG, followed by TEG, EG, and DEG. Total HHV always decreased with stage number for every component.

3.3. Contractor pressure

Overall highest sales gas, total LHV and total HHV and lowest CO_2 percentage of every glycol component were achieved at 80 bar (maximum pressure) and lowest H_2O percentage and highest CH_4 percentage, LHV and HHV were found at 40 bar (minimum pressure).

Overall lowest H_2O and highest CH_4 percentage, highest LHV and HHV were achieved by 95% TEG followed by 99% TEG, 90% TEG, 95% EG, 90% EG, 90% DEG, 99% EG, 95% DEG, 99% DEG, 99%TREG, 95% TREG and 90% TREG. Overall highest sales gas was obtained by 90% TREG followed by 95% TREG, 99% TREG, 99% DEG, 90% EG, 90% DEG, 95% DEG, 99% EG, 90% TEG, 95% EG, 95% TEG and 99% TEG. Overall lowest CO_2 composition was obtained by 90% TREG followed by 95% TREG, 99% TREG, 90% DEG, 90% EG, 99% DEG, 99% EG, 90% TEG, 95% DEG, 95% EG, 95% TEG and 99% TEG.

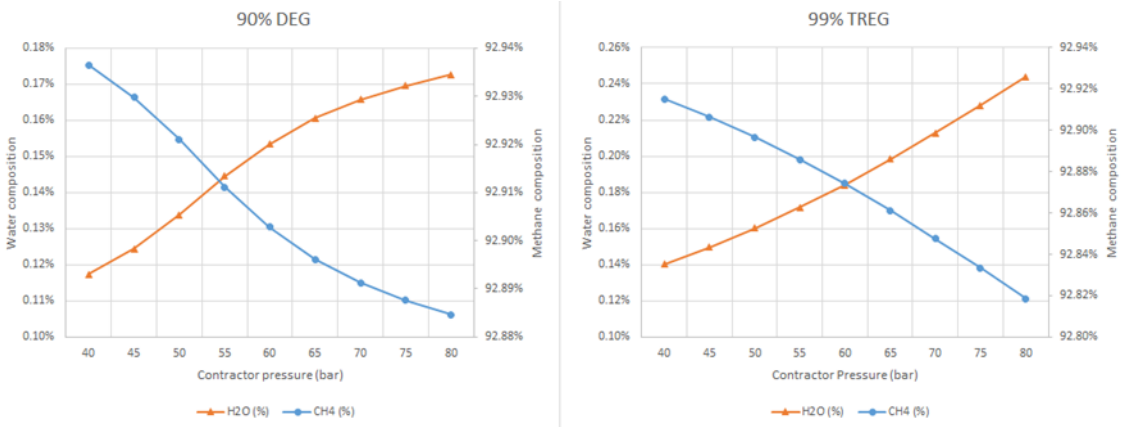

Figure 6. Change of H_2O and CH_4 composition with contractor pressure; (a) 90% DEG, (b) 99% TREG

Overall highest total LHV was found by 95% EG followed by 99% EG, 90% EG, 99% DEG, 95% DEG, 90% DEG, 99% TEG, 90% TREG, 95% TREG, 99% TREG, 95% TEG and 90% TEG. Overall highest total HHV was found by 90% TREG followed by 99% EG, 90% EG, 95% EG, 95% TREG, 99% TREG, 99% DEG, 95% DEG, 90% DEG, 90% TEG, 99% TEG and 95% TEG.

The amount of sales gas, H_2O percentage, total LHV, and total HHV of glycol components increased with contractor pressure; however, contractor pressure showed the opposite effect on CH_4 percentage, LHV, and HHV. H_2O percentage and sales gas followed a similar increasing pattern and almost opposite of CH_4 composition, LHV, and HHV. Two examples of H_2O and CH_4 composition change with contractor pressure are given in Figure 6. All glycol components exhibited almost linear changing trends for TEG and TREG, whereas non-linear trends were found for DEG and EG. EG showed maximum sensitivity on every parameter towards contractor pressure, followed by DEG, TREG, and TEG.

3.4. C_2H_6 and C_3H_8 in sales gas

Increasing and decreasing trend of the composition of C_2H_6 and C_3H_8 in sales gas found by all DEG, TEG, TREG components and 90% EG followed CH_4 precisely such as the maximum, and minimum composition of C_2H_6 and C_3H_8 was found at the glycol circulation rate, stage number or contractor pressure at same of CH_4. Composition of C_2H_6 and C_3H_8 of 95% and 99% EG followed the same trend of CH_4 composition; however, glycol circulation rate, stage number, or contractor pressure were different from CH_4. Additionally, when the concentration of EG increased from 95% to 99%, the circulation rate at where the maximum composition of C_2H_6 and C_3H_8 was found increased.

3.5. CO_2 in sales gas

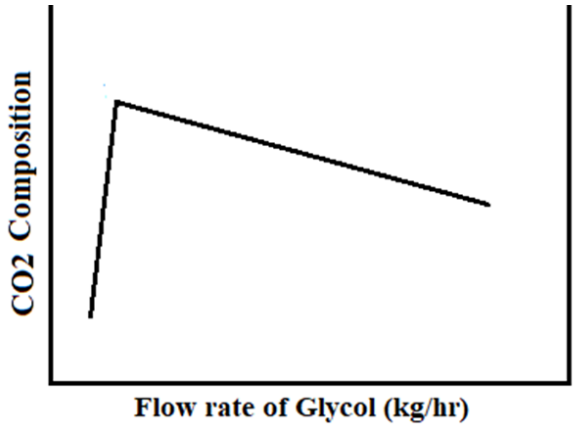

Figure 7. CO_2 composition change in sales gas with a glycol circulation rate

In sales gas, reduced CO_2 percentage is expected. At first, the CO_2 percentage in sales gas increased up to the highest composition with glycol circulation rate, and then the CO_2 percentage start decreasing. The schematic diagram of the CO_2 percentage changing trend is given in Figure 7 was followed by every glycol component. CO_2 composition decreased with an increase of stage number and contractor pressure for every glycol component. Among all DEG components, CO_2 was reduced most from NG by 99% concentration followed by 95% and 90% concentration, descendingly this order of EG and TEG was 99%, 90%, and 95% and of TREG was 90%, 95%, and 99%.

3.6. CH_4 loss and CO_2 absorption by glycols

This section discussed CH_4 and CO_2 in rich glycol. The increase of the circulation rate of every glycol component caused an increase in the amount of CH_4 and CO_2 in rich glycol, and the highest increase was found when 90% glycol components were circulated, followed by 95% and 99%. Among 90% and 99% glycols, the maximum increase of CH_4 and CO_2 in rich glycol was obtained by EG, followed by DEG, TEG, and TREG, and this order was descendingly EG, TEG, DEG and TREG for 95% glycols. Although the absolute amount of CH_4 and CO_2 increased with circulation rate, but the amount of CH_4 and CO_2 per kmole of rich glycol remained almost the same unless the amount of rich glycol was very high (which was directly dependent on glycol circulation rate). The Amount of CH_4 and CO_2 per kmole of rich glycol at a very high amount of rich glycol decreased for the circulation of DEG and EG components and increased for the circulation of TEG and TREG components.

Circulation of DEG, EG, and TEG components caused a reduction of CH_4 and CO_2 in rich glycol with contractor pressure; however, TREG components induced an increase of CH_4 and CO_2 in rich glycol up to 50 bar of contractor pressure, then CH_4 and CO_2 decreased. TREG components displayed a higher rate of change of CH_4 and CO_2 than other glycols. According to the amount of CH_4 and CO_2 found in rich glycol, the descending order of DEG and TEG was 90% > 95% > 99%, of EG was 95% > 90% > 99% and of TREG was 99% > 95% > 90%; however, considering only glycols, this order was TREG, TEG, EG, and DEG, respectively.

The amount of CH_4 and CO_2 in rich glycol showed positive change with stage number for every glycol component. Both the highest amount of CH_4 and CO_2 in rich glycol and the increasing rate of CH_4 and CO_2 were found maximum for TREG, followed by TEG, EG, and DEG.

3.7. Glycol temperature and pressure

Any of the glycol components in any condition did not show any effect on any parameter or composition in sales gas with varying inlet glycol temperature or pressure. So, during the design of the dehydration unit, glycol temperature and pressure should be selected on the basis of other plant parameters, not on its effect on dehydration performance.

4. Discussion

In the given schematic diagrams A and D represent starting and finishing points, respectively. B and C were the character-defining points. These two points represent the highest, lowest, or changes in trends. The horizontal distance between A and B, B, and C, C, and D reported about the requirement of glycol circulation rate to reach B or C, i.e., shorter AB in figure 5(a) imparted that heating value reached to B at lower glycol circulation rate. The slope of AB, BC, or CD reported about the sensitivity of the respective parameters, e.g., lower slope of CD in figure 2(a) reports that after C, H_2O composition did not increase much with glycol flow rate. In the graphs, AB, BC, or CD are not always straight lines.

According to the best results found by every component, glycol circulation rate appeared to be dominant variable for NG dehydration unit compared to stage number and contractor pressure, i.e., using 90% DEG, the least performer of glycol circulation rate produced sales gas with 22.4 times more water composition than of 99% EG, the best performer. The ratio of water composition in sales gas of 90% TREG and 95% TEG, least and best performer, respectively, for both stage number and contractor pressure, was 1.63 and 1.7, consecutively. The highest sales gas, CH_4 composition, and minimum H_2O were found from the 18^{th} to 25^{th} stages. Minimum H_2O composition was found by DEG and EG components at a lower circulation rate compared to the other two glycol components. At a lower circulation rate, the H_2O composition of sales gas dropped very fast for every glycol component. HHV and LHV of sales gas found reaching to highest value then started falling for all TEG components and the higher concentration of EG and TREG components. However, HHV and LHV found reaching to maximum then dropping to a minimum, after that again increasing slowly by all DEG components and the lower concentration of EG and TREG. Both the lowest water and highest methane composition were found at the lowest contractor pressure.

Considering the stage number and contractor pressure, TEG exhibited the best performance in terms of water removal. Considering the circulation rate, the highest concentration (99%) of every glycol displayed the highest water removal capacity. 99% TEG showed 2nd highest performance (20% more water content than 99% EG), although the required circulation rate was too high. 99% EG (at 1000 kg/hr), the best performer in glycol circulation rate produced sales gas of 25% and 33% more water content than of 99% TEG for stage number and contractor pressure, respectively. Considering only water removal, TEG seems the best choice, but considering the amount of glycol requirement, EG can be a suitable alternative too. TEG has less dew point depression. DEG is marginally lower in cost, but vapor pressure is larger, causing larger loss [11]. TEG absorbs more light hydrocarbons, and acid gases and its effectivity is more than of EG and DEG [15], and in the stripping chamber, an advanced enhancement is required to regenerate EG and DEG [16]. In the case of using DEG and EG, the lower composition of BTEX (benzene, toluene, ethylbenzene, xylene) is found in sales gas compared to

TEG [17]; even though BTEX was not considered in this study because BTEX is present in trace amount in NG in Bangladesh. TREG has a lower vapor pressure resulting in reduced losses. However, the cost of the TREG is higher, and it is more viscous than TEG [11]. High viscous fluids lead to higher pumping and pipe maintenance costs. TEG is economical compared to other glycols [18]. TEG is considered preferable glycol during operation due to better regeneration capability, high water affinity, high chemical stability, high hygroscopicity, low vapor pressure, low evaporation loss rate, and low thermal degradation rates in the regeneration system [12,15]. Although the report suggests one disadvantage of TEG, the purity of TEG after regeneration can be a maximum 98.8%, because the operating temperature of the reboiler should be kept below 204 ◦C to avoid the thermal degradation of it [19].

5. Conclusion

In the simulation, circulation rate, contractor pressure, and stage number were varied from low to high, but no single glycol component was able to remove water completely. However, the glycol circulation rate appeared to be a more sensitive parameter than stage number and contractor pressure. TEG outperforms other glycols in terms of water removal efficiency only, but EG also appears to be an option when glycol circulation rate is also given importance as well. During plant design cost, availability, environmental issues, corrosiveness, viscosity, degradation, etc. are also considered as well as water removal capacity, methane percentage and heating values of sales gas during the selection of suitable glycol.

Syngas from biomass gasification usually contains 10 to 50% water and up to 35% CO_2. Raw biogas may contain up to 10% water and 40% CO_2. Based on biomass feedstock, up to 900 ppm H_2S may be available in these gases. As many countries plan to increase the production of renewable energy by 2 to 4 times of present capacity or even 70% to 90% of total consumption by 2035 or 2040, pipeline transportation of renewable gases will be required. Removal of H_2O, CO_2, and H_2S from renewable gases is required for producing biomethane from biogas or syngas or producing renewable bio-liquid from biogas to use biofuel in the transport sector. The renewable gas upgrading plants use similar basic principles of NG treatment plants. The increase in production and consumption of renewable gas will increase the importance of gas upgrading/treatment as well as the gas dehydration process.

Nomenclature

DEG	*diethylene-glycol*	*NG*	*Natural gas*
EG	*ethylene-glycol*	*TEG*	*triethylene-glycol*
HHV	*higher heating value*	*TREG*	*tetraethylene-glycol*
LHV	*lower heating value*		

Supplementary data

Table 2. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 90% DEG

90% DEG	Sales gas	CH_4	H_2O	LHV	HHV	Total LHV	Total HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
10	2545.545	92.88219	0.17562	831424	914905	2116428147	2328931393
20	2545.402	92.88738	0.17004	831471	914954	2116427810	2328925196
30	2545.26	92.89257	0.16447	831517	915003	2116427479	2328919016
40	2545.118	92.89773	0.15893	831563	915051	2116427113	2328912833
50	2544.978	92.90283	0.15345	831609	915099	2116426762	2328906728
60	2544.837	92.90797	0.14793	831655	915147	2116426484	2328900660
70	2544.710	92.91260	0.14295	831696	915191	2116426025	2328894966
80	2544.595	92.91678	0.13846	831734	915230	2116425530	2328889746
90	2544.501	92.92023	0.13475	831764	915262	2116424916	2328885213
100	2544.400	92.92390	0.13082	831797	915297	2116424378	2328880527
150	2544.081	92.93551	0.11838	831900	915404	2116420202	2328863039
200	2543.901	92.94207	0.11140	831957	915464	2116414697	2328849813
250	2543.806	92.94550	0.10779	831985	915494	2116408350	2328839205

90% DEG	Sales gas	CH_4	H_2O	LHV	HHV	Total LHV	Total HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
300	2543.766	92.94694	0.10631	831995	915505	2116401333	2328830106
350	2543.755	92.94730	0.10602	831996	915505	2116393818	2328821698
400	2543.746	92.94759	0.10589	831993	915502	2116378387	2328804943
450	2543.745	92.94764	0.10584	831993	915503	2116378450	2328804955
500	2543.745	92.94760	0.10598	831990	915499	2116370497	2328796529
550	2543.746	92.94755	0.10613	831987	915496	2116362558	2328788130
600	2543.746	92.94752	0.10625	831984	915492	2116354573	2328779660
1000	2543.749	92.94721	0.10736	831957	915464	2116290064	2328711310
2000	2543.748	92.94675	0.10980	831894	915397	2116127289	2328538471
5000	2543.764	92.94466	0.11792	831695	915187	2115637047	2328018738
10000	2543.811	92.94045	0.13225	831358	914829	2114818350	2327151609
15000	2543.903	92.93461	0.14829	831007	914456	2114002103	2326288922
20000	2544.034	92.92738	0.16567	830649	914077	2113199005	2325441791
25000	2544.236	92.91752	0.18436	830316	913724	2112520598	2324730193
30000	2544.531	92.90432	0.20303	830070	913464	2112138895	2324337827
35000	2544.878	92.88930	0.22120	829887	913271	2111959840	2324162980
40000	2545.058	92.88048	0.23173	829789	913168	2111860744	2324066205
45000	2545.126	92.87583	0.23751	829736	913113	2111782229	2323986636
50000	2545.120	92.87394	0.24023	829711	913086	2111713051	2323913906
55000	2545.054	92.87425	0.24049	829707	913083	2111649908	2323845100
60000	2544.988	92.87454	0.24074	829706	913081	2111591067	2323780892
80000	2544.711	92.87617	0.24110	829707	913084	2111365728	2323534172
100000	2544.418	92.87833	0.24088	829715	913092	2111140975	2323287441
150000	2543.697	92.88318	0.24095	829728	913107	2110576808	2322668754

Table 3. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 95% DEG

95% DEG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
10	2545.505	92.88365	0.17405	831437	914918	2116427272	2328928834
20	2545.325	92.89019	0.16703	831496	914980	2116427921	2328922166
30	2545.145	92.89674	0.15998	831555	915042	2116427654	2328914514
40	2544.966	92.90329	0.15295	831613	915103	2116427206	2328906683
50	2544.788	92.90977	0.14597	831790	915283	2116728935	2329201123
60	2544.613	92.91615	0.13913	831728	915224	2116426807	2328891822
70	2544.452	92.92203	0.13280	831781	915280	2116426493	2328884881
80	2544.307	92.92731	0.12713	831828	915329	2116426028	2328878454
90	2544.180	92.93192	0.12218	831869	915372	2116425467	2328872687
100	2544.061	92.93626	0.11752	831908	915413	2116424752	2328867048
125	2543.800	92.94580	0.10728	831993	915502	2116422948	2328854425
150	2543.589	92.95347	0.09907	832061	915574	2116420598	2328843318
175	2543.417	92.95975	0.09235	832116	915632	2116418008	2328833516
200	2543.277	92.96487	0.08688	832161	915679	2116415072	2328824650
250	2543.06	92.97274	0.07849	832229	915750	2116408419	2328808733
300	2542.913	92.97810	0.07282	832274	915798	2116400945	2328794769
350	2542.813	92.98173	0.06902	832304	915829	2116392785	2328782015
400	2542.751	92.98396	0.06671	832320	915847	2116384022	2328770176
450	2542.715	92.98526	0.06543	832329	915855	2116374797	2328758901
500	2542.695	92.98597	0.06479	832331	915858	2116365249	2328747949
600	2542.677	92.98661	0.06433	832330	915856	2116345659	2328726375
700	2542.672	92.98676	0.06441	832324	915850	2116325579	2328704838
800	2542.667	92.98687	0.06453	832317	915843	2116305221	2328683039
900	2542.661	92.98705	0.06459	832311	915836	2116284861	2328661172
1000	2542.658	92.98711	0.06476	832304	915829	2116264456	2328639380

95% DEG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
1500	2542.634	92.98779	0.06528	832271	915794	2116161544	2328529090
2500	2542.596	92.98879	0.06669	832203	915721	2115954953	2328308088
5000	2542.492	92.99154	0.06996	832033	915540	2115436921	2327753641
10000	2542.301	92.99646	0.07712	831688	915173	2114401501	2326646096
15000	2542.125	93.00083	0.08480	831340	914803	2113370827	2325544213
20000	2542.011	93.00293	0.09298	831035	914479	2112500671	2324615547
25000	2542.055	92.99926	0.10165	830864	914297	2112101244	2324193844
30000	2542.188	92.99236	0.11039	830773	914202	2111981999	2324073651
35000	2542.315	92.98574	0.11815	830707	914132	2111918042	2324011950
100000	2541.700	92.98446	0.12602	830643	914067	2111245285	2323283510

Table 4. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 99% DEG

99% DEG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
10	2545.470	92.88490	0.17271	831449	914930	2116428277	2328928486
15	2545.362	92.88886	0.16845	831484	914968	2116428193	2328923943
20	2545.257	92.89260	0.16435	831518	915004	2116428082	2328919549
25	2545.147	92.89669	0.16004	831554	915041	2116427986	2328914935
30	2545.042	92.90052	0.15592	831589	915077	2116427796	2328910425
40	2544.825	92.90843	0.14741	831659	915152	2116427731	2328901476
50	2544.611	92.91624	0.13902	831729	915225	2116427352	2328892303
60	2544.400	92.92391	0.13078	831798	915298	2116427212	2328883542
70	2544.197	92.93133	0.12280	831864	915367	2116426927	2328874909
80	2544.032	92.93732	0.11636	831918	915424	2116426448	2328867670
90	2543.896	92.94229	0.11102	831962	915470	2116425841	2328861447
100	2543.752	92.94756	0.10537	832009	915520	2116425236	2328854895
125	2543.43	92.95930	0.09276	832114	915630	2116423310	2328839668
150	2543.15	92.96953	0.08180	832205	915725	2116421073	2328825821
175	2542.915	92.97810	0.07261	832281	915805	2116418439	2328813402
200	2542.715	92.98539	0.06481	832345	915872	2116415425	2328802027
225	2542.536	92.99194	0.05780	832402	915933	2116412218	2328791267
250	2542.381	92.99757	0.05178	832451	915984	2116408667	2328781172
275	2542.241	93.00267	0.04635	832496	916031	2116404929	2328771482
300	2542.116	93.00726	0.04146	832535	916072	2116400876	2328762023
350	2541.908	93.01482	0.03344	832600	916140	2116392379	2328744512
400	2541.744	93.02083	0.02709	832650	916193	2116383148	2328727960
450	2541.613	93.02559	0.02208	832689	916234	2116373413	2328712261
500	2541.510	93.02935	0.01817	832719	916265	2116363128	2328697112
550	2541.430	93.03225	0.01517	832741	916288	2116352497	2328682548
600	2541.368	93.03449	0.01290	832757	916305	2116341446	2328668286
700	2541.289	93.03734	0.01011	832774	916323	2116318531	2328640709
800	2541.246	93.03888	0.00874	832778	916327	2116294881	2328613826
900	2541.225	93.03961	0.00825	832776	916325	2116270650	2328587223
1000	2541.212	93.04007	0.00804	832771	916319	2116246228	2328560718
1500	2541.169	93.04147	0.00803	832736	916282	2116122737	2328427759
2000	2541.128	93.04280	0.00809	832701	916245	2115999022	2328294641
3000	2541.046	93.04546	0.00821	832630	916169	2115751724	2328028542
5000	2540.883	93.05076	0.00846	832490	916019	2115258499	2327497832
10000	2540.476	93.06394	0.00915	832138	915644	2114026203	2326171941
20000	2539.864	93.08297	0.01057	831622	915093	2112205842	2324213324
50000	2539.562	93.08440	0.01317	831566	915035	2111812894	2323788324
100000	2539.024	93.08877	0.01319	831555	915024	2111336946	2323268010

Table 5. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 90% EG

90% EG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2545.194	92.89495	0.16080	831549	915036	2116453561	2328944467
30	2544.913	92.90520	0.14964	831642	915134	2116456326	2328935942
40	2544.644	92.91502	0.13893	831731	915228	2116459377	2328928211
50	2544.42	92.92355	0.12965	831794	915294	2116433786	2328892034
60	2544.207	92.93093	0.12161	831875	915379	2116462896	2328914177
70	2544.046	92.93681	0.11522	831928	915435	2116463238	2328907973
80	2543.898	92.94220	0.10935	831977	915486	2116463372	2328902086
90	2543.768	92.94695	0.10420	832019	915530	2116462966	2328896346
100	2543.661	92.95084	0.09999	832053	915567	2116461813	2328890773
150	2543.299	92.96403	0.08576	832168	915687	2116451407	2328864968
200	2543.103	92.97115	0.07822	832225	915747	2116433744	2328838216
250	2543.022	92.97404	0.07533	832242	915765	2116410373	2328810112
300	2542.993	92.97509	0.07447	829468	912990	2109329809	2321726637
350	2542.979	92.97557	0.07427	832235	915756	2116354539	2328748977
400	2542.975	92.97566	0.07449	832224	915745	2116324068	2328716445
450	2542.97	92.97581	0.07467	832213	915734	2116292800	2328683001
500	2542.961	92.97609	0.07471	832203	915723	2116261210	2328649072
600	2542.949	92.97648	0.07499	832182	915701	2116196385	2328579648
700	2542.933	92.97699	0.07515	832161	915679	2116130488	2328508947
800	2542.916	92.97753	0.07528	832141	915657	2116064050	2328437636
900	2542.900	92.97805	0.07546	832120	915634	2115996499	2328365174
1000	2542.884	92.97855	0.07565	832098	915611	2115928896	2328292670
1500	2542.810	92.98087	0.07682	831988	915494	2115588812	2327928165
2000	2542.726	92.98359	0.07763	831880	915379	2115243454	2327557591
3000	2542.568	92.98865	0.07965	831660	915144	2114552263	2326816378
5000	2542.257	92.99855	0.08388	831219	914675	2113173218	2325337763
10000	2541.812	93.01119	0.09446	830509	913919	2110998541	2323009002
15000	2541.650	93.01348	0.10594	830091	913474	2109801268	2321731609
20000	2541.689	93.00848	0.11775	829850	913219	2109220996	2321118407
25000	2541.906	92.99694	0.13100	829730	913093	2109095209	2320995800
30000	2542.158	92.98414	0.14476	829623	912981	2109033518	2320942775
32500	2542.296	92.97728	0.15208	829567	912923	2109006267	2320920628
35000	2542.465	92.96931	0.16050	829503	912855	2108981097	2320901955
37500	2542.608	92.96231	0.16792	829446	912796	2108955585	2320881830
40000	2542.740	92.95578	0.17483	829393	912740	2108930392	2320861524

Table 6. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 95% EG

95% EG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2545.102	92.89831	0.15715	831579	915068	2116454622	2328941839
30	2544.780	92.91004	0.14436	831686	915180	2116458263	2328932601
40	2544.471	92.92133	0.13205	831789	915288	2116461844	2328923791
50	2544.209	92.93089	0.12164	831875	915379	2116464160	2328915574
60	2543.979	92.93927	0.11251	831951	915459	2116465844	2328908000
70	2543.781	92.94649	0.10466	832016	915527	2116466822	2328900975
80	2543.602	92.95302	0.09755	832075	915589	2116467229	2328894110
90	2543.453	92.95845	0.09166	832123	915640	2116466862	2328887662
100	2543.318	92.96337	0.08631	832167	915686	2116466211	2328881473
120	2543.08	92.97204	0.07693	832244	915767	2116463372	2328868770
150	2542.811	92.98183	0.06636	832329	915857	2116456399	2328850417
180	2542.617	92.98891	0.05877	832389	915919	2116446456	2328831942

95% EG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
200	2542.515	92.99263	0.05480	832419	915951	2116438386	2328819201
230	2542.393	92.99707	0.05014	832454	915987	2116424269	2328799226
250	2542.331	92.99930	0.04783	832470	916004	2116413653	2328785435
300	2542.230	93.00297	0.04416	832491	916026	2116383764	2328749538
350	2542.178	93.00485	0.04249	832495	916030	2116349674	2328711159
400	2542.152	93.00577	0.04189	832489	916024	2116312860	2328670963
450	2542.136	93.00633	0.04171	832479	916013	2116273954	2328628941
500	2542.124	93.00672	0.04171	832467	916000	2116233954	2328585938
600	2542.103	93.00742	0.04185	832441	915973	2116151293	2328497205
700	2542.081	93.00816	0.04197	832415	915945	2116066091	2328405725
800	2542.059	93.00891	0.04211	832388	915916	2115979442	2328312697
900	2542.035	93.00969	0.04221	832361	915887	2115891550	2328218299
1000	2542.012	93.01047	0.04233	832334	915858	2115802963	2328123170
1500	2541.895	93.01446	0.04290	832195	915711	2115353224	2327640199
2000	2541.778	93.01841	0.04357	832055	915560	2114897698	2327151116
3000	2541.539	93.02648	0.04478	831772	915259	2113981678	2326167460
5000	2541.094	93.04149	0.04731	831240	914692	2112258148	2324316875
7000	2540.839	93.04952	0.04962	830943	914375	2111291904	2323279736
10000	2540.588	93.05678	0.05343	830636	914048	2110302952	2322219183
15000	2540.391	93.06079	0.06011	830323	913715	2109344398	2321193992
20000	2540.456	93.05522	0.06696	830251	913640	2109215297	2321061425
25000	2540.574	93.04768	0.07482	830194	913581	2109168873	2321019026
30000	2540.705	93.03970	0.08301	830135	913519	2109128365	2320983462
40000	2541.03	93.02148	0.10138	830002	913381	2109060157	2320928673
50000	2541.208	93.00917	0.11390	829914	913290	2108983998	2320858704
60000	2541.120	93.00707	0.11671	829901	913277	2108878728	2320745922
70000	2540.919	93.00831	0.11675	829914	913291	2108743818	2320597435

Table 7. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 99% EG

99% EG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2545.021	92.90126	0.15393	831606	915096	2116455787	2328939778
30	2544.658	92.91450	0.13949	831727	915223	2116460112	2328929580
40	2544.319	92.92688	0.12600	831839	915341	2116463979	2328919865
50	2544.026	92.93756	0.11437	831936	915443	2116466743	2328910876
60	2543.769	92.94691	0.10418	832021	915532	2116468708	2328902512
70	2543.545	92.95511	0.09525	832095	915610	2116469952	2328894683
80	2543.342	92.96250	0.08721	832161	915680	2116470640	2328887161
90	2543.165	92.96897	0.08018	832219	915741	2116470481	2328879769
100	2543.009	92.97465	0.07401	832270	915794	2116470079	2328873009
110	2542.855	92.98027	0.06791	832320	915847	2116469106	2328865691
120	2542.724	92.98505	0.06273	832362	915891	2116467509	2328858656
130	2542.603	92.98947	0.05795	832401	915932	2116465703	2328851809
140	2542.488	92.99365	0.05343	832438	915971	2116463486	2328844787
150	2542.383	92.99748	0.04929	832471	916006	2116460865	2328837722
160	2542.287	93.00100	0.04549	832502	916038	2116457883	2328830619
170	2542.198	93.00425	0.04200	832529	916067	2116454558	2328823461
180	2542.116	93.00724	0.03879	832555	916094	2116450895	2328816222
190	2542.040	93.01001	0.03582	832578	916118	2116446919	2328808902
200	2541.969	93.01258	0.03308	832600	916141	2116442643	2328801492
210	2541.904	93.01495	0.03055	832619	916161	2116438071	2328793980
220	2541.844	93.01715	0.02821	832637	916180	2116433221	2328786366
230	2541.788	93.01919	0.02604	832653	916197	2116428105	2328778647

99% EG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
240	2541.736	93.02108	0.02405	832668	916213	2116422724	2328770813
250	2541.688	93.02284	0.02220	832682	916227	2116417094	2328762869
260	2541.643	93.02446	0.02050	832694	916240	2116411225	2328754813
270	2541.602	93.02596	0.01894	832705	916251	2116405116	2328746638
280	2541.564	93.02735	0.01749	832715	916262	2116398781	2328738348
290	2541.529	93.02864	0.01617	832724	916271	2116392233	2328729947
300	2541.496	93.02982	0.01495	832732	916280	2116385466	2328721426
310	2541.461	93.03111	0.01364	832741	916289	2116378561	2328712639
320	2541.437	93.03196	0.01278	832746	916294	2116371381	2328704053
330	2541.411	93.03291	0.01183	832752	916300	2116364239	2328695401
350	2541.367	93.03451	0.01026	832760	916309	2116348729	2328677109
380	2541.314	93.03645	0.00841	832768	916317	2116324609	2328649284
400	2541.285	93.03748	0.00747	832771	916320	2116307823	2328630274
450	2541.234	93.03931	0.00597	832770	916319	2116263124	2328580682
500	2541.201	93.04048	0.00521	832762	916310	2116215941	2328529174
550	2541.179	93.04127	0.00489	832750	916297	2116166279	2328475458
600	2541.161	93.04191	0.00476	832736	916282	2116115805	2328421051
1000	2541.035	93.04628	0.00473	832607	916145	2115683109	2327955833
5000	2539.873	93.08654	0.00530	831398	914855	2111646210	2323616173
10000	2539.240	93.10689	0.00605	830849	914270	2109725441	2321549888
20000	2539.024	93.10910	0.00759	830743	914157	2109276627	2321067701
50000	2538.837	93.09946	0.01318	830751	914170	2109141290	2320928189
100000	2538.108	93.10259	0.01357	830792	914215	2108640239	2320377220

Table 8. Amount of sales gas, composition of CH4 and H2O and heating values with circulation rate of 90% TEG

90% TEG	Sales gas	CH_4	H_2O	LHV Molar Basis (Std)	HHV Molar Basis (Std)	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
50	2545.261	92.89252	0.16462	831515	915000	2116422881	2328914127
100	2544.852	92.9074	0.14865	831648	915140	2116420670	2328895037
150	2544.599	92.91662	0.13877	831729	915225	2116417803	2328881617
200	2544.435	92.92259	0.13230	831782	915280	2116414385	2328871264
250	2544.352	92.92558	0.12922	831807	915307	2116410378	2328863629
300	2544.315	92.92691	0.12784	831817	915318	2116405887	2328857354
350	2544.300	92.92744	0.12732	831821	915321	2116401047	2328851591
400	2544.291	92.92776	0.12703	831822	915322	2116395997	2328845849
450	2544.284	92.92798	0.12686	831822	915322	2116390728	2328839995
500	2544.275	92.92831	0.12655	831823	915323	2116385544	2328834092
550	2544.272	92.92837	0.12655	831821	915322	2116380088	2328828212
600	2544.272	92.92835	0.12663	831819	915320	2116374586	2328822373
650	2544.269	92.92844	0.12660	831818	915318	2116369085	2328816407
700	2544.265	92.92860	0.12649	831817	915318	2116363535	2328810315
750	2544.260	92.92874	0.12639	831817	915317	2116357936	2328804187
800	2544.256	92.92886	0.12633	831816	915316	2116352306	2328798055
850	2544.255	92.92889	0.12636	831814	915314	2116346643	2328791988
900	2544.253	92.92892	0.12639	831812	915312	2116340797	2328785722
1000	2544.242	92.92928	0.12612	831811	915311	2116329522	2328773296
1200	2544.227	92.92975	0.12587	831807	915307	2116306513	2328748250
1500	2544.203	92.93052	0.12542	831802	915301	2116271685	2328710271
2000	2544.169	92.93157	0.12493	831790	915288	2116213193	2328646769
2500	2544.128	92.93286	0.12418	831780	915278	2116154718	2328583008
5000	2543.935	92.93885	0.12095	831727	915221	2115860868	2328263148
7500	2543.745	92.94477	0.11780	831674	915163	2115566154	2327942457

90% TEG	Sales gas	CH_4	H_2O	LHV Molar Basis (Std)	HHV Molar Basis (Std)	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
10000	2543.555	92.95070	0.11464	831620	915106	2115271085	2327621365
15000	2543.177	92.96244	0.10846	831511	914989	2114680976	2326979372
20000	2542.807	92.97390	0.10257	831401	914870	2114091674	2326338553
25000	2542.443	92.98517	0.09689	831288	914749	2113502516	2325698103
35000	2541.739	93.00679	0.08647	831056	914501	2112328375	2324422683
50000	2540.868	93.03244	0.07392	830814	914241	2110988826	2322965754
60000	2540.432	93.04397	0.06994	830681	914099	2110289246	2322206534
70000	2540.052	93.05329	0.06942	830496	913902	2109503723	2321358358
80000	2539.734	93.06033	0.06906	830366	913763	2108908652	2320715212
100000	2539.316	93.06633	0.06875	830303	913696	2108401137	2320163724
200000	2537.703	93.07837	0.06885	830407	913811	2107325931	2318980965
1000000	2524.776	93.17388	0.06885	831328	914823	2098916776	2309723972

Table 9. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 95% TEG

95% TEG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
50	2545.084	92.89898	0.15767	831573	915061	2116422899	2328906882
100	2544.515	92.91973	0.13540	831758	915256	2116420650	2328881171
150	2544.105	92.93466	0.11938	831891	915395	2116417692	2328861250
200	2543.809	92.94543	0.10785	831985	915494	2116412276	2328843410
250	2543.602	92.95300	0.09975	832052	915565	2116409662	2328832094
300	2543.449	92.95850	0.09386	832100	915615	2116404647	2328820538
350	2543.342	92.96245	0.08972	832135	915651	2116402896	2328814233
400	2543.259	92.96545	0.08656	832158	915676	2116393242	2328800630
450	2543.207	92.96735	0.08460	832172	915691	2116386010	2328790803
500	2543.161	92.96901	0.08289	832182	915701	2116373992	2328776206
550	2544.277	92.92821	0.12673	832186	915705	2117310840	2329806586
600	2544.272	92.92835	0.12664	832187	915706	2117311302	2329806800
650	2544.269	92.92844	0.12660	832186	915705	2117305409	2329800384
700	2544.263	92.92867	0.12641	832186	915705	2117298776	2329793037
750	2544.260	92.92875	0.12639	832185	915703	2117293733	2329787521
800	2544.258	92.92878	0.12642	832182	915700	2117284863	2329778036
850	2544.255	92.92887	0.12638	832178	915697	2117274568	2329766983
900	2544.251	92.92901	0.12629	832177	915695	2117267240	2329758988
1000	2544.243	92.92925	0.12615	832173	915691	2117250733	2329741106
1200	2544.225	92.92984	0.12578	832163	915680	2117208668	2329695693
1500	2544.203	92.93052	0.12542	832148	915664	2117152453	2329635000
2500	2544.131	92.93272	0.12433	832096	915608	2116960280	2329427659
5000	2543.929	92.93908	0.12069	831959	915462	2116444538	2328871022
7500	2543.738	92.94502	0.11752	831818	915312	2115928265	2328314211
10000	2543.549	92.95091	0.11441	831677	915161	2115412171	2327757633
15000	2543.168	92.96277	0.10809	831392	914857	2114370643	2326634515
20000	2542.805	92.97398	0.10249	831129	914576	2113400072	2325587536
25000	2542.457	92.98464	0.09750	830951	914385	2112657788	2324784700
30000	2542.091	92.99599	0.09181	830854	914281	2112105275	2324183870
35000	2541.743	93.00662	0.08680	830771	914192	2111608022	2323642777
40000	2541.417	93.01652	0.08214	830686	914101	2111120134	2323112280
45000	2541.118	93.02540	0.07747	830594	914002	2110636530	2322587201
50000	2540.972	93.02868	0.07747	830510	913913	2110303649	2322227299
55000	2540.671	93.03755	0.07191	830460	913859	2109924779	2321814369
60000	2540.448	93.04348	0.06982	830445	913843	2109702882	2321571391
70000	2540.058	93.05312	0.06929	830446	913845	2109381819	2321218566

80000	2539.732	93.06041	0.06894	830453	913852	2109127527	2320938779
90000	2539.502	93.06416	0.06898	830460	913860	2108954081	2320747900
100000	2539.318	93.06621	0.06892	830467	913867	2108819944	2320600268
110000	2539.15	93.06769	0.06883	830474	913875	2108698775	2320466904
120000	2538.988	93.06893	0.06884	830481	913883	2108581938	2320338307
130000	2538.829	93.07006	0.06891	830489	913891	2108468306	2320213237
150000	2538.502	93.07262	0.06868	830503	913907	2108234030	2319955377
200000	2537.700	93.07842	0.06883	830539	913947	2107659255	2319322738

Table 10. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 99% TEG

99% TEG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
50	2544.925	92.90479	0.15143	831625	915116	2116422911	2328900372
100	2544.210	92.93083	0.12346	831858	915360	2116420623	2328868674
150	2543.671	92.95051	0.10234	832033	915544	2116417559	2328843312
200	2543.261	92.96547	0.08631	832165	915684	2116413635	2328822346
250	2542.918	92.97800	0.07290	832276	915800	2116409058	2328803416
300	2542.641	92.98809	0.06211	832364	915893	2116403720	2328786409
350	2542.418	92.99623	0.05342	832435	915967	2116397601	2328770762
400	2542.226	93.00321	0.04600	832495	916030	2116390849	2328755747
450	2542.059	93.00931	0.03950	832547	916084	2116383509	2328741100
500	2541.928	93.01408	0.03448	832587	916126	2116375366	2328727079
550	2541.814	93.01827	0.03008	832621	916162	2116366654	2328713115
600	2541.716	93.02182	0.02636	832649	916192	2116357268	2328699143
650	2541.634	93.02480	0.02327	832672	916216	2116347270	2328685161
700	2541.564	93.02734	0.02065	832691	916235	2116336721	2328671083
750	2541.502	93.02961	0.01834	832707	916252	2116325520	2328656623
800	2541.453	93.03138	0.01656	832718	916264	2116313781	2328642145
850	2541.415	93.03279	0.01518	832726	916272	2116301162	2328627144
900	2541.379	93.03409	0.01393	832731	916278	2116285442	2328608999
1000	2541.336	93.03563	0.01257	832736	916282	2116261151	2328581385
2000	2541.19	93.04072	0.01084	832648	916189	2115917238	2328209746
3000	2541.068	93.04493	0.01074	832528	916060	2115510213	2327771969
4000	2540.939	93.04943	0.01063	832399	915923	2115075854	2327304806
5000	2540.806	93.05405	0.01054	832267	915782	2114627945	2326823086
10000	2540.143	93.07711	0.01009	831606	915077	2112398103	2324424909
15000	2539.744	93.09050	0.00961	831260	914707	2111187332	2323121686
20000	2539.445	93.10024	0.00901	831036	914468	2110370590	2322241716
30000	2539.023	93.11331	0.00801	830749	914161	2109289844	2321076626
50000	2538.782	93.11730	0.00628	830740	914152	2109067435	2320832865
75000	2538.543	93.11940	0.00575	830759	914173	2108918953	2320668908
100000	2538.306	93.12113	0.00575	830776	914192	2108764921	2320499311

Table 11. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 90% TREG

90% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2546.228	92.85721	0.20257	831199	914668	2116422317	2328953173
30	2545.995	92.86569	0.19345	831275	914748	2116422076	2328943373
40	2545.822	92.87200	0.18668	831331	914807	2116421869	2328936059
50	2545.681	92.87710	0.18117	831377	914855	2116421680	2328930088
60	2545.563	92.88144	0.17653	831416	914896	2116421504	2328925046
70	2545.446	92.88568	0.17198	831454	914936	2116421321	2328920082
80	2545.356	92.88898	0.16844	831483	914967	2116421154	2328916197
90	2545.275	92.89192	0.95173	831510	914994	2116420988	2328912710
100	2545.209	92.89432	0.16270	831531	915017	2116420828	2328909837

90% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
200	2544.835	92.90795	0.14807	831653	915145	2116419078	2328892641
300	2544.711	92.91240	0.14331	831692	915186	2116416801	2328885193
400	2544.691	92.91310	0.14260	831698	915192	2116413882	2328881287
800	2544.671	92.91371	0.14212	831698	915192	2116397015	2328862574
1000	2544.661	92.91397	0.14195	831697	915191	2116386550	2328851106
1500	2544.635	92.91475	0.14144	831694	915188	2116357171	2328818887
2000	2544.596	92.91600	0.14044	831812	915306	2116626210	2329084385
3000	2544.531	92.91801	0.13901	831807	915300	2116558364	2329009796
4000	2544.464	92.92011	0.08017	831801	915294	2116488118	2328932551
5000	2544.398	92.92215	0.13609	831795	915287	2116416737	2328854155
10000	2544.080	92.93193	0.12950	831756	915245	2116054255	2328456773
15000	2543.765	92.94163	0.12304	831715	915201	2115687833	2328055291
20000	2543.451	92.95130	0.11662	831674	915156	2115320943	2327653352
25000	2543.149	92.96049	0.11072	831628	915106	2114952995	2327250822
30000	2542.849	92.96965	0.10486	831581	915056	2114585326	2326848626
35000	2542.555	92.97856	0.09926	831533	915003	2114217546	2326446597
40000	2542.272	92.98713	0.09404	831480	914947	2113848873	2326044006
45000	2542.014	92.99472	0.08995	831416	914879	2113472515	2325634340
50000	2541.696	93.00448	0.08446	831338	914794	2113008363	2325128885
55000	2541.436	93.01211	0.08176	831221	914669	2112493960	2324572376
60000	2541.195	93.01897	0.07999	831096	914536	2111976104	2324013037
65000	2541.018	93.02344	0.07916	831015	914449	2111623324	2323631908
70000	2540.87	93.02683	0.07864	830958	914389	2111356118	2323342977
80000	2540.605	93.03244	0.07804	830865	914290	2110900389	2322850070
90000	2540.386	93.03672	0.07806	830783	914203	2110510312	2322428562
100000	2540.164	93.04111	0.07808	830699	914113	2110111086	2321997212
150000	2539.033	93.06099	0.07801	830376	913771	2108352802	2320094415
200000	2538.296	93.06719	0.07803	830400	913798	2107801556	2319489886

Table 12. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 95% TREG

95% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2546.148	92.86012	0.19944	831225	914695	2116422304	2328949887
30	2545.866	92.87039	0.18840	831317	914792	2116422048	2328938059
40	2545.655	92.87800	0.18013	831386	914864	2116421834	2328929172
50	2545.473	92.88472	0.17301	831445	914927	2116421635	2328921500
60	2545.342	92.88951	0.16787	831488	914972	2116421469	2328915944
70	2545.201	92.89465	0.16235	831534	915020	2116421288	2328909972
80	2545.078	92.89912	0.15754	831574	915062	2116421115	2328904761
90	2544.967	92.90315	0.15321	831610	915100	2116420945	2328900050
100	2544.868	92.90678	0.14932	831643	915134	2116420776	2328895790
120	2544.683	92.91350	0.14209	831703	915198	2116420429	2328887859
150	2544.493	92.92044	0.13464	831765	915263	2116419917	2328879518
180	2544.307	92.92723	0.12735	831826	915326	2116419341	2328871274
200	2544.211	92.93072	0.12360	831857	915359	2116418934	2328866912
250	2544.017	92.93779	0.11602	831920	915425	2116417801	2328857762
300	2543.860	92.94350	0.10989	831971	915479	2116416477	2328849926
350	2543.747	92.94762	0.10548	832007	915517	2116414949	2328843671
400	2543.676	92.95018	0.10275	832029	915541	2116413187	2328838919
450	2543.605	92.95275	0.10001	832052	915564	2116411223	2328833934
500	2543.575	92.95386	0.09884	832061	915574	2116409013	2328830325
600	2543.536	92.95523	0.09742	832071	915585	2116403883	2328823318
700	2543.505	92.95635	0.09628	832079	915593	2116397975	2328815757

95% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
800	2543.496	92.95665	0.09603	832080	915594	2116391281	2328808285
900	2543.492	92.95676	0.09599	832078	915592	2116383876	2328800269
1000	2543.491	92.95677	0.09608	832075	915589	2116375855	2328791719
1500	2543.460	92.95778	0.09550	832067	915580	2116329082	2328740757
2000	2543.424	92.95897	0.09482	832057	915570	2116274604	2328681402
3000	2543.365	92.96084	0.09413	832029	915539	2116152669	2328549456
4000	2543.298	92.96302	0.09322	831999	915507	2116021706	2328407561
5000	2543.221	92.96554	0.09198	831971	915477	2115886681	2328260958
10000	2542.879	92.97666	0.08769	831806	915301	2115182812	2327499057
15000	2542.524	92.98830	0.08303	831639	915122	2114462975	2326719603
20000	2542.178	92.99958	0.07877	831469	914939	2113741287	2325938579
25000	2541.839	93.01062	0.07478	831295	914754	2113017913	2325156030
30000	2541.527	93.02065	0.07156	831125	914572	2112327250	2324409427
35000	2541.223	93.03043	0.06738	831000	914438	2111756389	2323790547
40000	2540.971	93.03830	0.06362	830921	914353	2111345629	2323344143
45000	2540.747	93.04512	0.06008	830867	914295	2111022964	2322992626
50000	2540.534	93.05153	0.05711	830808	914232	2110696467	2322637516
55000	2540.356	93.05665	0.05567	830734	914152	2110359474	2322272686
60000	2540.096	93.06471	0.05278	830631	914043	2109882591	2321755804
80000	2539.688	93.07420	0.05331	830411	913809	2108986184	2320788960
100000	2539.467	93.07687	0.05333	830386	913782	2108736999	2320517879
120000	2539.282	93.07820	0.05334	830395	913792	2108607175	2320375207
150000	2539.009	93.08005	0.05336	830413	913812	2108425751	2320175519
200000	2538.554	93.08311	0.05338	830443	913845	2108124796	2319844225
250000	2538.098	93.08618	0.05340	830474	913878	2107823895	2319512988

Table 13. Amount of sales gas, composition of CH_4 and H_2O and heating values with circulation rate of 99% TREG

99% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
20	2546.058	92.86340	0.19592	831254	914726	2116422279	2328946177
30	2545.758	92.87433	0.18417	831352	914829	2116422029	2328933613
40	2545.527	92.88274	0.17513	831428	914908	2116421818	2328923924
50	2545.315	92.89048	0.16682	831497	914981	2116421615	2328915012
60	2545.131	92.89719	0.15961	831557	915044	2116421427	2328907263
70	2544.967	92.90317	0.15318	831610	915100	2116421247	2328900347
80	2544.819	92.90857	0.14738	831659	915151	2116421072	2328894095
90	2544.683	92.91351	0.14207	831703	915198	2116420900	2328888357
100	2544.558	92.91808	0.13717	831744	915241	2116420727	2328883039
120	2544.350	92.92569	0.12899	831812	915312	2116420390	2328874129
150	2544.046	92.93678	0.11708	831911	915416	2116419832	2328861081
180	2543.791	92.94605	0.10712	831994	915504	2116419231	2328850022
200	2543.647	92.95130	0.10149	832041	915553	2116418800	2328843670
225	2543.474	92.95761	0.09471	832097	915612	2116418220	2328835966
250	2543.323	92.96313	0.08878	832147	915664	2116417586	2328829089
275	2543.181	92.96833	0.08320	832193	915713	2116416903	2328822521
300	2543.048	92.97318	0.07800	832236	915758	2116416164	2328816293
325	2542.941	92.97709	0.07381	832271	915795	2116415358	2328811047
350	2542.829	92.98116	0.06944	832307	915833	2116414499	2328805560
375	2542.727	92.98488	0.06545	832340	915867	2116413568	2328800393
400	2542.630	92.98840	0.06168	832371	915900	2116412581	2328795390
450	2542.472	92.99416	0.05551	832422	915954	2116410390	2328786589
500	2542.316	92.99988	0.04939	832472	916006	2116407946	2328777575
600	2542.066	93.00898	0.03968	832552	916090	2116402240	2328761293

99% TREG	Sales gas	CH_4	H_2O	LHV	HHV	T LHV	T HHV
(kg/hr)	kmole/hr	(%)	(%)	kJ/kmole	kJ/kmole	kJ	kJ
700	2541.888	93.01548	0.03276	832608	916148	2116395375	2328746686
800	2541.743	93.02075	0.02719	832652	916195	2116387389	2328732278
900	2541.634	93.02473	0.02300	832684	916229	2116378264	2328718091
1000	2541.553	93.02766	0.01997	832707	916252	2116367977	2328703860
1100	2541.495	93.02977	0.01782	832721	916268	2116356626	2328689405
1200	2541.453	93.03128	0.01634	832730	916277	2116344100	2328674382
1300	2541.424	93.03233	0.01537	832734	916281	2116330517	2328658753
1400	2541.404	93.03305	0.01475	832735	916282	2116315980	2328642470
1500	2541.390	93.03354	0.01439	832733	916280	2116300407	2328625349
2000	2541.349	93.03493	0.01388	832711	916256	2116209989	2328527569
2500	2541.315	93.03609	0.01381	832680	916223	2116102060	2328411417
5000	2541.099	93.04349	0.01347	832475	916004	2115400767	2327656939
15000	2540.091	93.07851	0.01224	831491	914954	2112061766	2324065264
50000	2538.915	93.11498	0.00814	830719	914130	2109125262	2320898407
150000	2538.161	93.12106	0.00735	830776	914192	2108643328	2320367154
250000	2537.406	93.12659	0.00734	830829	914251	2108152005	2319826310

Table 14. Change of parameters with contactor pressure

Parameters	Contractor pressure (bar)	40	45	50	55	60	65	70	75	80
Sales gas (kmole/hr)	90% DEG	2544.056	2544.239	2544.477	2544.751	2544.978	2545.162	2545.294	2545.396	2545.476
	95% DEG	2544.296	2544.502	2544.746	2544.980	2545.145	2545.263	2545.347	2545.414	2545.466
	99% DEG	2544.502	2544.728	2544.956	2545.133	2545.257	2545.338	2545.399	2545.446	2545.484
	90% EG	2543.948	2544.146	2544.403	2544.660	2544.913	2545.108	2545.260	2545.382	2545.482
	95% EG	2543.825	2544.039	2544.278	2544.519	2544.780	2544.983	2545.143	2545.271	2545.375
	99% EG	2544.091	2544.307	2544.554	2544.806	2545.021	2545.170	2545.285	2545.382	2545.462
	90% TEG	2543.672	2543.834	2544.014	2544.219	2544.435	2544.682	2544.930	2545.174	2545.382
	95% TEG	2543.298	2543.458	2543.659	2543.877	2544.105	2544.368	2544.603	2544.809	2544.988
	99% TEG	2543.326	2543.511	2543.722	2543.945	2544.199	2544.457	2544.663	2544.815	2544.933
	90% TREG	2544.866	2545.097	2545.365	2545.680	2545.995	2546.359	2546.730	2547.128	2547.532
	95% TREG	2544.743	2544.986	2545.258	2545.556	2545.866	2546.233	2546.603	2546.998	2547.405
	99% TREG	2544.638	2544.879	2545.146	2545.443	2545.758	2546.119	2546.492	2546.882	2547.287
CH_4(%)	90% DEG	92.93650	92.92982	92.92111	92.91113	92.90283	92.89612	92.89129	92.88760	92.88467
	95% DEG	92.92774	92.92021	92.91132	92.90278	92.89674	92.89245	92.88939	92.88695	92.88505
	99% DEG	92.92022	92.91197	92.90367	92.89720	92.89267	92.88971	92.88748	92.88577	92.88439
	90% EG	92.94042	92.93318	92.92383	92.91443	92.90520	92.89811	92.89255	92.88811	92.88444
	95% EG	92.94493	92.93710	92.92838	92.91957	92.91004	92.90266	92.89682	92.89216	92.88837
	99% EG	92.93522	92.92732	92.91833	92.90913	92.90126	92.89583	92.89165	92.88811	92.88518
	90% TEG	92.95046	92.94455	92.93795	92.93046	92.92259	92.91355	92.90452	92.89561	92.88801
	95% TEG	92.96414	92.95831	92.95096	92.94300	92.93466	92.92505	92.91646	92.90896	92.90244
	99% TEG	92.96313	92.95639	92.94867	92.94052	92.93124	92.92182	92.91430	92.90877	92.90447
	90% TREG	92.90691	92.89848	92.88869	92.87721	92.86569	92.85242	92.83890	92.82441	92.80970
	95% TREG	92.91140	92.90250	92.89260	92.88172	92.87039	92.85702	92.84356	92.82917	92.81432
	99% TREG	92.91523	92.90641	92.89669	92.88583	92.87433	92.86119	92.84758	92.83338	92.81863
H_2O(%)	90% DEG	0.11733	0.12449	0.13384	0.14455	0.15345	0.16062	0.16576	0.16966	0.17271
	95% DEG	0.12673	0.13482	0.14435	0.15352	0.15998	0.16456	0.16779	0.17033	0.17229
	99% DEG	0.13481	0.14368	0.15258	0.15951	0.16435	0.16749	0.16983	0.17159	0.17298
	90% EG	0.11241	0.12006	0.12998	0.13992	0.14964	0.15698	0.16259	0.16691	0.17030
	95% EG	0.10751	0.11580	0.12502	0.13432	0.14436	0.15201	0.15792	0.16247	0.16599
	99% EG	0.11804	0.12642	0.13595	0.14568	0.15393	0.15946	0.16357	0.16690	0.16948
	90% TEG	0.10245	0.10880	0.11589	0.12394	0.13239	0.14210	0.15180	0.16137	0.16952
	95% TEG	0.08771	0.09397	0.10187	0.11042	0.11938	0.12971	0.13893	0.14697	0.15397
	99% TEG	0.08877	0.09600	0.10430	0.11306	0.12302	0.13314	0.14122	0.14715	0.15175
	90% TREG	0.14917	0.15822	0.16874	0.18108	0.19345	0.20772	0.22225	0.23781	0.25361
	95% TREG	0.14434	0.15390	0.16454	0.17623	0.18840	0.20277	0.21724	0.23270	0.24865
	99% TREG	0.14022	0.14970	0.16015	0.17182	0.18417	0.19829	0.21291	0.22817	0.24402

Parameters	Contractor pressure (bar)	40	45	50	55	60	65	70	75	80
LHV kJ/kmole	90% DEG	831909	831850	831772	831683	831609	831550	831507	831476	831452
	95% DEG	831831	831764	831684	831608	831555	831517	831491	831471	831456
	99% DEG	831764	831690	831616	831558	831518	831493	831474	831460	831450
	90% EG	831951	831888	831805	831723	831642	831581	831535	831500	831473
	95% EG	831992	831923	831847	831769	831686	831623	831574	831537	831509
	99% EG	831904	831835	831756	831675	831606	831561	831527	831500	831480
	90% TEG	832031	831978	831919	831852	831782	831701	831620	831541	831473
	95% TEG	832154	832102	832037	831965	831891	831805	831728	831661	831603
	99% TEG	832146	832086	832017	831944	831861	831777	831710	831661	831623
	90% TREG	831644	831568	831481	831378	831275	831156	831035	830906	830774
	95% TREG	831684	831604	831516	831418	831317	831197	831077	830948	830815
	99% TREG	831718	831639	831552	831455	831352	831235	831113	830986	830854
HHV kJ/kmole	90% DEG	915414	915352	915270	915177	915099	915037	914992	914959	914934
	95% DEG	915332	915262	915178	915098	915042	915002	914975	914954	914938
	99% DEG	915261	915184	915106	915046	915004	914977	914957	914943	914932
	90% EG	915459	915392	915305	915219	915134	915070	915022	914985	914957
	95% EG	915502	915429	915349	915268	915180	915114	915063	915024	914994
	99% EG	915409	915336	915253	915168	915096	915049	915013	914985	914964
	90% TEG	915542	915487	915425	915354	915280	915195	915111	915027	914956
	95% TEG	915672	915617	915548	915473	915395	915305	915224	915154	915093
	99% TEG	915664	915600	915528	915451	915364	915275	915205	915153	915114
	90% TREG	915135	915056	914964	914856	914748	914623	914496	914359	914221
	95% TREG	915178	915094	915001	914899	914792	914666	914540	914404	914265
	99% TREG	915214	915131	915039	914937	914829	914705	914577	914444	914305
T LHV kJ	90% DEG	2116423427	2116424079	2116424805	2116425658	2116426762	2116428530	2116431202	2116434939	2116439878
	95% DEG	2116424156	2116424757	2116425462	2116426342	2116427654	2116429734	2116432753	2116436685	2116441867
	99% DEG	2116424352	2116424923	2116425593	2116426594	2116428082	2116430311	2116433366	2116437478	2116442744
	90% EG	2116440749	2116444029	2116447421	2116451520	2116456326	2116463488	2116472833	2116484748	2116499427
	95% EG	2116441851	2116445126	2116448935	2116453367	2116458263	2116465437	2116474837	2116486735	2116501597
	99% EG	2116440175	2116443182	2116446736	2116450411	2116455787	2116463651	2116473607	2116486300	2116501421
	90% TEG	2116413657	2116413754	2116413918	2116414116	2116414385	2116414647	2116415006	2116415507	2116416546
	95% TEG	2116416887	2116417029	2116417178	2116417397	2116417692	2116417945	2116418407	2116419258	2116420640
	99% TEG	2116419853	2116419985	2116420172	2116420433	2116420672	2116420910	2116421475	2116422628	2116424463
	90% TREG	2116421942	2116421871	2116421870	2116421947	2116422076	2116422289	2116422564	2116422920	2116423352
	95% TREG	2116421915	2116421851	2116421853	2116421920	2116422048	2116422266	2116422546	2116422909	2116423350
	99% TREG	2116421892	2116421828	2116421827	2116421895	2116422029	2116422245	2116422532	2116422898	2116423344
T HHV kJ	90% DEG	2328865306	2328873505	2328884075	2328896203	2328906728	2328916171	2328924484	2328932661	2328941264

Parameters	Contractor pressure (bar)	40	45	50	55	60	65	70	75	80
	95% DEG	2328875913	2328885021	2328895766	2328906314	2328914514	2328921588	2328928273	2328935245	2328942968
	99% DEG	2328884568	2328894460	2328904506	2328912849	2328919549	2328925272	2328931070	2328937421	2328944638
	90% EG	2328879573	2328891239	2328905405	2328920390	2328935942	2328951645	2328967969	2328985815	2329005771
	95% EG	2328875704	2328888025	2328901924	2328916606	2328932601	2328948632	2328965339	2328983410	2329003697
	99% EG	2328884792	2328896907	2328910840	2328925132	2328939778	2328954370	2328969802	2328987469	2329007058
	90% TEG	2328839187	2328845919	2328853512	2328862133	2328871264	2328881707	2328892250	2328902812	2328912486
	95% TEG	2328827276	2328833974	2328842387	2328851560	2328861250	2328872325	2328882474	2328891824	2328900652
	99% TEG	2328831585	2328839283	2328848156	2328857588	2328868271	2328879113	2328888177	2328895645	2328902455
	90% TREG	2328896919	2328906305	2328917304	2328930292	2328943373	2328958531	2328974037	2328990720	2329007740
	95% TREG	2328891841	2328901770	2328912886	2328925189	2328938059	2328953327	2328968776	2328985352	2329002538
	99% TREG	2328887515	2328897350	2328908268	2328920548	2328933613	2328948618	2328964233	2328980599	2328997684

Table 15. Change of parameters with stage number

Parameters	Contractor pressure (bar)	3	5	8	10	12	15	18	20	22	25
Sales gas (kmole/hr)	90% DEG	2545.041	2545.006	2544.999	2544.997	2544.996	2544.995	2544.978	2544.973	2544.975	2544.976
	95% DEG	2545.161	2545.155	2545.153	2545.151	2545.150	2545.145	2545.143	2545.146	2545.144	2545.144
	99% DEG	2545.262	2545.260	2545.259	2545.259	2545.259	2545.257	2545.256	2545.256	2545.256	2545.256
	90% EG	2544.980	2544.958	2544.943	2544.938	2544.933	2544.913	2544.906	2544.908	2544.909	2544.909
	95% EG	2544.862	2544.836	2544.818	2544.812	2544.804	2544.780	2544.774	2544.773	2544.773	2544.772
	99% EG	2545.050	2545.029	2545.027	2545.026	2545.026	2545.021	2545.019	2545.021	2545.017	2545.017
	90% TEG	2544.682	2544.568	2544.494	2544.472	2544.454	2544.437	2544.426	2544.420	2544.417	2544.416
	95% TEG	2544.410	2544.264	2544.173	2544.146	2544.125	2544.106	2544.099	2544.088	2544.080	2544.079
	99% TEG	2544.431	2544.323	2544.253	2544.244	2544.230	2544.222	2544.205	2544.208	2544.205	2544.197
	90% TREG	2546.364	2546.157	2546.060	2546.034	2546.017	2545.995	2545.993	2545.994	2545.982	2545.982
	95% TREG	2546.271	2546.045	2545.941	2545.912	2545.894	2545.866	2545.867	2545.859	2545.857	2545.859
	99% TREG	2546.186	2545.945	2545.833	2545.803	2545.784	2545.758	2545.756	2545.754	2545.745	2545.750
CH4(%)	90% DEG	92.90054	92.90181	92.90206	92.90213	92.90219	92.90223	92.90284	92.90302	92.90293	92.90289
	95% DEG	92.89616	92.89638	92.89648	92.89653	92.89656	92.89674	92.89681	92.89671	92.89679	92.89679
	99% DEG	92.89249	92.89256	92.89259	92.89261	92.89262	92.89267	92.89272	92.89272	92.89273	92.89272
	90% EG	92.90276	92.90356	92.90410	92.90429	92.90449	92.90520	92.90547	92.90538	92.90534	92.90536
	95% EG	92.90705	92.90803	92.90868	92.90889	92.90916	92.91004	92.91027	92.91033	92.91033	92.91034
	99% EG	92.90022	92.90098	92.90105	92.90108	92.90110	92.90126	92.90135	92.90129	92.90142	92.90141
	90% TEG	92.91359	92.91774	92.92042	92.92124	92.92188	92.92251	92.92289	92.92315	92.92325	92.92328
	95% TEG	92.92355	92.92884	92.93218	92.93315	92.93393	92.93462	92.93488	92.93529	92.93556	92.93560
	99% TEG	92.92279	92.92674	92.92927	92.92961	92.93013	92.93041	92.93103	92.93093	92.93102	92.93131
	90% TREG	92.85227	92.85980	92.86331	92.86429	92.86490	92.86569	92.86577	92.86575	92.86617	92.86618
	95% TREG	92.85566	92.86387	92.86768	92.86874	92.86939	92.87039	92.87037	92.87066	92.87073	92.87066

Parameters	Contractor pressure (bar)	3	5	8	10	12	15	18	20	22	25
	99% TREG	92.85874	92.86752	92.87160	92.87272	92.87340	92.87433	92.87442	92.87448	92.87483	92.87462
H2O(%)	90% DEG	0.15591	0.15454	0.15427	0.15420	0.15414	0.15409	0.15344	0.15324	0.15334	0.15338
	95% DEG	0.16061	0.16037	0.16027	0.16021	0.16017	0.15998	0.15991	0.16002	0.15993	0.15993
	99% DEG	0.16455	0.16447	0.16444	0.16442	0.16441	0.16435	0.16430	0.16430	0.16430	0.16430
	90% EG	0.15228	0.15141	0.15083	0.15062	0.15042	0.14964	0.14934	0.14943	0.14949	0.14947
	95% EG	0.14759	0.14654	0.14583	0.14561	0.14531	0.14436	0.14411	0.14405	0.14405	0.14404
	99% EG	0.15505	0.15424	0.15416	0.15412	0.15411	0.15393	0.15383	0.15389	0.15375	0.15376
	90% TEG	0.14208	0.13761	0.13472	0.13385	0.13315	0.13248	0.13206	0.13179	0.13168	0.13164
	95% TEG	0.13135	0.12565	0.12205	0.12101	0.12017	0.11942	0.11914	0.11870	0.11842	0.11837
	99% TEG	0.13212	0.12786	0.12514	0.12478	0.12422	0.12391	0.12325	0.12336	0.12326	0.12294
	90% TREG	0.20787	0.19979	0.19601	0.19496	0.19430	0.19345	0.19337	0.19340	0.19294	0.19293
	95% TREG	0.20423	0.19542	0.19131	0.19018	0.18948	0.18840	0.18843	0.18812	0.18804	0.18811
	99% TREG	0.20092	0.19149	0.18711	0.18590	0.18517	0.18417	0.18408	0.18401	0.18363	0.18386
LHV kJ/kmole	90% DEG	831588	831600	831602	831603	831603	831604	831609	831611	829982	831610
	95% DEG	831550	831551	831552	831553	831553	831555	831555	831554	831555	831555
	99% DEG	831517	831517	831518	831518	831518	831518	831519	831519	831519	831519
	90% EG	831620	831627	831632	831634	831635	831642	831644	831644	831643	831643
	95% EG	831659	831668	831674	831676	831678	831686	831688	831689	831689	831689
	99% EG	831597	831604	831604	831605	831605	831606	831607	831607	831608	831608
	90% TEG	831700	831738	831762	831770	831775	831781	831784	831787	831788	831788
	95% TEG	831791	831838	831868	831877	831884	831891	831893	831897	831899	831899
	99% TEG	831785	831821	831843	831847	831851	831854	831859	831858	831859	831862
	90% TREG	831155	831222	831254	831262	831268	831275	831276	831275	831279	831279
	95% TREG	831185	831259	831293	831302	831308	831317	831317	831319	831320	831319
	99% TREG	831213	831291	831328	831338	831344	831352	831353	831354	831357	831355
HHV kJ/kmole	90% DEG	915077	915089	915092	915092	915093	915093	915099	915101	913472	915100
	95% DEG	915036	915038	915039	915040	915040	915042	915043	915042	915042	915042
	99% DEG	915002	915003	915003	915003	915003	915004	915004	915004	915004	915004
	90% EG	915111	915118	915123	915125	915127	915134	915136	915136	915135	915135
	95% EG	915152	915161	915167	915169	915172	915180	915182	915183	915183	915183
	99% EG	915086	915094	915094	915095	915095	915096	915097	915097	915098	915098
	90% TEG	915195	915234	915260	915268	915274	915280	915283	915286	915287	915287
	95% TEG	915290	915340	915372	915381	915388	915395	915397	915401	915404	915404
	99% TEG	915284	915321	915345	915348	915353	915356	915362	915361	915362	915365
	90% TREG	914621	914692	914725	914735	914740	914748	914748	914748	914752	914752
	95% TREG	914653	914731	914766	914776	914783	914792	914792	914794	914795	914794
	99% TREG	914682	914765	914803	914814	914820	914829	914830	914830	914834	914832

Parameters	Contractor pressure (bar)	3	5	8	10	12	15	18	20	22	25
T LHV kJ	90% DEG	2116426520	2116426627	2116426651	2116426665	2116426671	2116426675	2116426807	2116426842	2112284963	2116426800
	95% DEG	2116427595	2116427617	2116427627	2116427632	2116427638	2116427654	2116427691	2116427670	2116427693	2116427691
	99% DEG	2116428066	2116428071	2116428074	2116428077	2116428078	2116428082	2116428082	2116428079	2116428080	2116428081
	90% EG	2116455734	2116455914	2116456026	2116456066	2116456105	2116456326	2116456623	2116456705	2116456492	2116456525
	95% EG	2116457509	2116457735	2116457878	2116457912	2116457979	2116458263	2116458426	2116458470	2116458624	2116458472
	99% EG	2116455551	2116455754	2116455768	2116455773	2116455776	2116455787	2116455976	2116455931	2116456044	2116456032
	90% TEG	2116412890	2116413627	2116414113	2116414192	2116414291	2116414386	2116414443	2116414482	2116414496	2116414500
	95% TEG	2116415966	2116416857	2116417356	2116417491	2116417597	2116417691	2116417724	2116417781	2116417816	2116417817
	99% TEG	2116419585	2116420128	2116420443	2116420492	2116420548	2116420580	2116420640	2116420644	2116420654	2116420683
	90% TREG	2116422320	2116422182	2116422118	2116422101	2116422090	2116422076	2116422074	2116422075	2116422067	2116422067
	95% TREG	2116422315	2116422165	2116422096	2116422077	2116422065	2116422048	2116422048	2116422042	2116422041	2116422043
	99% TREG	2116422311	2116422150	2116422077	2116422057	2116422044	2116422029	2116422026	2116422025	2116422018	2116422022
T HHV kJ	90% DEG	2328909046	2328907722	2328907470	2328907409	2328907352	2328907307	2328906765	2328906599	2324764820	2328906697
	95% DEG	2328915107	2328914885	2328914785	2328914732	2328914702	2328914514	2328914480	2328914575	2328914510	2328914503
	99% DEG	2328919739	2328919662	2328919631	2328919617	2328919605	2328919549	2328919490	2328919485	2328919484	2328919490
	90% EG	2328938057	2328937344	2328936862	2328936687	2328936512	2328935942	2328935960	2328936148	2328935967	2328935985
	95% EG	2328935151	2328934299	2328933712	2328933521	2328933280	2328932601	2328932517	2328932500	2328932659	2328932491
	99% EG	2328940697	2328940066	2328940000	2328939965	2328939954	2328939778	2328939886	2328939904	2328939877	2328939882
	90% TEG	2328879789	2328875911	2328873413	2328872582	2328871962	2328871359	2328870985	2328870744	2328870639	2328870608
	95% TEG	2328871893	2328866896	2328863679	2328862733	2328861969	2328861286	2328861033	2328860634	2328860372	2328860323
	99% TEG	2328876605	2328872742	2328870236	2328869910	2328869386	2328869101	2328868471	2328868592	2328868498	2328868198
	90% TREG	2328958727	2328950117	2328946093	2328944972	2328944274	2328943373	2328943287	2328943313	2328942828	2328942811
	95% TREG	2328954913	2328945524	2328941155	2328939945	2328939202	2328938059	2328938082	2328937754	2328937672	2328937750
	99% TREG	2328951448	2328941395	2328936737	2328935451	2328934672	2328933613	2328933507	2328933441	2328933036	2328933277

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