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EXECUTIVE SUMMARY

The Department of Energy, Energy Efficiency and Renewable Energy Program has developed a national strategy for increasing woody biomass utilization. The intent of this strategy is to explore equipment and materials that enable creation of a reliable, sustainable supply of woody biomass and to encourage the formation of stable markets for converting that biomass supply into energy. The effort proposed in this project supports this strategy in terms of enhancing industrial energy security, specifically in the forest products industry, through fuel flexibility for industry.

Lime kilns are used throughout the forest products industry, specifically in the pulp and paper sector, to convert lime mud ($CaCO_3$) to lime (CaO) for reuse in the causticizing process. The conversion of lime mud to lime requires a significant amount of heat for the reaction to proceed, generally supplied by burning natural gas or fuel oil in the lime kiln. On average, lime kilns require seven to eight million BTUs per ton of lime product or between 1,500 and 2,000 standard cubic feet per minute of natural gas to produce 350 tons of lime per day. Substituting synthesis gas for industrial gas in lime kilns would aid in reducing the forest products industry's dependence on and consumption of fossil fuels.

This project addresses both the technical and economic feasibility of replacing industrial gas in lime kilns with synthesis gas from the gasification of hog fuel. The technical assessment includes a materials evaluation, processing equipment needs, and suitability of the heat content of the synthesis gas as a replacement for industrial gas. The economic assessment includes estimations for capital, construction, operating, maintenance, and management costs for the reference plant. To perform these assessments, detailed models of the gasification and lime kiln processes were developed using Aspen Plus, a steady state process modeling simulator. The material and energy balance outputs from the Aspen Plus model were used as inputs to both the material and economic evaluations. Figure ES - 1 presents the block flow diagram detailing the major plant areas included in the Aspen Plus process model.

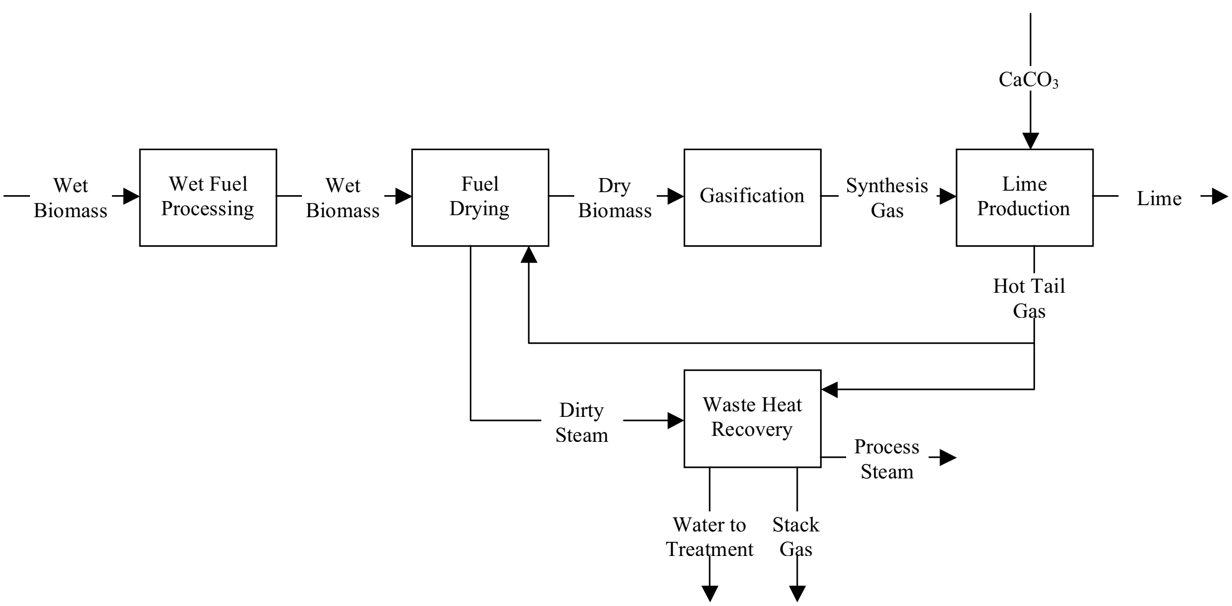

Figure ES - 1. Block Flow Diagram for the Hog Fuel Project

Three scenarios were modeled in Aspen Plus to assess the technical feasibility of gasifying hog fuel. The base case was for a lime kiln operated on natural gas. Case A assumed operation of two gasifiers, with each gasifier having the capacity to process up to 150 tons per day (6.25 tons per hour) of dried biomass at 10% moisture. Additionally, it was assumed that a tar cracker would be required between the gasifier and the lime kiln to prevent condensation of tars and oils present after gasification. The total raw biomass feedrate required for this case was 15.17 tons per hour. Case B assumed operation of two gasifiers, with each gasifier having the capacity to process up to 150 tons per day (6.25 tons per hour) of dried biomass at 10% moisture. This case assumed no tar cracker between the gasifier and the lime kiln. Condensation of tars and oils are avoided in this case by insulating the piping from the reactor outlet to the lime kiln inlet with refractory to maintain a high gas temperature and limiting the piping length. The total raw biomass feedrate required for this case was 14.47 tons per hour.

The gasifier is a refractory lined pressure vessel that will be designed to the requirements of the American Society of Mechanical Engineers Section VIII, Division 1 or 2 codes. The gasifier design is based on Emery Energy Company's E-100A gasifier. The design life is 20 years with anticipated component refurbishment during scheduled maintenance shutdowns. The maximum operating temperature range is 2000-2200°F with a hot gas outlet temperature of 950°F to preclude the formation of tars and oils. Given the elevated operating temperature of the gasifier, it is necessary to select robust materials for the gasifier components, specifically the refractory. Given these high temperatures, high purity alumina or chromia refractories may be more desirable than traditional silica refractories and proper selection of materials for the ash grate is essential.

The economic viability of firing synthesis gas generated from the gasification of hog fuel as a substitute for natural gas in a lime kiln was assessed using standard economic evaluation methods. The total project investment, based on the total equipment costs, along with the variable and fixed operating costs were calculated for each case. The present worth of the offset cost of utilizing biomass versus natural gas along with the capital investments were then calculated for various project payback periods and interest rates. The following table presents the total project investment, yearly manufacturing costs, and the present worth for an interest rate of 10% and project lives of 10 and 20 years for the various cases considered.

Table ES - 1 Economic Results Summary

	Base Case	Case A	Case B
Total Project Investment (TPI)	NA	\$35,496,589	\$28,415,837
Yearly Manufacturing Costs	\$6,270,198	\$5,372,873	\$5,250,369
Present Worth (*i*=10%)			
10 Year Project Investment	NA	-\$30,041,148	-\$22,141,254
20 Year Project Investment	NA	-\$27,905,151	-\$19,713,650

Given the high TPI required for this project and the small offset in the yearly manufacturing costs, utilization of a gasification system for the production of synthetic industrial gas for use in a lime kiln is not economically feasible at this point in time based on the economic evaluation methods utilized in this study. However, several options exist which could improve the economics of this system and cause it to become economically desirable, such as a credit for utilization of biomass as a feedstock or a significant increase in the price of natural gas. In addition, increasing the capacity or output of synthetic natural gas (i.e. increasing the scale of the facility) could improve the project economics.

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ACRONYMS AND NOMENCLATURE

ASME	American Society of Mechanical Engineers
BDT	bone dry ton
BTG	Biomass Technology Group
$CaCO_3$	lime mud
CaO	lime
CEPCI	Chemical Engineering Plant Cost Index
DOE	Department of Energy
EERE	Energy Efficiency and Renewable Energy
HHV	higher heating value
INL	Idaho National Laboratory
IP	intermediate pressure
IRR	internal rate of return
LHV	lower heating value
LP	low pressure
MARR	minimum annual rate of return
NREL	National Renewable Energy Laboratory
PNNL	Pacific Northwest National Laboratory
PW	present worth
TPI	total project investment

Ai	frequency factor for species i
C_1	equipment cost at capacity q_1
C_2	equipment cost at capacity q_2
Ei	activation energy for species i
F_k	cash flow at the end of period k
i	effective interest rate
$[i]$	concentration of species i
i'	internal rate of return
k	index for each compounding period
k_j	kinetic expression for the oxidizing or gasifying species j
k_m	mass transfer coefficient
N	number of compounding periods in the planning horizon
n	exponential factor for cost estimation
q_1	equipment capacity
q_2	equipment capacity
R	gas constant
r	initial particle radius
r_c	current particle radius
r_i	reaction rate for species i
T	temperature
U_s	current solid velocity
U_{so}	initial solid velocity
α	hydrogen content of the char
β	oxygen content of the char
χ	fuel ash content
ε	char bed void space
γ	ratio of CO_2 versus CO for char oxidation
ν_p	particle density number
θ'	discounted payback period

Economic and Technical Assessment of Wood Biomass Fuel Gasification for Industrial Gas Production

1. INTRODUCTION AND PROCESS DESCRIPTION

The objective of the wood biomass fuel gasification project, funded by the Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) Program, was to perform a technical and economic assessment of materials, conceptual designs, and equipment needs for the gasification of forest product biomass to produce synthesis gas suitable for combustion in a lime kiln or a similar industrial process. The objective was accomplished through the completion of a feasibility study for a fixed-bed gasifier and associated equipment required to produce synthesis gas from standard hog fuel as a substitute for natural gas in a conventional lime kiln. An economic assessment was also performed for the reference plant. This project ultimately provides greater understanding of the technical and economic feasibility of using forest product biomass to reduce industrial use of natural gas in the forest products industry. The following sections of this report outline the process model developed for the project, assess gasifier materials issues, and present an economic assessment of the project.

1.1 Introduction

The DOE EERE Program has developed a national strategy for increasing woody biomass utilization. The intent of this strategy is to explore equipment and materials that enable creation of a reliable, sustainable supply of woody biomass and to encourage the formation of stable markets for converting that biomass supply into energy. The effort proposed in this project supports this strategy in terms of enhancing industrial energy security, specifically in the forest products industry, through fuel flexibility for industry.

Lime kilns are used throughout the forest products industry, specifically in the pulp and paper sector, to convert $CaCO_3$ (lime mud) to CaO (lime) for reuse in the causticizing process. The conversion of lime mud to lime requires a significant amount of heat for the reaction to proceed, generally supplied by burning natural gas or fuel oil in the lime kiln. On average, lime kilns require seven to eight million BTUs per ton of lime product or between 1,500 and 2,000 standard cubic feet per minute (scfm) of natural gas to produce 350 tons of lime per day. Substituting synthesis gas for industrial gas in lime kilns would aid in reducing the forest products industry's dependence on and consumption of fossil fuels.

This project addresses both the technical and economic feasibility of replacing industrial gas in lime kilns with synthesis gas from the gasification of hog fuel. The technical assessment includes a materials evaluation, processing equipment needs, and suitability of the heat content of the synthesis gas as a replacement for industrial gas. The economic assessment includes estimations for capital, construction, operating, maintenance, and management costs for the reference plant. To perform these assessments, detailed models of the gasification and lime kiln processes were developed using Aspen Plus, a steady state process modeling simulator. The material and energy balance outputs from the Aspen Plus model were used as inputs to both the material and economic evaluations.

1.2 Process Description

To perform the technical and economic assessments, it was necessary to identify all necessary equipment items and create a general block flow diagram for the production of the synthesis gas, which would be used as a basis for the development of the Aspen Plus model. Figure 1 presents the generalized block flow diagram for the synthesis gas production. Major units include wet fuel processing, fuel drying, gasification, lime production, and waste heat recovery.

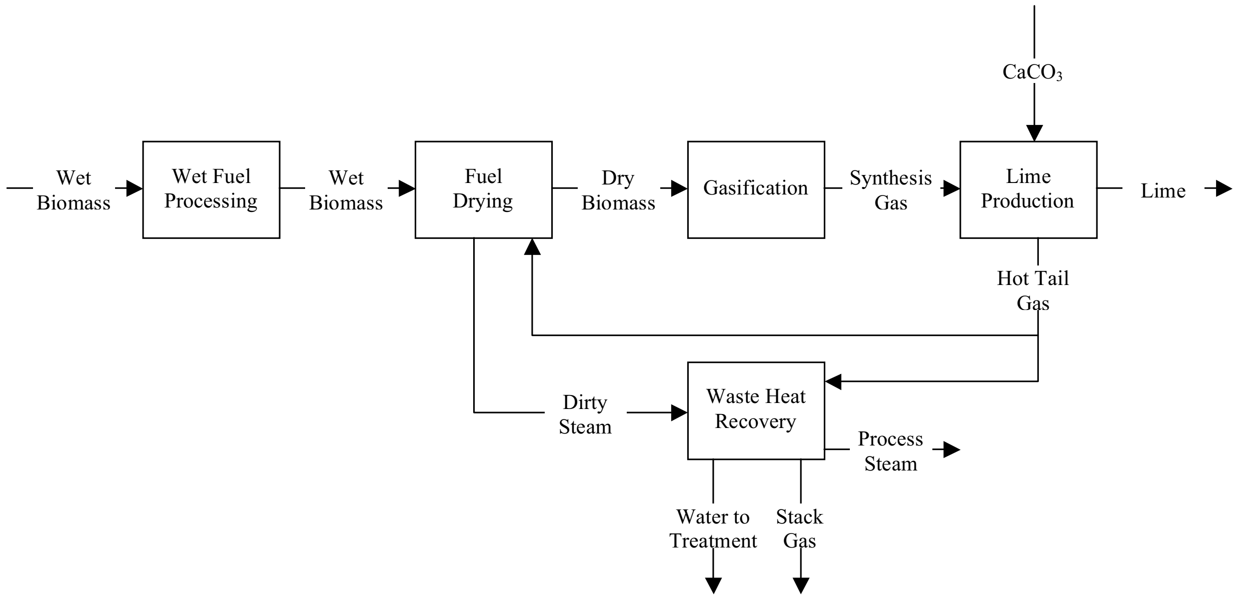

Figure 1. Block Flow Diagram for the Hog Fuel Project

Each process area presented in the block flow diagram is briefly described below:

- **Wet Fuel Processing –** Wet fuel, at approximately 50% moisture by weight, is delivered to the facility via truck. The trucks are weighed using electronic scales and the fuel is unloaded and transferred to a wet fuel storage pile; the storage pile provides seven days of storage. Wet fuel leaves the fuel storage pile and has any metal, stones, and dirt removed. The fuel is then sized; any oversized material is resized using a hammermill. The wet sized fuel is then transferred to an intermediate storage facility providing 12 hours of storage.

- **Fuel Drying –** The wet fuel is dried using a steam drying system. The material is continuously fed from the intermediate storage facility to a plug screw feeder. The wet feed then enters the dryer via a disc shredder and is dispersed into an atmosphere of superheated steam. The steam acts as a transport gas for the material through a drying duct where the moisture evaporates via indirect heat exchange with a portion of the hot tail gas from the lime kiln. The dried product is separated from the steam in a high efficiency cyclone, and discharged to the gasifier at approximately 10% moisture by weight. Steam is recycled back through the dryer using a centrifugal fan. Waste heat can be recovered by passing the surplus steam through a reboiler. Advantages of the superheated steam dryer include: no particle emissions to the atmosphere, low primary energy requirements, minimum thermal degradation due to the short residence time and absence of oxygen, accurate control of product moisture, and no risk of explosion.

- **Gasification –** The biomass is gasified in an atmospheric or near atmospheric air blown countercurrent gasifier based on Emery Energy Company's E-100A gasifier design. The gasifier is a refractory lined pressure vessel designed to American Society of Mechanical Engineers (ASME) codes. Fuel enters at the top of the gasifier, undergoing devolatilization as it flows down towards the ash grate, where a hot char pile develops. Air enters at the bottom of the gasifier and reacts with the char providing the heat for the gasification reactions and fuel devolatilization. A low value BTU synthesis gas is removed from the top of the gasifier. The ash is removed from the bottom of the unit through the ash grate. The temperature of the ash is controlled by the amount of air fed to the gasifier in order to prevent slagging. An optional tar cracker can be included to convert the tars and oils present in the synthesis gas to carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), and water (H_2O).

- **Lime Kiln –** The synthesis gas is delivered to the lime kiln to be combusted to provide the heat necessary to convert $CaCO_3$ to CaO and CO_2. The synthesis gas flow to the kiln is dictated by the amount of heat necessary to drive the conversion of $CaCO_3$. Tail gas from the kiln is used to dry the $CaCO_3$ mud and provide steam generation.

- **Waste Heat Recovery –** Waste heat is recovered from the dirty steam produced in the fuel dryer and the hot tail gas from the kiln to produce intermediate pressure (IP) and low pressure (LP) process steam.

2. PROCESS MODEL

2.1 Model Description

The plant model was developed using Aspen Plus. Aspen Plus is a steady-state process simulator that includes extensive thermodynamic databases, built-in routines for common unit operations, and the ability to properly handle complex chemical feedstocks such as coal and biomass. Due to the size and complexity of the process modeled, the simulation was constructed using “hierarchy” blocks, which is a method for nesting one simulation within another simulation. In this fashion, submodels for each major plant section can be constructed separately and then combined to represent the entire process. To facilitate utility tracking, Aspen Plus “utility” blocks were used to track IP and LP steam generated throughout the process.

2.2 Top-Level Model

2.2.1 Model Description

The top-level Aspen Plus flowsheet is shown in Figure 2. The principal purpose of this flowsheet is to tie together all of the detailed hierarchy blocks, or submodels. However, for convenience, some unit operations are modeled directly on the top-level flowsheet. A brief summary of these operations is presented below, while the individual hierarchy blocks are discussed in detail in Section 2.3 of this report.

- **Gas Compression –** The gas pressure of certain streams must be adjusted between blocks; hence, three compressors, Compr blocks, are included on the top-level flowsheet. Block AIR-BLWR is used to simulate a blower that increases the pressure of air from near atmospheric to 25 psi in preparation for injection into the gasifier. Block AIRBLWR2 is used to simulate a blower that increases the pressure of air from near atmospheric to 24 psi in preparation for injection into the tar cracker. Block TG-BLWR is used to simulate a blower which draws tail gas from the lime kiln and fuel dryer heat exchanger, and increases the pressure to atmospheric so it can be ejected out the stack.

- **Steam Generation –** LP steam is generated at 54 psi by recovering heat from the discharge steam from the biomass dryer in a reboiler. LP steam generation is modeled in a heat exchanger, Heater block, LPSTM. The outlet temperature of the dirty water exiting the

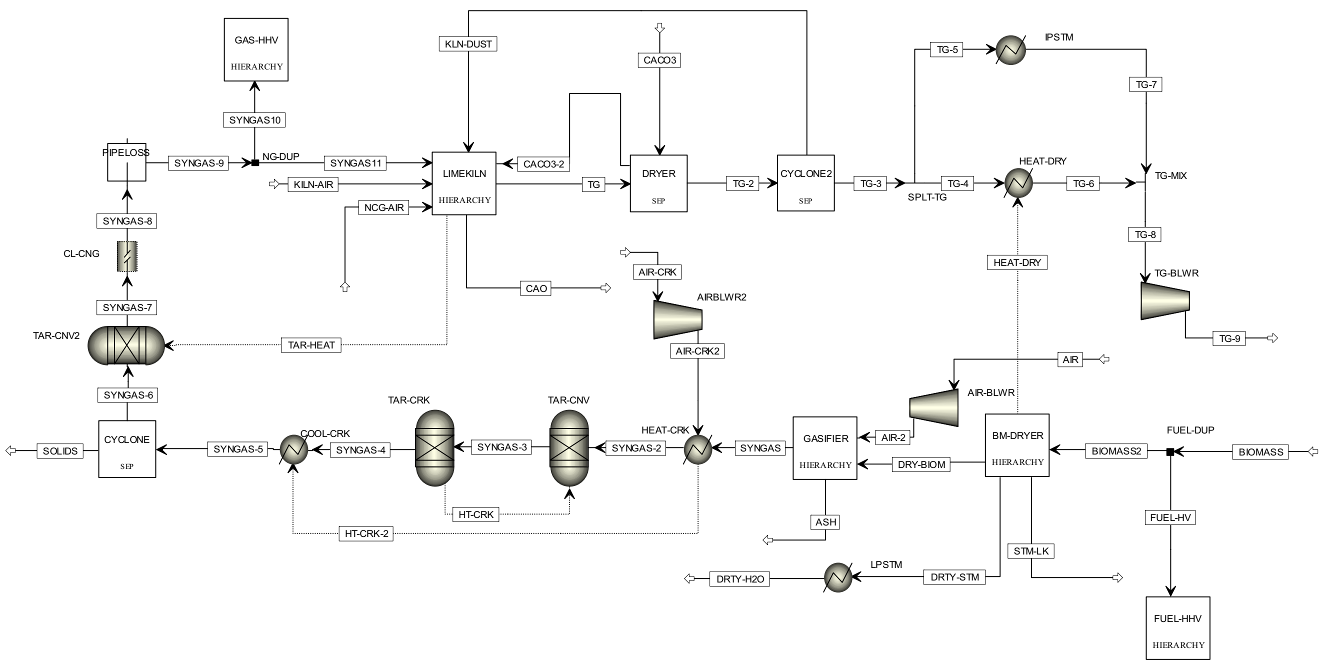

Figure 2. Top-Level Aspen Plus Process Flowsheet

reboiler was set to 176°F, this temperature was specified by the manufacturer, GEA Barr-Rosin, in the heat and mass balance of the Exergy® dryer. A pressure drop of one psi was assumed for the water exiting the reboiler. IP steam is generated at 170 psi by recovering heat from the portion of the tail gas not diverted to the biomass dryer. IP steam generation is also modeled using a Heater block, IPSTM. The outlet temperature of the tail gas exiting the IP steam generator is set to 250°F and a pressure drop of two psi was assumed.

- **Tar Cracking and Conversion –** A tar cracker is modeled using the TAR-CNV and TAR-CRK reactor blocks. TAR-CNV converts 96% of the non-conventional tar component present in the synthesis gas stream to carbon, hydrogen, and oxygen, which is dependent upon the ultimate analysis of the tar, using a reactor yield block, RYield. The 96% tar conversion is based on published conversion data from Biomass Technology Group (BTG) (BTG 2007). Fortran calculator block TARYLD is used to maintain the mass balance and block temperature when converting the tar. TAR-CRK reacts the carbon, hydrogen, and oxygen from the tar and the methane (CH_4), CO_2, CO, oxygen (O_2), H_2O, and H_2 from the synthesis gas and air streams at 1742°F to equilibrium using a Gibbs reactor block, RGibbs. It is necessary to preheat the air for cracking, AIR-CRK, and the synthesis gas entering the tar cracker to 1652°F using the hot synthesis gas exiting from the cracker. A heat exchanger is modeled using two interdependent Heater blocks, HEAT-CRK and COOL-CRK. A pressure loss of two psi is assumed for both the hot and cold synthesis gas streams exiting the heat exchanger and a minimum temperature approach of 90°F is assumed by setting the preheat temperature to 1652°F. The remaining non-conventional, highly refractory tar component is broken down to carbon, hydrogen, and oxygen using an additional RYield block, TAR-CNV2, prior to the syngas being fed to the lime kiln. Again, a Fortran calculator block, TARYLD2, is used to maintain the mass balance and block temperature when converting the tar.

- **Solids Separation –** The cyclone downstream of the gasifier and tar cracker, CYCLONE, is modeled using a generic separation block, Sep. This block removes all of the solid materials, including ash, unreacted fuel, and char from the gas stream. Solids are assumed to leave this block at atmospheric pressure and a pressure drop of two psi was assumed for the gas stream exiting the cyclone. The CYCLONE block is actually modeling two cyclones, one before and one after the tar cracker. The cyclone downstream of the lime kiln, CYCLONE2, is also modeled using a Sep block. This block separates the CaO dust from the tail gas. The CaO dust is then recycled back to the lime kiln, a pressure drop of one psi was assumed.

- **Piping –** Heat loss and pressure drop are simulated for the length of piping between the gasifier and lime kiln using a Heater block, PIPELOSS. Pressure drop in the piping is assumed to be 0.5 psi. The outlet temperature of the piping was set to 600°F to account for heat loss.

- **Lime Kiln Dryer** – The block DRYER, a Sep block, is used to simulate drying the moist $CaCO_3$ mud using heat from the hot tail gas from the lime kiln. The hot mud outlet temperature is specified at 635°F (Gorog 2002). The evaporated water leaves the dryer with the tail gas and the hot $CaCO_3$ is passed to the lime kiln.

- **Biomass Dryer Heat Exchanger** – A Heater block is used to simulate the heat loss from the portion of the tail gas used to dry the wet biomass. The heat required is dictated by the amount of moisture evaporated and removed from the biomass. A pressure drop of two psi was assumed for the tail gas exiting the heat exchanger.

2.2.2 Design Constraints and Specifications

The following design constraints are specified in the top-level model to control the operation of the biomass dryer, gasifier, and lime kiln:

- The flow of air to the gasifier is varied in the design specification AIR-GASF to maintain an ash outlet temperature of 2000°F. This ash temperature was chosen since it is well below the ash softening point for hog fuel, which is approximately 2400°F, and provides the exit gas a suitable temperature for either tar cracking or tar retention (Zygarlicke 2004).

- The flow of air to the tar cracker is varied in the design specification AIR-CRK so that the heat generated in the TAR-CRK block is equal to the heat required to convert the non-conventional tar to carbon, hydrogen, and oxygen while maintaining the inlet temperature of the gas stream across the TAR-CNV block.

- The flow of air to the lime kiln is varied in the design specification AIR-KILN so that there is 1.8% excess oxygen, on a mass basis, after the fuel is fired in the lime kiln. The amount of excess air was taken from a Weyerhaeuser lime kiln overview presentation for the Kamloops lime kiln (Gorog 2002).

- The flow of biomass to the biomass dryer is varied in the design specification FUEL. This design specification varies the feed rate of the fuel so that the outlet temperature of the tail gas exiting the lime kiln is approximately 1250°F (Gorog 2002).

- The design specification DRY-KILN sets the calculated duty of the $CaCO_3$ dryer, DRYER, to zero by adjusting the outlet flash temperature of the tail gas exiting the dryer.

- SPLT-TG controls the amount of tail gas sent to the heat exchanger used to dry the biomass SPLT-TG. This specification sets the outlet temperature of the tail gas leaving the heat exchanger to 250°F by adjusting the flow of tail gas to the heat exchanger HEAT-DRY.

- To maintain the temperature of the gas entering and exiting block TAR-CNV2, specification TARTEMP adjusts the heat stream to the block to the amount of duty required to convert tar to carbon, hydrogen, and oxygen. This heat stream is supplied from a heat stream in the LIMEKILN hierarchy, since this conversion would actually take place in the lime kiln burner.

- A Fortran calculator block, GASF-P, is used to set the pressure of the first block in the GASIFIER hierarchy to the outlet pressure of the AIR-BLWR block. This calculator block also adjusts the pressure of AIRBLWR2 to match the outlet pressure of the synthesis gas stream exiting the gasifier.

2.2.3 Data Sources, Assumptions, and Limitations

A combination of open literature and operating data was used to specify parameters for the unit operations, calculator blocks, and design specifications used in the top-level model. Proximate and ultimate analyses for hog fuel were obtained from literature (Zygarlicke 2004). Compressor efficiencies in this model have been set at Aspen Plus defaults of 72%. This can have a significant impact on the power requirements for the blowers used in this model; thus, it is recommended to tune these results based on performance data from vendors for more accurate modeling results. In addition, generalized pressure drops are assumed for the majority of the process equipment items; again, it is recommended to obtain pressure drop data from the vendors for the appropriate equipment items for increased accuracy.

2.3 Submodels

2.3.1 Biomass Dryer

2.3.1.1 Submodel Description

Biomass drying is modeled using design data supplied by GEA Barr-Rosin. The Aspen Plus flowsheet for this hierarchy block is shown in Figure 3. Biomass drying is simply modeled in Aspen Plus using four blocks. MOISTYLD, the first block, is modeled as a RYield reactor in Aspen Plus. In MOISTYLD, a Fortran calculator block is utilized to partition water from the solid biomass into the vapor phase, the moisture content of the biomass after drying is assumed to be 10% on a mass basis. Additionally, the pressure is raised to the pressure required to saturate the steam in the drying loop, 58.2 psi. In the second block, heat from the HEAT-DRY block in the top-level model is passed to the SPR-HTR, a Heater block, to raise the temperature of the outlet stream to 419°F. In the third block, DISCHRG, water vapor is separated from the biomass using a Sep block. The fourth block, STM-SPLT, separates a small percentage of the steam generated in the block lost to steam leakage using a Sep block, the remainder of the steam is sent to the reboiler in the top-level model.

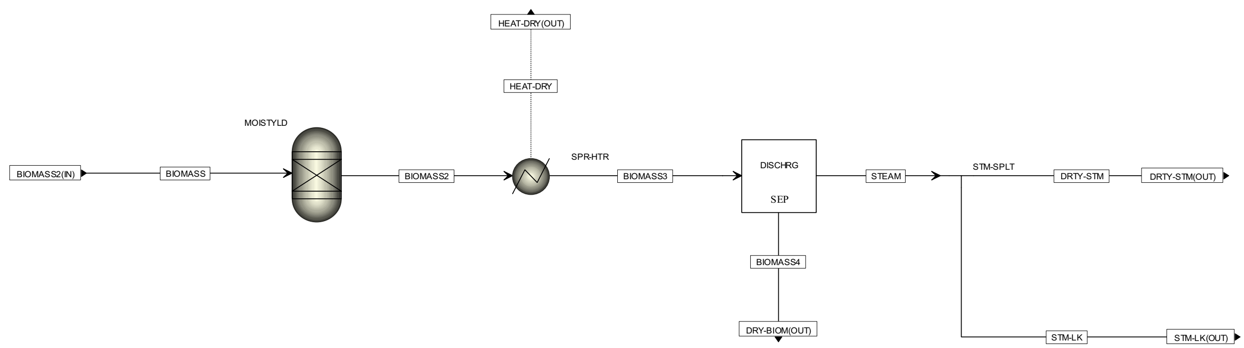

Figure 3. Aspen Plus Process Flowsheet for BM-DRYER Hierarchy Block

2.3.1.2 Data Sources, Assumptions, and Limitations

The heat and mass balance of the Exergy Dryer® from GEA Barr-Rosin was utilized as inputs to the unit operations used to model the biomass dryer. However, this data was for a steam to wet biomass heat exchanger; hence, it is recommended to tune these results based on heat and mass balance data from GEA Barr-Rosin for a tail gas to wet biomass heat exchanger, which was not available at the time of modeling.

2.3.2 Gasification

2.3.2.1 Submodel Description

Drying, devolatilization, and gasification of the biomass and ash separation are performed in the GASIFIER hierarchy block. Drying and devolatilization are performed separately from gasification to mimic the countercurrent operation of the fixed bed gasifier modeled, where the heat required to dry and devolatilize the fuel is exchanged with the outlet synthesis gas stream to determine the outlet temperature of the gas leaving the gasification zone. The Aspen Plus flowsheet for this hierarchy block is shown in Figure 4.

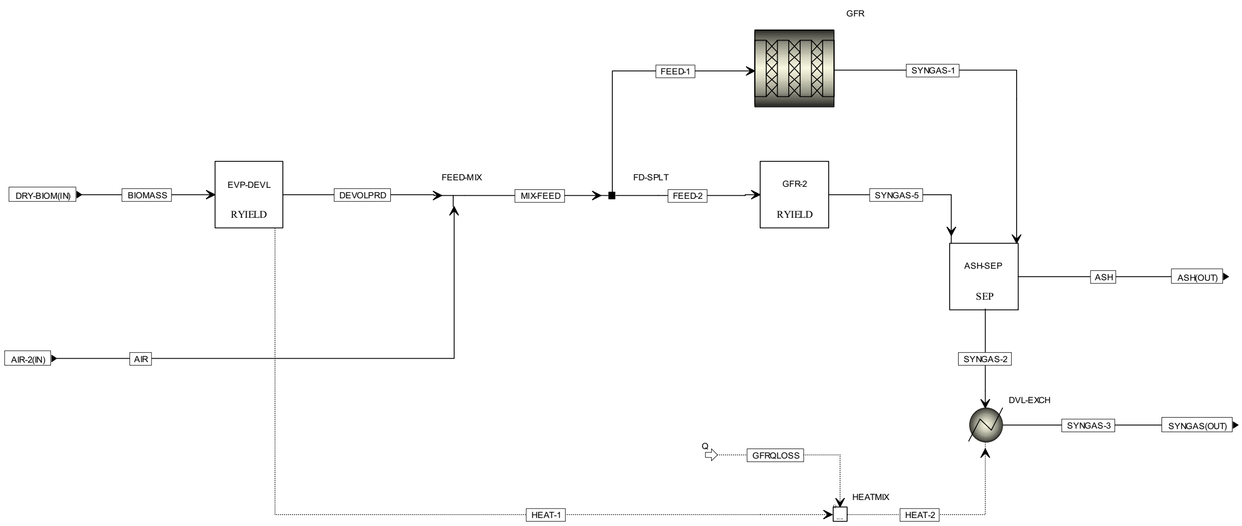

Figure 4. Aspen Plus Process Flowsheet for GASIFIER Hierarchy Block

Biomass drying and devolatilization are modeled simply in Aspen Plus using a single block. In this block, EVP-DEVL, the temperature is raised to the devolatilization temperature of 1652°F. Heat transfer from the gasifier outlet hot gas stream provides the heat required for drying and devolatilization. EVP-DEVL is modeled as a RYield reactor in Aspen Plus, and a Fortran calculator block, EVPDVL, is utilized to partition water from the solid biomass into the vapor phase. This Fortran block is also used to partition the carbon, hydrogen, and oxygen present in the fuel as water, char, tar, and gas products, including CO, CO_2, H_2, and CH_4. The amount of devolatilization products formed was taken from a study which evaluated the amount of various devolatilization products from biomass, including tar cracking reactions. This study was well suited for this modeling application, since the devolatilization experiments for wood were conducted using three to five millimeter wood chips versus typical experiments, which devolatilize fine particles of wood, such as sawdust (Fagbemi 2001).

After drying and devolatilization, four Aspen Plus blocks are used to model the remaining sections of the gasifier. First, air from the top-level model is mixed with the hot devolatilization products from the EVP-DEVL block. The flow is then split, and sent to one of two gasifier blocks. The first block, GFR, is modeled using a plug flow reactor block, RPlug, supplemented with a Fortran user kinetic subroutine. The second block, GFR-2, uses a Fortran calculator block, RNX-2, to assign product yields to an Aspen Plus RYield block to match the yields generated in the rigorous GFR block. Both gasifier blocks specify a pressure drop of 0.54 psi (Emery 2007). Next, the ash species generated in the gasification reaction, are separated from the gas products using a Sep block. Finally, the outlet temperature of the gases and tar leaving the gasifier is determined by the DVL-EXCH Heater block, which removes the required heat from the hot gas stream to devolatilize and dry the biomass. Heat loss from the gasifier is assumed to be one percent of the enthalpy of the products entering the reactor and is calculated in the Fortran block GFRQLOSS (Emery 2007).

2.3.2.2 Design Constraints and Specifications

The Fortran kinetic user subroutine is used to calculate the rate generation or depletion for each component in the system. This kinetic routine was developed based upon the kinetics described in the *Modeling Wood Gasification in a Countercurrent Fixed-Bed Reactor* (Di Blasi 2004). Individual kinetic expressions for the reactions modeled in the subroutine were obtained from literature. The reactions modeled can be broken down into gas phase reactions and char reactions.

Gas phase reactions include the reaction of CH_4, CO, and H_2 with O_2 and the forward and reverse water gas shift reactions. Kinetic expressions for the oxidation reactions were taken from "Solid Fuels Combustion and Gasification" (Souza-Santos 2004). The reaction of CH_4 and O_2 can be represented by the following chemical reaction and kinetic rate expression:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \quad (1)$$

$$r_{CH_4} = \varepsilon \cdot A_{CH_4} \cdot T^{-1} \cdot \exp\left(\frac{-E_{CH_4}}{T}\right) \cdot [CH_4] \cdot [O_2] \quad (2)$$

where ε is the void space in the bed, A_{CH4} is the frequency factor, E_{CH4} is the activation energy, T is the temperature in the reactor, $[CH_4]$ is the concentration of methane in the reactor, and $[O_2]$ is the concentration of oxygen in the reactor (Souza-Santos 2004). Similar expressions for the reactions of CO and H_2 with O_2 are defined as follows:

$$2CO + O_2 \rightarrow 2CO_2 \quad (3)$$

$$r_{CO} = 2 \cdot \varepsilon \cdot A_{CO} \cdot \exp\left(\frac{-E_{CO}}{T}\right) \cdot [CO] \cdot [O_2]^{0.25} \cdot [H_2O]^{0.5} \quad (4)$$

$$2H_2 + O_2 \rightarrow 2H_2O \quad (5)$$

$$r_{H_2} = 2 \cdot \varepsilon \cdot A_{H_2} \cdot T^{-1.5} \cdot \exp\left(\frac{-E_{H_2}}{T}\right) \cdot [H_2]^{1.5} \cdot [O_2] \quad (6)$$

where A_{CO} and A_{H2} are the frequency factors, E_{CO} and E_{H2} are the activation energies, $[CO]$ is the concentration of carbon monoxide in the reactor, $[H_2O]$ is the concentration of water in the reactor, and $[H_2]$ is the concentration of hydrogen in the reactor (Souza-Santos 2004).

To accurately model the water gas shift reaction, kinetic expressions were entered in the user subroutine for both the forward and reverse gas shift reactions. The forward reaction is represented in the code by the following chemical reaction and kinetic rate expression:

$$CO + H_2O \rightarrow CO_2 + H_2 \quad (7)$$

$$r_{fwgs} = \varepsilon \cdot A_{fwgs} \cdot \exp\left(\frac{-E_{fwgs}}{R \cdot T}\right) \cdot [H_2O] \cdot [CO]^{0.5} \quad (8)$$

where A_{fwgs} is the frequency factor, E_{fwgs} is the activation energy, and R is the gas constant (Enick 2005). The reverse water gas shift reaction rate expression takes a similar form to the forward reaction:

$$CO_2 + H_2 \rightarrow CO + H_2O \quad (9)$$

$$r_{rwgs} = \varepsilon \cdot A_{rwgs} \cdot \exp\left(\frac{-E_{rwgs}}{R \cdot T}\right) \cdot [H_2]^{a} \cdot [CO_2] \quad (10)$$

where A_{rwgs} is the frequency factor, E_{rwgs} is the activation energy, and a is the exponential factor for the hydrogen concentration; a is equal to 1/3 when the temperature is less than 1472°F and equal to 1/2 when temperature is greater than 1472°F (Bustamante 2005).

The combustion and gasification reactions of char are heterogeneous and best described by the unreacted core, shrinking particle model. The mechanisms of diffusion through the gas film surrounding the particle and chemical kinetics are considered for the global reaction rate. To account for the simultaneous effects of these two mechanisms, an effective volumetric reaction rate is introduced which assumes a linear dependency on the oxidizing/gasifying species concentration. Thus, shrinkage of the particle occurs as a consequence of the heterogeneous reactions (Di Blasi 2004). The following oxidation and gasification reactions were included in the model:

$$CH_\alpha O_\beta + \gamma O_2 \rightarrow \left(2 - 2\gamma - \beta + \frac{\alpha}{2}\right) CO + \left(2\gamma + \beta - \frac{\alpha}{2} - 1\right) CO_2 + \frac{\alpha}{2} H_2O \quad (11)$$

$$CH_\alpha O_\beta + CO_2 \rightarrow 2CO + \beta H_2O + \left(\frac{\alpha}{2} - \beta\right) H_2 \quad (12)$$

$$CH_\alpha O_\beta + \left(2 - \frac{\alpha}{2} + \beta\right) H_2 \rightarrow CH_4 + \beta H_2O \quad (13)$$

$$CH_\alpha O_\beta + (1 - \beta) H_2O \rightarrow CO + \left(1 - \beta + \frac{\alpha}{2}\right) H_2 \quad (14)$$

where α is the hydrogen content of the char, β is the oxygen content of the char, and γ defines the ratio of CO_2 versus CO formed in the char oxidation reaction (Di Blasi 2004). Gamma is defined as a function of reaction temperature as follows (Souza-Santos 2004):

$$\gamma = \frac{2 + 2500 \cdot \exp\left(\frac{-6240}{T}\right)}{2 + 2 \cdot 2500 \cdot \exp\left(\frac{-6240}{T}\right)} \quad (15)$$

The following reaction rates, r_i, are considered for each of the oxidation and gasification reactions:

$$r_i = \frac{[i]}{\frac{1}{k_m} + \frac{1}{k_i}} \cdot v_p \qquad i = O_2, CO_2, H_2, H_2O \quad (16)$$

where $[i]$ is the concentration of the oxidizing or gasifying species, k_m is the mass transfer coefficient (0.15 m/s), k_i is the kinetic expression for the oxidizing or gasifying species, and v_p is the particle density number. The kinetic expression for each oxidizing/gasifying species takes the following form:

$$k_i = A_i \cdot \exp\left(\frac{-E_i}{T_s}\right) \quad (17)$$

where A_i is the frequency factor for each oxidizing/gasifying species, E_i is the activation energy for each oxidizing/gasifying species, and T_s is the temperature of the solid (Di Blasi 2004). The values for the frequency factors and activation energies were taken from the fixed bed model developed by Hobbs (1992). To simplify the Aspen Plus model, it was assumed that the temperature of the solid is equal to the overall temperature in the reactor, given the long solids residence time compared to the time for the heat to distribute through the small particles. The particle density number is a function of the ash content of the fuel and the ratio of the current particle velocity to the initial particle velocity. The particle density number is defined in terms of the following expressions:

$$\nu_p = \frac{3(1-\varepsilon)}{r_c} \tag{18}$$

$$\left(\frac{r_c}{r}\right)^3 = (1-\chi)\cdot\frac{U_s}{U_{so}} + \chi \tag{19}$$

where r_c is the current particle radius, r is the initial particle radius, χ is the ash content of the fuel, U_s is the current solid velocity, and U_{so} is the initial solid velocity (Di Blasi 2004). The kinetic user subroutine used in the model and model results are presented in Appendices C and A, respectively.

2.3.2.3 Results Comparison

To assess the predictive capabilities of the kinetic model, model results were compared to actual gas compositions from industrial and laboratory scale updraft biomass gasifiers. Table 1 compares the operational gas compositions with those predicted by the Aspen Plus model for the Wellman single stage gasifier and a laboratory scale gasifier at Pacific Northwest National Laboratory (PNNL). Mass flows for biomass, air/oxygen, and steam were obtained directly from the technical articles, or back calculated from material balances. Biomass proximate and ultimate analyses were updated for the appropriate carbon, hydrogen, oxygen, moisture, and ash contents of the fuels. As shown below, the Aspen Plus kinetic model adequately predicts gas composition within 5% of measured results.

Table 1. Gas Composition Comparisons (vol%)

	Actual	Aspen Plus
Wellman Single Stage Gasifier (McLellan 2000)		
H_2	7.9	6.6
CH_4	1.2	2.5
H_2O	38.8	38.0
CO	18.3	17.2
N_2	29.4	29.5
CO_2	4.4	5.7
PNNL Laboratory Results (Baker 1984)		
H_2	27.5	28.9
CH_4	4.8	7.8
CO	51.6	52.7
CO_2	15.1	11.1

2.3.2.4 Data Sources, Assumptions, and Limitations

As mentioned previously, biomass drying and devolatilization are modeled simply in Aspen Plus using a single yield block supplemented with a Fortran block to determine the devolatilization products. Again, the amount of the devolatilization products formed was taken from the Fagbemi study; however, the devolatilization products from this study were altered slightly to maintain a similar tar composition for the tar produced from devolatilization in this study when compared to the tar composition in Fagbemi, as well as maintain the material balance for carbon, hydrogen, and oxygen. Table 2 compares the data presented in Fagbemi versus the devolatilization data used in the Aspen Plus model. For future models, devolatilization measurements should be obtained for the specific fuel in question, and tests should be run if measurements are not available.

Table 2. Comparison of Devolatilization Data

	Fagbemi	Aspen Plus
Devolatilization Products		
Gas Mass %	47	47
Tars Mass %	10	10.5
Char Mass %	20	22
Water Mass %	22	20.5
Fuel Composition		
Carbon	45.68	44.74
Hydrogen	6.3	5.5
Oxygen	47.42	43.45
Ash	0.3	6.31
Tar Composition		
Carbon	53.9	59.5
Hydrogen	6.8	7.1
Oxygen	39.3	33.4

The kinetic data for the gas phase and char reactions were pieced together from the most reliable and recent literature sources available. However, there is significant variation in the rates for many of the reactions present in this model. In addition, kinetic data for some reactions, such as the forward and reverse water gas shift reactions, have only been validated over a narrow temperature range. Thus, future work should involve verification of the various kinetic expressions to minimize uncertainty. Furthermore, formation of NO_x and SO_x is not included in this model. Incorporation of these criteria pollutants and their corresponding kinetic expressions should be included in future versions of the model.

The model does not account for gasification of the tars created during devolatilization. This is because the concentration of tars created in the devolatilization routine match literature data for the tar and oil concentrations in updraft biomass gasification, approximately 50 grams per normal cubic meter (Evans 1998). In addition, the model does not have predictive capabilities for char conversion. In the model, it is assumed that 95% of the char is converted to gas products, which is a conservative assumption for a properly operated updraft biomass gasifier.

2.3.3 Lime Kiln

2.3.3.1 Submodel Description

The lime kiln is modeled in the LIMEKILN hierarchy to predict the amount of fuel necessary to fire a standard lime kiln. The lime kiln was modeled based upon information from a Weyerhaeuser lime kiln overview presentation for the Kamloops lime kiln (Gorog 2002). The Aspen Plus flowsheet of the LIMEKILN hierarchy is shown in Figure 5.

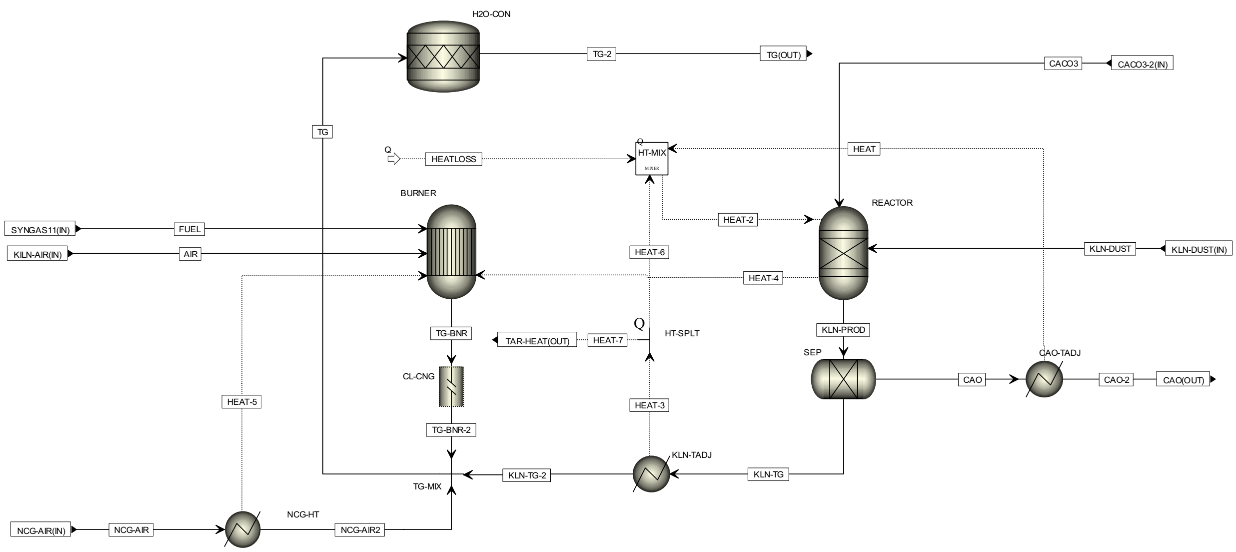

Figure 5. Aspen Plus Process Flowsheet for LIMEKILN Hierarchy Block

The LIMEKILN hierarchy is comprised of the following Aspen Plus unit operation blocks:

- **BURNER** – Combusts the synthesis gas and the air supplied to the lime kiln. This block is modeled using a RGibbs block at atmospheric pressure. The heat streams fed to the reactor dictate the reaction temperature of the block.

- **CL-CNG** – This block changes the stream class to MIXCISLD, since solid components are used in the lime kiln.

- **REACTOR** – This block reacts the $CaCO_3$ to CaO and CO_2 with the heat supplied from the BURNER block using a RGibbs block. The temperature of this reactor block is set at 2282°F, the average temperature for the lime reaction (Speight 2002).

- **SEP** – This Sep block separates the CaO from the tail gas after the REACTOR block. However, a portion of the CaO product leaves with the tail gas as entrained CaO dust.

- **KLN-TADJ** – Cools the tail gas from the REACTOR block to the temperature of the tail gas from TG-BNR, 1250°F, using a Heater block, as specified in the Weyerhaeuser presentation.

- **CAO-TADJ** – This Heater block cools the CaO product from the REACTOR block to 1300°F. Again this temperature was specified in the Weyerhaeuser presentation.

- **HT-SPLT –** Provides the heat required to the top-level model to convert the tar present in the synthesis gas to carbon, hydrogen, and oxygen based on a design specification in the top-level model which controls the split in HT-SPLT.

- **NCG-HT** – Heats the additional air fed to the gasifier to the outlet temperature of the tail gas using a Heater block. The excess air flow was specified in the Weyerhaeuser presentation.

- **H2O-CON** – The water fed with the $CaCO_3$ is converted to water in a stoichiometric reactor block, RStoic. Two types of water were used in this simulation to track the water dried from the lime mud and the water present in the tail gas after being burned in the lime kiln.

- **HT-MIX –** This block is used to mix all of the heat generated and consumed internally in the lime kiln to accurately predict the amount of fuel required to fire the lime kiln. The stream HEATLOSS was specified to match the heat loss listed in the Weyerhaeuser presentation.

2.3.3.2 Data Sources, Assumptions, and Limitations

The lime kiln was modeled based upon information from a Weyerhaeuser lime kiln overview presentation for the Kamloops lime kiln (Gorog 2002). The data from this report is for a specific kiln, it would be beneficial to verify the kiln requirements for other operational lime kilns. However, the results generated in the Aspen Plus model closely match the data from the Weyerhaeuser presentation as shown in the following table, when natural gas is used to fire the lime kiln.

Table 3. Comparison of Lime Kiln Data

	Weyerhaeuser	Aspen Plus
Mass Flows (ton/hr)		
Mud Feed	30.69	30.69
Kiln Product	14.75	14.75[1]
Combustion Air	42.10	41.29[1]
Natural Gas	2.24	2.29[1]
Kiln Dust	1.35	1.34
Tail Gas from Drier	60.8	61.4[1]
Kiln Heat Requirement (MMBTU/ton)		
Natural Gas Model	7.17	7.17[1]

1 – Indicates value predicted by Aspen Plus process model

2.3.4 Heating Value Calculations

2.3.4.1 Submodel Description

Two hierarchy blocks are included in the simulation that do not represent process unit operations: BIOMASS-HHV and GAS-HHV. These blocks are included as checks to calculate the heating value of the biomass feed and the synthesis gas. Because these blocks are similar, only one of them will be detailed in this report. The Aspen Plus flowsheet for hierarchy block BIOMASS-HHV is shown in Figure 6.

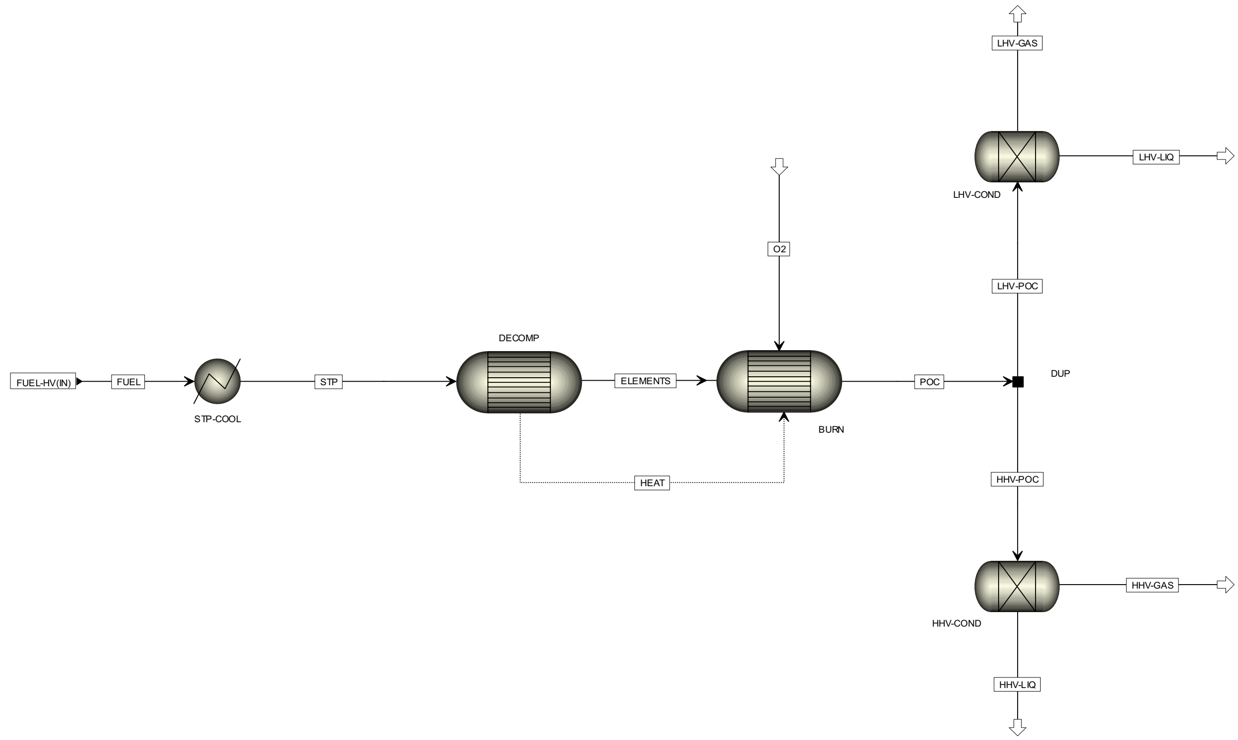

Figure 6. Aspen Plus Process Flowsheet for BIOMASS-HHV Hierarchy Block

The biomass feed is set to standard conditions for temperature and pressure in Heater block STP-COOL (68°F and 14.7 psi). This stream is then decomposed into H_2O, carbon (C), H_2, O_2 in RYield block DECOMP using a Fortran calculator block similar to that previously described for tar decomposition. To maintain the heat balance, all heat generated from decomposition of the biomass is transferred with the effluent gas to RStoic block BURN. In this block, a stoichiometric amount of oxygen is added to completely combust the gas. An unrealistically high temperature is predicted, but because temperature is a state function this will not adversely impact final calculation of the heating value for the biomass. The hot gas stream exiting block BURN is duplicated into two identical streams in Dupl block DUP. Each resulting stream is subsequently cooled back to 68°F either in block LHV-COND or HHV-COND, both of which are modeled as Sep blocks. These two blocks are specified to partition all gas species from the remaining solid ash. However, block LHV-COND partitions water as liquid with the ash, whereas block HHV-COND partitions water as vapor with the other gases. The resulting duty of each block is divided by the mass flow rate of biomass entering the hierarchy block to calculate the heating value of the biomass. Due to the different handling of water, the value calculated for LHV-COND is the lower heating value (LHV) for the biomass, while the value calculated for HHV-COND is the higher heating value (HHV) for the biomass.

2.3.4.2 Design Constraints and Specifications

The three calculator blocks used in this hierarchy block are briefly described below:

- **DECOMP** – The biomass proximate and ultimate analyses are utilized to calculate appropriate yield values for block DECOMP.

- **O2** – The stoichiometric amount of oxygen required for complete combustion of gas stream ELEMENTS is calculated, and the result is used to set the flow of stream O_2.

- **CALC** – The duties of blocks LHV-COND and HHV-COND are divided by the flow rate to calculate the LHV and HHV of the biomass. The results are written to the Aspen Plus control panel.

2.3.4.3 Data Sources, Assumptions, and Limitations

To perform a rigorous heating value calculation, a correction for free-moisture hydrogen is generally included. Because such a correction is not included in the calculation described above, the result will differ slightly from the input heating value for the biomass (i.e., Aspen Plus's built-in handling of enthalpy in block DECOMP does include a correction for free-moisture hydrogen). However, the calculations in this hierarchy block are performed only as a means to quickly identify a gross error in the model, and the accuracy is sufficient to accomplish this purpose.

2.3.5 Model Summary Calculations

Fortran calculator block CALC (discussed previously in Section 2.3.4) provides the results of the biomass and synthesis gas heating value calculation:

- LHV calculation (wet and dry basis)

- HHV calculation (wet and dry basis)

In addition, the CALC block provides results for the cold gas efficiency and the total heat supplied (MMBTU) to the lime kiln.

2.4 Modeling Results

2.4.1 Case Descriptions

Three scenarios were considered as part of the hog fuel project. The assumptions for each case are summarized briefly below:

- **Base Case** – Model for lime kiln operated on natural gas, based on Kamloops kiln.

- **Case A –** Two gasifiers will be operated. Each gasifier has a capacity to process up to 150 tons per day (6.25 tons per hour) of dried biomass at 10% moisture. Additionally, it is assumed that a tar cracker is required between the gasifier and the lime kiln to prevent condensation of tars and oils present after gasification. Total raw biomass feedrate for this case is 15.17 tons per hour.

- **Case B –** Two gasifiers will be operated. Each gasifier has a capacity to process up to 150 tons per day (6.25 tons per hour) of dried biomass at 10% moisture. This case assumes no tar cracker between the gasifier and the lime kiln and one less cyclone between the gasifier and the kiln; hence, CYCLONE only has a pressure drop of one psi. Condensation is avoided in this case by insulating the piping from the reactor outlet to the lime kiln inlet with refractory to maintain a high gas temperature, above 750°F (Knoeff 2007), and limiting the piping length to 65 feet (Mudge 1986). The outlet temperature of the PIPING block is set to 850°F. Total raw biomass feedrate for this case is 14.47 tons per hour.

2.4.2 Results Summary

A summary of the modeling results for the case studies is presented in Table 4. A more complete summary for each case can be found in Appendix A. In addition, a complete Aspen Plus model report for Case A is presented in Appendix B.

Table 4. Summary of Modeling Case Study Results

	Base Case	Case A	Case B
Biomass to Gasifier (50% Moisture, tons/hr)	NA	15.17	14.47
Air to Gasifier (tons/hr)	NA	6.28	6.09
Gasifier Operating Pressure (psi)	NA	25	17
Gasifier Exit Temperature (°F)	NA	940	947
Gasifier Exit Gas Composition (vol%)			
N_2	NA	29.2	29.5
CO_2	NA	4.3	4.7
CO	NA	31.3	30.7
Ar	NA	0.4	0.4
H_2O	NA	16.7	16.4
H_2	NA	13.8	14.0
Tars and Oils Concentration (mg/Nm^3)	NA	49.5	49.2
Air to Tar Cracker (tons/hr)	NA	2.96	NA
Tar Cracker Heat Exchanger Exit Temperature (°F)	NA	1000	NA
Gas to Lime Kiln (tons/hr)	2.29	17.0	13.5
Gas Temperature to Lime Kiln (°F)	68	600	850
Air to Lime Kiln (tons/hr)	41.29	31.7	32.9
Synthesis Gas Composition to Lime Kiln (vol%)			
N_2	Natural Gas	32.1	29.5
CO_2	Natural Gas	6.8	4.7
CO	Natural Gas	27.7	30.7
O_2	Natural Gas	0.04	0
Ar	Natural Gas	0.4	0.4
H_2O	Natural Gas	8.6	16.4
H_2	Natural Gas	24.2	14.0
Tars and Oils Concentration (mg/Nm^3)	Natural Gas	1.6	49.2
Cold Gas Efficiency	NA	83.7%	88.2%
Heat Supplied to Lime Kiln (MMBTU)	105.58	100.15	103.16
IP Steam Generated (tons/hr)	7.84	1.56	1.36
LP Steam Generated (tons/hr)	0	5.94	5.66
Power Required (HP)	489	1014	816

2.4.3 Areas for Future Improvement of the Model

Several areas where the model can be improved have been discussed previously in this report. These items, and other potential improvement areas, are summarized below:

- Tune efficiencies used in compressor block to actual operational parameters based on feedback from the appropriate technology vendors.

- Rigorously model or obtain data from the appropriate technology vendors for pressure drop in the gasifier, cyclones, tar cracker, and piping.

- Update the biomass dryer process blocks with results from an updated mass and energy balance from GEA Barr-Rosin which incorporates using hot tailgas from the lime kiln to indirectly dry the biomass instead of steam.

- Incorporation of a devolatilization routine into the kinetic model to increase predictive capabilities and/or obtaining actual devolatilization data for the feed material in question from laboratory experiments.

- Include a model for tar pyrolysis in the kinetic model to increase predictive capabilities.

- Include formation of NO_x and SO_x in the kinetic model.

- Additional validation of kinetic expressions utilized in the kinetic model based on laboratory or industrial process results.

- Validation of lime kiln model with operational data from additional lime kilns.

3. GASIFIER MATERIALS EVALUATION

The gasifier is a refractory lined pressure vessel that will be designed to the requirements of the ASME Section VIII, Division 1 or 2 codes. The design life is 20 years with anticipated component refurbishment during scheduled maintenance shutdowns. The nominal operating temperature range is 2000-2200°F. The hot gas composition is shown above, in Table 4. In addition to the gas components listed in Table 4 small amount H_2S, HCN, and other corrosive materials will be present. The gas composition for biomass gasification falls into the ranges described for various coal gasification environments (Barton 1981; Nangia 1982). In general, the data in the literature for material performance of gasifiers is based on performance in coal gasification systems. The subsequent sections will discuss materials issues associated with the gasifier vessel and the refractory lining.

3.1 Gasifier Vessel

The biomass gasifier vessel will be a refractory lined steel shell where the insulating capabilities of the refractory liner will set the shell temperature. The vessel shell will have various nozzle penetrations for biomass feed, synthesis gas removal, air, instrumentation probes, ash removal, and possible cooling water for the rotating grate. Based on the operating temperature and gas composition, the shell material can be susceptible to hydrogen attack, high-temperature sulfidation attack, metal wall thinning due to spallation, and possible aqueous corrosion due to condensate formation during shutdown.

The rotating ash grate material is of particular concern due to the expected exposure temperature of about 2000°F, and the possibility of carbonaceous char deposits. These deposits could induce metal dusting which is defined as a process of highly accelerated material wastage preceded by the saturation of the material with carbon (Natesan 2002). This operating temperature is well above the maximum that ASME allows for a pressure vessel boundary material but these rules do not apply as the grate is not a pressure component. The mechanical design of the grate will have to take into account high temperature mechanical loading issues such as fatigue and creep. Consequently, the use of air cooling of this grate has been specified. The tentative material choice of Emery Energy Company for this component is Type 310 stainless steel. However, other high temperature alloys such as Inconel alloy 693 and alloy 602CA may provide better performance (Natesan 2003; Natesan 2006; Wilson 2007).

3.2 Gasifier Refractory Lining

The refractory lining for the gasifier vessel will provide thermal insulation for the metallic pressure vessel and erosion resistance in high wear areas. The lining system proposed by Emery Energy Company is shown in Figure 7. An initial problem which was noted with the material choices here is that the manufacturer's data for the Versaflow Thermax Plus (75.9% SiO_2, 21.1% Al_2O_3) has a maximum recommended temperature of 2000°F. A general rule of thumb for refractory design is that the systems are operated at 80 % of the maximum recommended temperature. Another problem is that this refractory has a high silica content which may make it susceptible to silica volatilization (Sadler 1979).

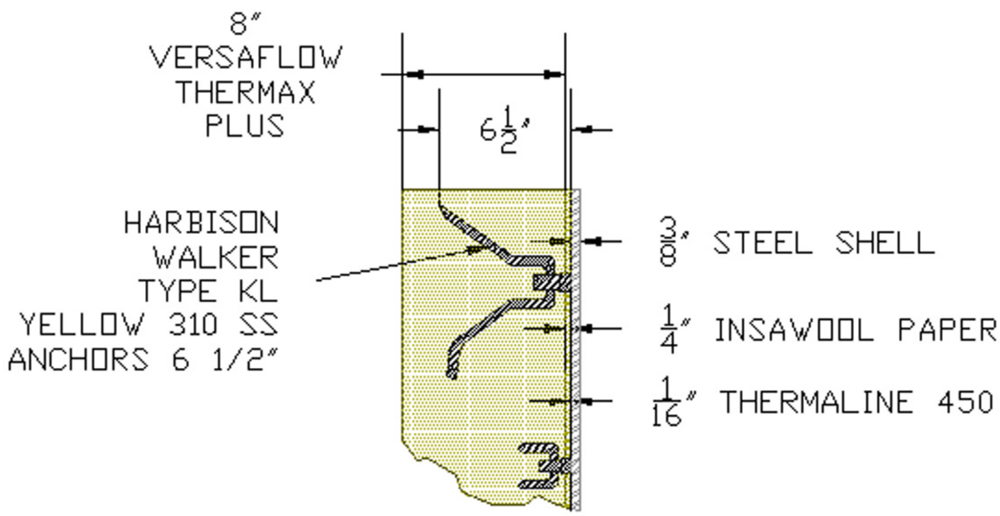

Figure 7. Proposed Gasifier Wall Construction Details (Emery Energy Company)

To evaluate this design, an analysis was performed to predict the gasifier wall temperature using MathCad software. It was assumed that eight inches of Versaflow Thermax Plus refractory was installed over the gasifier wall with a gas temperature of 2000°F. The predicted wall temperature is 651°F.

This temperature presents additional problems for this design. The Thermaline 450 epoxy coating (applied to prevent condensate corrosion) has a maximum recommended temperature limit of 450°F. Some other coating system or a corrosion resistant metallic coating (weld overlay) would need to be evaluated. Another issue is the choice of metallic anchors for the refractory. These anchors are generally recommended for use below 2000°F. Above this temperature, ceramic anchors would be used.

3.2.1 Refractory Material Alternatives

Refractory materials with higher alumina contents have been used and tested for coal gasification service (Sadler 1979; Nangia 1982). A refractory vendor recommended the following refractory compositions for 2100 °F with a six or nine inch thickness (Langenohl 2007):

- RESOCAST 17 AG, (95% alumina), 3400°F maximum service temperature, gun installation

- RESOCAST 17AC, (95% alumina), 3400°F maximum service temperature, vibration casting installation

- EZ CAST 3400, (98.7% alumina), 3400°F maximum service temperature, vibration casting installation

A recently presented paper reviewed refractory material for biomass gasifiers with emphasis on systems used for treatment of black liquor from the pulp and paper industry (Bennett 2007). This process was assumed to be a worst case for biomass gasification. The report describes good performance of a newly patented refractory, Aurex 95P. This material is a chrome-alumina (92.0% CrO_2, 4.7% Al_2O_3, 3.3% P_2O_5) brick.

3.3 Recommendations

A major factor of gasifier operation that will affect the material choices will be the nominal operating temperature. The process modeling performed by the Idaho National Laboratory (INL) has set the operating temperature range to 2000°F, with the possibility of localized hot spots. These parameters will preclude downstream condensation of tars and oils which can cause operational difficulties. However, the gasifier temperature envisioned by Emery Energy is 1,600°F. This temperature difference has major implications for the materials choices and expected life of the rotating ash grate. Therefore, it is recommended that a design study be conducted to analyze the problems of downstream piping and component tar deposition at the 1,600°F gasifier temperature as compared to providing robust materials for the rotating ash grate for service at 2,000°F. Based on these results, the choices for the refractory lining system and the material for the rotating grate should be given further evaluation.

4. PROCESS ECONOMICS

The economic viability of firing synthesis gas generated from the gasification of hog fuel as a substitute for natural gas in a lime kiln was assessed using standard economic evaluation methods. The economics were evaluated for the two cases described in Section 2.4.1, Case A (tar cracker) and Case B (no tar cracker). The total project investment, based on the total equipment costs, along with the variable and fixed operating costs were first calculated for the cases. The present worth of the offset cost of utilizing biomass versus natural gas along with the capital investments were then calculated for various project payback periods and interest rates. The following sections describe the methods used to calculate the capital costs, fixed and variable operating costs, and the methods used for the economic assessments. First, a detailed description of the process equipment items, which were costed for this study, are presented.

4.1 Equipment List

The equipment items priced for this study are divided into three categories, wet fuel processing, gasification island, and gas cleanup. Wet fuel processing includes all of the equipment necessary to receive, store, size, and dry the incoming biomass. The gasification island includes equipment items for gasifying and removing particulate from the synthesis gas. Gas cleanup includes equipment items for removing the tars and oils from the synthesis gas. Figure 8 presents the process flow diagram for the Hog Fuel Gasification Project. It is assumed that any wastewater generated can be treated at existing wastewater facilities and the tailgas from the system undergoes gas cleanup at existing facilities.

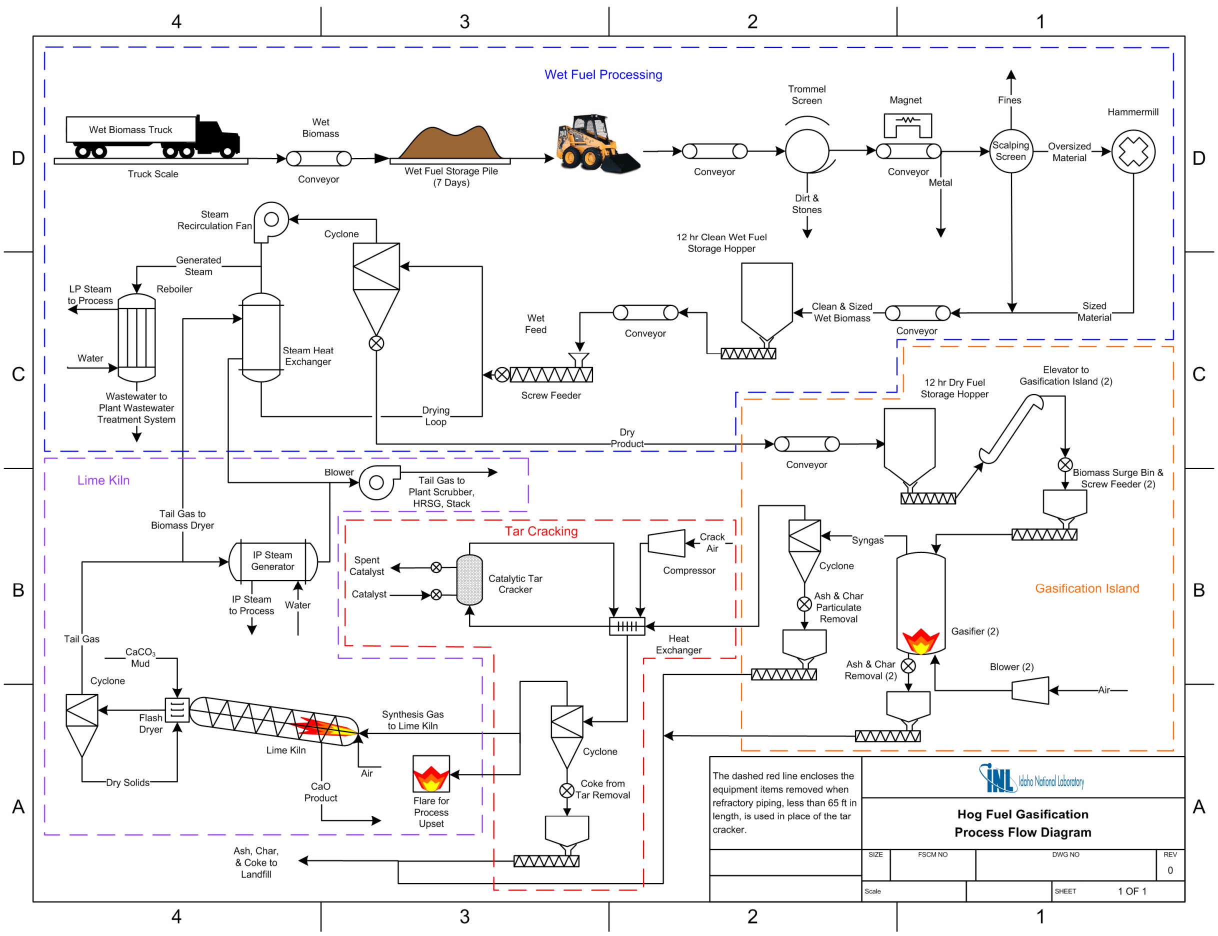

Figure 8. Hog Fuel Gasification Process Flow Diagram

4.1.1 Wet Fuel Processing

- **Truck Scale –** Heavy duty truck scale with 90,000 pound capacity. Includes digital weight indicator, ticket printer, remote display, traffic lights, foundation construction, and installation.

- **Wet Biomass Conveyor to Wet Fuel Storage –** Covered belt conveyor rated for 20 tons per hour of 50% moisture biomass, including 7.5 HP motor. Conveying distance of 100 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, and belt cleaner.

- **Wet Fuel Storage Pile** – The wet fuel storage pile is an open bunker style storage pile with seven days of wet biomass storage capacity. The bunker has a concrete floor and walls and an apron for loading. The dimensions of the bunker are 150 feet by 62 feet by 10 feet.

- **Front End Loader** – Compact front end loader with a bucket capacity of 1.8 cubic yards. Used to transfer fuel from the storage pile to the conveyor.

- **Wet Biomass Conveyor to Particulate Removal –** Covered belt conveyor rated for 20 tons per hour of 50% moisture biomass, including 7.5 HP motor. Conveying distance of 100 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, and belt cleaner.

- **Trommel Screen** – Stones and dirt are removed from the wood residue using a trommel screen. The trommel screen can accept up to 20 tons per hour and includes conveyors to and from the unit. Includes a 49 HP engine.

- **Wet Biomass Conveyor with Ferrous Metal Removal –** Covered belt conveyor rated for 20 tons per hour of 50% moisture biomass, including 7.5 HP motor. Conveying distance of 100 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, belt cleaner, and magnetic pulley for metal removal.

- **Scalping Screen –** Rated for 20 tons per hour with screen designed to pass all material smaller than 30 millimeters, includes 5 HP motor and oversized and sized material discharge chutes.

- **Hammermill –** Rated for 10 tons per hour (50% of feedstock flow). Designed to reduce the oversized material from the scalping screen to less than 30 millimeters, includes 200 HP motor.

- **Wet Biomass Conveyor to Storage –** Covered belt conveyor rated for 20 tons per hour of 50% moisture biomass, including 7.5 HP motor. Conveying distance of 150 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, and belt cleaner.

- **Sized Wet Fuel Storage Silo –** Metal silo with 20,000 cubic foot wet fuel storage capacity, approximately 12 hours of storage. Maximum height of 38 feet.

- **Silo Discharge** – 16-inch diameter by 12-foot-long horizontal screw feeder rated for 20 tons per hour of 50% moisture biomass. Includes 10 HP motor.

- **Wet Biomass Conveyor to Biomass Dryer –** Covered belt conveyor rated for 20 tons per hour of 50% moisture biomass, including 7.5 HP motor. Conveying distance of 100 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, and belt cleaner.

- **Superheated Steam Dryer** – Up to 20 tons per hour of 50% moisture biomass is continuously metered using plug screw feeder to the drying system. The wet feed then enters the dryer via a disc shredder and is dispersed into an atmosphere of superheated steam. The steam acts as a transport gas for the material through a drying duct where the moisture evaporates via a heat exchanger with a portion of the hot tail gas from the lime kiln. The dried product is separated from the steam in a high efficiency cyclone, and discharged to the gasifier at approximately 10% moisture. Steam is recycled back through the dryer using a centrifugal fan. Includes motors for all equipment items which sums to 794 HP.

- **Reboiler** – Waste heat is recovered from the steam exiting the superheated steam dryer by passing the surplus stream through a reboiler.

4.1.2 Gasification Island

- **Dry Biomass Conveyor to Storage** – Covered belt conveyor rated for 10 tons per hour of 10% moisture biomass, including 7.5 HP motor. Conveying distance of 150 feet with a 15-degree incline. The conveyor includes walkway and railings for one side, steel discharge chute, and belt cleaner.

- **Dry Fuel Storage Silo** – Metal silo with 20,000 cubic foot dry fuel storage capacity, approximately 12 hours of storage. Maximum height of 38 feet.

- **Silo Discharge** – 16-inch diameter by 12-foot-long horizontal screw feeder rated for 10 tons per hour of 10% moisture biomass. Includes 10 HP motor.

- **Fuel Elevator (2)** – Bucket elevator rated for 10 tons per hour of 10% moisture wood chips. Conveying height of 100 feet with 14 by 7 inch polyethylene buckets. Includes 5 HP motor.

- **Dry Fuel Feed Bin (2)** – Metal bin with 300 cubic foot dry fuel storage capacity.

- **Dry Fuel Screw Feeder (2)** – 16-inch diameter by 6-foot-long horizontal screw feeder rated for 5 tons per hour of 10% moisture biomass. Includes 10 HP motor.

- **Dry Fuel Rotary Airlock Valve (2)** – 16 inch rotary airlock valve rated for pressures up to 25 psi and temperatures up to 1000°F.

- **Gasifier (2)** – Near atmospheric, air blown, countercurrent gasifier based on Emery Energy Company's E-100A gasifier design. The gasifier is a refractory lined pressure vessel designed to ASME codes rated for 150 tons per day of 10% moisture biomass and pressures up to 25 psi. Fuel enters at the top of the gasifier and flows down, undergoing devolatilization, towards the ash grate, where a hot char pile develops. Air enters at the bottom of the gasifier and reacts with the char providing the heat for the gasification reactions and fuel devolatilization. A low value BTU synthesis gas is removed from the top of the gasifier at approximately 950°F. The ash is removed from the bottom of the unit through the ash grate. The temperature of the ash, 2000°F, is controlled by the amount of air fed to the gasifier in order to prevent slagging

- **Blower (Case A, 2)** – Air blower rated for 1,400 standard cubic feet per minute at 25 psi.

- **Blower (Case B, 2)** – Air blower rated for 1,400 standard cubic feet per minute at 17 psi.

- **Ash Storage Bin (2)** – High temperature metal bin, rated for up to2000°F, with 300 cubic foot ash storage capacity. It should be noted that the ash would cooled with water but this bin and other items associated with ash handling may experience temperature excursions up to 2000°F.

- **Ash Screw Feeder (2)** –Horizontal screw feeder rated for 1 tons per hour of high temperature ash (2000°F). Includes 10 HP motor.

- **Ash Rotary Airlock Valve (2)** – Rotary airlock valve rated for pressures up to 25 psi and temperature up to 2000°F.

- **Ash Cyclone** – High temperature (1000°F), above atmospheric pressure (up to 25 psi), cyclone rated for 10,000 standard cubic feet per minute of syngas flow.

- **Particulate Storage Bin** – High temperature metal bin, rated for 1000°F, with 300 cubic foot particulate storage capacity. It should be noted that the particulate would be cooled with water but this bin and other items associated with particulate handling may experience temperature excursions up to 1000°F.

- **Particulate Screw Feeder** – Horizontal screw feeder rated for 1 tons per hour of high temperature particulate (1000°F). Includes 10 HP motor.

- **Particulate Rotary Airlock Valve** – Rotary airlock valve rated for pressures up to 25 psi and temperatures up to 1000°F.

4.1.3 Gas Cleanup (Case A)

- **Gas Cleanup Blower** – Air blower rated for 1,400 standard cubic feet per minute at 25 psi.

- **Heat Exchanger** – Compact type heat exchanger rated for temperatures up to 1800°F. Constructed of high temperature metal alloy, such as Inconel. Area for heat exchange is approximately 7,700 square feet.

- **Catalytic Tar Cracker** – Bubbling fluidized bed reactor which converts tars and oils to CO and H_2. This unit is rated for 96% conversion of tars, oils, and methane; requires an inlet feed temperature of 1652°F; and has an outlet temperature of 1742°F. The reactor is required to accommodate 10,000 standard cubic feet per minute of syngas flow. The catalyst used in the reactor is a commercially available nickel catalyst.

- **Tar Cracker Rotary Airlock Valve (2)** – Rotary airlock valve rated for pressures up to 25 psi and temperatures up to 1800°F, or water cooled.

- **Particulate Cyclone** – High temperature (1000°F), above atmospheric pressure (up to 25 psi), cyclone rated for 10,000 standard cubic feet per minute of syngas flow.

- **Gas Cleanup Particulate Storage Bin** – High temperature metal bin, rated for 1000°F, with 300 cubic foot particulate storage capacity. Again, it should be noted that the particulate would be cooled with water but this bin and other items associated with particulate handling may experience temperature excursions up to 1000°F.

- **Gas Cleanup Particulate Screw Feeder** – Horizontal screw feeder rated for 1 ton per hour of high temperature particulate (1000°F), includes 10 HP motor.

- **Particulate Rotary Airlock Valve** – Rotary airlock valve rated for pressures up to 25 psi and temperatures up to 1000°F.

4.2 Economic Calculations

4.2.1 Fixed Capital Cost Estimation

The capital costs presented are for inside the battery limits, and exclude costs for administrative offices, storage areas, utilities, and other essential and nonessential auxiliary facilities. The estimate presented is a study (factored) estimate which has a probable error up to ±30% (Perry 1997). Fixed capital costs were estimated from vendor quotes, literature estimates, and scaled estimates (capacity, year, and material) from previous quotes. Capacity adjustments were based on the six-tenths factor rule:

$$C_2 = C_1\left(\frac{q_2}{q_1}\right)^n \qquad (20)$$

where C_1 is the cost of the equipment item at capacity q_1, C_2 is the cost of the equipment at capacity q_2, and n is the exponential factor, which typically has a value of 0.6 (Peters 1991).

Cost indices were used to adjust equipment prices from previous years to values in 2007 using the Chemical Engineering Plant Cost Index (CEPCI).

Table 5. CEPCI Data

Year	CEPCI	Year	CEPCI
1990	357.6	1999	390.6
1991	361.3	2000	394.1
1992	358.2	2001	394.3
1993	359.2	2002	395.6
1994	368.1	2003	402
1995	381.1	2004	444.2
1996	381.7	2005	468.2
1997	386.5	2006	499.6
1998	389.5	Dec-07	509.8

Cost adjustment factor for materials, listed in Table 6, were used to adjust cost estimates for carbon steel to equivalent alloy costs (Perry 1997).

Table 6. Material Cost Adjustment Factors

Year	Factor
Stainless Steel Alloys	1.8
Moly/Nickel Alloys	3.3

After cost estimates were obtained for each of the equipment items, the costs for field erection, equipment foundations and structural supports, piping, equipment insulation, piping insulation, electrical work, instrumentation, miscellaneous costs, and building costs were estimated using the Factor Method of Miller. The Factor Method of Miller allows the estimation of the above costs based on the delivered equipment cost and the unit complexity. Figure 9 presents the tables in Perry's Chemical Engineering Handbook used for the Factor Method of Miller.

Based on the Factor Method of Miller and the quotes for the equipment items listed in Section 4.1 costs were calculated for equipment field erection, equipment foundations and structural supports, piping, equipment insulation, piping insulation, electrical work, instrumentation, miscellaneous costs, and building costs. When delivery was not included in the price, it was assumed that equipment delivery would be approximately four percent of the unit cost. Table 7 lists all costs for the equipment items, as well as the total costs for the fuel processing section and the gasification section for Cases A and B, which includes the gasification island and gas cleanup operations; an indication is made if the quote has been updated for capacity[1], year[2], or material[3]. It was assumed that the plant is located in a temperate climate, and the plant design would be mainly open air with minor buildings.

TABLE 9-52 Factor Method of Miller (Based on Delivered-Equipment Costs = 100)*

		Battery-limit costs (range of factors in percent of basic equipment); average unit cost of main-plant item (MPI)						
		Under $9000	$9000 to $15,000	$15,000 to $21,000	$21,000 to $30,000	$30,000 to $39,000	$39,000 to $51,000	$51,000
Field erection of basic equipment	High percentage of equipment involving high field labor	23/18	21/17	19.5/16	18.5/15	17.5/14.2	16.5/13.5	15.5/13
	Average (mild steel) equipment	18/12.5	17/11.5	16/10.8	15/10	14.2/9.2	13.5/8.5	13/8
	High percentage of corrosion materials and other high-unit-cost equipment involving little field erection	12.5/7.5	11.5/6.7	10.8/6	10/5.5	9.2/5.2	8.5/5	8/4.8
Equipment foundations and structural supports	High: predominance of compressors or mild steel equipment requiring heavy foundations			17/12	15/10	14/9	12/8	10.5/6
	Average: for mild steel fabricated-equipment solids			12.5/7	11/6	9.5/5	8/4	7/3
	Average: for predominance of alloy and other high-unit-price fabricated equipment	7/3	8/3	8.5/3	7.5/3	6.5/2.5	5.5/2	4.5/1.5
	Low: equipment more or less sitting on floor	5/0	4/0	3/0	2.5/0	2/0	1.5/0	1/0
	Piling or rock excavation			Increase above values by 25 to 100%				
Piping, including ductwork but excluding insulation	High: gases and liquids, petrochemicals, plants with substantial ductwork	105/65	90/58	80/48	70/40	58/34	50/30	42/25
	Average for chemical plants: liquids, electrolytic plants	65/33	58/27	48/22	40/16	34/12	30/10	25/9
	Liquids and solids	33/13	27/10	22/8	16/6	12/5	10/4	9/3
	Low: solids	13/5	10/4	8/3	6/2	5/1	4/0	3/0
Insulation of equipment only	Very high: substantial mild steel equipment requiring lagging and very low temperatures	13/10	11.5/8.5	10/7.4	9/6.2	7.8/5.3	6.8/4.5	5.8/3.5
	High: substantial equipment requiring lagging and high temperatures (petrochemicals)	10.3/7.5	9/6.3	7.8/5.2	6.7/4.2	5.7/3.4	4.7/3.8	4.8/2.5
	Average for chemical plants	7.8/3.4	6.5/2.6	5.5/2.1	4.5/1.7	3.6/1.4	2.9/1.1	2.2/.8
	Low	3.5/0	2.7/0	2.2/0	1.8/0	1.5/0	1.2/0	1/0
Insulation of piping only	Very high: substantial mild steel piping requiring lagging and very low temperatures	22/16	19/13	16/11	14/9	12/7	9/5	6/3.5
	High: substantial piping requiring lagging and high temperatures (petrochemicals)	18/14	15/12	13/10	11/8	9/6	7/4	4.5/2.5
	Average for chemical plants	16/12	14/10	12/8	10/6	8/4	6/2	4/2
	Low	14/8	12/6	10/5	8/4	6/3	4/2	2/1

Figure 9. Factor Method of Miller (Perry 1997)

TABLE 9-52 Factor Method of Miller (Based on Delivered-Equipment Costs = 100) *(Concluded)*

		Battery-limit costs (range of factors in percent of basic equipment); average unit cost of main-plant item (MPI)						
		Under $9000	$9000 to $15,000	$15,000 to $21,000	$21,000 to $30,000	$30,000 to $39,000	$39,000 to $51,000	$51,000
All electrical except building, lighting, and instrumentation	Electrolytic plants, including rectification equipment		55/42	50/38	45/33	40/30	35/26	
	Plants with mild steel equipment, heavy drives, solids	26/17	22.5/15	19.5/12.5	17/10	14/8.5	12/7	10/6
	Plants with alloy or high-unit-cost equipment, chemical and petrochemical plants	18/9.5	15.5/8.5	13/6.5	11/5.5	9/4.5	7.3/3.5	6/2.5
Instrumentation*	Substantial instrumentation, central control panels, petrochemicals		58/31	46/24	37/18	29/13	23/10	18/7
	Miscellaneous chemical plants		32/13	26/10	20/7	15/5	11/3	8/2
	Little instrumentation, solids		21/9	17/7	13/5	10/3	7/2	5/1
Miscellaneous, including site preparation, painting, and other items not accounted for above	Top of range—large complicated processes; bottom of range—smaller, simple processes		Range for all values of basic equipment is 6 to 1%					

Buildings—architectural and structural, excludes building services†	Building evaluation when most process units are located inside buildings				
	High, brick and steel	Medium		Economical	Evaluation
Quality of construction	+4	+2		0	
	Very high unit cost equipment	Mostly alloy steel	Mixed materials	Costly carbon steel	
Type of equipment	−3	−2	−1	0	
	Very high	Intermediate		Atmosphere	
Operations pressures	−2	−1		0	
cost equipment, chemical	Building class = algebraic sum =				

		Average unit cost of MPI						
	Building class	Under $9000	$9000 to $15,000	$15,000 to $21,000	$21,000 to $30,000	$30,000 to $39,000	$39,000 to $51,000	$51,000
Cost of process	+2	92/68	82/61	74/56	67/49	59/44	52/39	46/33
Units inside buildings	+1 to −1	72/49	62/43	56/38	51/33	45/29	41/26	36/21
	−2	50/37	44/33	40/29	35/25	30/21	27/18	23/15
Open-air plants with minor buildings		37/16	32/13	28/11	24/8	20/6	17/4	14/2

Building services‡	High	Normal	Low
Compressed air for general service only	4	1½	0.5
Electric lighting	18	9	5
Sprinklers	10	6	3
Plumbing	20	12	3
Heating	25	16	8
Ventilation:			
Without air conditioning	18	8	0
With air conditioning	45	35	25
Total overall average§	85	55	20

The above factors apply to those items normally classified as building services. They do not include (1) services located outside the building such as substations, outside sewers, and outside water lines, all of which are considered to be outside the battery limit as well as outside the building; and (2) process services.

*Courtesy C. A. Miller of Canadian Industries Ltd. and the American Association of Cost Engineers.

NOTE: The average unit cost of the main-plant items is the total cost of the MPI divided by the total number of items. Figures include up to 3 percent for BL outside lighting, which is not covered in building services.

*Total instrumentation cost does not vary a great deal with size and hence is not readily calculated as a percentage of basic equipment. This is particularly true for distillation systems. If in doubt, detailed estimates should be made.

†When building specifications and dimensions are known, a high-speed building-cost estimate is recommended, especially if buildings are a significant item of cost. If a separate estimate is not possible, evaluate the buildings as shown before selecting the factors.

‡The following factors are for battery-limit (process) buildings only and are expressed in percentage of the building architectural and structural cost. They are not related to the basic equipment cost.

§The totals provide the ranges for the type of building involved and are useful when individual service requirements are not known. Note that the overall averages are not the sum of the individual columns.

Figure 9. Factor Method of Miller (Perry 1997) - continued

Table 7. Cost Data for Process Equipment Items

	Unit Cost	Delivery Cost	Installation Complexity	Field Erection	Equipment Foundations and Supports	Piping	Equipment Insulation	Piping Insulation	Electrical	Instrumen-tation	Misc	Building	Capacity	Brand	Model #
Fuel Processing															
Truck Scales	$75,000	Included	NA	Included	Included	NA	NA	NA	Included	NA	$2,625	$6,000	90000 lb	Fairbanks	Talon HV
Conveyor	$83,000	$4,016	Low	$5,569	$435	NA	NA	NA	$3,698	$2,610	$3,046	$6,961	100 ft, 24 in, 15°	Thomas Conveyor	BC
Wet Fuel Storage Pile	$103,368	Included	NA	Included	Included	NA	NA	NA	NA	NA	$3,618	$8,269	7 days	MUTH 2007	INL
Front End Loader	$108,450	$5,248	NA	NA	NA	NA	NA	NA	NA	NA	$3,979	$9,096	NA	Caterpillar	914G
Conveyor	$83,000	$4,016	Low	$5,569	$435	NA	NA	NA	$3,698	$2,610	$3,046	$6,961	100 ft, 24 in, 15°	Thomas Conveyor	BC
Trommel Screen	$93,000	$4,500	Low	$6,240	$488	NA	NA	NA	$4,144	$2,925	$3,413	$7,800	20 tons/hr	Wildcat	510 Cougar
Magnetic Conveyor															
Conveyor	$83,000	$4,016	Low	$5,569	$435	NA	NA	NA	$3,698	$2,610	$3,046	$6,961	100 ft, 24 in, 15°	Thomas Conveyor	BC
Magnetic Pulley	$3,000	$145	Low	$315	$79	NA	NA	NA	$432	NA	$110	$833	24 in, 30 in diameter	Storch Magnetics	Pulley
Scalping Screen	$34,000	$1,645	Low	$2,566	$356	NA	NA	NA	$2,406	$2,317	$1,248	$2,852	20 tons/hr	West Salem Machinery	36-7
Hammermill	$65,000	$3,145	Low	$4,361	$341	NA	NA	NA	$2,896	$2,044	$2,385	$5,452	10 tons/hr	West Salem Machinery	32-40b
Conveyor	$119,000	$5,758	Low	$7,985	$624	NA	NA	NA	$5,302	$3,743	$4,367	$9,981	150 ft, 24 in, 15°	Thomas Conveyor	BC
Wet Fuel Storage															
Fuel Storage Hopper	$322,202	Included	Low/Avg	Included	Included	NA	NA	NA	$13,694	$9,666	$11,277	$25,776	20000 ft^3	ORNL 2002	Updated Quote[1,2]
Screw Feeder	$10,000	$484	Low/Avg	$954	$577	NA	NA	NA	$1,258	$1,573	$367	$2,778	12 ft, 16 in diameter	Thomas Conveyor	SF
Conveyor	$83,000	$4,016	Low	$5,569	$435	NA	NA	NA	$3,698	$2,610	$3,046	$6,961	100 ft, 24 in, 15°	Thomas Conveyor	BC
Drying System															
Dryer	$3,000,000	Included	Medium	$315,000	$150,000	Included	$109,500	$142,500	$127,500	$150,000	$105,000	$240,000	20 tons/hr	GEA Barr-Rosin	SHSD
Reboiler	$275,000	Included	Medium	$28,875	$13,750	Included	$10,038	$13,063	$11,688	$13,750	$9,625	$22,000	20 tons/hr	GEA Barr-Rosin	SHSD
Fuel Processing Cost	$4,540,020	$36,990	NA	$388,572	$167,954		$119,538	$155,563	$184,113	$196,460	$160,195	$368,682			
Gasification Island															
Conveyor	$119,000	$5,758	Low	$7,985	$624	NA	NA	NA	$5,302	$3,743	$4,367	$9,981	150 ft, 24 in, 15°	Thomas Conveyor	BC
Dry Fuel Storage															
Fuel Storage Hopper	$322,202	Included	Low/Avg	Included	Included	NA	NA	NA	$13,694	$9,666	$11,277	$25,776	20000 ft^3	ORNL 2002	Updated Quote[1,2]
Screw Feeder	$10,000	$484	Low/Avg	$954	$577	NA	NA	NA	$1,258	$1,573	$367	$2,778	12 ft, 16 in diameter	Thomas Conveyor	SF
Fuel Elevator	$69,000	$3,339	Low/Avg	$4,630	$2,170	NA	NA	NA	$3,074	$2,170	$2,532	$5,787	100 ft, 14 x 7 in bucket	Thomas Conveyor	BE
Fuel Elevator	$69,000	$3,339	Low/Avg	$4,630	$2,170	NA	NA	NA	$3,074	$2,170	$2,532	$5,787	100 ft, 14 x 7 in bucket	Thomas Conveyor	BE
Dry Fuel Supply															
Dry Fuel Feed Bin	$25,000	$1,210	Low/Avg	$2,031	$1,376	NA	$813	NA	$2,162	$2,359	$917	$4,194	300 ft^3	SSPF	Updated Quote
Screw Feeder	$10,000	$484	Low/Avg	$954	$577	NA	NA	NA	$1,258	$1,573	$367	$2,778	6 ft, 16 in diameter	Thomas Conveyor	SF
Rotary Airlock Valve	$12,500	$605	Medium	$1,867	$1,278	$5,570	$596	$1,573	$1,573	$2,949	$459	$2,949	25 ft^3/min	Andritz-Sprout Bauer	Updated Quote
Dry Fuel Supply															
Dry Fuel Feed Bin	$25,000	$1,210	Low/Avg	$2,031	$1,376	NA	$813	NA	$2,162	$2,359	$917	$4,194	300 ft^3	SSPF	Updated Quote

	Unit Cost	Delivery Cost	Installation Complexity	Field Erection	Equipment Foundations and Supports	Piping	Equipment Insulation	Piping Insulation	Electrical	Instrumen-tation	Misc	Building	Capacity	Brand	Model #
Screw Feeder	$10,000	$484	Low/Avg	$954	$577	NA	NA	NA	$1,258	$1,573	$367	$2,778	6 ft, 16 in diameter	Thomas Conveyor	SF
Rotary Airlock Valve	$12,500	$605	Medium	$1,867	$1,278	$5,570	$596	$1,573	$1,573	$2,949	$459	$2,949	25 ft^3/min	Andritz-Sprout Bauer	Updated Quote
Blower (Case A)	$48,800	$2,361	Medium	$5,628	$3,709	$10,232	$1,023	$2,046	$2,763	$4,093	$1,791	$5,372	1400 scfm +10 psi	Literature	Literature
Blower (Case A)	$48,800	$2,361	Medium	$5,628	$3,709	$10,232	$1,023	$2,046	$2,763	$4,093	$1,791	$5,372	1400 scfm +10 psi	Literature	Literature
Blower (Case B)	$15,300	$740	Medium	$2,149	$1,564	$5,614	$610	$1,604	$1,564	$2,887	$561	$3,128	1400 scfm +3 psi	Literature	Literature
Blower (Case B)	$15,300	$740	Medium	$2,149	$1,564	$5,614	$610	$1,604	$1,564	$2,887	$561	$3,128	1400 scfm +3 psi	Literature	Literature
Gasifier	$2,200,000	$106,452	Medium	$242,177	$115,323	$392,097	$84,185	$109,556	$98,024	$115,323	$80,726	$184,516	150 tons/day	Emery Energy Co.	Updated Quote
Gasifier	$2,200,000	$106,452	Medium	$242,177	$115,323	$392,097	$84,185	$109,556	$98,024	$115,323	$80,726	$184,516	150 tons/day	Emery Energy Co.	Updated Quote
Ash Storage															
Bin	$65,000	$3,145	Medium	$7,155	$3,407	NA	$2,487	NA	$2,896	$3,407	$2,385	$5,452	300 ft^3	SSPF	Updated Quote
Screw Feeder	$18,000	$871	Medium	$1,463	$991	NA	$585	NA	$1,557	$1,698	$660	$3,019	1 ton/hr	Thomas Conveyor	Updated Quote[3]
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Ash Storage															
Bin	$65,000	$3,145	Medium	$7,155	$3,407	NA	$2,487	NA	$2,896	$3,407	$2,385	$5,452	300 ft^3	SSPF	Updated Quote
Screw Feeder	$18,000	$871	Medium	$1,463	$991	NA	$585	NA	$1,557	$1,698	$660	$3,019	1 ton/hr	Thomas Conveyor	Updated Quote[3]
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Cyclone	$95,005	$4,597	Medium	$10,458	$4,980	$16,932	$3,635	$4,731	$4,233	$4,980	$3,486	$7,968	10000 scfm	Fisher-Klosterman	Updated Quote[1]
Particulate Storage															
Bin	$65,000	$3,145	Medium	$7,155	$3,407	NA	$2,487	NA	$2,896	$3,407	$2,385	$5,452	300 ft^3	SSPF	Updated Quote
Screw Feeder	$18,000	$871	Medium	$1,463	$991	NA	$585	NA	$1,557	$1,698	$660	$3,019	1 ton/hr	Thomas Conveyor	Updated Quote[3]
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Box Flare	$68,000	$3,290	Low/Avg	$4,563	$2,139	$12,119	$2,602	$3,386	$3,030	$3,565	$2,495	$5,703		John Zinc	Updated Quote
Gas Cleanup (Case A)															
Blower	$48,800	$2,361	Medium	$5,628	$3,709	$10,232	$1,023	$2,046	$2,763	$4,093	$1,791	$5,372	1400 scfm + 10 psi	Literature	Literature
Heat Exchanger	$621,100	$30,053	Medium	$68,371	$32,558	$110,696	$23,767	$30,930	$27,674	$32,558	$22,790	$52,092	7700 ft^2	Literature	Literature
Catalytic Tar Cracker	$1,339,470	$64,813	Medium	$147,450	$70,214	$238,728	$51,256	$66,703	$59,682	$70,214	$49,150	$112,343	10000 scfm	PHILLIPS 2007	Updated Quote[1,2]
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Cyclone	$95,005	$4,597	Medium	$10,458	$4,980	$16,932	$3,635	$4,731	$4,233	$4,980	$3,486	$7,968	10000 scfm	Fisher-Klosterman	Updated Quote[1]
Particulate Storage															
Bin	$65,000	$3,145	Medium	$7,155	$3,407	NA	$2,487	NA	$2,896	$3,407	$2,385	$5,452	300 ft^3	SSPF	Updated Quote
Screw Feeder	$18,000	$871	Medium	$1,463	$991	NA	$585	NA	$1,557	$1,698	$660	$3,019	1 ton/hr	Thomas Conveyor	Updated Quote[3]
Rotary Airlock Valve	$34,000	$1,645	Medium	$4,170	$2,584	$8,198	$1,622	$2,673	$2,406	$3,565	$1,248	$4,634	10 ft^3/hr	Andritz-Sprout Bauer	Updated Quote
Gasification Costs (Case A)	**$7,985,181**	**$370,789**	**NA**	**$887,848**	**$401,742**	**$1,270,628**	**$281,175**	**$354,919**	**$371,825**	**$434,112**	**$292,459**	**$702,859**			
Gasification Costs (Case B)	**$5,628,806**	**$256,771**	**NA**	**$569,942**	**$273,840**	**$860,208**	**$192,728**	**$241,604**	**$263,405**	**$304,057**	**$205,995**	**$498,224**			

After the total fixed costs were calculated for the various equipment items, the costs associated with building services were calculated according to the Factor Method of Miller (Perry 1997). Table 8 lists the percentage of the building cost and the associated service costs for Cases A and B.

Table 8. Building Services Costs

	% of Building Cost	Case A	Case B
Compressed Air	1.5%	$16,073	$13,004
Electric Lighting	9%	$96,439	$78,022
Sprinklers	6%	$64,292	$52,014
Plumbing	12%	$128,585	$104,029

Additional project costs were calculated for field expenses; engineering; contractor's fees, overhead, and profit; and project contingency (Perry 1997). Table 9 lists the percentage of the delivered equipment costs for each of the additional costs and the associated dollar amount for each case.

Table 9. Additional Project Costs

	% of Delivered Equipment Costs	Case A	Case B
Field Expense	34%	$4,397,213	$3,557,280
Engineering	32%	$4,138,554	$3,348,028
Contractor's Fees, Overhead, Profit	18%	$2,327,936	$1,883,266
Contingency	36%	$4,655,873	$3,766,531

Finally, the total project investment (TPI), or total fixed cost, is calculated by summing the equipment, building services, and additional project costs. Table 10 lists the TPI for Cases A and B. There were no costs calculated for purchasing land, as it was assumed that the equipment would be installed at an existing facility.

Table 10. Total Project Investment (TPI)

	Case A	Case B
Fuel Processing Costs	$6,318,085	$6,318,085
Gasification Costs	$13,353,539	$9,295,579
Building Services Costs	$305,389	$247,068
Additional Costs	$15,519,576	$12,555,104
Total Project Investment (TPI)	**$35,496,589**	**$28,415,837**

4.2.1.1 Comparison of Fuel Processing and Gasification/Gas Cleanup Costs

The total costs for the fuel processing section and gasification sections (Case A) were compared to results from the recent study by the National Renewable Energy Laboratory (NREL), *Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Synthesis of Lignocellulosic Biomass* (Phillips 2007). The scaled cost for fuel processing is with the standard deviation of the average cost of the fuel processing systems presented, while the scaled cost for the gasification and gas cleanup are over two times greater than the average cost of the gasification and gas cleanup systems presented.

Table 11. Study Comparisons (Scaled to 185 tons/day, $K)

Study	Fuel Processing	Gasification & Gas Cleanup
NREL Study		
Average	$5,372	$4,630
Standard Deviation	±$1,417	±$1,808
Hog Fuel Project	$6,318	$13,499

Possibilities for the discrepancy between the two cases include: the NREL estimate was based on N^{th} plant component costs while the Hog Fuel project is based on first of a kind plant component costs, many of the equipment item costs in the NREL study were based on other cost estimates rather than directly pricing many of the equipment items. Additionally, the NREL report utilizes a gasifier which is significantly less expensive than the gasifier priced in this study.

4.2.2 Manufacturing Cost Estimation

Manufacturing costs are the sum of direct and indirect manufacturing costs. Direct manufacturing costs for this project include the cost of raw materials, utilities, operating labor, and maintenance and repairs. Indirect manufacturing costs include estimates for the cost of payroll overhead, general plant overhead, and insurance and taxes (Perry 1997). Table 12 lists the cost factors used for materials and utilities in this study and the corresponding references. A cost for wastewater treatment is included to differentiate between the base case (natural gas) and the biomass alternatives, since drying the biomass generates a significant amount of wastewater. In addition, cost factors are defined for intermediate pressure and low pressure steam, since all cases produce various amounts of process steam.

Table 12. Material and Utility Cost Factors

	Cost	Source
Materials		
Biomass Delivery (50% Moisture)	$8.41/ton	Dickinson 2006
Biomass (50% Moisture)	$3.04/ton	Weyerhaeuser 2000
Catalyst	$4.67/lb	Phillips 2007
Solids Disposal	$18.00/ton	Phillips 2007
Diesel Fuel (Front Loader)	$9.01/hr	Muth 2007
Wastewater Treatment	$2.07/100 ft^3	Phillips 2007
Utilities		
Electricity	$0.06/kWh	EIA 2007a
Natural Gas	$8.16/1000 ft^3	EIA 2007b
IP Steam	$4.22/1000 lb	Peters 1991
LP Steam	$2.33/1000 lb	Peters 1991

The cost estimate for the biomass delivery was based on a Virginia Tech estimate for silage hauling prices in 2006. The custom rate is $65 per hour, which includes fuel prices, labor charges, equipment, and operator time. The rate per ton of fuel delivered was based on three trucks, with a capacity of 23 tons of biomass per truck, each operating for an eight hour shift and delivering biomass from within a 40 mile radius. The cost of the biomass was estimated from the Weyerhaeuser 2020 Report, which lists the average delivered cost at $18 per bone dry ton (BDT). The cost of the 50% moisture biomass was calculated by inflating the Weyerhaeuser fuel price to 2007 dollars, account for the moisture level, and subtracting the delivery cost calculated above. The total price for 50% moisture biomass is $11.17 per ton, on a moisture free basis, which equates to $22.90 per BDT, which is in agreement with the $22.90 per BDT price inflated from year 2000 (Weyerhaeuser 2000).

Consumption of materials and utilities for the base case, Case A, and Case B were estimated from material and energy balances from Aspen Plus as well as electricity requirements for powered equipment provided by vendors.

Table 13. Material and Utility Consumption/Generation

	Base Case	Case A	Case B
Materials – Consumed/Generated			
Biomass (tons/hr)	0	15.17	14.47
Catalyst (lb/hr)	0	0.02	0
Solids (tons/hr)	0	0.66	0.63
Wastewater (ft^3/hr)	0	246.14	234.69
Utilities – Consumed			
Electricity (HP)	489	1864	1655
Natural Gas (ft^3/min)	1714.56	0	0
Utilities – Generated			
IP Steam (tons/hr)	7.84	1.56	1.36
LP Steam (tons/hr)	0	5.94	5.66

Labor requirements were estimated based on the labor requirement and costs in the NREL report, changing the number of employees to reflect the specific requirements for this project. It was assumed that there would be one plant engineer required for this operation, but no plant manager. Rather, the single plant engineer would oversee the fuel handling and gasification operations and report to the existing plant manager at the facility. It was assumed that there would be ¼ of a maintenance supervisor; this operation would borrow a portion of an existing maintenance supervisor. Based on a four shift system, there was assumed to be half a shift supervisor per shift, half a maintenance technician per shift, and two operators per shift. One operator would handle the fuel processing portion of the system and the other would hand the gasification island and the gas cleanup system, if installed. Finally, one clerk is assumed to handle the incoming trucks, telephone calls, and administrative work. Labor rates were inflated at 3.5% per year for the 2005 salaries listed in the NREL report.

Table 14. Labor Costs

	Number	Salary	Total Cost
Plant Engineer	1	$77,200	$77,200
Maintenance Supervisor	0.25	$71,261	$17,815
Shift Supervisor	2	$53,446	$106,892
Maintenance Technician	2	$47,507	$95,015
Shift Operators	8	$47,507	$380,060
Clerks and Secretaries	1	$29,692	$29,692
Total Salaries			**$706,673**

Costs for maintenance and repairs, payroll overhead, plant overhead, and insurance and taxes were calculated as a percentage of capital costs, labor costs, and TPI (Perry 1997). Table 15 lists these costs and the associated percentages.

Table 15. Additional Costs

	Dependency	Percentage	Case A	Case B
Maintenance and Repairs	Capital	6%	$1,198,621	$951,644
Payroll Overhead	Labor	18%	$123,668	$123,668
Plant Overhead	Labor	50%	$353,337	$353,337
Insurance and Taxes	TPI	3%	$1,064,898	$852,475

The total manufacturing costs were estimated from the above direct and indirect costs. As shown in Table 16, the yearly manufacturing costs for both Cases A and B, are less than the corresponding manufacturing costs for the natural gas base case. The plant was assumed to operate 90% of the year. Negative values indicate revenue, while positive values indicate expenses.

Table 16. Total Yearly Manufacturing Costs ($/yr)

	Base Case	Case A	Case B
Direct Costs			
Materials			
Biomass	$0	$1,369,916	$1,306,196
Catalyst	$0	$720	$0
Solids Disposal	$0	$93,492	$89,160
Diesel Fuel (Front Loader)	$0	$71,035	$71,035
Wastewater Treatment	$0	$40,170	$38,302
Utilities			
Electricity	$176,463	$672,483	$597,342
Natural Gas	$6,614,814	$0	$0
IP Steam	-$521,080	-$103,663	-$90,547
LP Steam	$0	-$218,477	-$208,314
Labor	$0	$0	$706,673
Maintenance	$0	$0	$1,198,621
Indirect Costs			
Payroll Overhead	$0	$123,668	$123,668
General Overhead	$0	$353,337	$353,337
Insurance and Taxes	$0	$1,064,898	$1,064,898
Yearly Manufacturing Costs	**$6,270,198**	**$5,372,873**	**$5,250,369**

4.2.3 Economic Comparison

A comparison of the economics for the natural gas fired kiln (base case) and the gasification alternatives, Cases A and B, was performed to assess the economic desirability of utilizing gasification derived synthesis gas in place of natural gas. To assess the desirability, the present worth, internal rate of return (IRR), and the discounted payback period for both cases were calculated. Cash flows for each year were assumed to be the difference between the yearly manufacturing costs of the base case and either Case A or Case B. Inflation was accounted for each year at 3.5%.

4.2.3.1 Present Worth

The present worth (PW) of the project is calculated by discounting all cash inflows and outflows to the present point in time at a specific interest rate, generally the minimum annual rate of return (MARR). The MARR was assumed to be 10% for this project. A project is economically viable if the PW is greater than or equal zero.

$$PW(i\%) = \sum_{k=0}^{N} F_k (1+i)^{-k} \tag{21}$$

where i is the effective interest rate, or MARR, per compounding period, k is the index for each compounding period, F_k is the cash flow at the end of period k, and N is the number of compounding periods in the planning horizon, i.e. the study period (Sullivan 2003). Present worth calculations were performed for both 10 year and 20 year project periods for the calculated TPI and at ±30% TPI. As shown in Table 17, the present worth for all variations of Case A and Case B for a project life of either 10 or 20 years are less than zero. Therefore, according to the present worth method, the project is not economically viable.

Table 17. Present Worth Results (MARR = 10%)

	N = 10 years	N = 20 years
Case A	-$30,041,148	-$27,905,151
Case A (-30% TPI)	-$17,426,609	-$14,530,147
Case A (+30% TPI)	-$42,655,687	-$41,280,156
Case B	-$22,141,254	-$19,713,650
Case B (-30% TPI)	-$11,650,940	-$8,462,871
Case B (+30% TPI)	-$32,631,600	-$30,964,429

4.2.3.2 Internal Rate of Return

The IRR method is the most widely used rate of return method for performing engineering economic analyses. This method solves for the interest rate that equates the equivalent worth of an alternative's cash inflows to the equivalent worth of cash outflows, the interest rate at which the PW is zero. The resulting interest is the IRR (i'). For the project to be economically viable the calculated IRR must be greater than the desired MARR (Sullivan 2003).

$$PW(i'\%) = \sum_{k=0}^{N} F_k (1+i')^{-k} = 0 \tag{22}$$

IRR calculations were performed for both 10 year and 20 year project periods for the calculated TPI and at ±30% TPI. As shown in Table 18, the IRR, for all variations of Case A and Case B for a project life of either 10 or 20 years, is less than the MARR of 10%. Therefore, according to the internal rate of return method, the project is not economically viable.

Table 18. Internal Rate of Return Results (i')

	N = 10 years	N = 20 years
Case A	-19.5%	-5.8%
Case A (-30% TPI)	-11.3%	-0.2%
Case A (+30% TPI)	-26.7%	-10.6%
Case B	-15.3%	-2.9%
Case B (-30% TPI)	-6.6%	3.1%
Case B (+30% TPI)	-22.5	-7.8%

4.2.3.3 Discounted Payback Period

All of the economics presented to this point reflect the profitability of a proposed alternative. The discounted payback period, or the breakeven life, indicates a project's liquidity rather than profitability, i.e. how quickly the invested capital would be recovered. The discounted payback period is the first year in which the cumulative discounted cash inflows exceed the capital investment.

$$\sum_{k=0}^{\theta'} F_k \left(1+i'\right)^{-k} \geq 0 \qquad (23)$$

where θ' is the smallest value that satisfies the above equation, or the first year where the cumulative present worth is greater than zero. Discounted payback period calculations were performed for base cases at the calculated TPI and at ±30% TPI. As shown in Table 19, the discounted payback period for each case and associated variations are significantly longer than 10 or 20 year project investment periods. Therefore, according to the discounted payback period method, the project is considered financially risky.

Table 19. Discounted Payback Period Results (MARR = 10%)

	θ'
Case A	Never
Case A (-30% TPI)	Never
Case A (+30% TPI)	Never
Case B	Never
Case B (-30% TPI)	Never
Case B (+30% TPI)	Never

4.2.4 Economic Sensitivity

Sensitivity analyses for biomass utilization credits, CO_2 derived biomass credits, and natural gas price increases were performed for the present worth calculations. The credit or price increase was determined to provide a PW of zero for both 10 year and 20 year project periods for the calculated TPI and at ±30% TPI for Cases A and B, again an MARR of 10% was assumed. The CO_2 credit is derived from the credit for dry biomass feed, relating the CO_2 credit to the percentage of carbon in the fuel and the ratios of the molecular weights of carbon and CO_2.

Table 20. Sensitivity Analyses Results (PW =0, MARR = 10%)

	N = 10 years	N = 20 years
Biomass Credit ($/BDT) / CO_2 Credit ($/ton Biomass Derived CO_2)		
Case A	81.62 / 49.79	54.67 / 33.35
Case A (-30% TPI)	47.35 / 28.88	28.74 / 17.36
Case A (+30% TPI)	115.90 / 70.70	80.87 / 49.33
Case B	63.09 / 38.49	40.51 / 24.71
Case B (-30% TPI)	33.20 / 20.25	17.39 / 10.61
Case B (+30% TPI)	92.99 / 56.72	63.62 / 38.81
Natural Gas Price ($/1000 ft^3)		
Case A	20.20	16.22
Case A (-30% TPI)	15.14	12.35
Case A (+30% TPI)	25.25	20.09
Case B	17.03	13.85
Case B (-30% TPI)	12.83	10.60
Case B (+30% TPI)	21.23	17.10

The results of the sensitivity analyses, presented in Table 20 above, show that the project can become economically viable if there is a credit for utilization of biomass as a feedstock, through either a direct credit or a credit for biomass based CO_2 emissions (green emissions), or if there is a significant increase in the price of natural gas through the project's life starting in year one.

5. CONCLUSIONS AND RECOMMENDATIONS

This analysis shows that it is technically feasible to produce synthetic industrial gas via gasification of hog fuel for direct firing a lime kiln. Two options exist for handling the tars and oils produced in updraft biomass gasification: tar removal (via catalytic tar cracking or an alternative tar removal method) or maintaining the temperature of the synthesis gas stream sufficiently above the tar condensation temperature. Given the capital investment required for tar removal mechanisms and the associated loss in the gas heating value, it is recommended to design the gasification and piping system downstream to maintain the synthesis gas temperature above the tar condensation temperature. This requires low moisture levels in the biomass fed to the gasifier and operating the gasifier below, but near the ash softening point to maximize the outlet temperature of the synthesis gas. In addition, it is recommended to limit the length of piping between the gasifier and the lime kiln to 65 feet or less.

To preclude the formation of tars and oils, the operating temperature of the gasifier near the ash grate is 2000°F, with the possibility of localized hot spots. Given the elevated operating temperature of the gasifier, it is necessary to select robust materials for the gasifier components, specifically the refractory. Given these high temperatures, high purity alumina or chromia refractories may be more desirable than traditional silica refractories and proper selection of materials for the ash grate is essential.

Given the high TPI required for this project and the small offset in the yearly manufacturing costs, utilization of a gasification system for the production of synthetic industrial gas for use in a lime kiln is not economically feasible at this point in time. However, several options exist which could improve the economics of this system and cause it to become economically desirable, such as a credit for utilization of biomass as a feedstock or a significant increase in the price of natural gas. Also, increasing the capacity or output of synthetic natural gas (i.e. increasing the scale of the facility) could improve the economics.

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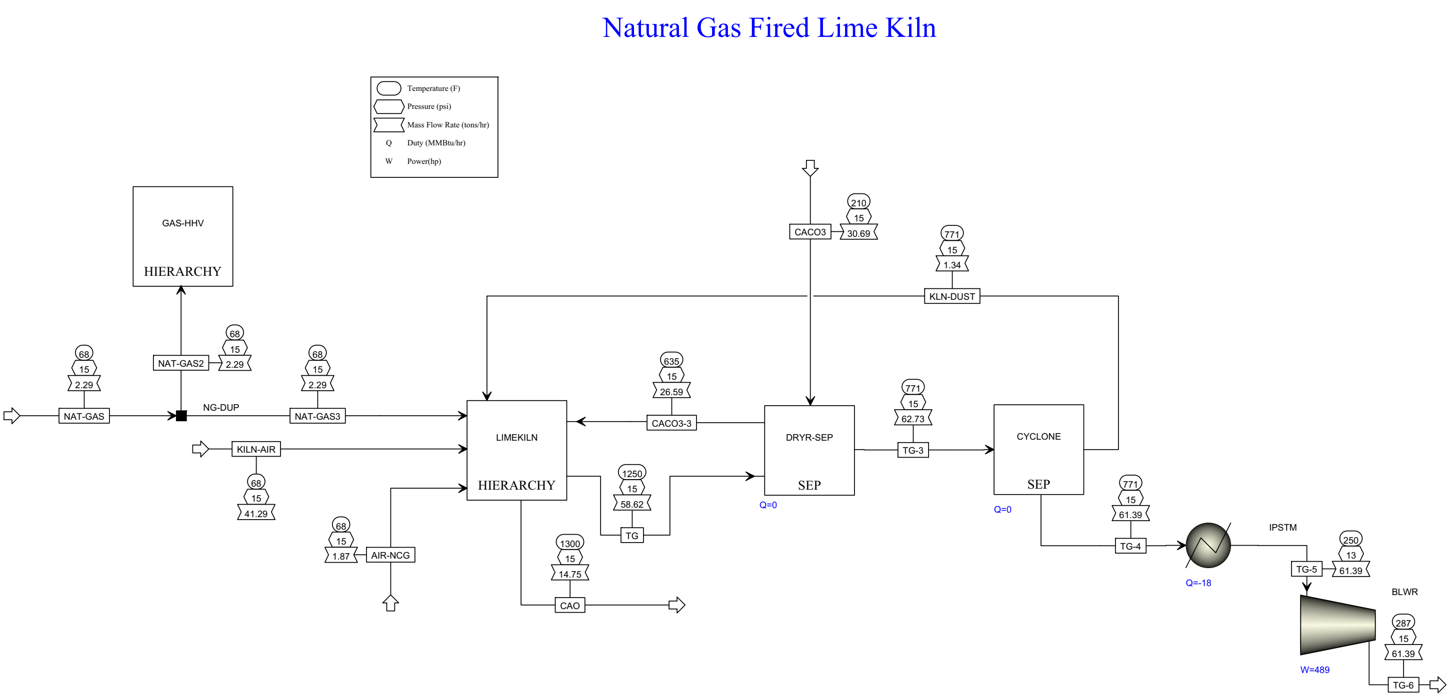
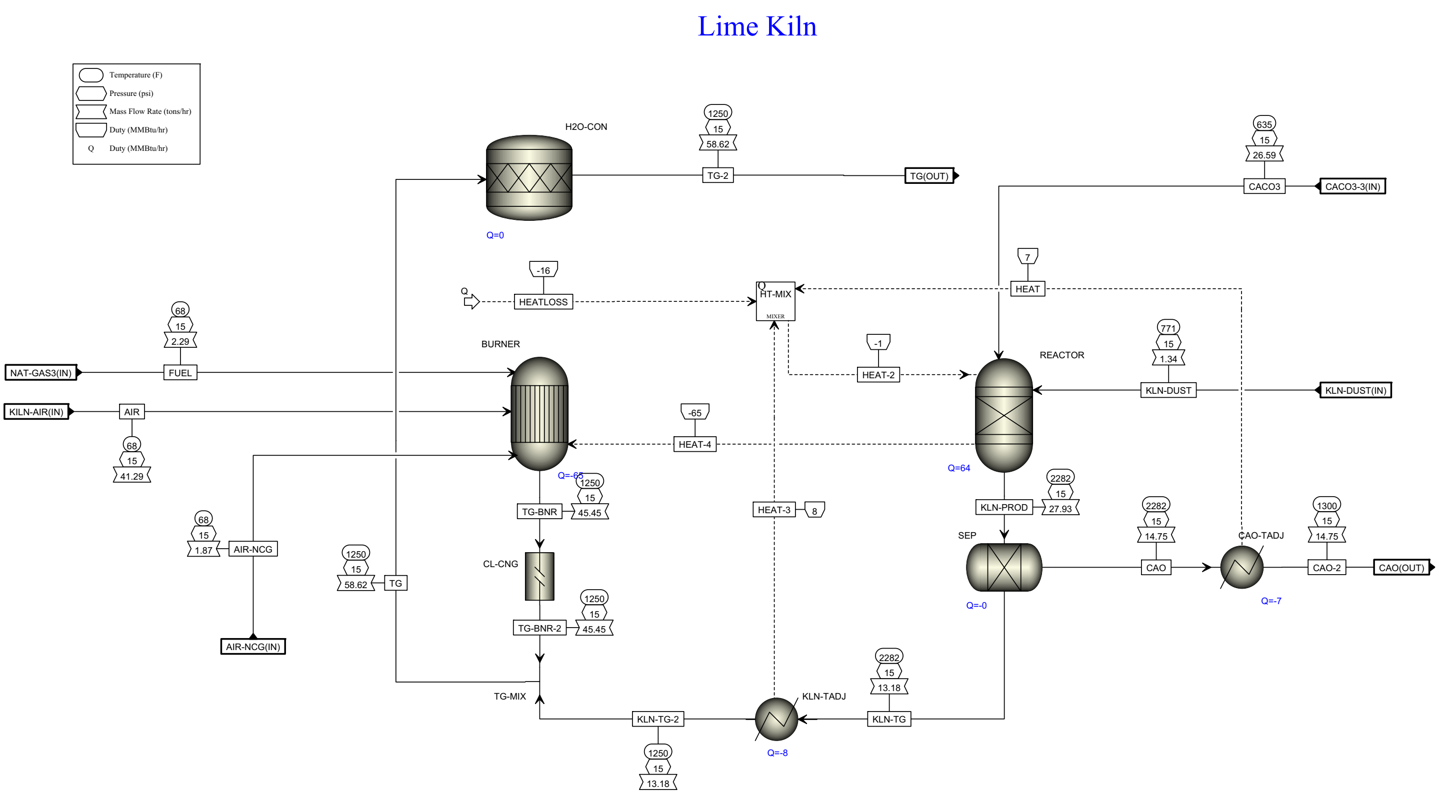
Appendix A

Hog Fuel Project Case Study Results

Base Case Aspen Plus Flowsheets



Base Case Aspen Plus Flowsheets



Base Case Aspen Plus Stream Results

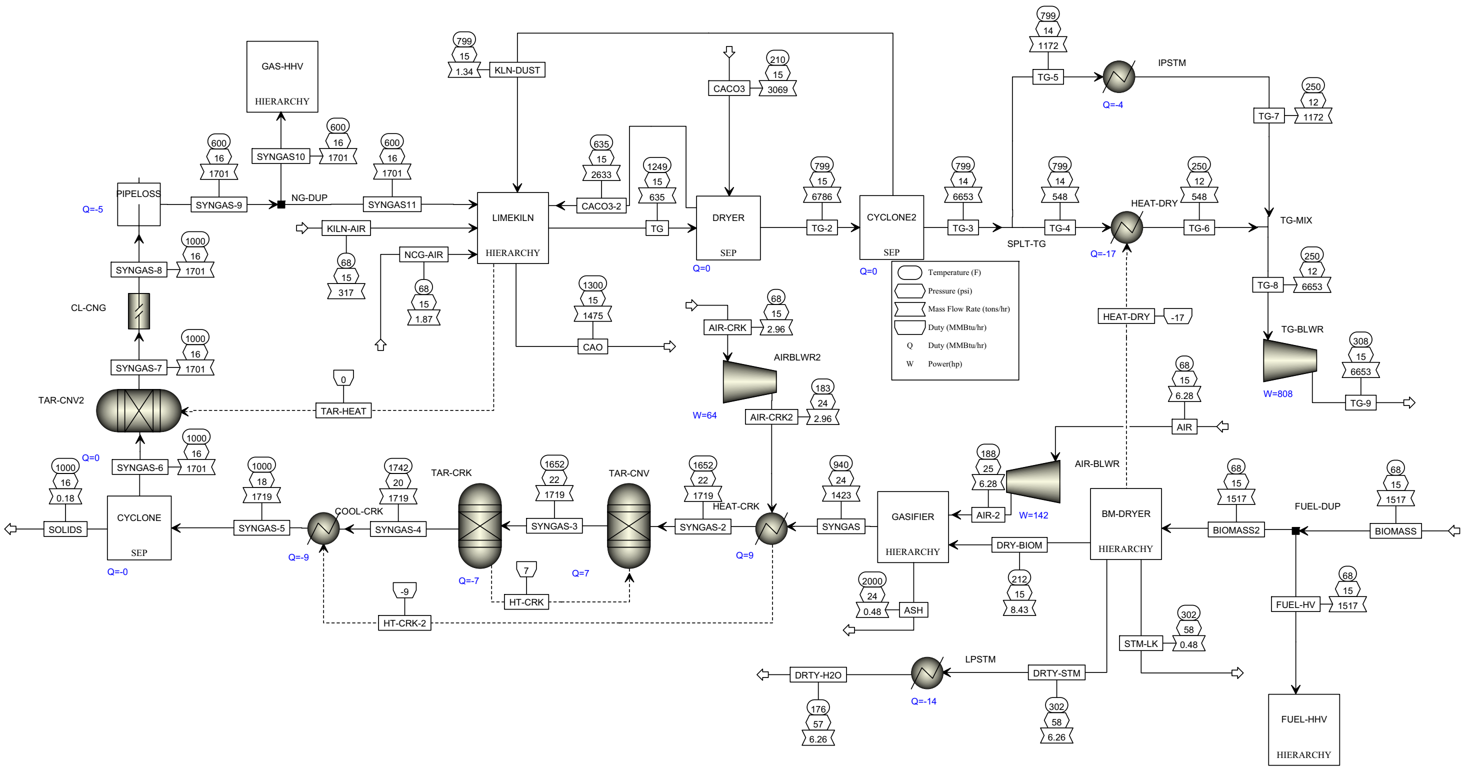
	AIR-NCG	CACO3	CACO3-3	CAO	KILN-AIR	KLN-DUST	NAT-GAS	NAT-GAS2	NAT-GAS3	TG	TG-3	TG-4	TG-5	TG-6
Mixed Substream														
Temperature F	68	210	635		68		68	68	68	1249.9	770.9	770.9	250	287.2
Pressure psi	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	12.7	14.7
Vapor Frac	1		1		1		1	1	1	1	1	1	1	1
Mole Flow lbmol/hr	129.173	484.478	29.069		2852.245		266.983	266.983	266.983	3811.513	4266.922	4266.922	4266.922	4266.922
Mass Flow tons/hr	1.87	4.364	0.262		41.291		2.285	2.285	2.285	57.284	61.386	61.386	61.386	61.386
Volume Flow cuft/hr	49749.865	174.446	23186.855		1.10E+06		102614.677	102614.677	102614.677	4.76E+06	3.83E+06	3.83E+06	2.56E+06	2.32E+06
Enthalpy MMBtu/hr	-0.029	-58.639	-2.888		-0.63		-8.628	-8.628	-8.628	-158.7	-219.449	-219.449	-237.611	-236.367
Mass Flow tons/hr														
C1							2.034	2.034	2.034					
C2							0.076	0.076	0.076					
C3							0.029	0.029	0.029					
I-C4							0.039	0.039	0.039					
N-C4							0.008	0.008	0.008					
N-C5							0.01	0.01	0.01					
I-C5							0.01	0.01	0.01					
C6							0.012	0.012	0.012					
N2	1.41				31.142		0.056	0.056	0.056	32.609	32.609	32.609	32.609	32.609
CO2	0.001				0.019		0.012	0.012	0.012	17.73	17.73	17.73	17.73	17.73
CACO3														
CAO														
CO										0.003	0.003	0.003	0.003	0.003
O2	0.433				9.569					1.22	1.22	1.22	1.22	1.22
AR	0.024				0.535					0.559	0.559	0.559	0.559	0.559
NO2														
NO														
H2O	0.001				0.026					5.164	5.164	5.164	5.164	5.164
H2														
H2O-MUD		4.364	0.262								4.102	4.102	4.102	4.102
Mass Frac														
C1							0.89	0.89	0.89					
C2							0.033	0.033	0.033					
C3							0.013	0.013	0.013					
I-C4							0.017	0.017	0.017					
N-C4							0.003	0.003	0.003					
N-C5							0.004	0.004	0.004					
I-C5							0.004	0.004	0.004					
C6							0.005	0.005	0.005					
N2	0.754				0.754		0.025	0.025	0.025	0.569	0.531	0.531	0.531	0.531
CO2							0.005	0.005	0.005	0.31	0.289	0.289	0.289	0.289
CACO3														
CAO														
CO														
O2	0.232				0.232					0.021	0.02	0.02	0.02	0.02
AR	0.013				0.013					0.01	0.009	0.009	0.009	0.009
NO2														
NO														
H2O	0.001				0.001					0.09	0.084	0.084	0.084	0.084
H2														
H2O-MUD		1	1								0.067	0.067	0.067	0.067
Mole Flow lbmol/hr														
C1							253.631	253.631	253.631					
C2							5.073	5.073	5.073					
C3							1.335	1.335	1.335					
I-C4							1.335	1.335	1.335					
N-C4							0.267	0.267	0.267					
N-C5							0.267	0.267	0.267					

Base Case Aspen Plus Stream Results

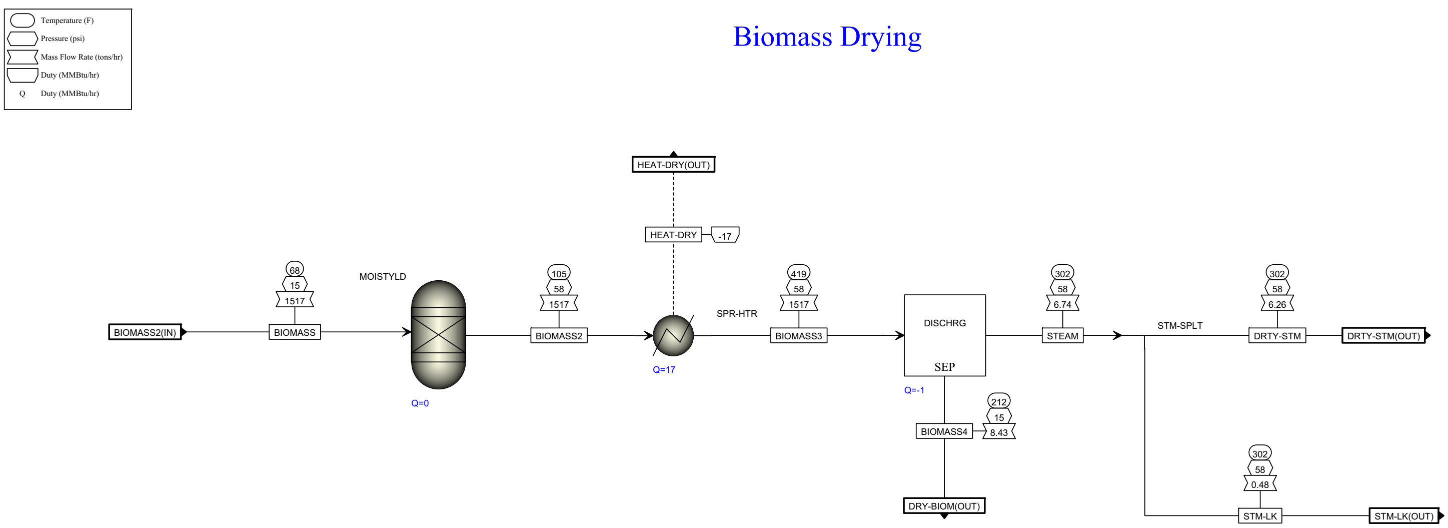
	AIR-NCG	CACO3	CACO3-3	CAO	KILN-AIR	KLN-DUST	NAT-GAS	NAT-GAS2	NAT-GAS3	TG	TG-3	TG-4	TG-5	TG-6
I-C5							0.267	0.267	0.267					
C6							0.267	0.267	0.267					
N2	100.693				2223.384		4.005	4.005	4.005	2328.081	2328.081	2328.081	2328.081	2328.081
CO2	0.039				0.855		0.534	0.534	0.534	805.708	805.708	805.708	805.708	805.708
CACO3														
CAO														
CO										0.241	0.241	0.241	0.241	0.241
O2	27.086				598.088					76.237	76.237	76.237	76.237	76.237
AR	1.213				26.784					27.997	27.997	27.997	27.997	27.997
NO2														
NO														
H2O	0.129				2.849		0.003	0.003	0.003	573.247	573.247	573.247	573.247	573.247
H2	0.013				0.285					0.002	0.002	0.002	0.002	0.002
H2O-MUD		484.478	29.069								455.409	455.409	455.409	455.409
Mole Frac														
C1							0.95	0.95	0.95					
C2							0.019	0.019	0.019					
C3							0.005	0.005	0.005					
I-C4							0.005	0.005	0.005					
N-C4							0.001	0.001	0.001					
N-C5							0.001	0.001	0.001					
I-C5							0.001	0.001	0.001					
C6							0.001	0.001	0.001					
N2	0.78				0.78		0.015	0.015	0.015	0.611	0.546	0.546	0.546	0.546
CO2							0.002	0.002	0.002	0.211	0.189	0.189	0.189	0.189
CACO3														
CAO														
CO														
O2	0.21				0.21					0.02	0.018	0.018	0.018	0.018
AR	0.009				0.009					0.007	0.007	0.007	0.007	0.007
NO2														
NO														
H2O	0.001				0.001					0.15	0.134	0.134	0.134	0.134
H2														
H2O-MUD		1	1								0.107	0.107	0.107	0.107
Solid Substream														
Mass Flow tons/hr		30.69	26.588	14.75		1.339				58.623	62.726	61.386	61.386	61.386
Enthalpy MMBtu/hr		-330.268	-269.233	-135.746		-12.641				-171.054	-232.09	-219.449	-237.611	-236.367
Temperature F		210	635	1300		770.9				1249.9	770.9			
Pressure psi		14.7	14.7	14.7		14.7				14.7	14.7	14.7	12.7	14.7
Vapor Frac														
Mole Flow lbmol/hr		526.061	526.061	526.061		47.759				47.759	47.759			
Mass Flow tons/hr		26.326	26.326	14.75		1.339				1.339	1.339			
Volume Flow cuft/hr		311.289	312.885	143.299		13.01				13.01	13.01			
Enthalpy MMBtu/hr		-271.629	-266.345	-135.746		-12.641				-12.354	-12.641			
Mass Flow tons/hr														
CACO3		26.326	26.326											
CAO				14.75		1.339				1.339	1.339			
Mass Frac														
CACO3		1	1											
CAO				1		1				1	1			
Mole Flow lbmol/hr														
CACO3		526.061	526.061											
CAO				526.061		47.759				47.759	47.759			
Mole Frac														
CACO3		1	1											
CAO				1		1				1	1			

Case A Aspen Plus Flowsheets

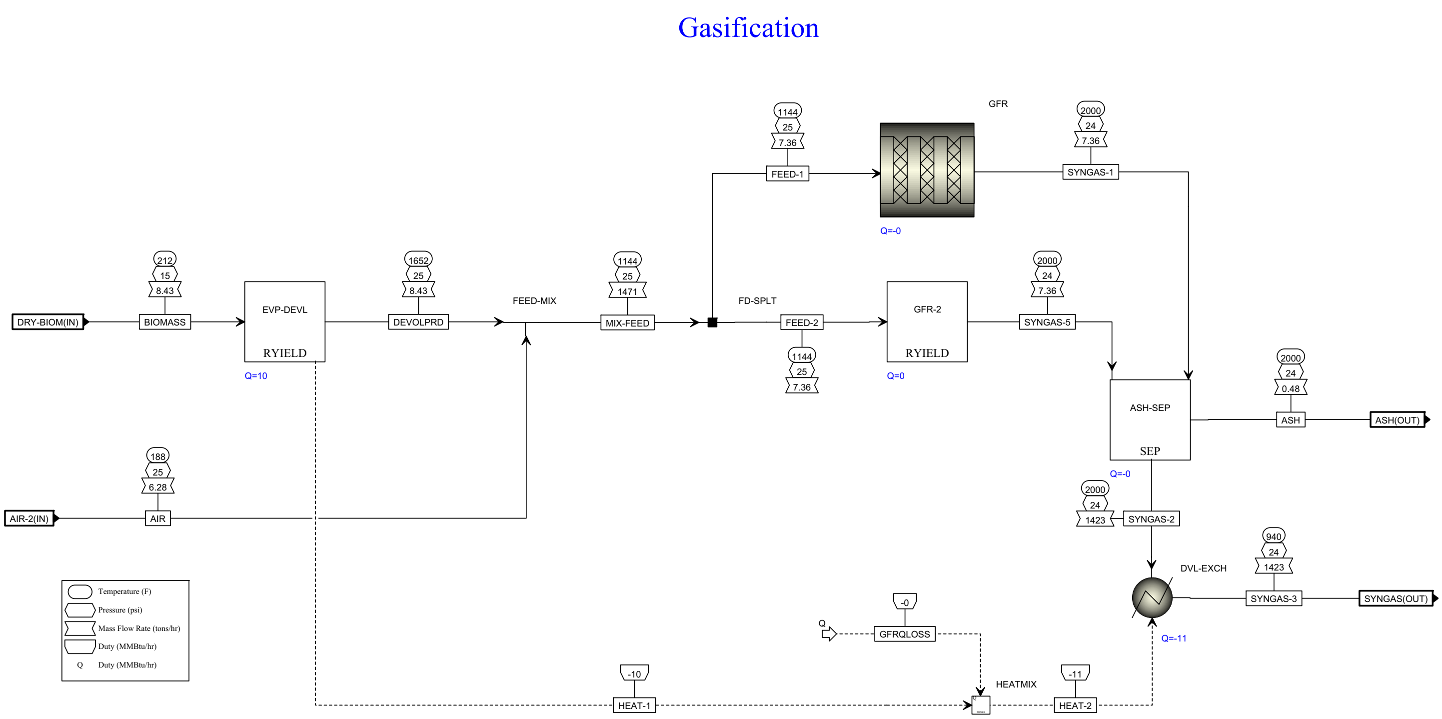
Hog Fuel Gasification with Optional Tar Cracker



Case A Aspen Plus Flowsheets

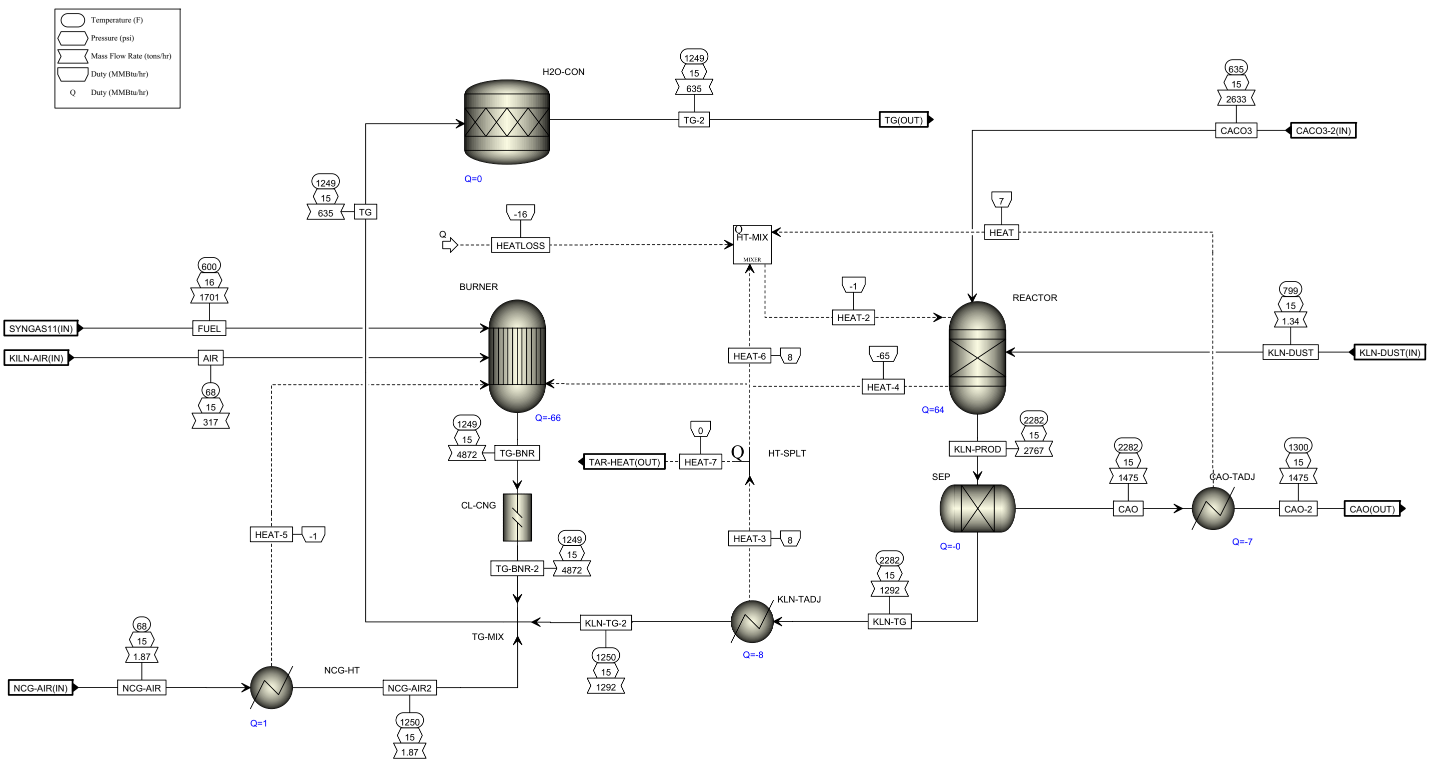


Case A Aspen Plus Flowsheets

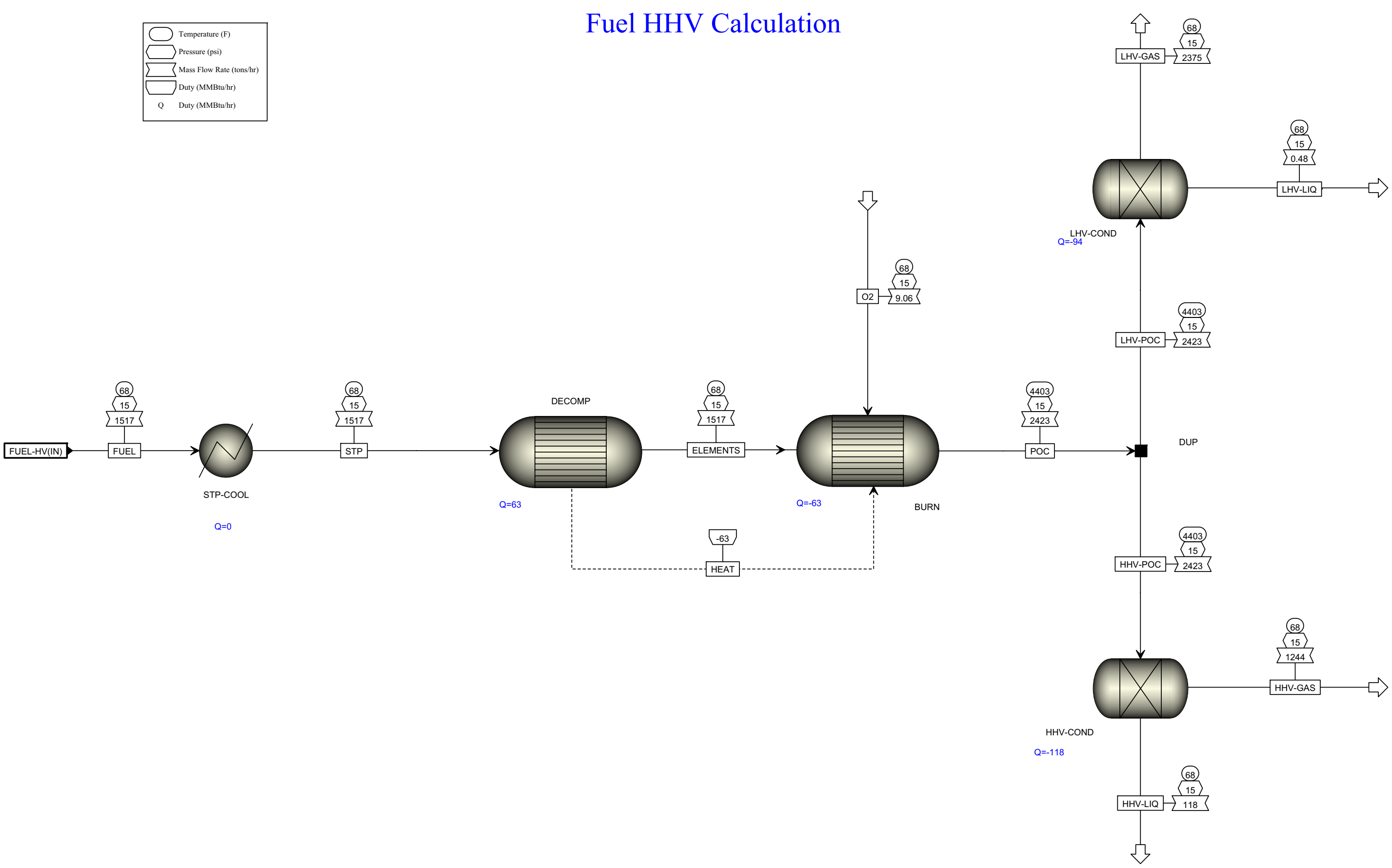


Case A Aspen Plus Flowsheets

Lime Kiln

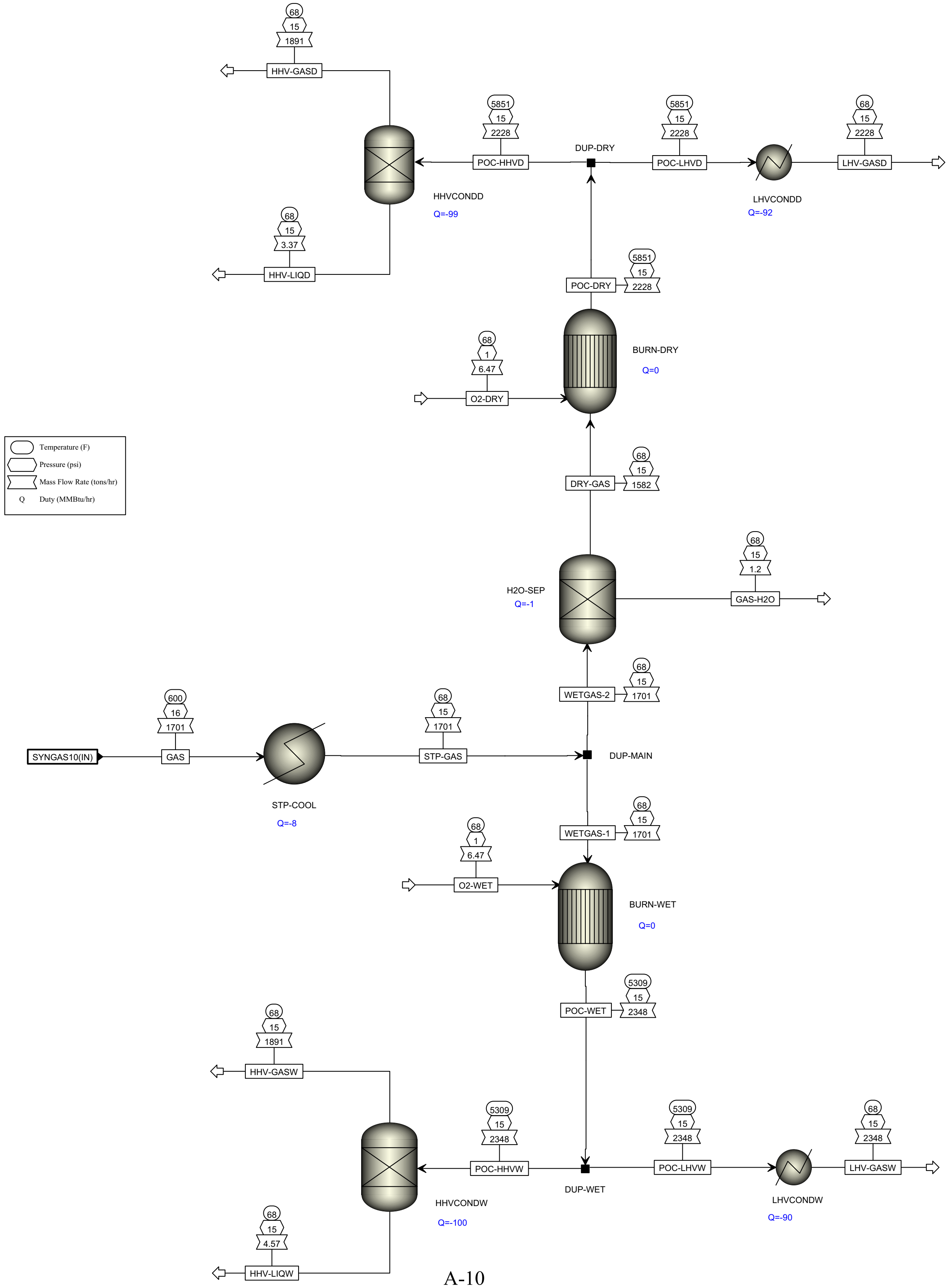


Case A Aspen Plus Flowsheets



Case A Aspen Plus Flowsheets

Gas HHV Calculation



Case A Aspen Plus Stream Results

	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH	BIOMASS	BIOMASS2	CACO3	CACO3-2	CAO	DRTY-H2O	DRTY-STM	DRY-BIOM	FUEL-HV
Mixed Substream														
Temperature F	68	187.9	68	182.6				210	635		176	302		
Pressure psi	14.7	25	14.7	24.46	24.46	14.7	14.7	14.7	14.7	14.7	57.21	58.21	14.7	14.7
Vapor Frac	1	1	1	1					1			1		
Mole Flow lbmol/hr	433.935	433.935	204.303	204.303				484.478			695.032	695.032		
Mass Flow tons/hr	6.282	6.282	2.958	2.958				4.364			6.261	6.261		
Volume Flow cuft/hr	167126.308	120635.19	78685.411	57578.454				174.446	0.004		246.144	95176.605		
Enthalpy MMBtu/hr	-0.096	0.266	-0.045	0.118				-58.639			-84.587	-71.06		
Mass Flow tons/hr														
N2	4.738	4.738	2.231	2.231										
CO2	0.003	0.003	0.001	0.001										
CACO3														
CAO														
CO														
O2	1.456	1.456	0.685	0.685										
AR	0.081	0.081	0.038	0.038										
NO2														
NO														
H2O	0.004	0.004	0.002	0.002							6.261	6.261		
H2														
H2O-MUD								4.364						
CH4														
C														
Mass Frac														
N2	0.754	0.754	0.754	0.754										
CO2														
CACO3														
CAO														
CO														
O2	0.232	0.232	0.232	0.232										
AR	0.013	0.013	0.013	0.013										
NO2														
NO														
H2O	0.001	0.001	0.001	0.001							1	1		
H2														
H2O-MUD								1	1					
CH4														
C														
Mole Flow lbmol/hr														
N2	338.261	338.261	159.258	159.258										
CO2	0.13	0.13	0.061	0.061										
CACO3														
CAO														
CO														
O2	90.992	90.992	42.84	42.84										
AR	4.075	4.075	1.919	1.919										
NO2														
NO														
H2O	0.434	0.434	0.204	0.204							695.032	695.032		
H2	0.043	0.043	0.02	0.02										
H2O-MUD								484.478						
CH4														
C														
Mole Frac														
N2	0.78	0.78	0.78	0.78										
CO2														
CACO3														

Case A Aspen Plus Stream Results

	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH	BIOMASS	BIOMASS2	CACO3	CACO3-2	CAO	DRTY-H2O	DRTY-STM	DRY-BIOM	FUEL-HV
CAO														
CO														
O2	0.21	0.21	0.21	0.21										
AR	0.009	0.009	0.009	0.009										
NO2														
NO														
H2O	0.001	0.001	0.001	0.001							1	1		
H2														
H2O-MUD								1	1					
CH4														
C														
Nonconventional Substream														
Mass Flow tons/hr	6.282	6.282	2.958	2.958	0.479	15.175	15.175	30.69	26.326	14.75	6.261	6.261	8.43	15.175
Enthalpy MMBtu/hr	-0.096	0.266	-0.045	0.118	0.552	-132.811	-132.811	-330.268	-266.345	-135.746	-84.587	-71.06	-40.47	-132.811
Temperature F					1999.9	68	68						212	68
Pressure psi	14.7	25	14.7	24.46	24.46	14.7	14.7				57.21	58.21	14.7	14.7
Vapor Frac														
Mass Flow tons/hr					0.479	15.175	15.175						8.43	15.175
Enthalpy MMBtu/hr					0.552	-132.811	-132.811						-40.47	-132.811
Mass Flow tons/hr														
CHAR														
FUEL						15.175	15.175						8.43	15.175
TAR														
ASH					0.479									
Mass Frac														
CHAR														
FUEL						1	1						1	1
TAR														
ASH					1									
Soid Substream														
Temperature F								210	635	1300				
Pressure psi								14.7	14.7	14.7				
Vapor Frac														
Mole Flow lbmol/hr								526.061	526.061	526.061				
Mass Flow tons/hr								26.326	26.326	14.75				
Volume Flow cuft/hr								311.289	312.885	143.299				
Enthalpy MMBtu/hr								-271.629	-266.345	-135.746				
Mass Flow tons/hr														
CACO3								26.326	26.326					
CAO										14.75				
Mass Frac														
CACO3								1	1					
CAO										1				
Mole Flow lbmol/hr														
CACO3								526.061	526.061					
CAO										526.061				
Mole Frac														
CACO3								1	1					
CAO										1				

Case A Aspen Plus Stream Results

	KILN-AIR	KLN-DUST	NCG-AIR	SOLIDS	STM-LK	SYNGAS	SYNGAS-2	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7	SYNGAS-8
Mixed Substream													
Temperature F	68		68		302	940.1	1652	1652	1742	1000.2	1000.2	1000.2	1000.2
Pressure psi	14.7	14.7	14.7	16.46	58.21	24.46	22.46	22.46	20.46	18.46	16.46	16.46	16.46
Vapor Frac	1		1		1	1	1	0.953	1	1	1	0.998	0.998
Mole Flow lbmol/hr	2190.038		129.173		53.704	1159.389	1363.691	1500.077	1542.765	1542.765	1542.765	1548.448	1548.448
Mass Flow tons/hr	31.705		1.87		0.484	13.307	16.265	16.981	16.981	16.981	16.981	17.011	17.011
Volume Flow cuft/hr	843475.129		49749.865		7354.099	712327.275	1.38E+06	1.44E+06	1.78E+06	1.31E+06	1.47E+06	1.47E+06	1.47E+06
Enthalpy MMBtu/hr	-0.483		-0.029		-5.491	-39.664	-30.125	-24.397	-31.846	-41.267	-41.267	-41.082	-41.082
Mass Flow tons/hr													
N2	23.912		1.41			4.738	6.969	6.969	6.969	6.969	6.969	6.969	6.969
CO2	0.014		0.001			1.092	1.093	1.093	2.311	2.311	2.311	2.311	2.311
CACO3													
CAO													
CO						5.088	5.088	5.088	6.01	6.01	6.01	6.01	6.01
O2	7.347		0.433				0.685	0.925				0.01	0.01
AR	0.411		0.024			0.081	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NO2													
NO													
H2O	0.02		0.001		0.484	1.743	1.745	1.745	1.196	1.196	1.196	1.196	1.196
H2						0.162	0.162	0.212	0.375	0.375	0.375	0.377	0.377
H2O-MUD													
CH4						0.403	0.403	0.403					
C								0.426				0.018	0.018
Mass Frac													
N2	0.754		0.754			0.356	0.428	0.41	0.41	0.41	0.41	0.41	0.41
CO2						0.082	0.067	0.064	0.136	0.136	0.136	0.136	0.136
CACO3													
CAO													
CO						0.382	0.313	0.3	0.354	0.354	0.354	0.353	0.353
O2	0.232		0.232				0.042	0.054				0.001	0.001
AR	0.013		0.013			0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007
NO2													
NO													
H2O	0.001		0.001		1	0.131	0.107	0.103	0.07	0.07	0.07	0.07	0.07
H2						0.012	0.01	0.013	0.022	0.022	0.022	0.022	0.022
H2O-MUD													
CH4						0.03	0.025	0.024					
C								0.025				0.001	0.001
Mole Flow lbmol/hr													
N2	1707.18		100.693			338.261	497.519	497.519	497.519	497.519	497.519	497.519	497.519
CO2	0.656		0.039			49.607	49.669	49.669	105.04	105.04	105.04	105.04	105.04
CACO3													
CAO													
CO						363.294	363.294	363.294	429.159	429.159	429.159	429.159	429.159
O2	459.23		27.086				42.84	57.802				0.623	0.623
AR	20.566		1.213			4.075	5.993	5.993	5.993	5.993	5.993	5.993	5.993
NO2													
NO													
H2O	2.188		0.129		53.704	193.537	193.741	193.741	132.737	132.737	132.737	132.737	132.737
H2	0.219		0.013			160.333	160.354	210.787	372.28	372.28	372.28	374.381	374.381
H2O-MUD													
CH4						50.282	50.282	50.282	0.037	0.037	0.037	0.037	0.037
C								70.991				2.958	2.958
Mole Frac													
N2	0.78		0.78			0.292	0.365	0.332	0.322	0.322	0.322	0.321	0.321
CO2						0.043	0.036	0.033	0.068	0.068	0.068	0.068	0.068
CACO3													

Case A Aspen Plus Stream Results

	KILN-AIR	KLN-DUST	NCG-AIR	SOLIDS	STM-LK	SYNGAS	SYNGAS-2	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7	SYNGAS-8
CAO													
CO						0.313	0.266	0.242	0.278	0.278	0.278	0.277	0.277
O2	0.21		0.21				0.031	0.039					
AR	0.009		0.009			0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
NO2													
NO													
H2O	0.001		0.001		1	0.167	0.142	0.129	0.086	0.086	0.086	0.086	0.086
H2						0.138	0.118	0.141	0.241	0.241	0.241	0.242	0.242
H2O-MUD													
CH4						0.043	0.037	0.034					
C								0.047				0.002	0.002
Nonconventional Substream													
Mass Flow tons/hr		1.339		0.18	0.484	14.234	17.191	17.191	17.191	17.191	17.011	17.011	
Enthalpy MMBtu/hr		-12.624		0.299	-5.491	-41.158	-31.619	-24.17	-31.619	-41.04	-41.339	-41.082	
Temperature F				1000.2		940.1	1652	1652	1742	1000.2	1000.2		
Pressure psi				16.46	58.21	24.46	22.46	22.46	20.46	18.46	16.46	16.46	
Vapor Frac													
Mass Flow tons/hr				0.18		0.926	0.926	0.21	0.21	0.21	0.03		
Enthalpy MMBtu/hr				0.299		-1.494	-1.494	0.227	0.227	0.227	-0.072		
Mass Flow tons/hr													
CHAR				0.18		0.18	0.18	0.18	0.18	0.18			
FUEL													
TAR						0.746	0.746	0.03	0.03	0.03	0.03		
ASH													
Mass Frac													
CHAR				1		0.194	0.194	0.858	0.858	0.858			
FUEL													
TAR						0.806	0.806	0.142	0.142	0.142	1		
ASH													
Soid Substream													
Temperature F		798.9											
Pressure psi		14.7											
Vapor Frac													
Mole Flow lbmol/hr		47.759											
Mass Flow tons/hr		1.339											
Volume Flow cuft/hr		13.01											
Enthalpy MMBtu/hr		-12.624											
Mass Flow tons/hr													
CACO3													
CAO		1.339											
Mass Frac													
CACO3													
CAO		1											
Mole Flow lbmol/hr													
CACO3													
CAO		47.759											
Mole Frac													
CACO3													
CAO		1											

Case A Aspen Plus Stream Results

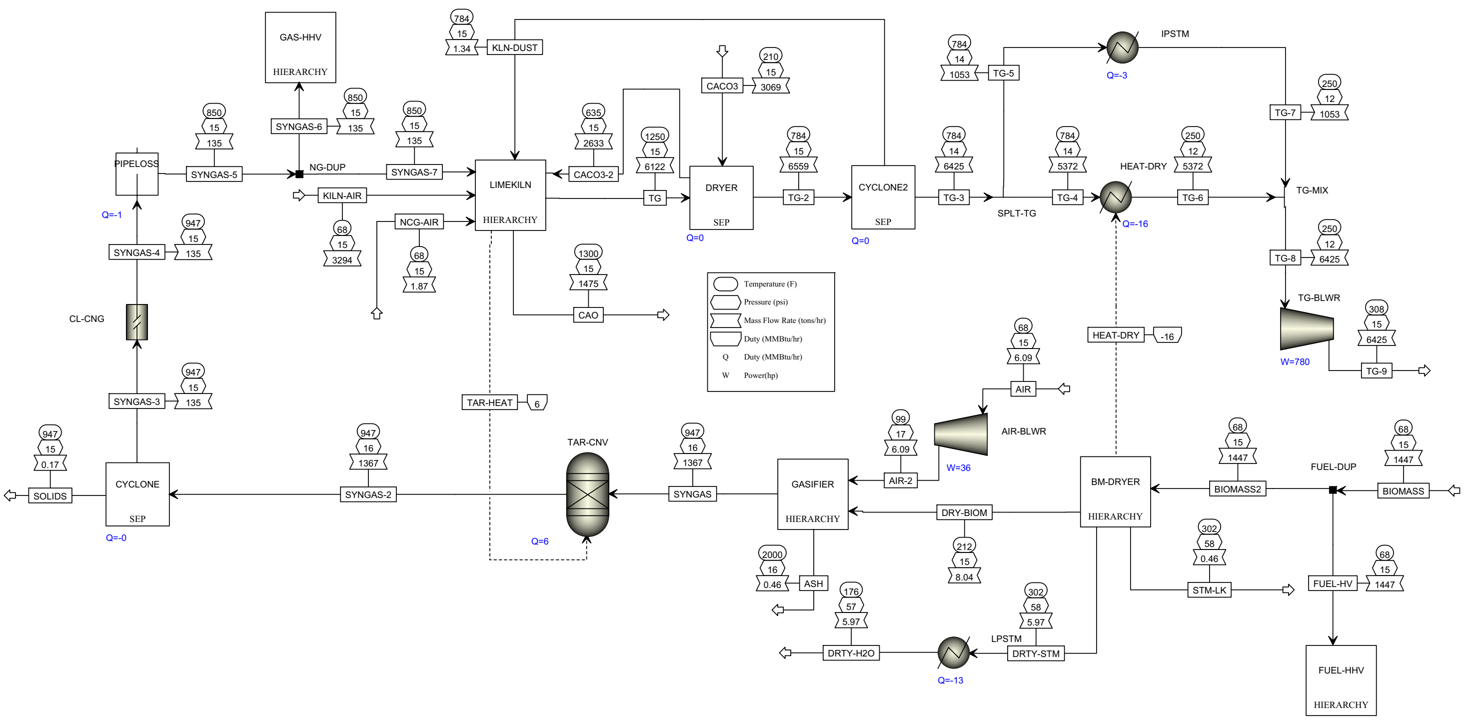
	SYNGAS-9	SYNGAS10	SYNGAS11	TG	TG-2	TG-3	TG-4	TG-5	TG-6	TG-7	TG-8	TG-9
Mixed Substream												
Temperature F	600	600	600	1249.2	798.9	798.9	798.9	798.9	250	250	250	307.7
Pressure psi	15.96	15.96	15.96	14.7	14.7	13.7	13.7	13.7	11.7	11.7	11.7	14.7
Vapor Frac	0.998	0.998	0.998	1	1	1	1	1	1	1	1	1
Mole Flow lbmol/hr	1548.448	1548.448	1548.448	3989.002	4473.479	4473.479	3685.268	788.211	3685.268	788.211	4473.479	4473.479
Mass Flow tons/hr	17.011	17.011	17.011	62.162	66.526	66.526	54.804	11.722	54.804	11.722	66.526	66.526
Volume Flow cuft/hr	1.10E+06	1.10E+06	1.10E+06	4.98E+06	4.11E+06	4.41E+06	3.63E+06	777384.367	2.40E+06	512712.19	2.91E+06	2.50E+06
Enthalpy MMBtu/hr	-45.889	-45.889	-45.889	-193.168	-256.821	-256.821	-211.57	-45.251	-228.462	-48.864	-277.325	-275.27
Mass Flow tons/hr												
N2	6.969	6.969	6.969	32.291	32.291	32.291	26.601	5.69	26.601	5.69	32.291	32.291
CO2	2.311	2.311	2.311	23.407	23.407	23.407	19.283	4.124	19.283	4.124	23.407	23.407
CACO3												
CAO												
CO	6.01	6.01	6.01	0.003	0.003	0.003	0.003	0.001	0.003	0.001	0.003	0.003
O2	0.01	0.01	0.01	1.314	1.314	1.314	1.083	0.232	1.083	0.232	1.314	1.314
AR	0.12	0.12	0.12	0.555	0.555	0.555	0.457	0.098	0.457	0.098	0.555	0.555
NO2												
NO												
H2O	1.196	1.196	1.196	4.591	4.591	4.591	3.782	0.809	3.782	0.809	4.591	4.591
H2	0.377	0.377	0.377									
H2O-MUD					4.364	4.364	3.595	0.769	3.595	0.769	4.364	4.364
CH4												
C	0.018	0.018	0.018									
Mass Frac												
N2	0.41	0.41	0.41	0.519	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485
CO2	0.136	0.136	0.136	0.377	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352
CACO3												
CAO												
CO	0.353	0.353	0.353									
O2	0.001	0.001	0.001	0.021	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
AR	0.007	0.007	0.007	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
NO2												
NO												
H2O	0.07	0.07	0.07	0.074	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
H2	0.022	0.022	0.022									
H2O-MUD					0.066	0.066	0.066	0.066	0.066	0.066	0.066	0.066
CH4												
C	0.001	0.001	0.001									
Mole Flow lbmol/hr												
N2	497.519	497.519	497.519	2305.392	2305.392	2305.392	1899.19	406.202	1899.19	406.202	2305.392	2305.392
CO2	105.04	105.04	105.04	1063.712	1063.712	1063.712	876.29	187.422	876.29	187.422	1063.712	1063.712
CACO3												
CAO												
CO	429.159	429.159	429.159	0.238	0.238	0.238	0.196	0.042	0.196	0.042	0.238	0.238
O2	0.623	0.623	0.623	82.147	82.147	82.147	67.673	14.474	67.673	14.474	82.147	82.147
AR	5.993	5.993	5.993	27.772	27.772	27.772	22.879	4.893	22.879	4.893	27.772	27.772
NO2												
NO												
H2O	132.737	132.737	132.737	509.728	509.728	509.728	419.916	89.812	419.916	89.812	509.728	509.728
H2	374.381	374.381	374.381	0.013	0.013	0.013	0.011	0.002	0.011	0.002	0.013	0.013
H2O-MUD					484.478	484.478	399.114	85.363	399.114	85.363	484.478	484.478
CH4	0.037	0.037	0.037									
C	2.958	2.958	2.958									
Mole Frac												
N2	0.321	0.321	0.321	0.578	0.515	0.515	0.515	0.515	0.515	0.515	0.515	0.515
CO2	0.068	0.068	0.068	0.267	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238
CACO3												

Case A Aspen Plus Stream Results

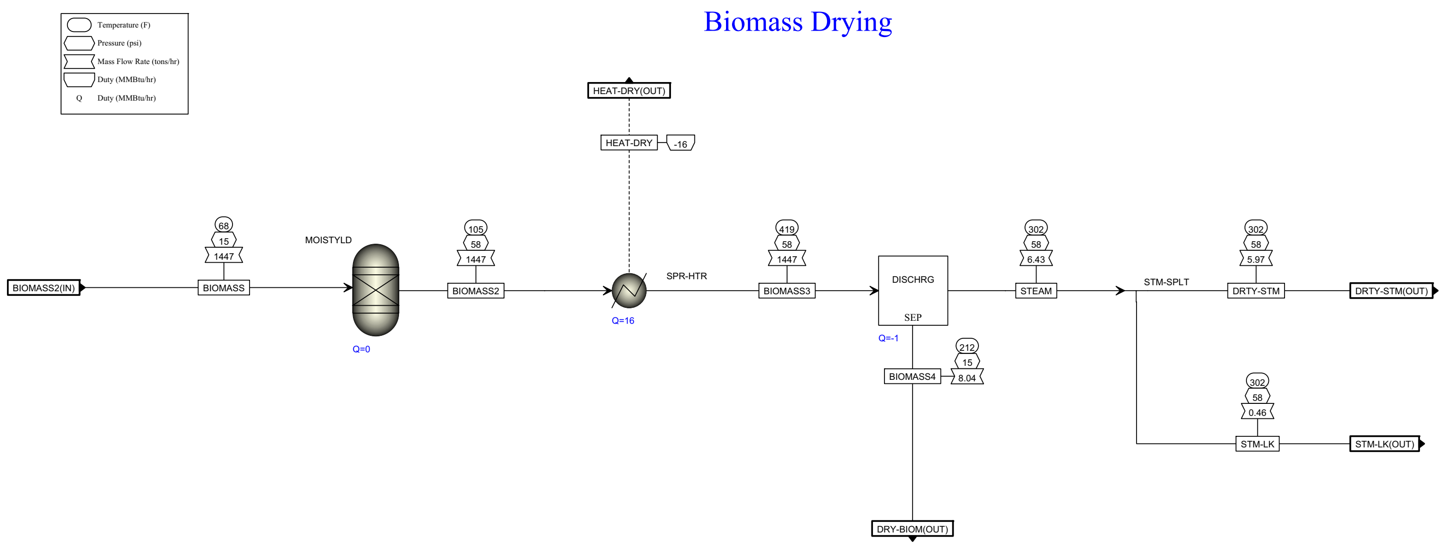
	SYNGAS-9	SYNGAS10	SYNGAS11	TG	TG-2	TG-3	TG-4	TG-5	TG-6	TG-7	TG-8	TG-9
CAO												
CO	0.277	0.277	0.277									
O2				0.021	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
AR	0.004	0.004	0.004	0.007	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
NO2												
NO												
H2O	0.086	0.086	0.086	0.128	0.114	0.114	0.114	0.114	0.114	0.114	0.114	0.114
H2	0.242	0.242	0.242									
H2O-MUD					0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
CH4												
C	0.002	0.002	0.002									
Nonconventional Substream												
Mass Flow tons/hr				63.501	67.865	66.526	54.804	11.722	54.804	11.722	66.526	66.526
Enthalpy MMBtu/hr				-205.522	-269.445	-256.821	-211.57	-45.251	-228.462	-48.864	-277.325	-275.27
Temperature F												
Pressure psi												
Vapor Frac												
Mass Flow tons/hr												
Enthalpy MMBtu/hr												
Mass Flow tons/hr												
CHAR												
FUEL												
TAR												
ASH												
Mass Frac												
CHAR												
FUEL												
TAR												
ASH												
Soid Substream												
Temperature F				1249.2	798.9							
Pressure psi				14.7	14.7	13.7	13.7	13.7	11.7	11.7	11.7	14.7
Vapor Frac												
Mole Flow lbmol/hr				47.759	47.759							
Mass Flow tons/hr				1.339	1.339							
Volume Flow cuft/hr				13.01	13.01							
Enthalpy MMBtu/hr				-12.355	-12.624							
Mass Flow tons/hr												
CACO3												
CAO				1.339	1.339							
Mass Frac												
CACO3												
CAO				1	1							
Mole Flow lbmol/hr												
CACO3												
CAO				47.759	47.759							
Mole Frac												
CACO3												
CAO				1	1							

Case B Aspen Plus Flowsheets

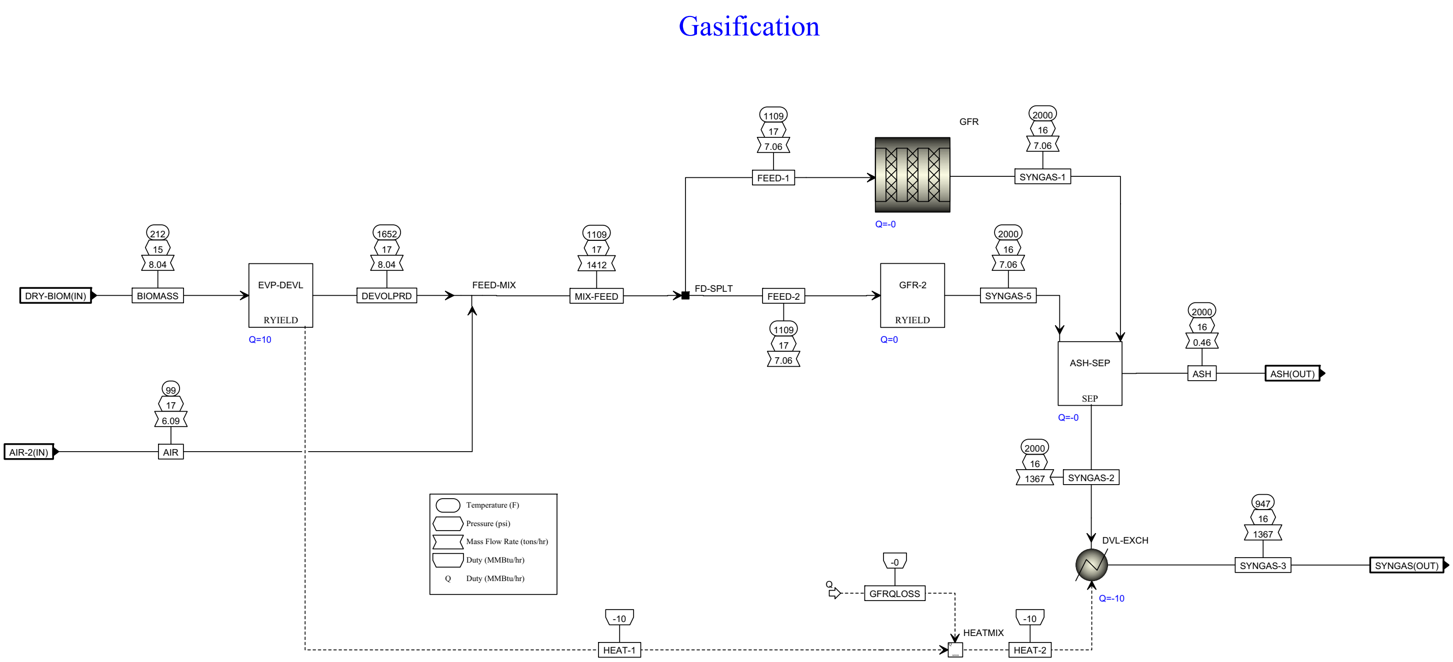
Hog Fuel Gasification



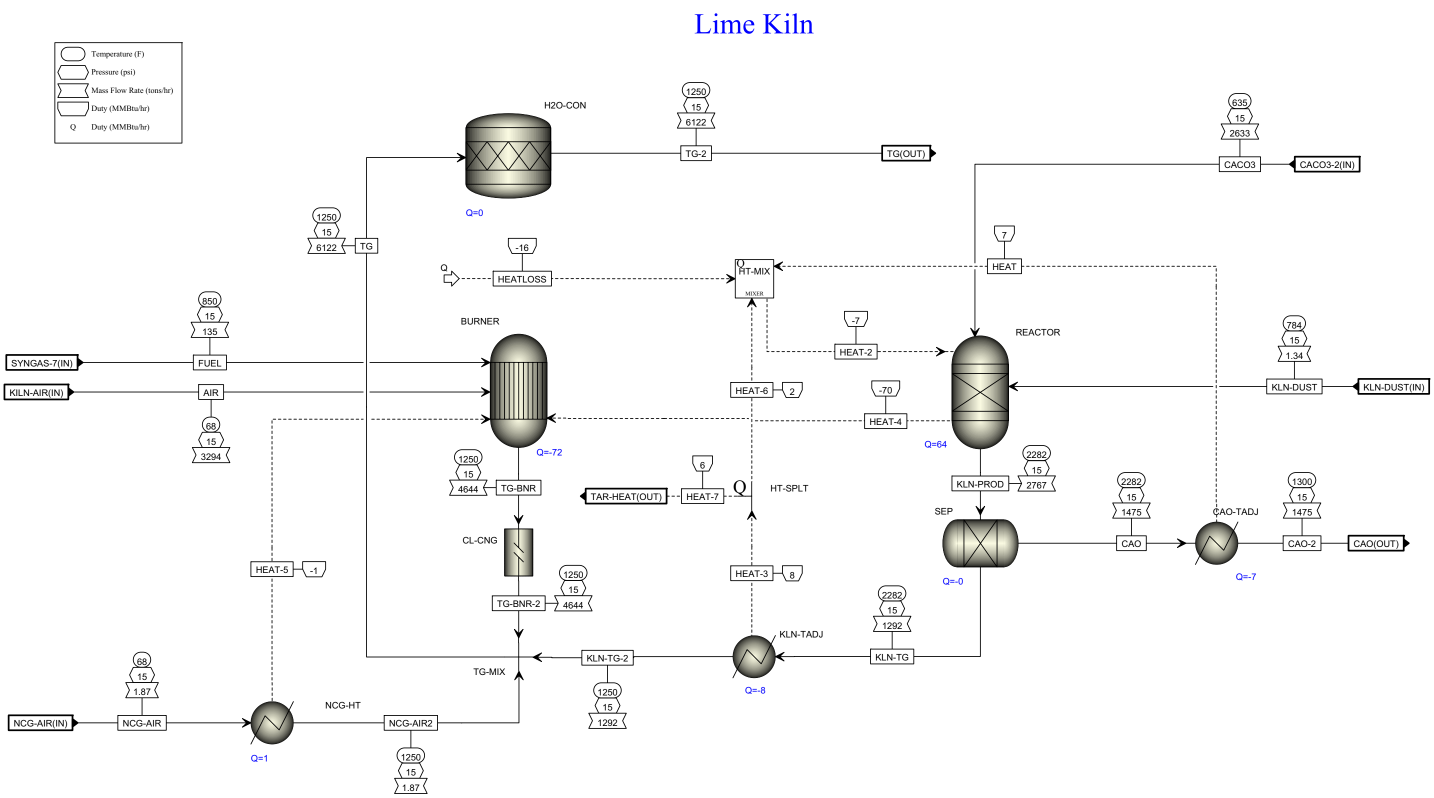
Case B Aspen Plus Flowsheets



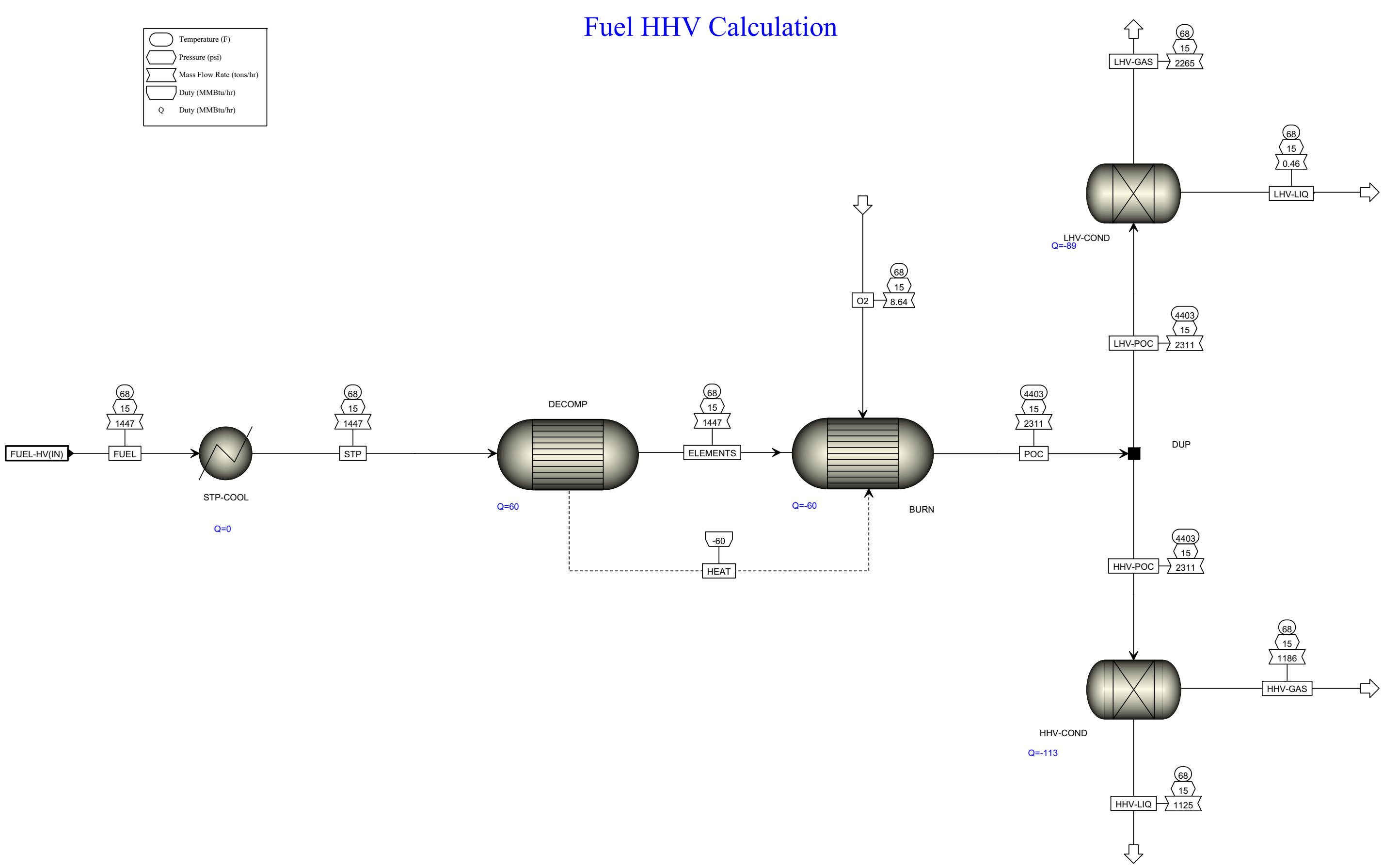
Case B Aspen Plus Flowsheets



Case B Aspen Plus Flowsheets

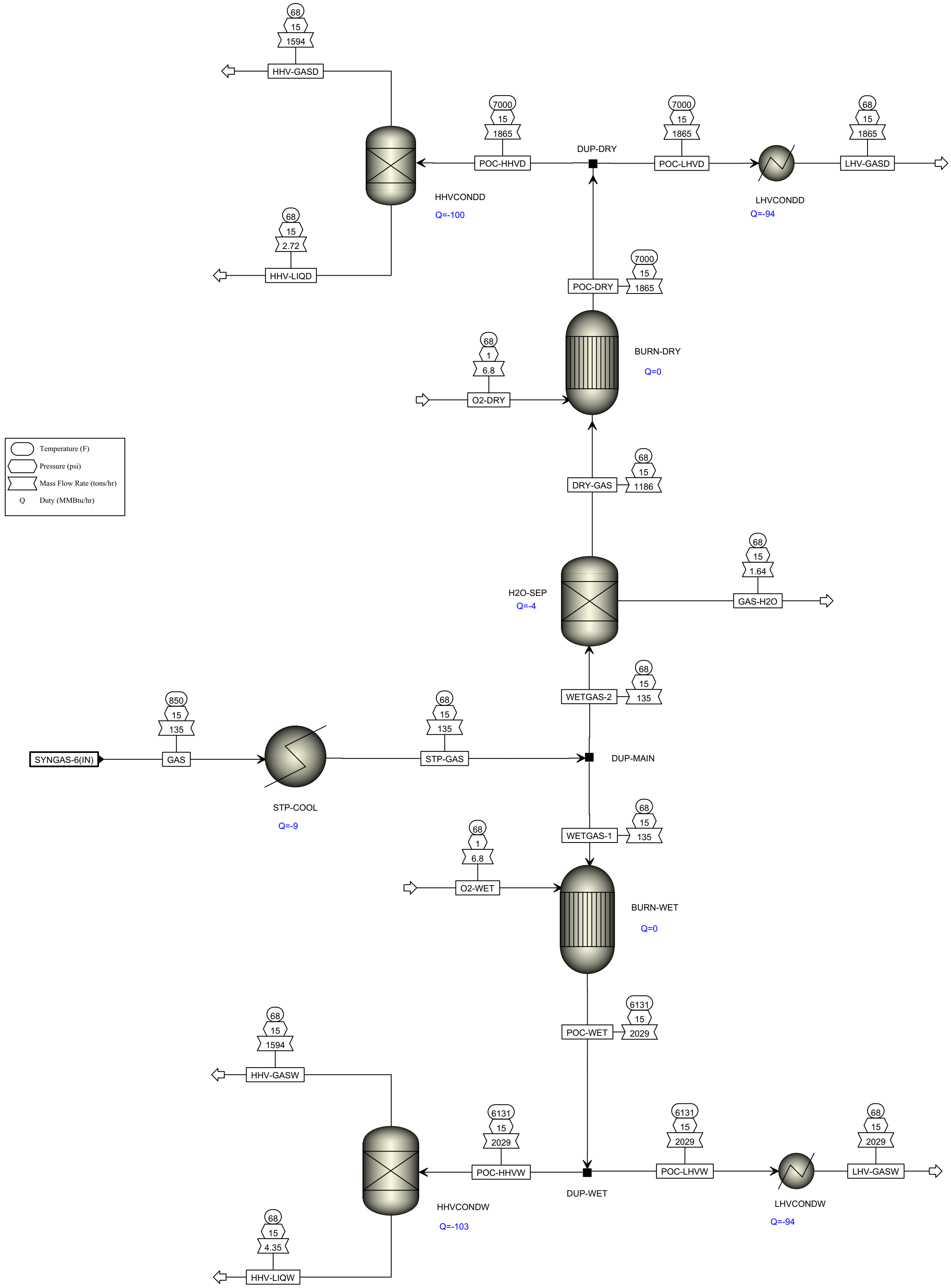


Case B Aspen Plus Flowsheets



Case B Aspen Plus Flowsheets

Gas HHV Calculation



Case B Aspen Plus Stream Results

	AIR	AIR-2	ASH	BIOMASS	BIOMASS2	CACO3	CACO3-2	CAO	DRTY-H2O	DRTY-STM	DRY-BIOM	FUEL-HV	KILN-AIR	KLN-DUST
Mixed Substream														
Temperature F	68	99.1				210	635		176	302			68	
Pressure psi	14.7	17	16.46	14.7	14.7	14.7	14.7	14.7	57.21	58.21	14.7	14.7	14.7	14.7
Vapor Frac	1	1					1			1			1	
Mole Flow lbmol/hr	420.37	420.37				484.478			662.704	662.704			2275.541	
Mass Flow tons/hr	6.086	6.086				4.364			5.969	5.969			32.942	
Volume Flow cuft/hr	161901.883	148236.456				174.446	0.004		234.695	90749.585			876405.721	
Enthalpy MMBtu/hr	-0.093	-0.002				-58.639			-80.652	-67.755			-0.502	
Mass Flow tons/hr														
N2	4.59	4.59											24.846	
CO2	0.003	0.003											0.015	
CACO3														
CAO														
CO														
O2	1.41	1.41											7.634	
AR	0.079	0.079											0.427	
NO2														
NO														
H2O	0.004	0.004							5.969	5.969			0.02	
H2														
H2O-MUD						4.364								
CH4														
C														
Mass Frac														
N2	0.754	0.754											0.754	
CO2														
CACO3														
CAO														
CO														
O2	0.232	0.232											0.232	
AR	0.013	0.013											0.013	
NO2														
NO														
H2O	0.001	0.001							1	1			0.001	
H2														
H2O-MUD						1	1							
CH4														
C														
Mole Flow lbmol/hr														
N2	327.687	327.687											1773.831	
CO2	0.126	0.126											0.682	
CACO3														
CAO														
CO														
O2	88.147	88.147											477.159	
AR	3.948	3.948											21.369	
NO2														
NO														
H2O	0.42	0.42							662.704	662.704			2.273	
H2	0.042	0.042											0.227	
H2O-MUD						484.478								
CH4														
C														
Mole Frac														
N2	0.78	0.78											0.78	
CO2														
CACO3														

Case B Aspen Plus Stream Results

	AIR	AIR-2	ASH	BIOMASS	BIOMASS2	CACO3	CACO3-2	CAO	DRTY-H2O	DRTY-STM	DRY-BIOM	FUEL-HV	KILN-AIR	KLN-DUST
CAO														
CO														
O2	0.21	0.21											0.21	
AR	0.009	0.009											0.009	
NO2														
NO														
H2O	0.001	0.001							1	1			0.001	
H2														
H2O-MUD						1	1							
CH4														
C														
Nonconventional Substream														
Mass Flow tons/hr	6.086	6.086	0.456	14.469	14.469	30.69	26.326	14.75	5.969	5.969	8.038	14.469		1.339
Enthalpy MMBtu/hr	-0.093	-0.002	0.527	-126.634	-126.634	-330.268	-266.345	-135.746	-80.652	-67.755	-38.587	-126.634		-12.633
Temperature F			2000	68	68						212	68		
Pressure psi	14.7	17	16.46	14.7	14.7				57.21	58.21	14.7	14.7		
Vapor Frac														
Mass Flow tons/hr			0.456	14.469	14.469						8.038	14.469		
Enthalpy MMBtu/hr			0.527	-126.634	-126.634						-38.587	-126.634		
Mass Flow tons/hr														
CHAR														
FUEL				14.469	14.469						8.038	14.469		
TAR														
ASH			0.456											
Mass Frac														
CHAR														
FUEL				1	1						1	1		
TAR														
ASH			1											
Solid Substream														
Temperature F						210	635	1300						784.1
Pressure psi						14.7	14.7	14.7						14.7
Vapor Frac														
Mole Flow lbmol/hr						526.061	526.061	526.061						47.759
Mass Flow tons/hr						26.326	26.326	14.75						1.339
Volume Flow cuft/hr						311.289	312.885	143.299						13.01
Enthalpy MMBtu/hr						-271.629	-266.345	-135.746						-12.633
Mass Flow tons/hr														
CACO3						26.326	26.326							
CAO								14.75						1.339
Mass Frac														
CACO3						1	1							
CAO								1						1
Mole Flow lbmol/hr														
CACO3						526.061	526.061							
CAO								526.061						47.759
Mole Frac														
CACO3						1	1							
CAO								1						1

Case B Aspen Plus Stream Results

	NCG-AIR	SOLIDS	STM-LK	SYNGAS	SYNGAS-2	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7	TG	TG-2	TG-3	TG-4
Mixed Substream														
Temperature F	68		302	946.9	946.9	946.9	946.9	850	850	850	1250.1	784.1	784.1	784.1
Pressure psi	14.7	15.46	58.21	16.46	16.46	15.46	15.46	14.96	14.96	14.96	14.7	14.7	13.7	13.7
Vapor Frac	1		1	1	0.943	0.943	0.943	0.943	0.943	0.943	1	1	1	1
Mole Flow lbmol/hr	129.173		51.206	1111.036	1246.497	1246.497	1246.497	1246.497	1246.497	1246.497	3833.131	4317.609	4317.609	3610.212
Mass Flow tons/hr	1.87		0.461	12.784	13.496	13.496	13.496	13.496	13.496	13.496	59.884	64.248	64.248	53.722
Volume Flow cuft/hr	49749.865		7012.032	1.02E+06	1.08E+06	1.15E+06	1.15E+06	1.11E+06	1.11E+06	1.11E+06	4.79E+06	3.92E+06	4.21E+06	3.52E+06
Enthalpy MMBtu/hr	-0.029		-5.235	-38.078	-33.771	-33.771	-33.771	-34.856	-34.856	-34.856	-187.921	-251.566	-251.565	-210.349
Mass Flow tons/hr														
N2	1.41			4.59	4.59	4.59	4.59	4.59	4.59	4.59	30.846	30.846	30.846	25.792
CO2	0.001			1.156	1.156	1.156	1.156	1.156	1.156	1.156	22.856	22.856	22.856	19.111
CACO3														
CAO														
CO				4.78	4.78	4.78	4.78	4.78	4.78	4.78	0.003	0.003	0.003	0.003
O2	0.433				0.238	0.238	0.238	0.238	0.238	0.238	1.271	1.271	1.271	1.063
AR	0.024			0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.53	0.53	0.53	0.443
NO2														
NO														
H2O	0.001		0.461	1.639	1.639	1.639	1.639	1.639	1.639	1.639	4.378	4.378	4.378	3.661
H2				0.157	0.208	0.208	0.208	0.208	0.208	0.208				
H2O-MUD												4.364	4.364	3.649
CH4				0.383	0.383	0.383	0.383	0.383	0.383	0.383				
C					0.423	0.423	0.423	0.423	0.423	0.423				
Mass Frac														
N2	0.754			0.359	0.34	0.34	0.34	0.34	0.34	0.34	0.515	0.48	0.48	0.48
CO2				0.09	0.086	0.086	0.086	0.086	0.086	0.086	0.382	0.356	0.356	0.356
CACO3														
CAO														
CO				0.374	0.354	0.354	0.354	0.354	0.354	0.354				
O2	0.232				0.018	0.018	0.018	0.018	0.018	0.018	0.021	0.02	0.02	0.02
AR	0.013			0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.009	0.008	0.008	0.008
NO2														
NO														
H2O	0.001		1	0.128	0.121	0.121	0.121	0.121	0.121	0.121	0.073	0.068	0.068	0.068
H2				0.012	0.015	0.015	0.015	0.015	0.015	0.015				
H2O-MUD												0.068	0.068	0.068
CH4				0.03	0.028	0.028	0.028	0.028	0.028	0.028				
C					0.031	0.031	0.031	0.031	0.031	0.031				
Mole Flow lbmol/hr														
N2	100.693			327.687	327.687	327.687	327.687	327.687	327.687	327.687	2202.21	2202.21	2202.21	1841.4
CO2	0.039			52.555	52.555	52.555	52.555	52.555	52.555	52.555	1038.675	1038.675	1038.675	868.498
CACO3														
CAO														
CO				341.307	341.307	341.307	341.307	341.307	341.307	341.307	0.238	0.238	0.238	0.199
O2	27.086				14.86	14.86	14.86	14.86	14.86	14.86	79.445	79.445	79.445	66.429
AR	1.213			3.948	3.948	3.948	3.948	3.948	3.948	3.948	26.529	26.529	26.529	22.183
NO2														
NO														
H2O	0.129		51.206	181.906	181.906	181.906	181.906	181.906	181.906	181.906	486.021	486.021	486.021	406.391
H2	0.013			155.875	205.966	205.966	205.966	205.966	205.966	205.966	0.013	0.013	0.013	0.011
H2O-MUD												484.478	484.478	405.101
CH4				47.76	47.76	47.76	47.76	47.76	47.76	47.76				
C					70.51	70.51	70.51	70.51	70.51	70.51				
Mole Frac														
N2	0.78			0.295	0.263	0.263	0.263	0.263	0.263	0.263	0.575	0.51	0.51	0.51
CO2				0.047	0.042	0.042	0.042	0.042	0.042	0.042	0.271	0.241	0.241	0.241
CACO3														

Case B Aspen Plus Stream Results

	NCG-AIR	SOLIDS	STM-LK	SYNGAS	SYNGAS-2	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7	TG	TG-2	TG-3	TG-4
CAO														
CO				0.307	0.274	0.274	0.274	0.274	0.274	0.274				
O2	0.21				0.012	0.012	0.012	0.012	0.012	0.012	0.021	0.018	0.018	0.018
AR	0.009			0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.007	0.006	0.006	0.006
NO2														
NO														
H2O	0.001		1	0.164	0.146	0.146	0.146	0.146	0.146	0.146	0.127	0.113	0.113	0.113
H2				0.14	0.165	0.165	0.165	0.165	0.165	0.165				
H2O-MUD												0.112	0.112	0.112
CH4				0.043	0.038	0.038	0.038	0.038	0.038	0.038				
C					0.057	0.057	0.057	0.057	0.057	0.057				
Nonconventional Substream														
Mass Flow tons/hr		0.172	0.461	13.667	13.667	13.496					61.223	65.587	64.248	53.722
Enthalpy MMBtu/hr		0.285	-5.235	-39.502	-33.486	-33.771					-200.275	-264.198	-251.565	-210.349
Temperature F		946.9		946.9	946.9									
Pressure psi		15.46	58.21	16.46	16.46	15.46								
Vapor Frac														
Mass Flow tons/hr		0.172		0.883	0.172									
Enthalpy MMBtu/hr		0.285		-1.424	0.285									
Mass Flow tons/hr														
CHAR		0.172		0.172	0.172									
FUEL														
TAR				0.712										
ASH														
Mass Frac														
CHAR		1		0.194	1									
FUEL														
TAR				0.806										
ASH														
Solid Substream														
Temperature F											1250.1	784.1		
Pressure psi											14.7	14.7	13.7	13.7
Vapor Frac														
Mole Flow lbmol/hr											47.759	47.759		
Mass Flow tons/hr											1.339	1.339		
Volume Flow cuft/hr											13.01	13.01		
Enthalpy MMBtu/hr											-12.354	-12.633		
Mass Flow tons/hr														
CACO3														
CAO											1.339	1.339		
Mass Frac														
CACO3														
CAO											1	1		
Mole Flow lbmol/hr														
CACO3														
CAO											47.759	47.759		
Mole Frac														
CACO3														
CAO											1	1		

Case B Aspen Plus Stream Results

	TG-5	TG-6	TG-7	TG-8	TG-9
Mixed Substream					
Temperature F	784.1	250	250	250	307.6
Pressure psi	13.7	11.7	11.7	11.7	14.7
Vapor Frac	1	1	1	1	1
Mole Flow lbmol/hr	707.397	3610.212	707.397	4317.609	4317.609
Mass Flow tons/hr	10.526	53.722	10.526	64.248	64.248
Volume Flow cuft/hr	689431.89	2.35E+06	460135.848	2.81E+06	2.42E+06
Enthalpy MMBtu/hr	-41.216	-226.455	-44.372	-270.827	-268.843
Mass Flow tons/hr					
N2	5.054	25.792	5.054	30.846	30.846
CO2	3.745	19.111	3.745	22.856	22.856
CACO3					
CAO					
CO	0.001	0.003	0.001	0.003	0.003
O2	0.208	1.063	0.208	1.271	1.271
AR	0.087	0.443	0.087	0.53	0.53
NO2					
NO					
H2O	0.717	3.661	0.717	4.378	4.378
H2					
H2O-MUD	0.715	3.649	0.715	4.364	4.364
CH4					
C					
Mass Frac					
N2	0.48	0.48	0.48	0.48	0.48
CO2	0.356	0.356	0.356	0.356	0.356
CACO3					
CAO					
CO					
O2	0.02	0.02	0.02	0.02	0.02
AR	0.008	0.008	0.008	0.008	0.008
NO2					
NO					
H2O	0.068	0.068	0.068	0.068	0.068
H2					
H2O-MUD	0.068	0.068	0.068	0.068	0.068
CH4					
C					
Mole Flow lbmol/hr					
N2	360.81	1841.4	360.81	2202.21	2202.21
CO2	170.176	868.498	170.176	1038.675	1038.675
CACO3					
CAO					
CO	0.039	0.199	0.039	0.238	0.238
O2	13.016	66.429	13.016	79.445	79.445
AR	4.347	22.183	4.347	26.529	26.529
NO2					
NO					
H2O	79.63	406.391	79.63	486.021	486.021
H2	0.002	0.011	0.002	0.013	0.013
H2O-MUD	79.377	405.101	79.377	484.478	484.478
CH4					
C					
Mole Frac					
N2	0.51	0.51	0.51	0.51	0.51
CO2	0.241	0.241	0.241	0.241	0.241
CACO3					

Case B Aspen Plus Stream Results

	TG-5	TG-6	TG-7	TG-8	TG-9
CAO					
CO					
O2	0.018	0.018	0.018	0.018	0.018
AR	0.006	0.006	0.006	0.006	0.006
NO2					
NO					
H2O	0.113	0.113	0.113	0.113	0.113
H2					
H2O-MUD	0.112	0.112	0.112	0.112	0.112
CH4					
C					
Nonconventional Substream					
Mass Flow tons/hr	10.526	53.722	10.526	64.248	64.248
Enthalpy MMBtu/hr	-41.216	-226.455	-44.372	-270.827	-268.843
Temperature F					
Pressure psi					
Vapor Frac					
Mass Flow tons/hr					
Enthalpy MMBtu/hr					
Mass Flow tons/hr					
CHAR					
FUEL					
TAR					
ASH					
Mass Frac					
CHAR					
FUEL					
TAR					
ASH					
Solid Substream					
Temperature F					
Pressure psi	13.7	11.7	11.7	11.7	14.7
Vapor Frac					
Mole Flow lbmol/hr					
Mass Flow tons/hr					
Volume Flow cuft/hr					
Enthalpy MMBtu/hr					
Mass Flow tons/hr					
CACO3					
CAO					
Mass Frac					
CACO3					
CAO					
Mole Flow lbmol/hr					
CACO3					
CAO					
Mole Frac					
CACO3					
CAO					

Appendix B

Aspen Plus Model Report for Case A

```
                                                                        TM
AAAAA   SSSSS   PPPPP   EEEEE   NN    N   PPPPP   L       U   U   SSSSS
A   A   S       P   P   E       N N   N   P   P   L       U   U   S
AAAAA   SSSSS   PPPPP   EEEEE   N  N  N   PPPPP   L       U   U   SSSSS
A   A       S   P       E       N   NN    P       L       U   U       S
A   A   SSSSS   P       EEEEE   N    N    P       LLLLL   UUUUU   SSSSS
```

ASPEN PLUS IS A TRADEMARK OF
ASPEN TECHNOLOGY, INC.
TEN CANAL PARK
CAMBRIDGE, MASSACHUSETTS 02141
617/949-1000

HOTLINE:
U.S.A. 888/996-7100
EUROPE (32) 2/701-9555

PLATFORM: WIN32
VERSION: 20.0 1 Build 75
INSTALLATION:

SEPTEMBER 27, 2007
THURSDAY
7:12:03 A.M.

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RUN CONTROL SECTION

```
RUN CONTROL INFORMATION
-----------------------

THIS COPY OF ASPEN PLUS LICENSED TO IDAHO NATL ENGR & ENV

TYPE OF RUN: NEW

INPUT FILE NAME: _0934kie.inm

OUTPUT PROBLEM DATA FILE NAME: _0934kie
LOCATED IN:


PDF SIZE USED FOR INPUT TRANSLATION:
  NUMBER OF FILE RECORDS (PSIZE) =     0
  NUMBER OF IN-CORE RECORDS      =   256
PSIZE NEEDED FOR SIMULATION    =   256

CALLING PROGRAM NAME:          apmain
LOCATED IN:                    C:\PROGRA~1\ASPENT~1\ASPENP~1\Engine\xeq

SIMULATION REQUESTED FOR ENTIRE FLOWSHEET
```


FLOWSHEET SECTION

```
FLOWSHEET CONNECTIVITY BY STREAMS
---------------------------------

FLOWSHEET SECTION GASIFIER
  STREAM     SOURCE     DEST            STREAM     SOURCE     DEST
  ASH        $C-13      ----            SYNGAS     $C-9       HEAT-CRK
  SOLIDS     CYCLONE    ----            SYNGAS-6   CYCLONE    TAR-CNV2
  SYNGAS-8   CL-CNG     PIPELOSS

FLOWSHEET SECTION GLOBAL
  STREAM     SOURCE     DEST            STREAM     SOURCE     DEST
  KILN-AIR   ----       $C-8            NCG-AIR    ----       $C-5
  CAO        $C-6       ----            TG         $C-2       DRYER
  TAR-HEAT   $C-12      TAR-CNV2        SYNGAS11   NG-DUP     $C-3
  SYNGAS10   NG-DUP     $C-1            SYNGAS-5   COOL-CRK   CYCLONE
  SYNGAS-4   TAR-CRK    COOL-CRK        HT-CRK     TAR-CRK    TAR-CNV
  SYNGAS-3   TAR-CNV    TAR-CRK         SYNGAS-2   HEAT-CRK   TAR-CNV
  HT-CRK-2   HEAT-CRK   COOL-CRK        SYNGAS-7   TAR-CNV2   CL-CNG

FLOWSHEET SECTION KILN
  STREAM     SOURCE     DEST            STREAM     SOURCE     DEST
  CACO3      ----       DRYER           AIR        ----       AIR-BLWR
  AIR-CRK    ----       AIRBLWR2        BIOMASS    ----       FUEL-DUP
  DRY-BIOM   $C-19      $C-11           STM-LK     $C-16      ----
  DRTY-STM   $C-17      LPSTM           HEAT-DRY   $C-14      HEAT-DRY
  KLN-DUST   CYCLONE2   $C-4            TG-3       CYCLONE2   SPLT-TG
  CACO3-2    DRYER      $C-7            TG-2       DRYER      CYCLONE2
  TG-6       HEAT-DRY   TG-MIX          TG-4       SPLT-TG    HEAT-DRY
  TG-5       SPLT-TG    IPSTM           SYNGAS-9   PIPELOSS   NG-DUP
  AIR-2      AIR-BLWR   $C-10           TG-9       TG-BLWR    ----
  TG-8       TG-MIX     TG-BLWR         AIR-CRK2   AIRBLWR2   HEAT-CRK
  BIOMASS2   FUEL-DUP   $C-18           FUEL-HV    FUEL-DUP   $C-15
  TG-7       IPSTM      TG-MIX          DRTY-H2O   LPSTM      ----

FLOWSHEET CONNECTIVITY BY BLOCKS
--------------------------------

FLOWSHEET SECTION GASIFIER
  BLOCK        INLETS                          OUTLETS
  $C-10        AIR-2                           AIR
  $C-11        DRY-BIOM                        BIOMASS
  $C-13        ASH                             ASH
  $C-9         SYNGAS-3                        SYNGAS
  CYCLONE      SYNGAS-5                        SOLIDS SYNGAS-6
  CL-CNG       SYNGAS-7                        SYNGAS-8

FLOWSHEET SECTION GLOBAL
  BLOCK        INLETS                          OUTLETS
  $C-1         SYNGAS10                        GAS
  $C-8         KILN-AIR                        AIR
  $C-3         SYNGAS11                        FUEL
  $C-7         CACO3-2                         CACO3
  $C-5         NCG-AIR                         NCG-AIR
  $C-4         KLN-DUST                        KLN-DUST
  $C-6         CAO-2                           CAO
  $C-2         TG-2                            TG
```


FLOWSHEET SECTION

```
FLOWSHEET CONNECTIVITY BY BLOCKS (CONTINUED)
  $C-12        HEAT-7                          TAR-HEAT
  NG-DUP       SYNGAS-9                        SYNGAS11 SYNGAS10
  COOL-CRK     SYNGAS-4 HT-CRK-2               SYNGAS-5
  TAR-CRK      SYNGAS-3                        SYNGAS-4 HT-CRK
  TAR-CNV      SYNGAS-2 HT-CRK                 SYNGAS-3
  HEAT-CRK     SYNGAS AIR-CRK2                 SYNGAS-2 HT-CRK-2
  TAR-CNV2     SYNGAS-6 TAR-HEAT               SYNGAS-7

FLOWSHEET SECTION KILN
  BLOCK        INLETS                          OUTLETS
  $C-18        BIOMASS2                        BIOMASS
  $C-19        BIOMASS4                        DRY-BIOM
  $C-16        STM-LK                          STM-LK
  $C-17        DRTY-STM                        DRTY-STM
  $C-14        HEAT-DRY                        HEAT-DRY
  $C-15        FUEL-HV                         FUEL
  CYCLONE2     TG-2                            KLN-DUST TG-3
  DRYER        CACO3 TG                        CACO3-2 TG-2
  HEAT-DRY     TG-4 HEAT-DRY                   TG-6
  SPLT-TG      TG-3                            TG-4 TG-5
  PIPELOSS     SYNGAS-8                        SYNGAS-9
  AIR-BLWR     AIR                             AIR-2
  TG-BLWR      TG-8                            TG-9
  TG-MIX       TG-7 TG-6                       TG-8
  AIRBLWR2     AIR-CRK                         AIR-CRK2
  FUEL-DUP     BIOMASS                         BIOMASS2 FUEL-HV
  IPSTM        TG-5                            TG-7
  LPSTM        DRTY-STM                        DRTY-H2O

CONVERGENCE STATUS SUMMARY
--------------------------

  DESIGN-SPEC SUMMARY
  ===================


  DESIGN                                                              CONV
  SPEC             ERROR        TOLERANCE    ERR/TOL       VARIABLE   STAT  BLOCK
  ------           -----        ---------    -------       --------   ----  -----
  GAS-HHV.O2-DRY -0.70486E-11  0.10000E-04 -0.70486E-06    404.18      #    $OLVER02

  GAS-HHV.O2-WET -0.69917E-11  0.10000E-04 -0.69917E-06    404.18      #    $OLVER03

  AIR-CRK         0.19971E-05  0.10000E-02  0.19971E-02    2.9576      #    $OLVER04

  AIR-GASF       -0.13840       1.0000     -0.13840        6.2820      #    GASIFIER

  AIR-KILN        0.44204E-04  0.10000E-03  0.44204        2190.0      #    $OLVER05

  DRY-KILN       -0.79621E-05  0.10000E-03 -0.79621E-01    798.92      #    $OLVER06

  FUEL           -0.98990       1.0000     -0.98990        15.175      #    GASIFIER

  SPLT-TG         0.18126E-04  0.10000E-02  0.18126E-01  0.82380      #    $OLVER07

  TARTEMP        -0.17620E-04  0.10000E-03 -0.17620      0.32221E-01 #    $OLVER08

  TEAR STREAM SUMMARY
  ===================


  STREAM           MAXIMUM                     MAXIMUM      VARIABLE               CONV
  ID               ERROR        TOLERANCE      ERR/TOL      ID               STAT  BLOCK
  ------           -------      ---------      --------     --------         ----  -----
  LIMEKILN.TG      0.37842E-07  0.36140E-05    0.10471E-01  MASS ENTHALPY     #
$OLVER01
```


FLOWSHEET SECTION

```
CONVERGENCE STATUS SUMMARY (CONTINUED)
  LIMEKILN.HEAT-2   0.0000       33.823       0.0000      INFO-VAR         #
$OLVER01

  HT-CRK            0.0000       218.29       0.0000      INFO-VAR         #
$OLVER01


  #  = CONVERGED
  *  = NOT CONVERGED
  LB = AT LOWER BOUNDS
  UB = AT UPPER BOUNDS

DESIGN-SPEC:  AIR-CRK
---------------------

  SAMPLED VARIABLES:
    QCRK     : INFO-VAR IN STREAM HT-CRK ID: HEAT
    QTAR     : SENTENCE=PARAM VARIABLE=QCALC IN UOS BLOCK TAR-CNV

  SPECIFICATION:
    MAKE QCRK APPROACH QTAR
    WITHIN        0.00100000

  MANIPULATED VARIABLES:
    VARY     : TOTAL MASSFLOW IN STREAM AIR-CRK SUBSTREAM MIXED
    LOWER LIMIT =          0.0                         TONS/HR
    UPPER LIMIT =          5.00000                     TONS/HR
    FINAL VALUE =          2.95763                     TONS/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE        VALUE AT START       FINAL VALUE      UNITS
                       OF LOOP
    --------        --------------       -----------      -----
    QCRK              7.44853             7.44853         MMBTU/HR
    QTAR              7.44853             7.44853         MMBTU/HR

DESIGN-SPEC:  AIR-GASF
----------------------

  SAMPLED VARIABLES:
    ASHTMP   : TEMPERATURE IN STREAM GASIFIER.ASH SUBSTREAM NC

  SPECIFICATION:
    MAKE ASHTMP APPROACH 2,000.00
    WITHIN        1.00000

  MANIPULATED VARIABLES:
    VARY     : TOTAL MASSFLOW IN STREAM AIR SUBSTREAM MIXED
    LOWER LIMIT =          5.00000                     TONS/HR
    UPPER LIMIT =         20.0000                      TONS/HR
    FINAL VALUE =          6.28195                     TONS/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE        VALUE AT START       FINAL VALUE      UNITS
                       OF LOOP
    --------        --------------       -----------      -----
    ASHTMP            1999.86             1999.86         F
```


FLOWSHEET SECTION

```
DESIGN-SPEC:  AIR-KILN
----------------------

  SAMPLED VARIABLES:
    COMBO2   : PROPERTY STRMPROP COMB-O2 IN STREAM SYNGAS11
    O2       : O2 MASSFRAC IN STREAM LIMEKILN.TG-BNR SUBSTREAM MIXED

  SPECIFICATION:
    MAKE O2 APPROACH 0.018000
    WITHIN          0.000100000

  MANIPULATED VARIABLES:
    VARY     : TOTAL MOLEFLOW IN STREAM KILN-AIR SUBSTREAM MIXED
    LOWER LIMIT IS COMBO2/0.21
    UPPER LIMIT IS 2.*(COMBO2/0.21)
    FINAL VALUE =        2,190.04                      LBMOL/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE      VALUE AT START      FINAL VALUE     UNITS
                     OF LOOP
    --------      --------------      -----------     -----
    COMBO2           407.588           404.179        LBMOL/HR
    O2             0.218460E-01      0.180442E-01

DESIGN-SPEC:  DRY-KILN
----------------------

  SAMPLED VARIABLES:
    DRYDTY   : SENTENCE=RESULTS VARIABLE=QCALC IN UOS BLOCK DRYER

  SPECIFICATION:
    MAKE DRYDTY APPROACH 0.0
    WITHIN          0.000100000

  MANIPULATED VARIABLES:
    VARY     : SENTENCE=FLASH-SPECS VARIABLE=TEMP ID1=TG-2 IN UOS BLOCK DRYER
    LOWER LIMIT =          700.000                     F
    UPPER LIMIT =        1,200.00                      F
    FINAL VALUE =          798.922                     F

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE      VALUE AT START      FINAL VALUE     UNITS
                     OF LOOP
    --------      --------------      -----------     -----
    DRYDTY         0.138409E-01      -0.796208E-05    MMBTU/HR

DESIGN-SPEC:  FUEL
------------------

  SAMPLED VARIABLES:
    TMPBNR   : TEMPERATURE IN STREAM LIMEKILN.TG-BNR SUBSTREAM MIXED
```



```
DESIGN-SPEC:  FUEL (CONTINUED)

  SPECIFICATION:
    MAKE TMPBNR APPROACH 1,250.00
    WITHIN          1.00000

  MANIPULATED VARIABLES:
    VARY     : TOTAL MASSFLOW IN STREAM BIOMASS SUBSTREAM NC
    LOWER LIMIT =         10.0000                      TONS/HR
    UPPER LIMIT =         20.0000                      TONS/HR
    FINAL VALUE =         15.1748                      TONS/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE      VALUE AT START      FINAL VALUE     UNITS
                     OF LOOP
    --------      --------------      -----------     -----
    TMPBNR           1249.01           1249.01        F

DESIGN-SPEC:  SPLT-TG
---------------------

  SAMPLED VARIABLES:
    TEMPTG   : TEMPERATURE IN STREAM TG-6 SUBSTREAM MIXED

  SPECIFICATION:
    MAKE TEMPTG APPROACH 250.000
    WITHIN          0.00100000

  MANIPULATED VARIABLES:
    VARY     : SENTENCE=FRAC VARIABLE=FRAC ID1=TG-4 IN UOS BLOCK SPLT-TG
    LOWER LIMIT =          0.0
    UPPER LIMIT =          1.00000
    FINAL VALUE =          0.82380

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE      VALUE AT START      FINAL VALUE     UNITS
                     OF LOOP
    --------      --------------      -----------     -----
    TEMPTG          -441.670           250.000        F

DESIGN-SPEC:  TARTEMP
---------------------

  SAMPLED VARIABLES:
    QTAR     : INFO-VAR IN STREAM TAR-HEAT ID: HEAT
    QREQ     : SENTENCE=PARAM VARIABLE=QCALC IN UOS BLOCK TAR-CNV2

  SPECIFICATION:
    MAKE QTAR APPROACH QREQ
    WITHIN          0.000100000
```



```
DESIGN-SPEC:  TARTEMP (CONTINUED)

  MANIPULATED VARIABLES:
    VARY     : SENTENCE=FRAC VARIABLE=FRAC ID1=HEAT-7 IN UOS BLOCK
               LIMEKILN.HT-SPLT
    LOWER LIMIT =          0.0
    UPPER LIMIT =          0.50000
    FINAL VALUE =          0.032221

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE      VALUE AT START      FINAL VALUE     UNITS
                     OF LOOP
    --------      --------------      -----------     -----
    QTAR            0.256956           0.256956       MMBTU/HR
    QREQ            0.256973           0.256973       MMBTU/HR

CALCULATOR BLOCK:   CALC
------------------------

  SAMPLED VARIABLES:
    HHVQ     : SENTENCE=RESULTS VARIABLE=QCALC IN UOS BLOCK GAS-HHV.HHVCONDW
    LHVQ     : SENTENCE=PARAM VARIABLE=QCALC IN UOS BLOCK GAS-HHV.LHVCONDW
    WMASF    : TOTAL MASSFLOW IN STREAM GAS-HHV.WETGAS-1 SUBSTREAM MIXED
    DHVQ     : SENTENCE=RESULTS VARIABLE=QCALC IN UOS BLOCK GAS-HHV.HHVCONDD
    DLVQ     : SENTENCE=PARAM VARIABLE=QCALC IN UOS BLOCK GAS-HHV.LHVCONDD
    DMASF    : TOTAL MASSFLOW IN STREAM GAS-HHV.DRY-GAS SUBSTREAM MIXED
    DDENS    : MASS DENSITY IN STREAM GAS-HHV.DRY-GAS SUBSTREAM MIXED
    HHVQF    : SENTENCE=RESULTS VARIABLE=QCALC IN UOS BLOCK FUEL-HHV.HHV-COND
    LHVQF    : SENTENCE=RESULTS VARIABLE=QCALC IN UOS BLOCK FUEL-HHV.LHV-COND
    FUEL     : TOTAL MASSFLOW IN STREAM FUEL-HHV.FUEL SUBSTREAM NC
    H2O      : COMP-ATTR-VA IN STREAM FUEL-HHV.FUEL SUBSTREAM NC ID: PROXANAL
    CAOPRD   : TOTAL MASSFLOW IN STREAM CAO SUBSTREAM CISOLID
    STPHT    : SENTENCE=PARAM VARIABLE=QCALC IN UOS BLOCK GAS-HHV.STP-COOL

  FORTRAN STATEMENTS:
        DOUBLE PRECISION LHVM1,LDVSG1,LDVM1,LHVFUE,LHVFUW
  C ********************************************************************
  C      CALCULATE THE HHV FOR THE SYNGAS THAT EXITS THE GASIFIFER
  C      (AFTER FLOWSHEET CONVERGED):
  C ********************************************************************

        HHVM1=-(HHVQ*1000000.)/WMASF
        HDVM1=-(DHVQ*1000000.)/DMASF
        HDVSG1=-(DHVQ*1000000.)/(DMASF/DDENS)
        LHVM1=-(LHVQ*1000000.)/WMASF
        LDVM1=-(DLVQ*1000000.)/DMASF
        LDVSG1=-(DLVQ*1000000.)/(DMASF/DDENS)
        WRITE(NTERM,5)HDVM1,HHVM1,HDVSG1,LDVM1,LHVM1,LDVSG1
        WRITE(NRPT,5)HDVM1,HHVM1,HDVSG1,LDVM1,LHVM1,LDVSG1
        WRITE(NHSTRY,5)HDVM1,HHVM1,HDVSG1,LDVM1,LHVM1,LDVSG1
      5 FORMAT(/,6X,'GAS HHV CALCULATIONS:',
       $/,9X,'GAS HHV (DRY):',12X,F7.1,1X,'BTU/LB',
       $/,9X,'GAS HHV (WET):',12X,F7.1,1X,'BTU/LB',
```



```
CALCULATOR BLOCK:   CALC (CONTINUED)
       $/,9X,'GAS HHV (DRY, 68 DEG. F):',2X,F6.1,1X,'BTU/SCF',
       $/,9X,'GAS LHV (DRY):',12X,F7.1,1X,'BTU/LB',
       $/,9X,'GAS LHV (WET):',12X,F7.1,1X,'BTU/LB',
       $/,9X,'GAS LHV (DRY, 68 DEG. F):',3X,F5.1,1X,'BTU/SCF')

  C ********************************************************************
  C CALCULATES THE HIGH AND LOW HEATING VALUE OF THE FUEL ON A DRY BASIS
  C AND A WET BASIS AFTER THE SIMULATION IS COMPLETE.
  C ********************************************************************

        HHVFUE=-HHVQF*1000000./(FUEL*(1-H2O/100.))
        LHVFUE=-LHVQF*1000000./(FUEL*(1-H2O/100.))
        HHVFUW=-HHVQF*1000000./FUEL
        LHVFUW=-LHVQF*1000000./FUEL
        WRITE(NTERM,6)HHVFUE,HHVFUW,LHVFUE,LHVFUW
        WRITE(NRPT,6)HHVFUE,HHVFUW,LHVFUE,LHVFUW
        WRITE(NHSTRY,6)HHVFUE,HHVFUW,LHVFUE,LHVFUW
      6 FORMAT(/,6X,'CALCULATED HEATING VALUES:',
       $/,9X,'SOLID FUEL HHV (DRY):  ',F7.1,1X,'BTU/LB',
       $/,9X,'SOLID FUEL HHV (WET):  ',F7.1,1X,'BTU/LB',
       $/,9X,'SOLID FUEL LHV (DRY):  ',F7.1,1X,'BTU/LB',
       $/,9X,'SOLID FUEL LHV (WET):  ',F7.1,1X,'BTU/LB')

  C ********************************************************************
  C CALCULATES THE MMBTU REQUIRED IN THE KILN
  C ********************************************************************

        BTUKILN=((WMASF*HHVM1)/1000000.)
        WRITE(NTERM,7)BTUKILN
        WRITE(NRPT,7)BTUKILN
        WRITE(NHSTRY,7)BTUKILN
      7 FORMAT(/,6X,'CALCULATED MMBTU REQUIRED IN KILN:',
       $/,9X,'ENERGY REQUIREMENT:  ',F7.2,1X,'MMBTU')

  C ********************************************************************
  C CALCULATES THE COLD GAS EFFICIENCY BASED ON THE DRY HHV
  C ********************************************************************

        CGEFF=HDVM1*DMASF*100./(HHVFUE*(FUEL*(1-H2O/100.)))
        WRITE(NTERM,8)CGEFF
        WRITE(NRPT,8)CGEFF
        WRITE(NHSTRY,8)CGEFF
      8 FORMAT(/,6X,'CALCULATED COLD GAS EFFICIENCY:',
       $/,9X,'EFFICIENCY:  ',F7.1,1X,'%')

  EXECUTE LAST

  VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
    VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
    --------        ----------      -------------    -----
    HHVQ            -100.145         -100.145        MMBTU/HR
    LHVQ            -90.1366         -90.1366        MMBTU/HR
    WMASF            34022.4          34022.4        LB/HR
    DHVQ            -99.1353         -99.1353        MMBTU/HR
    DLVQ            -91.7456         -91.7456        MMBTU/HR
    DMASF            31631.1          31631.1        LB/HR
```



```
CALCULATOR BLOCK:   CALC (CONTINUED)
    DDENS           0.581281E-01    0.581281E-01     LB/CUFT
    HHVQF           -118.376         -118.376        MMBTU/HR
    LHVQF           -93.5912         -93.5912        MMBTU/HR
    FUEL             30349.5          30349.5        LB/HR
    H2O              50.0000          50.0000
    CAOPRD           29500.1          29500.1        LB/HR
    STPHT           -7.69780         -7.69780        MMBTU/HR

CALCULATOR BLOCK:   GASF-P
--------------------------

  SAMPLED VARIABLES:
    GASFP    : SENTENCE=PARAM VARIABLE=PRES IN UOS BLOCK GASIFIER.EVP-DEVL
    AIRP     : PRESSURE IN STREAM AIR-2 SUBSTREAM MIXED
    AIRP2    : SENTENCE=PARAM VARIABLE=PRES IN UOS BLOCK AIRBLWR2
    GASFOP   : PRESSURE IN STREAM SYNGAS SUBSTREAM MIXED

  FORTRAN STATEMENTS:
  C ********************************************************************
  C SETS THE PRESSURE IN THE DEVOLATILIZATION BLOCK TO THE PRESSURE
  C SPECIFIED IN THE AIR COMPRESSOR.
  C ********************************************************************

        GASFP=AIRP

  C ********************************************************************
  C SETS THE PRESSURE IN THE TAR AIR COMPRESSOR TO THE PRESSURE
  C OF THE SYNGAS OUTLET STREAM.
  C ********************************************************************

        AIRP2=GASFOP

  EXECUTE BEFORE BLOCK GASIFIER.EVP-DEVL

  VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
```

```
      VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
      --------        ----------      -------------    -----
      GASFP           25.0000         25.0000          PSI
      AIRP            25.0000         25.0000          PSI
      AIRP2           24.4581         24.4581          PSI
      GASFOP          24.4581         24.4581          PSI

CALCULATOR BLOCK:   HV
----------------------

   SAMPLED VARIABLES:
     FUELU    : COMPONENT-AT VEC IN STREAM BIOMASS SUBSTREAM NC ID: ULTANAL
     HHV      : PROPERTY PARAMETER HCOMB, DATA SET 1

   FORTRAN STATEMENTS:
   C ***********************************************************************
   C CALCULATION OF HEATING VALUE OF TAR AND CHAR (HHV) BASED ON IGT
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 10
                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CALCULATOR BLOCK:   HV (CONTINUED)
   C EQUATION PRESENTED IN FAGBEMI (297).
   C ***********************************************************************

         HHV=(354.68*FUELU(2)+1376.29*FUELU(3)+71.26-15.92*FUELU(1)
        +-124.69*FUELU(7))*1000.

   EXECUTE BEFORE BLOCK FUEL-DUP

   VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
      VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
      --------        ----------      -------------    -----
      FUELU(1)         6.31000         6.31000
      FUELU(2)         44.7400         44.7400
      FUELU(3)         5.50000         5.50000
      FUELU(4)         0.00000         0.00000
      FUELU(5)         0.00000         0.00000
      FUELU(6)         0.00000         0.00000
      FUELU(7)         43.4500         43.4500
      HHV             0.179910E+08    0.179910E+08

CALCULATOR BLOCK:   TARYLD
-------------------------

   SAMPLED VARIABLES:
     ULTTAR   : COMPONENT-AT VEC IN STREAM SYNGAS-2 SUBSTREAM NC ID: ULTANAL
     FLOW     : TAR MASSFLOW IN STREAM SYNGAS-2 SUBSTREAM NC
     YLDC     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=C IN UOS BLOCK
                TAR-CNV
     YLDH     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2 IN UOS
                BLOCK TAR-CNV
     YLDO     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=O2 IN UOS
                BLOCK TAR-CNV
     YLDT     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=TAR IN UOS BLOCK
                TAR-CNV
     CIN      : C MASSFLOW IN STREAM SYNGAS-2 SUBSTREAM MIXED
     HIN      : H2 MASSFLOW IN STREAM SYNGAS-2 SUBSTREAM MIXED
     OIN      : O2 MASSFLOW IN STREAM SYNGAS-2 SUBSTREAM MIXED
     TEMPB    : SENTENCE=PARAM VARIABLE=TEMP IN UOS BLOCK TAR-CNV
     TEMPG    : TEMPERATURE IN STREAM SYNGAS-2 SUBSTREAM MIXED

   FORTRAN STATEMENTS:
         REAL OXYGEN
         REAL MFNR
   C ***********************************************************************
```

```
   C CALCULATES THE TOTAL CARBON, HYDROGEN, AND OXYGEN FLOWS WHEN 96%
   C OF THE TAR IS CONVERTED TO CARBON, HYDROGEN, AND OXYGEN.  INCLUDES
   C INLET FLOW OF CARBON, HYDROGEN, AND OXYGEN IF PRESENT.
   C ***********************************************************************

         CARBON=CIN+FLOW*(ULTTAR(2)/100.)*(96./100.)
         HYDROGEN=HIN+FLOW*(ULTTAR(3)/100.)*(96./100.)
         OXYGEN=OIN+FLOW*(ULTTAR(7)/100.)*(96./100.)

   C ***********************************************************************
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 11
                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CALCULATOR BLOCK:   TARYLD (CONTINUED)
   C SUMS THE TOTAL FLOW OF NON-INERTS OUT OF THE YIELD BLOCK.
   C ***********************************************************************

         TOTAL=CARBON+HYDROGEN+OXYGEN+(4./100.)*FLOW

   C ***********************************************************************
   C CALCUATES THE YIELDS OF TAR, CARBON, HYDROGEN, AND OXYGEN OUT OF
   C THE YIELD BLOCK.
   C ***********************************************************************

         YLDT=FLOW*(4./100.)/TOTAL
         YLDC=CARBON/TOTAL
         YLDH=HYDROGEN/TOTAL
         YLDO=OXYGEN/TOTAL

   C ***********************************************************************
   C SETS THE OPERATING TEMPERATURE OF THE YIELD BLOCK TO THE TEMPERATURE
   C OF THE INLET GAS.
   C ***********************************************************************

         TEMPB=TEMPG

   EXECUTE BEFORE BLOCK TAR-CNV

   VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
      VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
      --------        ----------      -------------    -----
      ULTTAR(1)        0.00000         0.00000
      ULTTAR(2)        59.4990         59.4990
      ULTTAR(3)        7.09419         7.09419
      ULTTAR(4)        0.00000         0.00000
      ULTTAR(5)        0.00000         0.00000
      ULTTAR(6)        0.00000         0.00000
      ULTTAR(7)        33.4068         33.4068
      FLOW             0.746405        0.746405        TONS/HR
      YLDC             0.267557        0.267557
      YLDH             0.133333        0.133333
      YLDO             0.580372        0.580372
      YLDT             0.187368E-01    0.187368E-01
      CIN              0.00000         0.00000         TONS/HR
      HIN              0.161627        0.161627        TONS/HR
      OIN              0.685418        0.685418        TONS/HR
      TEMPB            1652.00         1652.00         F
      TEMPG            1652.00         1652.00         F

CALCULATOR BLOCK:   TARYLD2
--------------------------

   SAMPLED VARIABLES:
     ULTTAR   : COMPONENT-AT VEC IN STREAM SYNGAS-6 SUBSTREAM NC ID: ULTANAL
     FLOW     : TAR MASSFLOW IN STREAM SYNGAS-6 SUBSTREAM NC
```

```
     YLDC     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=C IN UOS BLOCK
                TAR-CNV2
     YLDH     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2 IN UOS
                BLOCK TAR-CNV2
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 12
                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CALCULATOR BLOCK:   TARYLD2 (CONTINUED)
     YLDO     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=O2 IN UOS
                BLOCK TAR-CNV2
     CIN      : C MASSFLOW IN STREAM SYNGAS-6 SUBSTREAM MIXED
     HIN      : H2 MASSFLOW IN STREAM SYNGAS-6 SUBSTREAM MIXED
     OIN      : O2 MASSFLOW IN STREAM SYNGAS-6 SUBSTREAM MIXED
     TEMPB    : SENTENCE=PARAM VARIABLE=TEMP IN UOS BLOCK TAR-CNV2
     TEMPG    : TEMPERATURE IN STREAM SYNGAS-6 SUBSTREAM MIXED

   FORTRAN STATEMENTS:
         REAL OXYGEN
         REAL MFNR
   C ***********************************************************************
   C CALCULATES THE TOTAL CARBON, HYDROGEN, AND OXYGEN FLOWS WHEN THE
   C REMAINING TAR IS CONVERTED TO CARBON, HYDROGEN, AND OXYGEN.
   C INCLUDES INLET FLOW OF CARBON, HYDROGEN, AND OXYGEN IF PRESENT.
   C ***********************************************************************

         CARBON=CIN+FLOW*(ULTTAR(2)/100.)
         HYDROGEN=HIN+FLOW*(ULTTAR(3)/100.)
         OXYGEN=OIN+FLOW*(ULTTAR(7)/100.)

   C ***********************************************************************
   C SUMS THE TOTAL FLOW OF NON-INERTS OUT OF THE YIELD BLOCK.
   C ***********************************************************************

         TOTAL=CARBON+HYDROGEN+OXYGEN

   C ***********************************************************************
   C CALCUATES THE YIELDS OF TAR, CARBON, HYDROGEN, AND OXYGEN OUT OF
   C THE YIELD BLOCK.
   C ***********************************************************************

         YLDC=CARBON/TOTAL
         YLDH=HYDROGEN/TOTAL
         YLDO=OXYGEN/TOTAL

   C ***********************************************************************
   C SETS THE OPERATING TEMPERATURE OF THE YIELD BLOCK TO THE TEMPERATURE
   C OF THE INLET GAS.
   C ***********************************************************************

         TEMPB=TEMPG

   EXECUTE BEFORE BLOCK TAR-CNV2

   VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
      VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
      --------        ----------      -------------    -----
      ULTTAR(1)        0.00000         0.00000
      ULTTAR(2)        59.4990         59.4990
      ULTTAR(3)        7.09419         7.09419
      ULTTAR(4)        0.00000         0.00000
      ULTTAR(5)        0.00000         0.00000
      ULTTAR(6)        0.00000         0.00000
      ULTTAR(7)        33.4068         33.4068
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 13
                     HOG FUEL GASIFICATION PROJECT CASE A
```

```
                               FLOWSHEET SECTION

CALCULATOR BLOCK:   TARYLD2 (CONTINUED)
      FLOW             0.298562E-01    0.298562E-01    TONS/HR
      YLDC             0.438521E-01    0.438521E-01
      YLDH             0.931526        0.931526
      YLDO             0.246216E-01    0.246216E-01
      CIN              0.00000         0.00000         TONS/HR
      HIN              0.375236        0.375236        TONS/HR
      OIN              0.00000         0.00000         TONS/HR
      TEMPB            1000.19         1000.19         F
      TEMPG            1000.19         1000.19         F

CONVERGENCE BLOCK:  GASIFIER
----------------------------
      SPECS: AIR-GASF  FUEL
      MAXIT =   30
      PERTURBATION SIZE (% OF RANGE):  AIR-GASF    1.0000
                                       FUEL    1.0000
      MAXIMUM STEP SIZE (% OF RANGE):  AIR-GASF    100.00
                                       FUEL    100.00
      METHOD: BROYDEN          STATUS: CONVERGED
      TOTAL NUMBER OF ITERATIONS:    23
      NUMBER OF ITERATIONS ON LAST OUTER LOOP:      1

                           *** FINAL VALUES ***

    VARIABLE                          VALUE            PREV VALUE       ERR/TOL
TOTAL MASSFL     TONS/HR          6.2820            6.2820          -0.1384
TOTAL MASSFL     TONS/HR          15.1748           15.1748         -0.9899

                         *** ITERATION HISTORY ***

      DESIGN-SPEC ID: AIR-GASF

      ITERATION  VARIABLE          ERROR           ERR/TOL
      ---------  --------          -----           -------
          1      6.282           -0.1384         -0.1384

      DESIGN-SPEC ID: FUEL

      ITERATION  VARIABLE          ERROR           ERR/TOL
      ---------  --------          -----           -------
          1      15.17           -0.9899         -0.9899
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 14
                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CONVERGENCE BLOCK:  $OLVER01
----------------------------
      Tear Stream    :  LIMEKILN.TG    LIMEKILN.HEAT-2    HT-CRK
      Tolerance used:  0.100D-03  0.100D-03  0.100D-03
      Trace molefrac:  0.100D-05
      Trace substr-2:  0.100D-05

      MAXIT=   30 WAIT   1 ITERATIONS BEFORE ACCELERATING
      QMAX =   0.0      QMIN =  -5.0
      METHOD: WEGSTEIN         STATUS: CONVERGED
      TOTAL NUMBER OF ITERATIONS:   102
      NUMBER OF ITERATIONS ON LAST OUTER LOOP:      2

                           *** FINAL VALUES ***

    VARIABLE                          VALUE            PREV VALUE       ERR/TOL
```

```
TOTAL MOLEFLOW   LBMOL/HR      3989.0017      3989.0017      2.2089-12
TOTAL MOLEFLOW   LBMOL/HR        47.7590        47.7590      0.0
N2 MOLEFLOW      LBMOL/HR      2305.3916      2305.3916      0.0
CO2 MOLEFLOW     LBMOL/HR      1063.7121      1063.7121      0.0
CACO3 MOLEFLOW   LBMOL/HR         0.0            0.0         0.0
CAO MOLEFLOW     LBMOL/HR         0.0            0.0         0.0
CO MOLEFLOW      LBMOL/HR         0.2378         0.2378      0.0
O2 MOLEFLOW      LBMOL/HR        82.1471        82.1471      0.0
AR MOLEFLOW      LBMOL/HR        27.7722        27.7722      0.0
NO2 MOLEFLOW     LBMOL/HR         0.0            0.0         0.0
NO MOLEFLOW      LBMOL/HR         0.0            0.0         0.0
H2O MOLEFLOW     LBMOL/HR       509.7279       509.7279      0.0
H2 MOLEFLOW      LBMOL/HR      1.2904-02      1.2904-02      0.0
H2O-MUD MOLEFLOW LBMOL/HR      2.4222-06      2.4222-06      0.0
CH4 MOLEFLOW     LBMOL/HR         0.0            0.0         0.0
C MOLEFLOW       LBMOL/HR         0.0            0.0         0.0
PRESSURE         PSI             14.6959        14.6959      0.0
MASS ENTHALPY    BTU/LB       -1553.7510     -1553.7493     -1.0471-02
N2 MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
CO2 MOLEFLOW     LBMOL/HR        0.0            0.0          0.0
CACO3 MOLEFLOW   LBMOL/HR        0.0            0.0          0.0
CAO MOLEFLOW     LBMOL/HR       47.7590        47.7590       0.0
CO MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
O2 MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
AR MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
NO2 MOLEFLOW     LBMOL/HR        0.0            0.0          0.0
NO MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
H2O MOLEFLOW     LBMOL/HR        0.0            0.0          0.0
H2 MOLEFLOW      LBMOL/HR        0.0            0.0          0.0
H2O-MUD MOLEFLOW LBMOL/HR        0.0            0.0          0.0
CH4 MOLEFLOW     LBMOL/HR        0.0            0.0          0.0
C MOLEFLOW       LBMOL/HR        0.0            0.0          0.0
PRESSURE         PSI            14.6959        14.6959       0.0
MASS ENTHALPY    BTU/LB      -4613.0451     -4613.0439     -2.6703-03
INFO-VAR                     -3.3823+05     -3.3823+05       0.0
 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                 09/27/2007  PAGE 15
                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CONVERGENCE BLOCK:  $OLVER01 (CONTINUED)
INFO-VAR                       2.1829+06      2.1829+06       0.0

                         *** ITERATION HISTORY ***

    TEAR STREAMS:

    ITERATION   MAX-ERR/TOL   STREAM ID   VARIABLE
    ---------   -----------   ---------   --------
        1          81.75      TG          O2 MOLEFLOW
        2       -0.1047E-01   TG          MASS ENTHALPY

CONVERGENCE BLOCK:  $OLVER02
----------------------------
    SPECS: GAS-HHV.O2-DRY
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:     3

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
TOTAL MOLEFL     LBMOL/HR         404.1826       3.2437+04     -7.0486-07

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: GAS-HHV.O2-DRY


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      0.2344E+05        0.2303E+05       0.2303E+10
        2      0.3244E+05        0.3203E+05       0.3203E+10
        3       404.2           -0.7049E-11      -0.7049E-06

CONVERGENCE BLOCK:  $OLVER03
----------------------------
    SPECS: GAS-HHV.O2-WET
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:     3
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                     HOG FUEL GASIFICATION PROJECT CASE A
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CONVERGENCE BLOCK:  $OLVER03 (CONTINUED)

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
TOTAL MOLEFL     LBMOL/HR         404.1826       3.2437+04     -6.9917-07

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: GAS-HHV.O2-WET


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      0.2344E+05        0.2303E+05       0.2303E+10
        2      0.3244E+05        0.3203E+05       0.3203E+10
        3       404.2           -0.6992E-11      -0.6992E-06

CONVERGENCE BLOCK:  $OLVER04
----------------------------
    SPECS: AIR-CRK
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:    47
    NUMBER OF ITERATIONS ON LAST OUTER LOOP:      1

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
TOTAL MASSFL     TONS/HR          2.9576          2.9576       1.9971-03

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: AIR-CRK


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1       2.958            0.1997E-05       0.1997E-02

CONVERGENCE BLOCK:  $OLVER05
----------------------------
    SPECS: AIR-KILN
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                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CONVERGENCE BLOCK:  $OLVER05 (CONTINUED)
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:     4

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
TOTAL MOLEFL     LBMOL/HR        2190.0385       2186.8612        0.4420

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: AIR-KILN


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      2270.             0.3846E-02       38.46
        2      2289.             0.4744E-02       47.44
        3      2187.            -0.1577E-03      -1.577
        4      2190.             0.4420E-04       0.4420

CONVERGENCE BLOCK:  $OLVER06
----------------------------
    SPECS: DRY-KILN
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:   215
    NUMBER OF ITERATIONS ON LAST OUTER LOOP:      2

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
BLOCK-VAR          F              798.9216        799.2700     -7.9621-02

                         *** ITERATION HISTORY ***
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                               FLOWSHEET SECTION

CONVERGENCE BLOCK:  $OLVER06 (CONTINUED)

    DESIGN-SPEC ID: DRY-KILN


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      799.3             0.1384E-01       138.4
        2      798.9            -0.7962E-05      -0.7962E-01

CONVERGENCE BLOCK:  $OLVER07
----------------------------
    SPECS: SPLT-TG
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:     8

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
BLOCK-VAR                         0.8238          0.8239       1.8126-02

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: SPLT-TG


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      0.1000           -691.7           -0.6917E+06
        2      0.1100           -691.7           -0.6917E+06
        3       1.000     UB     100.7            0.1007E+06
        4      0.5550           -120.9           -0.1209E+06
        5      0.7978           -18.82           -0.1882E+05
        6      0.8335            6.718            6718.
        7      0.8239            0.4256E-01       42.56
        8      0.8238            0.1813E-04       0.1813E-01

CONVERGENCE BLOCK:  $OLVER08
----------------------------
    SPECS: TARTEMP
    MAXIT=   30 STEP-SIZE=     1.0000     % OF RANGE
                MAX-STEP=       100.      % OF RANGE
                XTOL=        1.000000E-08
    THE NEW ALGORITHM WAS USED WITH BRACKETING=YES
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                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

CONVERGENCE BLOCK:  $OLVER08 (CONTINUED)
    METHOD: SECANT          STATUS: CONVERGED
    TOTAL NUMBER OF ITERATIONS:    11
    NUMBER OF ITERATIONS ON LAST OUTER LOOP:      1

                         *** FINAL VALUES ***

   VARIABLE                        VALUE          PREV VALUE      ERR/TOL
BLOCK-VAR                       3.2221-02       3.2221-02        -0.1762

                         *** ITERATION HISTORY ***

    DESIGN-SPEC ID: TARTEMP


    ITERATION  VARIABLE          ERROR            ERR/TOL
    ---------  --------          -----            -------
        1      0.3222E-01       -0.1762E-04      -0.1762
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                     HOG FUEL GASIFICATION PROJECT CASE A
                               FLOWSHEET SECTION

COMPUTATIONAL SEQUENCE
----------------------

SEQUENCE USED WAS:
```

```
LPS-GEN IPS-GEN $C-5 LIMEKILN.NCG-HT
$OLVER05
| $OLVER08
| | GASIFIER
| | | $OLVER04
| | | | $OLVER01 LIMEKILN.H2O-CON $C-2
| | | | | $OLVER06 DRYER
| | | | | (RETURN $OLVER06)
| | | | | $C-7 CYCLONE2 $C-4 LIMEKILN.REACTOR LIMEKILN.SEP
| | | | | LIMEKILN.CAO-TADJ LIMEKILN.KLN-TADJ $C-8 LIMEKILN.HT-SPLT
| | | | | $C-12 AIR-BLWR $C-10 HV FUEL-DUP $C-18 BM-DRYER.DRY-FUEL
| | | | | BM-DRYER.MOISTYLD BM-DRYER.SPR-HTR BM-DRYER.DISCHRG $C-19
| | | | | $C-11 GASF-P GASIFIER.EVPDVL GASIFIER.EVP-DEVL
| | | | | GASIFIER.FEED-MIX GASIFIER.FD-SPLT GASIFIER.GFR
| | | | | GASIFIER.RXN-2 GASIFIER.GFR-2 GASIFIER.ASH-SEP
| | | | | GASIFIER.GFRQLOSS GASIFIER.HEATMIX GASIFIER.DVL-EXCH $C-9
| | | | | AIRBLWR2 HEAT-CRK TARYLD TAR-CNV TAR-CRK COOL-CRK CYCLONE
| | | | | TARYLD2 TAR-CNV2 CL-CNG PIPELOSS NG-DUP $C-3 LIMEKILN.BURNER
| | | | | LIMEKILN.CL-CNG LIMEKILN.TG-MIX LIMEKILN.HT-MIX
| | | | (RETURN $OLVER01)
| | | (RETURN $OLVER04)
| | (RETURN GASIFIER)
| (RETURN $OLVER08)
(RETURN $OLVER05)
$C-13 $C-1 GAS-HHV.STP-COOL GAS-HHV.DUP-MAIN GAS-HHV.H2O-SEP
$OLVER03
(RETURN $OLVER03)
GAS-HHV.BURN-DRY GAS-HHV.DUP-DRY GAS-HHV.LHVCONDD GAS-HHV.HHVCONDD
$OLVER02
(RETURN $OLVER02)
GAS-HHV.BURN-WET GAS-HHV.DUP-WET GAS-HHV.HHVCONDW GAS-HHV.LHVCONDW
$C-14 BM-DRYER.STM-SPLT $C-16 $C-17 LPSTM $C-15 FUEL-HHV.STP-COOL
FUEL-HHV.DECOMP FUEL-HHV.DECOMP FUEL-HHV.O2 FUEL-HHV.BURN FUEL-HHV.DUP
FUEL-HHV.HHV-COND FUEL-HHV.LHV-COND $C-6
$OLVER07 SPLT-TG HEAT-DRY
(RETURN $OLVER07)
IPSTM TG-MIX TG-BLWR CALC
```

OVERALL FLOWSHEET BALANCE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	2305.39	4295.47	-0.463297
CO2	0.886348	4342.98	-0.999796
CACO3	526.061	0.00000	1.00000
CAO	0.00000	526.061	-1.00000
CO	0.00000	0.237845	-1.00000
O2	1994.72	82.1633	0.958810

OVERALL FLOWSHEET BALANCE (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
AR	27.7722	51.7460	-0.463297
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	2.95449	5667.19	-0.999479
H2	0.295449	0.129044E-01	0.956323
H2O-MUD	484.478	484.478	0.100000E-07
CH4	0.00000	0.00000	0.00000
C	0.00000	0.00000	0.00000
SUBTOTAL(LBMOL/HR)	5342.56	15450.3	-0.654211
(TONS/HR)	95.4965	228.246	-0.581607
NON-CONVENTIONAL COMPONENTS (TONS/HR)			
CHAR	0.00000	0.180040	-1.00000
FUEL	15.1748	0.843043E-07	1.00000
TAR	0.00000	0.00000	0.00000
ASH	0.00000	1.43629	-1.00000
SUBTOTAL(TONS/HR)	15.1748	1.61633	0.893486
TOTAL BALANCE			
MASS(TONS/HR)	110.671	229.862	-0.518532
ENTHALPY(MMBTU/HR)	-479.864	-1559.11	0.692219

FLOWSHEET SECTION BALANCE: GASIFIER

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	1671.56	1671.56	0.00000
CO2	259.817	259.817	0.00000
CACO3	0.00000	0.00000	0.00000
CAO	0.00000	0.00000	0.00000
CO	1221.61	1221.61	0.00000
O2	91.6153	91.6153	0.620458E-15
AR	20.1367	20.1367	0.00000
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	459.445	459.445	0.00000
H2	907.037	907.037	0.00000
H2O-MUD	0.00000	0.00000	0.00000
CH4	50.3556	50.3556	0.00000
C	2.95798	2.95798	0.00000
SUBTOTAL(LBMOL/HR)	4684.54	4684.54	0.00000
(TONS/HR)	53.5817	53.5817	0.00000

FLOWSHEET SECTION BALANCE: GASIFIER (CONTINUED)

	IN	OUT	RELATIVE DIFF.
NON-CONVENTIONAL COMPONENTS (TONS/HR)			
CHAR	0.360081	0.360081	0.00000
FUEL	8.43043	8.43043	0.00000
TAR	0.776262	0.776262	0.00000
ASH	0.478764	0.478764	0.00000
SUBTOTAL(TONS/HR)	10.0455	10.0455	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	63.6272	63.6272	0.00000
ENTHALPY(MMBTU/HR)	-162.930	-162.930	0.767204E-08

FLOWSHEET SECTION BALANCE: GLOBAL

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	5605.82	6103.34	-0.815158E-01
CO2	1324.16	1484.57	-0.108052
CACO3	526.061	526.061	0.00000
CAO	621.579	621.579	0.00000
CO	1221.85	1716.87	-0.288329
O2	611.927	570.333	0.679713E-01
AR	67.5314	73.5248	-0.815158E-01
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	971.260	1042.99	-0.687767E-01
H2	907.259	1495.67	-0.393409
H2O-MUD	0.484478E-05	0.484478E-05	0.00000
CH4	50.3556	0.147857	0.997064
C	2.95798	8.87394	-0.666667
SUBTOTAL(LBMOL/HR)	11910.8	13644.0	-0.127031
(TONS/HR)	189.748	207.506	-0.855766E-01
NON-CONVENTIONAL COMPONENTS (TONS/HR)			
CHAR	0.180040	0.180040	0.00000
FUEL	0.843043E-07	0.843043E-07	0.00000
TAR	0.776262	0.298562E-01	0.961538
ASH	0.00000	0.00000	0.00000
SUBTOTAL(TONS/HR)	0.956302	0.209897	0.780512
TOTAL BALANCE			
MASS(TONS/HR)	190.704	207.715	-0.818967E-01
ENTHALPY(MMBTU/HR)	-748.760	-794.650	0.577480E-01

FLOWSHEET SECTION BALANCE: KILN

FLOWSHEET SECTION BALANCE: KILN (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	3300.43	3300.43	0.00000
CO2	1168.94	1168.94	0.00000
CACO3	526.061	526.061	0.00000
CAO	47.7590	47.7590	0.00000
CO	429.397	429.397	0.00000
O2	216.603	216.603	0.00000
AR	39.7591	39.7591	0.00000
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	1391.84	1391.84	0.00000
H2	374.458	374.458	0.00000
H2O-MUD	484.478	484.478	0.00000
CH4	0.369641E-01	0.369641E-01	0.00000
C	2.95798	2.95798	0.00000
SUBTOTAL(LBMOL/HR)	7982.72	7982.72	0.00000
(TONS/HR)	127.186	127.186	0.00000
NON-CONVENTIONAL COMPONENTS (TONS/HR)			
CHAR	0.00000	0.00000	0.00000
FUEL	23.6052	38.7800	-0.391304
TAR	0.00000	0.00000	0.00000
ASH	0.00000	0.00000	0.00000
SUBTOTAL(TONS/HR)	23.6052	38.7800	-0.391304
TOTAL BALANCE			
MASS(TONS/HR)	150.791	165.966	-0.914331E-01
ENTHALPY(MMBTU/HR)	-843.737	-995.915	0.152802

COMPONENTS

ID	TYPE	FORMULA	NAME OR ALIAS	REPORT NAME
N2	C	N2	N2	N2
CO2	C	CO2	CO2	CO2
CACO3	C	CACO3	CACO3	CACO3
CAO	C	CAO	CAO	CAO
CO	C	CO	CO	CO
O2	C	O2	O2	O2
AR	C	AR	AR	AR
NO2	C	NO2	NO2	NO2
NO	C	NO	NO	NO
H2O	C	H2O	H2O	H2O
H2	C	H2	H2	H2
H2O-MUD	C	H2O	H2O	H2O-MUD
CHAR	NC		MISSING	CHAR
CH4	C	CH4	CH4	CH4
FUEL	NC		MISSING	FUEL
TAR	NC		MISSING	TAR
ASH	NC		MISSING	ASH
C	C	C	C	C

ID	ATTRIBUTE TYPES
CHAR	PROXANAL ULTANAL SULFANAL
FUEL	PROXANAL ULTANAL SULFANAL
TAR	PROXANAL ULTANAL SULFANAL
ASH	GENANAL

REACTION: CHAR1 TYPE: USER

Unit operations referencing this reaction model:

Reactor Name: GFR Block Type: RPLUG

BLOCK: $C-1 MODEL: CONNECT

INLET STREAM: SYNGAS10
OUTLET STREAM: GAS-HHV.GAS

BLOCK: $C-10 MODEL: CONNECT

INLET STREAM: AIR-2
OUTLET STREAM: GASIFIER.AIR

BLOCK: $C-11 MODEL: CONNECT

INLET STREAM: DRY-BIOM
OUTLET STREAM: GASIFIER.BIOMASS

BLOCK: $C-12 MODEL: CONNECT

INLET STREAM: LIMEKILN.HEAT-7
OUTLET STREAM: TAR-HEAT

BLOCK: $C-13 MODEL: CONNECT

INLET STREAM: GASIFIER.ASH
OUTLET STREAM: ASH

BLOCK: $C-14 MODEL: CONNECT

INLET STREAM: BM-DRYER.HEAT-DRY
OUTLET STREAM: HEAT-DRY

BLOCK: $C-15 MODEL: CONNECT

INLET STREAM: FUEL-HV
OUTLET STREAM: FUEL-HHV.FUEL

```
BLOCK:  $C-16    MODEL: CONNECT
-------------------------------
 INLET STREAM:          BM-DRYER.STM-LK
 OUTLET STREAM:         STM-LK

BLOCK:  $C-17    MODEL: CONNECT
-------------------------------
 INLET STREAM:          BM-DRYER.DRTY-STM
 OUTLET STREAM:         DRTY-STM
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BLOCK:  $C-18    MODEL: CONNECT
-------------------------------
 INLET STREAM:          BIOMASS2
 OUTLET STREAM:         BM-DRYER.BIOMASS

BLOCK:  $C-19    MODEL: CONNECT
-------------------------------
 INLET STREAM:          BM-DRYER.BIOMASS4
 OUTLET STREAM:         DRY-BIOM

BLOCK:  $C-2     MODEL: CONNECT
-------------------------------
 INLET STREAM:          LIMEKILN.TG-2
 OUTLET STREAM:         TG

BLOCK:  $C-3     MODEL: CONNECT
-------------------------------
 INLET STREAM:          SYNGAS11
 OUTLET STREAM:         LIMEKILN.FUEL

BLOCK:  $C-4     MODEL: CONNECT
-------------------------------
 INLET STREAM:          KLN-DUST
 OUTLET STREAM:         LIMEKILN.KLN-DUST

BLOCK:  $C-5     MODEL: CONNECT
-------------------------------
 INLET STREAM:          NCG-AIR
 OUTLET STREAM:         LIMEKILN.NCG-AIR

BLOCK:  $C-6     MODEL: CONNECT
-------------------------------
 INLET STREAM:          LIMEKILN.CAO-2
 OUTLET STREAM:         CAO

BLOCK:  $C-7     MODEL: CONNECT
-------------------------------
 INLET STREAM:          CACO3-2
 OUTLET STREAM:         LIMEKILN.CACO3

BLOCK:  $C-8     MODEL: CONNECT
-------------------------------
 INLET STREAM:          KILN-AIR
 OUTLET STREAM:         LIMEKILN.AIR
```



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BLOCK:  $C-9     MODEL: CONNECT
-------------------------------
 INLET STREAM:          GASIFIER.SYNGAS-3
 OUTLET STREAM:         SYNGAS

BLOCK:  AIR-BLWR MODEL: COMPR
-----------------------------
 INLET STREAM:          AIR
 OUTLET STREAM:         AIR-2
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN             OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)      433.935         433.935          0.00000
                (TONS/HR )      6.28195         6.28195          0.00000
     NONCONV. COMP(TONS/HR )    0.00000         0.00000          0.00000
  TOTAL BALANCE
     MASS(TONS/HR )             6.28195         6.28195          0.00000
     ENTHALPY(MMBTU/HR)       -0.957975E-01     0.266452        -1.35953

                           ***  INPUT DATA  ***

 ISENTROPIC CENTRIFUGAL COMPRESSOR
  OUTLET PRESSURE  PSI                                       25.0000
  ISENTROPIC EFFICIENCY                                       0.72000
  MECHANICAL EFFICIENCY                                       1.00000
```



```
BLOCK:  AIR-BLWR MODEL: COMPR (CONTINUED)

                           ***  RESULTS  ***

 INDICATED  HORSEPOWER REQUIREMENT  HP                      142.370
 BRAKE      HORSEPOWER REQUIREMENT  HP                      142.370
 NET WORK REQUIRED                  HP                      142.370
 POWER LOSSES                       HP                        0.0
 ISENTROPIC HORSEPOWER REQUIREMENT  HP                      102.506
 CALCULATED OUTLET TEMP  F                                  187.908
 ISENTROPIC TEMPERATURE  F                                  154.478
 EFFICIENCY (POLYTR/ISENTR) USED                              0.72000
 OUTLET VAPOR FRACTION                                        1.00000
 HEAD DEVELOPED,          FT-LBF/LB                      16,154.4
 MECHANICAL EFFICIENCY USED                                   1.00000
 INLET HEAT CAPACITY RATIO                                    1.39892
 INLET VOLUMETRIC FLOW RATE , CUFT/HR                   167,126.
 OUTLET VOLUMETRIC FLOW RATE, CUFT/HR                   120,635.
 INLET  COMPRESSIBILITY FACTOR                                0.99954
 OUTLET COMPRESSIBILITY FACTOR                                1.00010
 AV. ISENT. VOL. EXPONENT                                     1.40130
 AV. ISENT. TEMP EXPONENT                                     1.39987
 AV. ACTUAL VOL. EXPONENT                                     1.62987
 AV. ACTUAL TEMP EXPONENT                                     1.62709

BLOCK:  AIRBLWR2 MODEL: COMPR
-----------------------------
 INLET STREAM:          AIR-CRK
 OUTLET STREAM:         AIR-CRK2
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN             OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)      204.303         204.303          0.00000
                (TONS/HR )      2.95763         2.95763         -0.150150E-15
     NONCONV. COMP(TONS/HR )    0.00000         0.00000          0.00000
  TOTAL BALANCE
     MASS(TONS/HR )             2.95763         2.95763         -0.150150E-15
     ENTHALPY(MMBTU/HR)       -0.451028E-01     0.117890        -1.38258
```



```
BLOCK:  AIRBLWR2 MODEL: COMPR (CONTINUED)

                           ***  INPUT DATA  ***

 ISENTROPIC CENTRIFUGAL COMPRESSOR
  OUTLET PRESSURE  PSI                                       24.4581
  ISENTROPIC EFFICIENCY                                       0.72000
  MECHANICAL EFFICIENCY                                       1.00000

                           ***  RESULTS  ***

 INDICATED  HORSEPOWER REQUIREMENT  HP                       64.0585
 BRAKE      HORSEPOWER REQUIREMENT  HP                       64.0585
 NET WORK REQUIRED                  HP                       64.0585
 POWER LOSSES                       HP                        0.0
 ISENTROPIC HORSEPOWER REQUIREMENT  HP                       46.1221
 CALCULATED OUTLET TEMP  F                                  182.607
 ISENTROPIC TEMPERATURE  F                                  150.652
 EFFICIENCY (POLYTR/ISENTR) USED                              0.72000
 OUTLET VAPOR FRACTION                                        1.00000
 HEAD DEVELOPED,          FT-LBF/LB                      15,438.3
 MECHANICAL EFFICIENCY USED                                   1.00000
 INLET HEAT CAPACITY RATIO                                    1.39892
 INLET VOLUMETRIC FLOW RATE , CUFT/HR                    78,685.4
 OUTLET VOLUMETRIC FLOW RATE, CUFT/HR                    57,578.5
 INLET  COMPRESSIBILITY FACTOR                                0.99954
 OUTLET COMPRESSIBILITY FACTOR                                1.00007
 AV. ISENT. VOL. EXPONENT                                     1.40132
 AV. ISENT. TEMP EXPONENT                                     1.39991
 AV. ACTUAL VOL. EXPONENT                                     1.63104
 AV. ACTUAL TEMP EXPONENT                                     1.62827

BLOCK:  CL-CNG   MODEL: CLCHNG
------------------------------
 INLET STREAM:          SYNGAS-7
 OUTLET STREAM:         SYNGAS-8
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE
```



```
BLOCK:  CL-CNG   MODEL: CLCHNG (CONTINUED)

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN             OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)      1548.45         1548.45          0.00000
                (TONS/HR )      17.0112         17.0112          0.00000
     NONCONV. COMP(TONS/HR )    0.00000         0.00000          0.00000
  TOTAL BALANCE
     MASS(TONS/HR )             17.0112         17.0112          0.00000
     ENTHALPY(MMBTU/HR)        -41.0818        -41.0818          0.00000

BLOCK:  COOL-CRK MODEL: HEATER
------------------------------
 INLET STREAM:          SYNGAS-4
 INLET HEAT STREAM:     HT-CRK-2
 OUTLET STREAM:         SYNGAS-5
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN             OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)      1542.76         1542.76          0.00000
                (TONS/HR )      16.9814         16.9814          0.00000
     NONCONV. COMP(TONS/HR )    0.209897        0.209897         0.00000
  TOTAL BALANCE
     MASS(TONS/HR )             17.1913         17.1913          0.00000
     ENTHALPY(MMBTU/HR)        -41.0398        -41.0398          0.732055E-08

                           ***  INPUT DATA  ***
 TWO    PHASE  PQ  FLASH
 PRESSURE DROP                         PSI                       2.00000
 DUTY FROM INLET HEAT STREAM(S)        MMBTU/HR                 -9.42120
 MAXIMUM NO. ITERATIONS                                         30
 CONVERGENCE TOLERANCE                                           0.000100000


                           ***  RESULTS  ***
 OUTLET TEMPERATURE    F                                     1000.2
 OUTLET PRESSURE       PSI                                   18.458
 OUTLET VAPOR FRACTION                                       1.0000
 PRESSURE-DROP CORRELATION PARAMETER                         264.98
```



```
BLOCK:  COOL-CRK MODEL: HEATER (CONTINUED)

 V-L PHASE EQUILIBRIUM :

     COMP              F(I)          X(I)           Y(I)           K(I)
     N2              0.32249       0.25610E-07    0.32249        748.59
     CO2             0.68085E-01   0.40365E-05    0.68085E-01    706.66
     CO              0.27818       0.23417E-07    0.27818        751.45
     AR              0.38849E-02   0.65884E-08    0.38849E-02    698.88
     H2O             0.86039E-01   1.0000         0.86039E-01    556.99
     H2              0.24131       0.64743E-07    0.24131        678.01
     CH4             0.23960E-04   0.19390E-10    0.23960E-04    728.45

BLOCK:  CYCLONE  MODEL: SEP
---------------------------
 INLET STREAM:          SYNGAS-5
 OUTLET STREAMS:        SOLIDS         SYNGAS-6
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN             OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)      1542.76         1542.76          0.00000
                (TONS/HR )      16.9814         16.9814          0.00000
     NONCONV. COMP(TONS/HR )    0.209897        0.209897         0.00000
  TOTAL BALANCE
     MASS(TONS/HR )             17.1913         17.1913          0.00000
     ENTHALPY(MMBTU/HR)        -41.0398        -41.0398          0.304584E-07

                           ***  INPUT DATA  ***

 INLET PRESSURE DROP   PSI                                      2.00000

 FLASH SPECS FOR STREAM SOLIDS
 TWO    PHASE  TP  FLASH
 PRESSURE DROP              PSI                                 0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FLASH SPECS FOR STREAM SYNGAS-6
 TWO    PHASE  TP  FLASH
```

```
 PRESSURE DROP          PSI                                     0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 33
                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION

BLOCK:  CYCLONE  MODEL: SEP (CONTINUED)

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= SOLIDS    CPT= N2        FRACTION=          0.0
   SUBSTREAM= NC
     STREAM= SOLIDS    CPT= CHAR      FRACTION=          1.00000
                            FUEL                         1.00000
                            TAR                          0.0
                            ASH                          1.00000

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                                 -0.12500E-05

COMPONENT = N2
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = CO2
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = CO
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = AR
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = H2O
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = H2
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = CH4
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    MIXED                 1.00000

COMPONENT = CHAR
  STREAM      SUBSTREAM    SPLIT FRACTION
  SOLIDS      NC                    1.00000

COMPONENT = FUEL
  STREAM      SUBSTREAM    SPLIT FRACTION
  SOLIDS      NC                    1.00000

COMPONENT = TAR
  STREAM      SUBSTREAM    SPLIT FRACTION
  SYNGAS-6    NC                    1.00000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 34
                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION
```

```
BLOCK:  CYCLONE2 MODEL: SEP
---------------------------
 INLET STREAM:          TG-2
 OUTLET STREAMS:        KLN-DUST    TG-3
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

                      ***  MASS AND ENERGY BALANCE  ***
                                        IN              OUT        RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)              4521.24          4521.24          0.00000
     MASS(TONS/HR )              67.8648          67.8648          0.00000
     ENTHALPY(MMBTU/HR)         -269.445         -269.445         -0.199630E-05

                          ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM KLN-DUST
 TWO    PHASE  TP  FLASH
 PRESSURE DROP          PSI                                     0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FLASH SPECS FOR STREAM TG-3
 TWO    PHASE  TP  FLASH
 PRESSURE DROP          PSI                                     1.00000
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= KLN-DUST  CPT= CH4       FRACTION=          0.0
   SUBSTREAM= CISOLID
     STREAM= KLN-DUST  CPT= CACO3     FRACTION=          1.00000
                            CAO                          1.00000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 35
                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION

BLOCK:  CYCLONE2 MODEL: SEP (CONTINUED)

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                                 0.53789E-03

COMPONENT = N2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = CO2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = CAO
  STREAM      SUBSTREAM    SPLIT FRACTION
  KLN-DUST    CISOLID               1.00000

COMPONENT = CO
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = O2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = AR
```

```
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = H2O
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = H2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000

COMPONENT = H2O-MUD
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-3        MIXED                 1.00000
BLOCK:  DRYER    MODEL: SEP
---------------------------
 INLET STREAMS:         CACO3       TG
 OUTLET STREAMS:        CACO3-2     TG-2
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 36
                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION

BLOCK:  DRYER    MODEL: SEP (CONTINUED)

                      ***  MASS AND ENERGY BALANCE  ***
                                        IN              OUT        RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)              5047.30          5047.30          0.00000
     MASS(TONS/HR )              94.1908          94.1908          0.00000
     ENTHALPY(MMBTU/HR)         -535.791         -535.791          0.148604E-07

                          ***  INPUT DATA  ***

 INLET PRESSURE:  MINIMUM OF INLET STREAM PRESSURES

 FLASH SPECS FOR STREAM CACO3-2
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE F                                      635.000
 PRESSURE DROP          PSI                                     0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FLASH SPECS FOR STREAM TG-2
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE F                                      798.922
 PRESSURE DROP          PSI                                     0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= CACO3-2   CPT= H2O-MUD   FRACTION=          0.100000-07
   SUBSTREAM= CISOLID
     STREAM= CACO3-2   CPT= CACO3     FRACTION=          1.00000
                            CAO                          0.0

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                                 -0.79621E-05

COMPONENT = N2
  STREAM      SUBSTREAM    SPLIT FRACTION
```

```
  TG-2        MIXED                 1.00000

COMPONENT = CO2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000
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                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION

BLOCK:  DRYER    MODEL: SEP (CONTINUED)

COMPONENT = CACO3
  STREAM      SUBSTREAM    SPLIT FRACTION
  CACO3-2     CISOLID               1.00000

COMPONENT = CAO
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        CISOLID               1.00000

COMPONENT = CO
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000

COMPONENT = O2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000

COMPONENT = AR
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000

COMPONENT = H2O
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000

COMPONENT = H2
  STREAM      SUBSTREAM    SPLIT FRACTION
  TG-2        MIXED                 1.00000

COMPONENT = H2O-MUD
  STREAM      SUBSTREAM    SPLIT FRACTION
  CACO3-2     MIXED                 0.100000-07
  TG-2        MIXED                 1.00000
BLOCK:  FUEL-DUP MODEL: DUPL
----------------------------
 INLET STREAM:          BIOMASS
 OUTLET STREAMS:        BIOMASS2    FUEL-HV

BLOCK:  HEAT-CRK MODEL: HEATER
------------------------------
 INLET STREAMS:         SYNGAS      AIR-CRK2
 OUTLET STREAM:         SYNGAS-2
 OUTLET HEAT STREAM:    HT-CRK-2
 PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 38
                   HOG FUEL GASIFICATION PROJECT CASE A
                            U-O-S BLOCK SECTION

BLOCK:  HEAT-CRK MODEL: HEATER (CONTINUED)

                      ***  MASS AND ENERGY BALANCE  ***
                                        IN              OUT        RELATIVE DIFF.
      CONV. COMP.(LBMOL/HR)      1363.69          1363.69          0.00000
                 (TONS/HR )      16.2648          16.2648          0.00000
      NONCONV. COMP(TONS/HR )   0.926446         0.926446          0.00000
```

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MASS(TONS/HR)	17.1913	17.1913	0.00000
ENTHALPY(MMBTU/HR)	-41.0398	-41.0398	0.611394E-08

*** INPUT DATA ***

TWO PHASE TP FLASH
SPECIFIED TEMPERATURE F 1,652.00
PRESSURE DROP PSI 2.00000
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 1652.0
OUTLET PRESSURE PSI 22.458
HEAT DUTY MMBTU/HR 9.4212
OUTLET VAPOR FRACTION 1.0000
PRESSURE-DROP CORRELATION PARAMETER 397.24

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
N2	0.36483	0.35269	0.36483	881.07
CO2	0.36422E-01	0.35079E-01	0.36422E-01	884.35
CO	0.26640	0.25611	0.26640	886.00
O2	0.31415E-01	0.31992E-01	0.31415E-01	836.38
AR	0.43950E-02	0.44786E-02	0.43950E-02	835.85
H2O	0.14207	0.15921	0.14207	760.04
H2	0.11759	0.12513	0.11759	800.38
CH4	0.36872E-01	0.35301E-01	0.36872E-01	889.65

BLOCK: HEAT-DRY MODEL: HEATER

INLET STREAM: TG-4
INLET HEAT STREAM: HEAT-DRY
OUTLET STREAM: TG-6
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

BLOCK: HEAT-DRY MODEL: HEATER (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	3685.24	3685.24	0.00000
MASS(TONS/HR)	54.8037	54.8037	0.259305E-15
ENTHALPY(MMBTU/HR)	-228.460	-228.460	-0.990515E-08

*** INPUT DATA ***

TWO PHASE PQ FLASH
PRESSURE DROP PSI 2.00000
DUTY FROM INLET HEAT STREAM(S) MMBTU/HR -16.8918
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 250.00
OUTLET PRESSURE PSI 11.696
OUTLET VAPOR FRACTION 1.0000

PRESSURE-DROP CORRELATION PARAMETER 42.091

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
N2	0.51535	0.29502E-07	0.51535	0.85295E+06
CO2	0.23778	0.81938E-05	0.23778	9546.0
CO	0.53168E-04	0.32192E-11	0.53168E-04	0.82336E+06
O2	0.18363E-01	0.21398E-07	0.18363E-01	0.10208E+06
AR	0.62082E-02	0.69003E-08	0.62082E-02	0.10148E+06
H2O	0.11394	0.51269	0.11394	2.4364
H2	0.28846E-05	0.55658E-12	0.28846E-05	0.26437E+06
H2O-MUD	0.10830	0.48730	0.10830	2.4364

BLOCK: IPSTM MODEL: HEATER

INLET STREAM: TG-5
OUTLET STREAM: TG-7
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

BLOCK: IPSTM MODEL: HEATER (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	788.241	788.241	0.00000
MASS(TONS/HR)	11.7220	11.7220	0.151540E-15
ENTHALPY(MMBTU/HR)	-45.2526	-48.8656	0.739380E-01

*** INPUT DATA ***

TWO PHASE TP FLASH
SPECIFIED TEMPERATURE F 250.000
PRESSURE DROP PSI 2.00000
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 250.00
OUTLET PRESSURE PSI 11.696
HEAT DUTY MMBTU/HR -3.6130
OUTLET VAPOR FRACTION 1.0000
PRESSURE-DROP CORRELATION PARAMETER 920.03

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
N2	0.51535	0.66216E-05	0.51535	0.85295E+06
CO2	0.23778	0.27299E-03	0.23778	9546.0
CO	0.53168E-04	0.70770E-09	0.53168E-04	0.82336E+06
O2	0.18363E-01	0.19714E-05	0.18363E-01	0.10208E+06
AR	0.62082E-02	0.67048E-06	0.62082E-02	0.10148E+06
H2O	0.11394	0.51255	0.11394	2.4364
H2	0.28846E-05	0.11958E-09	0.28846E-05	0.26437E+06
H2O-MUD	0.10830	0.48716	0.10830	2.4364

*** ASSOCIATED UTILITIES ***

UTILITY ID FOR STEAM IPS-GEN
RATE OF CONSUMPTION 1.5588 TONS/HR
COST 0.0 $/HR

BLOCK: LPSTM MODEL: HEATER

INLET STREAM: DRTY-STM
OUTLET STREAM: DRTY-H2O
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

BLOCK: LPSTM MODEL: HEATER (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)	695.032	695.032	0.00000
(TONS/HR)	6.26060	6.26060	0.00000
NONCONV. COMP(TONS/HR)	0.00000	0.00000	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	6.26060	6.26060	0.00000
ENTHALPY(MMBTU/HR)	-71.0598	-84.5868	0.159919

*** INPUT DATA ***

TWO PHASE TP FLASH
SPECIFIED TEMPERATURE F 176.000
PRESSURE DROP PSI 1.00000
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 176.00
OUTLET PRESSURE PSI 57.207
HEAT DUTY MMBTU/HR -13.527
OUTLET VAPOR FRACTION 0.0000
PRESSURE-DROP CORRELATION PARAMETER 11645.

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
H2O	1.0000	1.0000	1.0000	0.11569

*** ASSOCIATED UTILITIES ***

UTILITY ID FOR STEAM LPS-GEN
RATE OF CONSUMPTION 5.9388 TONS/HR
COST 0.0 $/HR

BLOCK: NG-DUP MODEL: DUPL

INLET STREAM: SYNGAS-9
OUTLET STREAMS: SYNGAS11 SYNGAS10

BLOCK: PIPELOSS MODEL: HEATER

INLET STREAM: SYNGAS-8
OUTLET STREAM: SYNGAS-9
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

BLOCK: PIPELOSS MODEL: HEATER (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	1548.45	1548.45	0.00000
MASS(TONS/HR)	17.0112	17.0112	0.00000
ENTHALPY(MMBTU/HR)	-41.0818	-45.8895	0.104766

*** INPUT DATA ***

TWO PHASE TP FLASH
SPECIFIED TEMPERATURE F 600.000
PRESSURE DROP PSI 0.50000
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 600.00
OUTLET PRESSURE PSI 15.958
HEAT DUTY MMBTU/HR -4.8077
OUTLET VAPOR FRACTION 0.99809
PRESSURE-DROP CORRELATION PARAMETER 79.464

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
N2	0.32130	0.32207E-20	0.32192	0.99953E+20
CO2	0.67835E-01	0.67962E-21	0.67965E-01	0.10001E+21
CO	0.27715	0.27781E-20	0.27768	0.99954E+20
O2	0.40260E-03	0.40348E-23	0.40337E-03	0.99973E+20
AR	0.38706E-02	0.38790E-22	0.38780E-02	0.99974E+20
H2O	0.85723E-01	0.85803E-21	0.85887E-01	0.10010E+21
H2	0.24178	0.24232E-20	0.24224	0.99967E+20
CH4	0.23872E-04	0.23922E-24	0.23917E-04	0.99981E+20
C	0.19103E-02	1.0000	0.15275E-41	0.15275E-41

BLOCK: SPLT-TG MODEL: FSPLIT

INLET STREAM: TG-3
OUTLET STREAMS: TG-4 TG-5
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

BLOCK: SPLT-TG MODEL: FSPLIT (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	4473.48	4473.48	0.00000
MASS(TONS/HR)	66.5257	66.5257	0.00000
ENTHALPY(MMBTU/HR)	-256.820	-256.820	0.00000

*** INPUT DATA ***

FRACTION OF FLOW STRM=TG-4 FRAC= 0.82380

*** RESULTS ***

STREAM= TG-4 SPLIT= 0.82380 KEY= 0 STREAM-ORDER= 1

```
      TG-5                              0.17620          0                   2

BLOCK:  TAR-CNV  MODEL: RYIELD
------------------------------
   INLET STREAM:            SYNGAS-2
   INLET HEAT STREAM:       HT-CRK
   OUTLET STREAM:           SYNGAS-3
   PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                            ***  MASS AND ENERGY BALANCE  ***
                                IN          OUT       GENERATION    RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)       1363.69      1500.08      136.386        0.00000
           (TONS/HR )       16.2648      16.9814                    -0.421962E-01
NONCONV COMP(TONS/HR )    0.926446      0.209897                     0.773439
   TOTAL BALANCE
     MASS(TONS/HR )         17.1913      17.1913                    -0.206658E-15
     ENTHALPY(MMBTU/HR) -24.1701        -24.1701                     0.826265E-07
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 44
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CNV  MODEL: RYIELD (CONTINUED)

                                ***  INPUT DATA  ***
   TWO    PHASE  TP  FLASH
   SPECIFIED TEMPERATURE F                                  1,652.00
   PRESSURE DROP           PSI                                 0.0
   MAXIMUM NO. ITERATIONS                                     30
   CONVERGENCE TOLERANCE                                        0.000100000

    MASS-YIELD
     SUBSTREAM MIXED   :
     O2       0.580        H2          0.133         C           0.268
     SUBSTREAM NC       :
     TAR      0.187E-01

   INERTS:          N2          CO2          CACO3        CAO          CO
                    AR          NO2          NO           H2O          H2O-MUD
                    CHAR        CH4          FUEL         ASH
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 45
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CNV  MODEL: RYIELD (CONTINUED)

                                ***  RESULTS  ***
   OUTLET TEMPERATURE     F                                      1652.0
   OUTLET PRESSURE        PSI                                    22.458
   HEAT DUTY              MMBTU/HR                               7.4485
   NET DUTY               MMBTU/HR                              -0.19971E-05
   VAPOR FRACTION                                                0.95267


   V-L PHASE EQUILIBRIUM :

      COMP               F(I)          X(I)          Y(I)          K(I)
      N2                 0.33166       0.34827E-20   0.34814       0.99961E+20
      CO2                0.33111E-01   0.34769E-21   0.34756E-01   0.99962E+20
      CO                 0.24218       0.25432E-20   0.25421       0.99960E+20
      O2                 0.38533E-01   0.40459E-21   0.40447E-01   0.99969E+20
      AR                 0.39954E-02   0.41952E-22   0.41939E-02   0.99969E+20
      H2O                0.12915       0.28537E-19   0.13557       0.47506E+19
      H2                 0.14052       0.14753E-20   0.14750       0.99976E+20
      CH4                0.33519E-01   0.35198E-21   0.35185E-01   0.99961E+20
      C                  0.47325E-01   1.0000        0.23878E-15   0.23878E-15
```

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BLOCK:  TAR-CNV2 MODEL: RYIELD
------------------------------
   INLET STREAM:            SYNGAS-6
   INLET HEAT STREAM:       TAR-HEAT
   OUTLET STREAM:           SYNGAS-7
   PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                            ***  MASS AND ENERGY BALANCE  ***
                                IN          OUT       GENERATION    RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)       1542.76      1548.45      5.68275        0.00000
           (TONS/HR )       16.9814      17.0112                    -0.175509E-02
NONCONV COMP(TONS/HR )    0.298562E-01  0.00000                      1.00000
   TOTAL BALANCE
     MASS(TONS/HR )         17.0112      17.0112                    -0.417691E-15
     ENTHALPY(MMBTU/HR) -41.0818        -41.0818                    -0.428901E-06
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 46
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CNV2 MODEL: RYIELD (CONTINUED)

                                ***  INPUT DATA  ***
   TWO    PHASE  TP  FLASH
   SPECIFIED TEMPERATURE F                                  1,000.19
   PRESSURE DROP           PSI                                 0.0
   MAXIMUM NO. ITERATIONS                                     30
   CONVERGENCE TOLERANCE                                        0.000100000

    MASS-YIELD
     SUBSTREAM MIXED   :
     O2       0.246E-01    H2          0.932         C           0.439E-01

   INERTS:          N2          CO2          CACO3        CAO          CO
                    AR          NO2          NO           H2O          H2O-MUD
                    CHAR        CH4          FUEL         ASH
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 47
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CNV2 MODEL: RYIELD (CONTINUED)

                                ***  RESULTS  ***
   OUTLET TEMPERATURE     F                                      1000.2
   OUTLET PRESSURE        PSI                                    16.458
   HEAT DUTY              MMBTU/HR                               0.25697
   NET DUTY               MMBTU/HR                               0.17620E-04
   VAPOR FRACTION                                                0.99809


   V-L PHASE EQUILIBRIUM :

      COMP               F(I)          X(I)          Y(I)          K(I)
      N2                 0.32130       0.32205E-20   0.32192       0.99960E+20
      CO2                0.67835E-01   0.67983E-21   0.67965E-01   0.99973E+20
      CO                 0.27715       0.27780E-20   0.27768       0.99959E+20
      O2                 0.40260E-03   0.40348E-23   0.40337E-03   0.99971E+20
      AR                 0.38706E-02   0.38791E-22   0.38780E-02   0.99971E+20
      H2O                0.85723E-01   0.85872E-21   0.85887E-01   0.10002E+21
      H2                 0.24178       0.24230E-20   0.24224       0.99975E+20
      CH4                0.23872E-04   0.23925E-24   0.23917E-04   0.99967E+20
      C                  0.19103E-02   1.0000        0.76896E-27   0.76896E-27

BLOCK:  TAR-CRK  MODEL: RGIBBS
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   INLET STREAM:            SYNGAS-3
   OUTLET STREAM:           SYNGAS-4
   OUTLET HEAT STREAM:      HT-CRK
   PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                            ***  MASS AND ENERGY BALANCE  ***
                                IN          OUT       GENERATION    RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)       1500.08      1542.76      42.6876        0.00000
           (TONS/HR )       16.9814      16.9814                     0.418425E-14
NONCONV COMP(TONS/HR )    0.209897      0.209897                     0.00000
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 48
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CRK  MODEL: RGIBBS (CONTINUED)
   TOTAL BALANCE
     MASS(TONS/HR )         17.1913      17.1913                     0.413316E-14
     ENTHALPY(MMBTU/HR) -24.1701        -24.1701                     0.146988E-15

                                ***  INPUT DATA  ***

   EQUILIBRIUM SPECIFICATIONS:
     ONLY CHEMICAL EQUILIBRIUM IS CONSIDERED, THE FLUID PHASE IS VAPOR
     SYSTEM TEMPERATURE     F                               1742.0
     TEMPERATURE FOR FREE ENERGY EVALUATION     F           1742.0
     SYSTEM PRESSURE DROP  PSI                              2.0000

   FLUID PHASE SPECIES IN PRODUCT LIST:
     N2 CO2 CO O2 AR H2O H2 CH4 C

   ATOM MATRIX:
   ELEMENT        H    C    N    O    AR   CA
     N2         0.00 0.00 2.00 0.00 0.00 0.00
     CO2        0.00 1.00 0.00 2.00 0.00 0.00
     CACO3      0.00 1.00 0.00 3.00 0.00 1.00
     CAO        0.00 0.00 0.00 1.00 0.00 1.00
     CO         0.00 1.00 0.00 1.00 0.00 0.00
     O2         0.00 0.00 0.00 2.00 0.00 0.00
     AR         0.00 0.00 0.00 0.00 1.00 0.00
     NO2        0.00 0.00 1.00 2.00 0.00 0.00
     NO         0.00 0.00 1.00 1.00 0.00 0.00
     H2O        2.00 0.00 0.00 1.00 0.00 0.00
     H2         2.00 0.00 0.00 0.00 0.00 0.00
     H2O-MUD    2.00 0.00 0.00 1.00 0.00 0.00
     CH4        4.00 1.00 0.00 0.00 0.00 0.00
     C          0.00 1.00 0.00 0.00 0.00 0.00

   PRODUCT SPECIFICATIONS:
     N2          1.0000       FRACTION OF FEED
     AR          1.0000       FRACTION OF FEED

                                ***  RESULTS  ***
   TEMPERATURE            F                                 1742.0
   PRESSURE               PSI                               20.458
   HEAT DUTY              MMBTU/HR                          -7.4485
   VAPOR FRACTION                                           1.0000
   NUMBER OF FLUID PHASES                                              1
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 49
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TAR-CRK  MODEL: RGIBBS (CONTINUED)

   FLUID PHASE MOLE FRACTIONS:

   PHASE                 VAPOR
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   OF TYPE             VAPOR
   PHASE FRACTION      1.000000
   PLACED IN STREAM    SYNGAS-4
     N2               0.3224852
     CO2              0.6808532E-01
     CO               0.2781752
     O2               0.3715278E-16
     AR               0.3884866E-02
     H2O              0.8603852E-01
     H2               0.2413068
     CH4              0.2395967E-04
     C                0.5827997E-24

   LBMOL/HR           1542.765

BLOCK:  TG-BLWR  MODEL: COMPR
-----------------------------
   INLET STREAM:            TG-8
   OUTLET STREAM:           TG-9
   PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                            ***  MASS AND ENERGY BALANCE  ***
                                     IN               OUT            RELATIVE DIFF.
    TOTAL BALANCE
      MOLE(LBMOL/HR)              4473.48          4473.48            0.00000
      MASS(TONS/HR )              66.5257          66.5257            0.00000
      ENTHALPY(MMBTU/HR)         -277.325         -275.270           -0.741137E-02

                                ***  INPUT DATA  ***

   ISENTROPIC CENTRIFUGAL COMPRESSOR
    OUTLET PRESSURE  PSI                                      14.6959
    ISENTROPIC EFFICIENCY                                      0.72000
    MECHANICAL EFFICIENCY                                      1.00000
 ASPEN PLUS    PLAT: WIN32      VER: 20.0 1                   09/27/2007  PAGE 50
                         HOG FUEL GASIFICATION PROJECT CASE A
                                   U-O-S BLOCK SECTION

BLOCK:  TG-BLWR  MODEL: COMPR (CONTINUED)

                                ***  RESULTS  ***

    INDICATED  HORSEPOWER REQUIREMENT  HP                     807.787
    BRAKE      HORSEPOWER REQUIREMENT  HP                     807.787
    NET WORK REQUIRED                  HP                     807.787
    POWER LOSSES                       HP                       0.0
    ISENTROPIC HORSEPOWER REQUIREMENT  HP                     581.607
    CALCULATED OUTLET TEMP  F                                 307.667
    ISENTROPIC TEMPERATURE  F                                 291.636
    EFFICIENCY (POLYTR/ISENTR) USED                             0.72000
    OUTLET VAPOR FRACTION                                       1.00000
    HEAD DEVELOPED,        FT-LBF/LB                        8,655.16
    MECHANICAL EFFICIENCY USED                                  1.00000
    INLET HEAT CAPACITY RATIO                                   1.33313
    INLET VOLUMETRIC FLOW RATE , CUFT/HR                2,909,890.
    OUTLET VOLUMETRIC FLOW RATE, CUFT/HR                2,504,330.
    INLET  COMPRESSIBILITY FACTOR                               0.99897
    OUTLET COMPRESSIBILITY FACTOR                               0.99908
    AV. ISENT. VOL. EXPONENT                                    1.33292
    AV. ISENT. TEMP EXPONENT                                    1.33279
    AV. ACTUAL VOL. EXPONENT                                    1.52124
    AV. ACTUAL TEMP EXPONENT                                    1.52014

BLOCK:  TG-MIX   MODEL: MIXER
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   INLET STREAMS:           TG-7         TG-6
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OUTLET STREAM: TG-8
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	4473.48	4473.48	0.00000
MASS(TONS/HR)	66.5257	66.5257	-0.213614E-15
ENTHALPY(MMBTU/HR)	-277.325	-277.325	-0.990518E-08

BLOCK: TG-MIX MODEL: MIXER (CONTINUED)

*** INPUT DATA ***

TWO PHASE FLASH	
MAXIMUM NO. ITERATIONS	30
CONVERGENCE TOLERANCE	0.000100000
OUTLET PRESSURE: MINIMUM OF INLET STREAM PRESSURES	

CACO3 CACO3-2 CAO KLN-DUST TG

STREAM ID	CACO3	CACO3-2	CAO	KLN-DUST	TG
FROM :	----	DRYER	$C-6	CYCLONE2	$C-2
TO :	DRYER	$C-7	----	$C-4	DRYER
CLASS:	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD
TOTAL STREAM:					
TONS/HR	30.6900	26.3260	14.7501	1.3391	63.5008
MMBTU/HR	-330.2684	-266.3454	-135.7456	-12.6242	-205.5221
SUBSTREAM: MIXED					
PHASE:	LIQUID	VAPOR	MISSING	MISSING	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	2305.3916
CO2	0.0	0.0	0.0	0.0	1063.7121
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.2378
O2	0.0	0.0	0.0	0.0	82.1471
AR	0.0	0.0	0.0	0.0	27.7722
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	509.7279
H2	0.0	0.0	0.0	0.0	1.2904-02
H2O-MUD	484.4776	4.8448-06	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.5779
CO2	0.0	0.0	0.0	0.0	0.2667
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	5.9625-05
O2	0.0	0.0	0.0	0.0	2.0593-02
AR	0.0	0.0	0.0	0.0	6.9622-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.1278
H2	0.0	0.0	0.0	0.0	3.2350-06
H2O-MUD	1.0000	1.0000	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	32.2910
CO2	0.0	0.0	0.0	0.0	23.4069
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	3.3311-03
O2	0.0	0.0	0.0	0.0	1.3143
AR	0.0	0.0	0.0	0.0	0.5547
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	4.5914
H2	0.0	0.0	0.0	0.0	1.3007-05
H2O-MUD	4.3640	4.3640-08	0.0	0.0	0.0

CACO3 CACO3-2 CAO KLN-DUST TG (CONTINUED)

STREAM ID	CACO3	CACO3-2	CAO	KLN-DUST	TG
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	0.0	MISSING	MISSING	0.5195
CO2	0.0	0.0	MISSING	MISSING	0.3765
CACO3	0.0	0.0	MISSING	MISSING	0.0
CAO	0.0	0.0	MISSING	MISSING	0.0
CO	0.0	0.0	MISSING	MISSING	5.3587-05
O2	0.0	0.0	MISSING	MISSING	2.1143-02
AR	0.0	0.0	MISSING	MISSING	8.9239-03
NO2	0.0	0.0	MISSING	MISSING	0.0
NO	0.0	0.0	MISSING	MISSING	0.0
H2O	0.0	0.0	MISSING	MISSING	7.3863-02
H2	0.0	0.0	MISSING	MISSING	2.0924-07
H2O-MUD	1.0000	1.0000	MISSING	MISSING	0.0
CH4	0.0	0.0	MISSING	MISSING	0.0
C	0.0	0.0	MISSING	MISSING	0.0
TOTAL FLOW:					
LBMOL/HR	484.4776	4.8448-06	0.0	0.0	3989.0017
TONS/HR	4.3640	4.3640-08	0.0	0.0	62.1617
CUFT/HR	174.4462	3.8645-03	0.0	0.0	4.9791+06
STATE VARIABLES:					
TEMP F	210.0000	635.0000	MISSING	MISSING	1249.2310
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959
VFRAC	0.0	1.0000	MISSING	MISSING	1.0000
LFRAC	1.0000	0.0	MISSING	MISSING	0.0
SFRAC	0.0	0.0	MISSING	MISSING	0.0
ENTHALPY:					
BTU/LBMOL	-1.2104+05	-9.9334+04	MISSING	MISSING	-4.8425+04
BTU/LB	-6718.5425	-5513.8944	MISSING	MISSING	-1553.7493
MMBTU/HR	-58.6394	-4.8125-07	MISSING	MISSING	-193.1675
ENTROPY:					
BTU/LBMOL-R	-35.7064	-4.7023	MISSING	MISSING	10.5776
BTU/LB-R	-1.9820	-0.2610	MISSING	MISSING	0.3394
DENSITY:					
LBMOL/CUFT	2.7772	1.2537-03	MISSING	MISSING	8.0115-04
LB/CUFT	50.0326	2.2585-02	MISSING	MISSING	2.4969-02
AVG MW	18.0153	18.0153	MISSING	MISSING	31.1666
MIXED SUBSTREAM PROPERTIES:					
*** ALL PHASES ***					
MW UNITLESS					
N2	MISSING	MISSING	MISSING	MISSING	28.0135
CO2	MISSING	MISSING	MISSING	MISSING	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	28.0104
O2	MISSING	MISSING	MISSING	MISSING	31.9988
AR	MISSING	MISSING	MISSING	MISSING	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

CACO3 CACO3-2 CAO KLN-DUST TG (CONTINUED)

STREAM ID	CACO3	CACO3-2	CAO	KLN-DUST	TG
H2O	MISSING	MISSING	MISSING	MISSING	18.0153
H2	MISSING	MISSING	MISSING	MISSING	2.0159
H2O-MUD	18.0153	18.0153	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	18.0153	18.0153	MISSING	MISSING	31.1666
QVALGRS BTU/LB	1049.9837	1049.9837	MISSING	MISSING	77.8004
QVALNET BTU/LB	0.0	0.0	MISSING	MISSING	0.2436
*** VAPOR PHASE ***					
MUMX LB/FT-HR	MISSING	3.8532-02	MISSING	MISSING	9.6723-02
PR	MISSING	0.5448	MISSING	MISSING	0.6934
KMX BTU/HR-FT-R	MISSING	3.4243-02	MISSING	MISSING	4.1740-02
* 68.0000 F *					
VVSTD CUM/SEC					
N2	MISSING	MISSING	MISSING	MISSING	6.9873
CO2	MISSING	MISSING	MISSING	MISSING	3.2239
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	7.2087-04
O2	MISSING	MISSING	MISSING	MISSING	0.2490
AR	MISSING	MISSING	MISSING	MISSING	8.4173-02
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	MISSING	MISSING	MISSING	MISSING	1.5449
H2	MISSING	MISSING	MISSING	MISSING	3.9111-05
H2O-MUD	MISSING	1.4684-08	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	MISSING	3.1113-05	MISSING	MISSING	2.5617+04
SUBSTREAM: CISOLID	STRUCTURE: CONVENTIONAL				
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	526.0613	526.0613	0.0	0.0	0.0
CAO	0.0	0.0	526.0613	47.7590	47.7590
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	1.0000	1.0000	0.0	0.0	0.0

CACO3 CACO3-2 CAO KLN-DUST TG (CONTINUED)

STREAM ID	CACO3	CACO3-2	CAO	KLN-DUST	TG
CAO	0.0	0.0	1.0000	1.0000	1.0000
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	26.3260	26.3260	0.0	0.0	0.0
CAO	0.0	0.0	14.7501	1.3391	1.3391
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	1.0000	1.0000	0.0	0.0	0.0
CAO	0.0	0.0	1.0000	1.0000	1.0000
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	526.0613	526.0613	526.0613	47.7590	47.7590
TONS/HR	26.3260	26.3260	14.7501	1.3391	1.3391
CUFT/HR	311.2886	312.8851	143.2989	13.0095	13.0095
STATE VARIABLES:					
TEMP F	210.0000	635.0000	1300.0000	798.9216	1249.2310
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959
VFRAC	0.0	0.0	0.0	0.0	0.0
LFRAC	0.0	0.0	0.0	0.0	0.0
SFRAC	1.0000	1.0000	1.0000	1.0000	1.0000

CACO3 CACO3-2 CAO KLN-DUST TG (CONTINUED)

STREAM ID	CACO3	CACO3-2	CAO	KLN-DUST	TG
ENTHALPY:					
BTU/LBMOL	-5.1634+05	-5.0630+05	-2.5804+05	-2.6433+05	-2.5869+05
BTU/LB	-5158.9487	-5058.5993	-4601.5238	-4713.6739	-4613.0439
MMBTU/HR	-271.6290	-266.3454	-135.7456	-12.6242	-12.3546
ENTROPY:					
BTU/LBMOL-R	-58.3700	-46.8325	-10.8664	-15.0691	-11.2390
BTU/LB-R	-0.5832	-0.4679	-0.1938	-0.2687	-0.2004
DENSITY:					
LBMOL/CUFT	1.6899	1.6813	3.6711	3.6711	3.6711
LB/CUFT	169.1421	168.2790	205.8644	205.8644	205.8644
AVG MW	100.0872	100.0872	56.0774	56.0774	56.0774

TG-2 TG-3 TG-4 TG-5 TG-6

STREAM ID	TG-2	TG-3	TG-4	TG-5	TG-6
FROM :	DRYER	CYCLONE2	SPLT-TG	SPLT-TG	HEAT-DRY
TO :	CYCLONE2	SPLT-TG	HEAT-DRY	IPSTM	TG-MIX
CLASS:	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD
TOTAL STREAM:					
TONS/HR	67.8648	66.5257	54.8037	11.7220	54.8037
MMBTU/HR	-269.4451	-256.8205	-211.5679	-45.2526	-228.4597
SUBSTREAM: MIXED					
PHASE:	VAPOR	VAPOR	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	2305.3916	2305.3916	1899.1743	406.2173	1899.1743
CO2	1063.7121	1063.7121	876.2826	187.4294	876.2826
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.2378	0.2378	0.1959	4.1909-02	0.1959
O2	82.1471	82.1471	67.6726	14.4746	67.6726
AR	27.7722	27.7722	22.8787	4.8936	22.8787
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	509.7279	509.7279	419.9122	89.8157	419.9122
H2	1.2904-02	1.2904-02	1.0631-02	2.2738-03	1.0631-02
H2O-MUD	484.4776	484.4776	399.1111	85.3665	399.1111
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.5153	0.5153	0.5153	0.5153	0.5153
CO2	0.2378	0.2378	0.2378	0.2378	0.2378
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	5.3168-05	5.3168-05	5.3168-05	5.3168-05	5.3168-05
O2	1.8363-02	1.8363-02	1.8363-02	1.8363-02	1.8363-02
AR	6.2082-03	6.2082-03	6.2082-03	6.2082-03	6.2082-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.1139	0.1139	0.1139	0.1139	0.1139
H2	2.8846-06	2.8846-06	2.8846-06	2.8846-06	2.8846-06
H2O-MUD	0.1083	0.1083	0.1083	0.1083	0.1083
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	32.2910	32.2910	26.6012	5.6898	26.6012
CO2	23.4069	23.4069	19.2825	4.1244	19.2825
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	3.3311-03	3.3311-03	2.7441-03	5.8695-04	2.7441-03
O2	1.3143	1.3143	1.0827	0.2316	1.0827
AR	0.5547	0.5547	0.4570	9.7744-02	0.4570
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	4.5914	4.5914	3.7824	0.8090	3.7824
H2	1.3007-05	1.3007-05	1.0715-05	2.2918-06	1.0715-05
H2O-MUD	4.3640	4.3640	3.5950	0.7690	3.5950

TG-2 TG-3 TG-4 TG-5 TG-6 (CONTINUED)

STREAM ID	TG-2	TG-3	TG-4	TG-5	TG-6
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.4854	0.4854	0.4854	0.4854	0.4854
CO2	0.3518	0.3518	0.3518	0.3518	0.3518
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	5.0072-05	5.0072-05	5.0072-05	5.0072-05	5.0072-05
O2	1.9756-02	1.9756-02	1.9756-02	1.9756-02	1.9756-02
AR	8.3385-03	8.3385-03	8.3385-03	8.3385-03	8.3385-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	6.9018-02	6.9018-02	6.9018-02	6.9018-02	6.9018-02
H2	1.9552-07	1.9552-07	1.9552-07	1.9552-07	1.9552-07
H2O-MUD	6.5599-02	6.5599-02	6.5599-02	6.5599-02	6.5599-02
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	4473.4794	4473.4794	3685.2381	788.2413	3685.2381
TONS/HR	66.5257	66.5257	54.8037	11.7220	54.8037
CUFT/HR	4.1119+06	4.4121+06	3.6346+06	7.7742+05	2.3972+06
STATE VARIABLES:					
TEMP F	798.9216	798.9216	798.9216	798.9216	250.0000
PRES PSI	14.6959	13.6959	13.6959	13.6959	11.6959
VFRAC	1.0000	1.0000	1.0000	1.0000	1.0000
LFRAC	0.0	0.0	0.0	0.0	0.0
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-5.7410+04	-5.7410+04	-5.7410+04	-5.7410+04	-6.1993+04
BTU/LB	-1930.2385	-1930.2344	-1930.2344	-1930.2344	-2084.3468
MMBTU/HR	-256.8210	-256.8205	-211.5679	-45.2526	-228.4597
ENTROPY:					
BTU/LBMOL-R	7.2772	7.4172	7.4172	7.4172	2.9683
BTU/LB-R	0.2447	0.2494	0.2494	0.2494	9.9801-02
DENSITY:					
LBMOL/CUFT	1.0879-03	1.0139-03	1.0139-03	1.0139-03	1.5373-03
LB/CUFT	3.2358-02	3.0156-02	3.0156-02	3.0156-02	4.5724-02
AVG MW	29.7423	29.7423	29.7423	29.7423	29.7423

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	28.0135	28.0135	28.0135	28.0135	28.0135
CO2	44.0098	44.0098	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	28.0104	28.0104	28.0104	28.0104	28.0104
O2	31.9988	31.9988	31.9988	31.9988	31.9988
AR	39.9480	39.9480	39.9480	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

TG-2 TG-3 TG-4 TG-5 TG-6 (CONTINUED)

STREAM ID	TG-2	TG-3	TG-4	TG-5	TG-6
H2O	18.0153	18.0153	18.0153	18.0153	18.0153
H2	2.0159	2.0159	2.0159	2.0159	2.0159
H2O-MUD	18.0153	18.0153	18.0153	18.0153	18.0153
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	29.7423	29.7423	29.7423	29.7423	29.7423
QVALGRS BTU/LB	141.5743	141.5743	141.5743	141.5743	141.5743
QVALNET BTU/LB	0.2276	0.2276	0.2276	0.2276	0.2276
*** VAPOR PHASE ***					
MUMX LB/FT-HR	7.3961-02	7.3959-02	7.3959-02	7.3959-02	4.5910-02
PR	0.6571	0.6571	0.6571	0.6571	0.5648
KMX BTU/HR-FT-R	3.3131-02	3.3127-02	3.3127-02	3.3127-02	2.1718-02
* 68.0000 F *					
VVSTD CUM/SEC					
N2	6.9873	6.9873	5.7561	1.2312	5.7561
CO2	3.2239	3.2239	2.6559	0.5681	2.6559
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	7.2087-04	7.2087-04	5.9385-04	1.2702-04	5.9385-04
O2	0.2490	0.2490	0.2051	4.3870-02	0.2051
AR	8.4173-02	8.4173-02	6.9342-02	1.4832-02	6.9342-02
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	1.5449	1.5449	1.2727	0.2722	1.2727
H2	3.9111-05	3.9111-05	3.2220-05	6.8915-06	3.2220-05
H2O-MUD	1.4684	1.4684	1.2096	0.2587	1.2096
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	2.8729+04	2.8729+04	2.3667+04	5062.0837	2.3667+04

SUBSTREAM: CISOLID STRUCTURE: CONVENTIONAL

COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	47.7590	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0

TG-2 TG-3 TG-4 TG-5 TG-6 (CONTINUED)

STREAM ID	TG-2	TG-3	TG-4	TG-5	TG-6
CAO	1.0000	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	1.3391	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	MISSING	MISSING	MISSING	MISSING
CO2	0.0	MISSING	MISSING	MISSING	MISSING
CACO3	0.0	MISSING	MISSING	MISSING	MISSING
CAO	1.0000	MISSING	MISSING	MISSING	MISSING
CO	0.0	MISSING	MISSING	MISSING	MISSING
O2	0.0	MISSING	MISSING	MISSING	MISSING
AR	0.0	MISSING	MISSING	MISSING	MISSING
NO2	0.0	MISSING	MISSING	MISSING	MISSING
NO	0.0	MISSING	MISSING	MISSING	MISSING
H2O	0.0	MISSING	MISSING	MISSING	MISSING
H2	0.0	MISSING	MISSING	MISSING	MISSING
H2O-MUD	0.0	MISSING	MISSING	MISSING	MISSING
CH4	0.0	MISSING	MISSING	MISSING	MISSING
C	0.0	MISSING	MISSING	MISSING	MISSING
TOTAL FLOW:					
LBMOL/HR	47.7590	0.0	0.0	0.0	0.0
TONS/HR	1.3391	0.0	0.0	0.0	0.0
CUFT/HR	13.0095	0.0	0.0	0.0	0.0
STATE VARIABLES:					
TEMP F	798.9216	MISSING	MISSING	MISSING	MISSING
PRES PSI	14.6959	13.6959	13.6959	13.6959	11.6959
VFRAC	0.0	MISSING	MISSING	MISSING	MISSING
LFRAC	0.0	MISSING	MISSING	MISSING	MISSING
SFRAC	1.0000	MISSING	MISSING	MISSING	MISSING

TG-2 TG-3 TG-4 TG-5 TG-6 (CONTINUED)

STREAM ID	TG-2	TG-3	TG-4	TG-5	TG-6
ENTHALPY:					
BTU/LBMOL	-2.6433+05	MISSING	MISSING	MISSING	MISSING
BTU/LB	-4713.6739	MISSING	MISSING	MISSING	MISSING
MMBTU/HR	-12.6242	MISSING	MISSING	MISSING	MISSING
ENTROPY:					

BTU/LBMOL-R	-15.0691	MISSING	MISSING	MISSING	MISSING
BTU/LB-R	-0.2687	MISSING	MISSING	MISSING	MISSING
DENSITY:					
LBMOL/CUFT	3.6711	MISSING	MISSING	MISSING	MISSING
LB/CUFT	205.8644	MISSING	MISSING	MISSING	MISSING
AVG MW	56.0774	MISSING	MISSING	MISSING	MISSING

TG-7 TG-8 TG-9

STREAM ID	TG-7	TG-8	TG-9
FROM :	IPSTM	TG-MIX	TG-BLWR
TO :	TG-MIX	TG-BLWR	----
CLASS:	MIXCISLD	MIXCISLD	MIXCISLD
TOTAL STREAM:			
TONS/HR	11.7220	66.5257	66.5257
MMBTU/HR	-48.8656	-277.3253	-275.2700
SUBSTREAM: MIXED			
PHASE:	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR			
N2	406.2173	2305.3916	2305.3916
CO2	187.4294	1063.7121	1063.7121
CACO3	0.0	0.0	0.0
CAO	0.0	0.0	0.0
CO	4.1909-02	0.2378	0.2378
O2	14.4746	82.1471	82.1471
AR	4.8936	27.7722	27.7722
NO2	0.0	0.0	0.0
NO	0.0	0.0	0.0
H2O	89.8157	509.7279	509.7279
H2	2.2738-03	1.2904-02	1.2904-02
H2O-MUD	85.3665	484.4776	484.4776
CH4	0.0	0.0	0.0
C	0.0	0.0	0.0
COMPONENTS: MOLE FRAC			
N2	0.5153	0.5153	0.5153
CO2	0.2378	0.2378	0.2378
CACO3	0.0	0.0	0.0
CAO	0.0	0.0	0.0
CO	5.3168-05	5.3168-05	5.3168-05
O2	1.8363-02	1.8363-02	1.8363-02
AR	6.2082-03	6.2082-03	6.2082-03
NO2	0.0	0.0	0.0
NO	0.0	0.0	0.0
H2O	0.1139	0.1139	0.1139
H2	2.8846-06	2.8846-06	2.8846-06
H2O-MUD	0.1083	0.1083	0.1083
CH4	0.0	0.0	0.0
C	0.0	0.0	0.0
COMPONENTS: TONS/HR			
N2	5.6898	32.2910	32.2910
CO2	4.1244	23.4069	23.4069
CACO3	0.0	0.0	0.0
CAO	0.0	0.0	0.0
CO	5.8695-04	3.3311-03	3.3311-03
O2	0.2316	1.3143	1.3143
AR	9.7744-02	0.5547	0.5547
NO2	0.0	0.0	0.0
NO	0.0	0.0	0.0
H2O	0.8090	4.5914	4.5914
H2	2.2918-06	1.3007-05	1.3007-05
H2O-MUD	0.7690	4.3640	4.3640

TG-7 TG-8 TG-9 (CONTINUED)

STREAM ID	TG-7	TG-8	TG-9
CH4	0.0	0.0	0.0
C	0.0	0.0	0.0
COMPONENTS: MASS FRAC			
N2	0.4854	0.4854	0.4854
CO2	0.3518	0.3518	0.3518
CACO3	0.0	0.0	0.0
CAO	0.0	0.0	0.0
CO	5.0072-05	5.0072-05	5.0072-05
O2	1.9756-02	1.9756-02	1.9756-02
AR	8.3385-03	8.3385-03	8.3385-03
NO2	0.0	0.0	0.0
NO	0.0	0.0	0.0
H2O	6.9018-02	6.9018-02	6.9018-02
H2	1.9552-07	1.9552-07	1.9552-07
H2O-MUD	6.5599-02	6.5599-02	6.5599-02
CH4	0.0	0.0	0.0
C	0.0	0.0	0.0
TOTAL FLOW:			
LBMOL/HR	788.2413	4473.4794	4473.4794
TONS/HR	11.7220	66.5257	66.5257
CUFT/HR	5.1273+05	2.9099+06	2.5043+06
STATE VARIABLES:			
TEMP F	250.0000	250.0001	307.6674
PRES PSI	11.6959	11.6959	14.6959
VFRAC	1.0000	1.0000	1.0000
LFRAC	0.0	0.0	0.0
SFRAC	0.0	0.0	0.0
ENTHALPY:			
BTU/LBMOL	-6.1993+04	-6.1993+04	-6.1534+04
BTU/LB	-2084.3468	-2084.3467	-2068.8989
MMBTU/HR	-48.8656	-277.3253	-275.2700
ENTROPY:			
BTU/LBMOL-R	2.9683	2.9683	3.1377
BTU/LB-R	9.9801-02	9.9801-02	0.1055
DENSITY:			
LBMOL/CUFT	1.5373-03	1.5373-03	1.7863-03
LB/CUFT	4.5724-02	4.5724-02	5.3129-02
AVG MW	29.7423	29.7423	29.7423

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS			
N2	28.0135	28.0135	28.0135
CO2	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING
CO	28.0104	28.0104	28.0104
O2	31.9988	31.9988	31.9988
AR	39.9480	39.9480	39.9480
NO2	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING

TG-7 TG-8 TG-9 (CONTINUED)

STREAM ID	TG-7	TG-8	TG-9
H2O	18.0153	18.0153	18.0153
H2	2.0159	2.0159	2.0159
H2O-MUD	18.0153	18.0153	18.0153
CH4	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING
MWMX	29.7423	29.7423	29.7423
QVALGRS BTU/LB	141.5743	141.5743	141.5743
QVALNET BTU/LB	0.2276	0.2276	0.2276
*** VAPOR PHASE ***			
MUMX LB/FT-HR	4.5910-02	4.5910-02	4.9654-02
PR	0.5648	0.5648	0.5635
KMX BTU/HR-FT-R	2.1718-02	2.1718-02	2.3810-02
* 68.0000 F *			
VVSTD CUM/SEC			
N2	1.2312	6.9873	6.9873
CO2	0.5681	3.2239	3.2239
CACO3	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING
CO	1.2702-04	7.2087-04	7.2087-04
O2	4.3870-02	0.2490	0.2490
AR	1.4832-02	8.4173-02	8.4173-02
NO2	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING
H2O	0.2722	1.5449	1.5449
H2	6.8915-06	3.9111-05	3.9111-05
H2O-MUD	0.2587	1.4684	1.4684
CH4	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING
* 68.0000 F *			
VVSTDMX CUFT/MIN	5062.0837	2.8729+04	2.8729+04

AIR AIR-2 AIR-CRK AIR-CRK2 ASH

STREAM ID	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH
FROM :	----	AIR-BLWR	----	AIRBLWR2	$C-13
TO :	AIR-BLWR	$C-10	AIRBLWR2	HEAT-CRK	----
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	6.2820	6.2820	2.9576	2.9576	0.4788
MMBTU/HR	-9.5798-02	0.2665	-4.5103-02	0.1179	0.5524
SUBSTREAM: MIXED					
PHASE:	VAPOR	VAPOR	VAPOR	VAPOR	MISSING
COMPONENTS: LBMOL/HR					
N2	338.2609	338.2609	159.2580	159.2580	0.0
CO2	0.1301	0.1301	6.1230-02	6.1230-02	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	90.9919	90.9919	42.8403	42.8403	0.0
AR	4.0749	4.0749	1.9185	1.9185	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.4335	0.4335	0.2041	0.2041	0.0
H2	4.3350-02	4.3350-02	2.0410-02	2.0410-02	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.7795	0.7795	0.7795	0.7795	0.0
CO2	2.9970-04	2.9970-04	2.9970-04	2.9970-04	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.2097	0.2097	0.2097	0.2097	0.0
AR	9.3906-03	9.3906-03	9.3906-03	9.3906-03	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	9.9900-04	9.9900-04	9.9900-04	9.9900-04	0.0
H2	9.9900-05	9.9900-05	9.9900-05	9.9900-05	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	4.7379	4.7379	2.2307	2.2307	0.0
CO2	2.8617-03	2.8617-03	1.3473-03	1.3473-03	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	1.4558	1.4558	0.6854	0.6854	0.0
AR	8.1392-02	8.1392-02	3.8321-02	3.8321-02	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	3.9048-03	3.9048-03	1.8384-03	1.8384-03	0.0
H2	4.3694-05	4.3694-05	2.0572-05	2.0572-05	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0

AIR AIR-2 AIR-CRK AIR-CRK2 ASH (CONTINUED)

STREAM ID	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.7542	0.7542	0.7542	0.7542	MISSING
CO2	4.5555-04	4.5555-04	4.5555-04	4.5555-04	MISSING
CACO3	0.0	0.0	0.0	0.0	MISSING
CAO	0.0	0.0	0.0	0.0	MISSING
CO	0.0	0.0	0.0	0.0	MISSING
O2	0.2317	0.2317	0.2317	0.2317	MISSING
AR	1.2957-02	1.2957-02	1.2957-02	1.2957-02	MISSING
NO2	0.0	0.0	0.0	0.0	MISSING
NO	0.0	0.0	0.0	0.0	MISSING
H2O	6.2159-04	6.2159-04	6.2159-04	6.2159-04	MISSING
H2	6.9555-06	6.9555-06	6.9555-06	6.9555-06	MISSING
H2O-MUD	0.0	0.0	0.0	0.0	MISSING
CH4	0.0	0.0	0.0	0.0	MISSING
C	0.0	0.0	0.0	0.0	MISSING
TOTAL FLOW:					
LBMOL/HR	433.9346	433.9346	204.3025	204.3025	0.0
TONS/HR	6.2820	6.2820	2.9576	2.9576	0.0
CUFT/HR	1.6713+05	1.2064+05	7.8685+04	5.7578+04	0.0
STATE VARIABLES:					
TEMP F	68.0000	187.9075	68.0000	182.6067	MISSING
PRES PSI	14.6959	25.0000	14.6959	24.4581	24.4581
VFRAC	1.0000	1.0000	1.0000	1.0000	MISSING
LFRAC	0.0	0.0	0.0	0.0	MISSING
SFRAC	0.0	0.0	0.0	0.0	MISSING
ENTHALPY:					
BTU/LBMOL	-220.7649	614.0381	-220.7649	577.0357	MISSING
BTU/LB	-7.6248	21.2078	-7.6248	19.9298	MISSING
MMBTU/HR	-9.5798-02	0.2665	-4.5103-02	0.1179	MISSING
ENTROPY:					
BTU/LBMOL-R	1.0096	1.3802	1.0096	1.3663	MISSING

BTU/LB-R	3.4868-02	4.7668-02	3.4868-02	4.7190-02	MISSING
DENSITY:					
LBMOL/CUFT	2.5964-03	3.5971-03	2.5964-03	3.5482-03	MISSING
LB/CUFT	7.5176-02	0.1041	7.5176-02	0.1027	MISSING
AVG MW	28.9534	28.9534	28.9534	28.9534	MISSING

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***					
MW UNITLESS					
N2	28.0135	28.0135	28.0135	28.0135	MISSING
CO2	44.0098	44.0098	44.0098	44.0098	MISSING
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	31.9988	31.9988	31.9988	31.9988	MISSING
AR	39.9480	39.9480	39.9480	39.9480	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

AIR AIR-2 AIR-CRK AIR-CRK2 ASH (CONTINUED)

STREAM ID	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH
H2O	18.0153	18.0153	18.0153	18.0153	MISSING
H2	2.0159	2.0159	2.0159	2.0159	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	28.9534	28.9534	28.9534	28.9534	MISSING
QVALGRS BTU/LB	1.0766	1.0766	1.0766	1.0766	MISSING
QVALNET BTU/LB	0.3587	0.3587	0.3587	0.3587	MISSING
*** VAPOR PHASE ***					
MUMX LB/FT-HR	4.5004-02	5.2368-02	4.5004-02	5.2059-02	MISSING
PR	0.6983	0.6992	0.6983	0.6992	MISSING
KMX BTU/HR-FT-R	1.5501-02	1.8099-02	1.5501-02	1.7988-02	MISSING
* 68.0000 F *					
VVSTD CUM/SEC					
N2	1.0252	1.0252	0.4827	0.4827	MISSING
CO2	3.9416-04	3.9416-04	1.8558-04	1.8558-04	MISSING
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	0.2758	0.2758	0.1298	0.1298	MISSING
AR	1.2350-02	1.2350-02	5.8148-03	5.8148-03	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	1.3139-03	1.3139-03	6.1859-04	6.1859-04	MISSING
H2	1.3139-04	1.3139-04	6.1859-05	6.1859-05	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	2786.7270	2786.7270	1312.0302	1312.0302	MISSING

SUBSTREAM: NC STRUCTURE: NON CONVENTIONAL

COMPONENTS: TONS/HR					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	0.0	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	0.0	0.0	0.0	0.4788
COMPONENTS: MASS FRAC					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	0.0	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	0.0	0.0	0.0	1.0000
TOTAL FLOW:					
TONS/HR	0.0	0.0	0.0	0.0	0.4788
STATE VARIABLES:					
TEMP F	MISSING	MISSING	MISSING	MISSING	1999.8616
PRES PSI	14.6959	25.0000	14.6959	24.4581	24.4581
VFRAC	MISSING	MISSING	MISSING	MISSING	0.0
LFRAC	MISSING	MISSING	MISSING	MISSING	0.0
SFRAC	MISSING	MISSING	MISSING	MISSING	1.0000

AIR AIR-2 AIR-CRK AIR-CRK2 ASH (CONTINUED)

STREAM ID	AIR	AIR-2	AIR-CRK	AIR-CRK2	ASH
ENTHALPY:					
BTU/LB	MISSING	MISSING	MISSING	MISSING	576.8585
MMBTU/HR	MISSING	MISSING	MISSING	MISSING	0.5524
DENSITY:					
LB/CUFT	MISSING	MISSING	MISSING	MISSING	187.2839
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
ULTANAL					
SULFANAL					
FUEL PROXANAL					
ULTANAL					
SULFANAL					
TAR PROXANAL					
ULTANAL					
SULFANAL					
ASH GENANAL					
ELEM1	MISSING	MISSING	MISSING	MISSING	100.0000
ELEM2	MISSING	MISSING	MISSING	MISSING	0.0
ELEM3	MISSING	MISSING	MISSING	MISSING	0.0
ELEM4	MISSING	MISSING	MISSING	MISSING	0.0
ELEM5	MISSING	MISSING	MISSING	MISSING	0.0
ELEM6	MISSING	MISSING	MISSING	MISSING	0.0
ELEM7	MISSING	MISSING	MISSING	MISSING	0.0
ELEM8	MISSING	MISSING	MISSING	MISSING	0.0
ELEM9	MISSING	MISSING	MISSING	MISSING	0.0
ELEM10	MISSING	MISSING	MISSING	MISSING	0.0
ELEM11	MISSING	MISSING	MISSING	MISSING	0.0
ELEM12	MISSING	MISSING	MISSING	MISSING	0.0
ELEM13	MISSING	MISSING	MISSING	MISSING	0.0
ELEM14	MISSING	MISSING	MISSING	MISSING	0.0
ELEM15	MISSING	MISSING	MISSING	MISSING	0.0
ELEM16	MISSING	MISSING	MISSING	MISSING	0.0
ELEM17	MISSING	MISSING	MISSING	MISSING	0.0
ELEM18	MISSING	MISSING	MISSING	MISSING	0.0
ELEM19	MISSING	MISSING	MISSING	MISSING	0.0
ELEM20	MISSING	MISSING	MISSING	MISSING	0.0

BIOMASS BIOMASS2 DRTY-H2O DRTY-STM DRY-BIOM

STREAM ID	BIOMASS	BIOMASS2	DRTY-H2O	DRTY-STM	DRY-BIOM
FROM :	----	FUEL-DUP	LPSTM	$C-17	$C-19
TO :	FUEL-DUP	$C-18	----	LPSTM	$C-11
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	15.1748	15.1748	6.2606	6.2606	8.4304
MMBTU/HR	-132.8114	-132.8114	-84.5868	-71.0598	-40.4698
SUBSTREAM: MIXED					
PHASE:	MISSING	MISSING	LIQUID	VAPOR	MISSING
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	695.0322	695.0322	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	1.0000	1.0000	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	6.2606	6.2606	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0

BIOMASS BIOMASS2 DRTY-H2O DRTY-STM DRY-B (CONTINUED)

STREAM ID	BIOMASS	BIOMASS2	DRTY-H2O	DRTY-STM	DRY-BIOM
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	MISSING	MISSING	0.0	0.0	MISSING
CO2	MISSING	MISSING	0.0	0.0	MISSING
CACO3	MISSING	MISSING	0.0	0.0	MISSING
CAO	MISSING	MISSING	0.0	0.0	MISSING
CO	MISSING	MISSING	0.0	0.0	MISSING
O2	MISSING	MISSING	0.0	0.0	MISSING
AR	MISSING	MISSING	0.0	0.0	MISSING
NO2	MISSING	MISSING	0.0	0.0	MISSING
NO	MISSING	MISSING	0.0	0.0	MISSING
H2O	MISSING	MISSING	1.0000	1.0000	MISSING
H2	MISSING	MISSING	0.0	0.0	MISSING
H2O-MUD	MISSING	MISSING	0.0	0.0	MISSING
CH4	MISSING	MISSING	0.0	0.0	MISSING
C	MISSING	MISSING	0.0	0.0	MISSING
TOTAL FLOW:					
LBMOL/HR	0.0	0.0	695.0322	695.0322	0.0
TONS/HR	0.0	0.0	6.2606	6.2606	0.0
CUFT/HR	0.0	0.0	246.1437	9.5177+04	0.0
STATE VARIABLES:					
TEMP F	MISSING	MISSING	176.0000	302.0000	MISSING
PRES PSI	14.6959	14.6959	57.2073	58.2073	14.6959
VFRAC	MISSING	MISSING	0.0	1.0000	MISSING
LFRAC	MISSING	MISSING	1.0000	0.0	MISSING
SFRAC	MISSING	MISSING	0.0	0.0	MISSING
ENTHALPY:					
BTU/LBMOL	MISSING	MISSING	-1.2170+05	-1.0224+05	MISSING
BTU/LB	MISSING	MISSING	-6755.4868	-5675.1574	MISSING
MMBTU/HR	MISSING	MISSING	-84.5868	-71.0598	MISSING
ENTROPY:					
BTU/LBMOL-R	MISSING	MISSING	-36.7307	-10.5759	MISSING
BTU/LB-R	MISSING	MISSING	-2.0389	-0.5871	MISSING
DENSITY:					
LBMOL/CUFT	MISSING	MISSING	2.8237	7.3026-03	MISSING
LB/CUFT	MISSING	MISSING	50.8695	0.1316	MISSING
AVG MW	MISSING	MISSING	18.0153	18.0153	MISSING

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***					
MW UNITLESS					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	MISSING	MISSING	MISSING	MISSING	MISSING
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	MISSING	MISSING	MISSING	MISSING	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

BIOMASS BIOMASS2 DRTY-H2O DRTY-STM DRY-B (CONTINUED)

STREAM ID	BIOMASS	BIOMASS2	DRTY-H2O	DRTY-STM	DRY-BIOM
H2O	MISSING	MISSING	18.0153	18.0153	MISSING
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	MISSING	MISSING	18.0153	18.0153	MISSING
QVALGRS BTU/LB	MISSING	MISSING	1049.9837	1049.9837	MISSING
QVALNET BTU/LB	MISSING	MISSING	0.0	0.0	MISSING
*** VAPOR PHASE ***					
MUMX LB/FT-HR	MISSING	MISSING	MISSING	2.5563-02	MISSING
PR	MISSING	MISSING	MISSING	0.6008	MISSING
KMX BTU/HR-FT-R	MISSING	MISSING	MISSING	1.9927-02	MISSING
* 68.0000 F *					

VVSTD CUM/SEC					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	MISSING	MISSING	MISSING	MISSING	MISSING
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	MISSING	MISSING	MISSING	MISSING	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	MISSING	MISSING	MISSING	2.1065	MISSING
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	MISSING	MISSING	MISSING	4463.4953	MISSING
SUBSTREAM: NC	STRUCTURE: NON CONVENTIONAL				
COMPONENTS: TONS/HR					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	15.1748	15.1748	0.0	0.0	8.4304
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	1.0000	1.0000	0.0	0.0	1.0000
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
TONS/HR	15.1748	15.1748	0.0	0.0	8.4304
STATE VARIABLES:					
TEMP F	68.0000	68.0000	MISSING	MISSING	212.0000
PRES PSI	14.6959	14.6959	57.2073	58.2073	14.6959
VFRAC	0.0	0.0	MISSING	MISSING	0.0
LFRAC	0.0	0.0	MISSING	MISSING	0.0
SFRAC	1.0000	1.0000	MISSING	MISSING	1.0000

BIOMASS BIOMASS2 DRTY-H2O DRTY-STM DRY-B (CONTINUED)

STREAM ID	BIOMASS	BIOMASS2	DRTY-H2O	DRTY-STM	DRY-BIOM
ENTHALPY:					
BTU/LB	-4376.0584	-4376.0584	MISSING	MISSING	-2400.2212
MMBTU/HR	-132.8114	-132.8114	MISSING	MISSING	-40.4698
DENSITY:					
LB/CUFT	82.7971	82.7971	MISSING	MISSING	82.7971
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
ULTANAL					
SULFANAL					
FUEL PROXANAL					
MOISTURE	50.0000	50.0000	MISSING	MISSING	10.0000
FC	0.0	0.0	MISSING	MISSING	0.0
VM	0.0	0.0	MISSING	MISSING	0.0
ASH	6.3100	6.3100	MISSING	MISSING	6.3100
ULTANAL					
ASH	6.3100	6.3100	MISSING	MISSING	6.3100
CARBON	44.7400	44.7400	MISSING	MISSING	44.7400
HYDROGEN	5.5000	5.5000	MISSING	MISSING	5.5000
NITROGEN	0.0	0.0	MISSING	MISSING	0.0
CHLORINE	0.0	0.0	MISSING	MISSING	0.0
SULFUR	0.0	0.0	MISSING	MISSING	0.0
OXYGEN	43.4500	43.4500	MISSING	MISSING	43.4500
SULFANAL					
PYRITIC	0.0	0.0	MISSING	MISSING	0.0
SULFATE	0.0	0.0	MISSING	MISSING	0.0
ORGANIC	0.0	0.0	MISSING	MISSING	0.0
TAR PROXANAL					
ULTANAL					
SULFANAL					
ASH GENANAL					

FUEL-HV SOLIDS STM-LK SYNGAS SYNGAS-2

STREAM ID	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
FROM :	FUEL-DUP	CYCLONE	$C-16	$C-9	HEAT-CRK
TO :	$C-15	----	----	HEAT-CRK	TAR-CNV
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	15.1748	0.1800	0.4837	14.2336	17.1913
MMBTU/HR	-132.8114	0.2989	-5.4906	-41.1577	-31.6186
SUBSTREAM: MIXED					
PHASE:	MISSING	MISSING	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	338.2609	497.5189
CO2	0.0	0.0	0.0	49.6074	49.6686
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	363.2938	363.2938
O2	0.0	0.0	0.0	0.0	42.8403
AR	0.0	0.0	0.0	4.0749	5.9934
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	53.7037	193.5367	193.7408
H2	0.0	0.0	0.0	160.3333	160.3537
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	50.2817	50.2817
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.2918	0.3648
CO2	0.0	0.0	0.0	4.2788-02	3.6422-02
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.3133	0.2664
O2	0.0	0.0	0.0	0.0	3.1415-02
AR	0.0	0.0	0.0	3.5147-03	4.3950-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	1.0000	0.1669	0.1421
H2	0.0	0.0	0.0	0.1383	0.1176
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	4.3369-02	3.6872-02
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	4.7379	6.9686
CO2	0.0	0.0	0.0	1.0916	1.0930
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	5.0880	5.0880
O2	0.0	0.0	0.0	0.0	0.6854
AR	0.0	0.0	0.0	8.1392-02	0.1197
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.4837	1.7433	1.7451
H2	0.0	0.0	0.0	0.1616	0.1616
H2O-MUD	0.0	0.0	0.0	0.0	0.0

FUEL-HV SOLIDS STM-LK SYNGAS SYNGAS-2 (CONTINUED)

STREAM ID	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
CH4	0.0	0.0	0.0	0.4033	0.4033
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	MISSING	MISSING	0.0	0.3560	0.4284
CO2	MISSING	MISSING	0.0	8.2031-02	6.7197-02
CACO3	MISSING	MISSING	0.0	0.0	0.0
CAO	MISSING	MISSING	0.0	0.0	0.0
CO	MISSING	MISSING	0.0	0.3824	0.3128
O2	MISSING	MISSING	0.0	0.0	4.2141-02
AR	MISSING	MISSING	0.0	6.1164-03	7.3602-03
NO2	MISSING	MISSING	0.0	0.0	0.0
NO	MISSING	MISSING	0.0	0.0	0.0
H2O	MISSING	MISSING	1.0000	0.1310	0.1073
H2	MISSING	MISSING	0.0	1.2144-02	9.9372-03
H2O-MUD	MISSING	MISSING	0.0	0.0	0.0
CH4	MISSING	MISSING	0.0	3.0309-02	2.4798-02
C	MISSING	MISSING	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	0.0	0.0	53.7037	1159.3887	1363.6912
TONS/HR	0.0	0.0	0.4837	13.3072	16.2648
CUFT/HR	0.0	0.0	7354.0988	7.1233+05	1.3765+06
STATE VARIABLES:					
TEMP F	MISSING	MISSING	302.0000	940.0563	1652.0000
PRES PSI	14.6959	16.4581	58.2073	24.4581	22.4581
VFRAC	MISSING	MISSING	1.0000	1.0000	1.0000
LFRAC	MISSING	MISSING	0.0	0.0	0.0
SFRAC	MISSING	MISSING	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	MISSING	MISSING	-1.0224+05	-3.4211+04	-2.2091+04
BTU/LB	MISSING	MISSING	-5675.1574	-1490.3197	-926.0732
MMBTU/HR	MISSING	MISSING	-5.4906	-39.6639	-30.1248
ENTROPY:					
BTU/LBMOL-R	MISSING	MISSING	-10.5759	13.5715	16.6339
BTU/LB-R	MISSING	MISSING	-0.5871	0.5912	0.6973
DENSITY:					
LBMOL/CUFT	MISSING	MISSING	7.3026-03	1.6276-03	9.9070-04
LB/CUFT	MISSING	MISSING	0.1316	3.7363-02	2.3632-02
AVG MW	MISSING	MISSING	18.0153	22.9555	23.8541
MIXED SUBSTREAM PROPERTIES:					
*** ALL PHASES ***					
MW UNITLESS					
N2	MISSING	MISSING	MISSING	28.0135	28.0135
CO2	MISSING	MISSING	MISSING	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	28.0104	28.0104
O2	MISSING	MISSING	MISSING	MISSING	31.9988
AR	MISSING	MISSING	MISSING	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

FUEL-HV SOLIDS STM-LK SYNGAS SYNGAS-2 (CONTINUED)

STREAM ID	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
H2O	MISSING	MISSING	18.0153	18.0153	18.0153
H2	MISSING	MISSING	MISSING	2.0159	2.0159
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	16.0428	16.0428
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	MISSING	MISSING	18.0153	22.9555	23.8541
QVALGRS BTU/LB	MISSING	MISSING	1049.9837	3262.0188	2669.0414
QVALNET BTU/LB	MISSING	MISSING	0.0	2939.0371	2404.6609
*** VAPOR PHASE ***					
MUMX LB/FT-HR	MISSING	MISSING	2.5563-02	7.2800-02	0.1072
PR	MISSING	MISSING	0.6008	0.5781	0.6050
KMX BTU/HR-FT-R	MISSING	MISSING	1.9927-02	4.5255-02	6.6196-02
* 68.0000 F *					
VVSTD CUM/SEC					
N2	MISSING	MISSING	MISSING	1.0252	1.5079
CO2	MISSING	MISSING	MISSING	0.1504	0.1505
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	1.1011	1.1011
O2	MISSING	MISSING	MISSING	MISSING	0.1298
AR	MISSING	MISSING	MISSING	1.2350-02	1.8165-02
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	MISSING	MISSING	0.1628	0.5866	0.5872
H2	MISSING	MISSING	MISSING	0.4859	0.4860
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	0.1524	0.1524
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	MISSING	MISSING	344.8850	7445.5914	8757.6216
SUBSTREAM: NC	STRUCTURE: NON CONVENTIONAL				
COMPONENTS: TONS/HR					
CHAR	0.0	0.1800	0.0	0.1800	0.1800
FUEL	15.1748	8.4304-08	0.0	8.4304-08	8.4304-08
TAR	0.0	0.0	0.0	0.7464	0.7464
ASH	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
CHAR	0.0	1.0000	0.0	0.1943	0.1943
FUEL	1.0000	4.6825-07	0.0	9.0998-08	9.0998-08
TAR	0.0	0.0	0.0	0.8057	0.8057
ASH	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
TONS/HR	15.1748	0.1800	0.0	0.9264	0.9264
STATE VARIABLES:					
TEMP F	68.0000	1000.1897	MISSING	940.0563	1652.0000
PRES PSI	14.6959	16.4581	58.2073	24.4581	22.4581
VFRAC	0.0	0.0	MISSING	0.0	0.0
LFRAC	0.0	0.0	MISSING	0.0	0.0
SFRAC	1.0000	1.0000	MISSING	1.0000	1.0000

FUEL-HV SOLIDS STM-LK SYNGAS SYNGAS-2 (CONTINUED)

STREAM ID	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
ENTHALPY:					
BTU/LB	-4376.0584	830.1277	MISSING	-806.2184	-806.2184

	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
MMBTU/HR	-132.8114	0.2989	MISSING	-1.4938	-1.4938
DENSITY:					
LB/CUFT	82.7971	122.4330	MISSING	81.4171	81.4171
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
MOISTURE	MISSING	0.0	MISSING	0.0	0.0
FC	MISSING	0.0	MISSING	0.0	0.0
VM	MISSING	0.0	MISSING	0.0	0.0
ASH	MISSING	0.0	MISSING	0.0	0.0
ULTANAL					
ASH	MISSING	0.0	MISSING	0.0	0.0
CARBON	MISSING	94.2164	MISSING	94.2164	94.2164
HYDROGEN	MISSING	0.6269	MISSING	0.6269	0.6269
NITROGEN	MISSING	0.0	MISSING	0.0	0.0
CHLORINE	MISSING	0.0	MISSING	0.0	0.0
SULFUR	MISSING	0.0	MISSING	0.0	0.0
OXYGEN	MISSING	5.1567	MISSING	5.1567	5.1567
SULFANAL					
PYRITIC	MISSING	0.0	MISSING	0.0	0.0
SULFATE	MISSING	0.0	MISSING	0.0	0.0
ORGANIC	MISSING	0.0	MISSING	0.0	0.0
FUEL PROXANAL					
MOISTURE	50.0000	0.0	MISSING	0.0	0.0
FC	0.0	0.0	MISSING	0.0	0.0
VM	0.0	0.0	MISSING	0.0	0.0
ASH	6.3100	6.3100	MISSING	6.3100	6.3100
ULTANAL					
ASH	6.3100	6.3100	MISSING	6.3100	6.3100
CARBON	44.7400	44.7400	MISSING	44.7400	44.7400
HYDROGEN	5.5000	5.5000	MISSING	5.5000	5.5000
NITROGEN	0.0	0.0	MISSING	0.0	0.0
CHLORINE	0.0	0.0	MISSING	0.0	0.0
SULFUR	0.0	0.0	MISSING	0.0	0.0
OXYGEN	43.4500	43.4500	MISSING	43.4500	43.4500
SULFANAL					
PYRITIC	0.0	0.0	MISSING	0.0	0.0
SULFATE	0.0	0.0	MISSING	0.0	0.0
ORGANIC	0.0	0.0	MISSING	0.0	0.0
TAR PROXANAL					
MOISTURE	MISSING	MISSING	MISSING	0.0	0.0
FC	MISSING	MISSING	MISSING	0.0	0.0
VM	MISSING	MISSING	MISSING	0.0	0.0
ASH	MISSING	MISSING	MISSING	0.0	0.0
ULTANAL					
ASH	MISSING	MISSING	MISSING	0.0	0.0
CARBON	MISSING	MISSING	MISSING	59.4990	59.4990
HYDROGEN	MISSING	MISSING	MISSING	7.0942	7.0942
NITROGEN	MISSING	MISSING	MISSING	0.0	0.0
CHLORINE	MISSING	MISSING	MISSING	0.0	0.0

FUEL-HV SOLIDS STM-LK SYNGAS SYNGAS-2 (CONTINUED)

STREAM ID	FUEL-HV	SOLIDS	STM-LK	SYNGAS	SYNGAS-2
SULFUR	MISSING	MISSING	MISSING	0.0	0.0
OXYGEN	MISSING	MISSING	MISSING	33.4068	33.4068
SULFANAL					
PYRITIC	MISSING	MISSING	MISSING	0.0	0.0
SULFATE	MISSING	MISSING	MISSING	0.0	0.0
ORGANIC	MISSING	MISSING	MISSING	0.0	0.0
ASH GENANAL					

SYNGAS-3 SYNGAS-4 SYNGAS-5 SYNGAS-6 SYNGAS-7

STREAM ID	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
FROM :	TAR-CNV	TAR-CRK	COOL-CRK	CYCLONE	TAR-CNV2
TO :	TAR-CRK	COOL-CRK	CYCLONE	TAR-CNV2	CL-CNG
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	17.1913	17.1913	17.1913	17.0112	17.0112
MMBTU/HR	-24.1701	-31.6186	-41.0398	-41.3388	-41.0818
SUBSTREAM: MIXED					
PHASE:	MIXED	VAPOR	VAPOR	VAPOR	MIXED
COMPONENTS: LBMOL/HR					
N2	497.5189	497.5189	497.5189	497.5189	497.5189
CO2	49.6686	105.0396	105.0396	105.0396	105.0396
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	363.2938	429.1590	429.1590	429.1590	429.1590
O2	57.8018	5.7318-14	5.7318-14	0.0	0.6234
AR	5.9934	5.9934	5.9934	5.9934	5.9934
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	193.7408	132.7372	132.7372	132.7372	132.7372
H2	210.7866	372.2797	372.2797	372.2797	374.3811
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	50.2817	3.6964-02	3.6964-02	3.6964-02	3.6964-02
C	70.9915	8.9912-22	8.9912-22	0.0	2.9580
COMPONENTS: MOLE FRAC					
N2	0.3317	0.3225	0.3225	0.3225	0.3213
CO2	3.3111-02	6.8085-02	6.8085-02	6.8085-02	6.7835-02
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.2422	0.2782	0.2782	0.2782	0.2772
O2	3.8533-02	3.7153-17	3.7153-17	0.0	4.0260-04
AR	3.9954-03	3.8849-03	3.8849-03	3.8849-03	3.8706-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.1292	8.6039-02	8.6039-02	8.6039-02	8.5723-02
H2	0.1405	0.2413	0.2413	0.2413	0.2418
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	3.3519-02	2.3960-05	2.3960-05	2.3960-05	2.3872-05
C	4.7325-02	5.8280-25	5.8280-25	0.0	1.9103-03
COMPONENTS: TONS/HR					
N2	6.9686	6.9686	6.9686	6.9686	6.9686
CO2	1.0930	2.3114	2.3114	2.3114	2.3114
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	5.0880	6.0105	6.0105	6.0105	6.0105
O2	0.9248	9.1705-16	9.1705-16	0.0	9.9740-03
AR	0.1197	0.1197	0.1197	0.1197	0.1197
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1.7451	1.1956	1.1956	1.1956	1.1956
H2	0.2125	0.3752	0.3752	0.3752	0.3774
H2O-MUD	0.0	0.0	0.0	0.0	0.0

SYNGAS-3 SYNGAS-4 SYNGAS-5 SYNGAS-6 SYNG (CONTINUED)

STREAM ID	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
CH4	0.4033	2.9650-04	2.9650-04	2.9650-04	2.9650-04
C	0.4263	5.3997-24	5.3997-24	0.0	1.7764-02
COMPONENTS: MASS FRAC					
N2	0.4104	0.4104	0.4104	0.4104	0.4096
CO2	6.4362-02	0.1361	0.1361	0.1361	0.1359
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.2996	0.3539	0.3539	0.3539	0.3533
O2	5.4459-02	5.4004-17	5.4004-17	0.0	5.8632-04
AR	7.0497-03	7.0497-03	7.0497-03	7.0497-03	7.0373-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.1028	7.0410-02	7.0410-02	7.0410-02	7.0286-02
H2	1.2511-02	2.2097-02	2.2097-02	2.2097-02	2.2183-02
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	2.3751-02	1.7461-05	1.7461-05	1.7461-05	1.7430-05
C	2.5106-02	3.1798-25	3.1798-25	0.0	1.0443-03
TOTAL FLOW:					
LBMOL/HR	1500.0772	1542.7648	1542.7648	1542.7648	1548.4476
TONS/HR	16.9814	16.9814	16.9814	16.9814	17.0112
CUFT/HR	1.4425+06	1.7823+06	1.3099+06	1.4690+06	1.4716+06
STATE VARIABLES:					
TEMP F	1652.0000	1742.0000	1000.1855	1000.1897	1000.1897
PRES PSI	22.4581	20.4581	18.4581	16.4581	16.4581
VFRAC	0.9527	1.0000	1.0000	1.0000	0.9981
LFRAC	4.7325-02	0.0	0.0	0.0	1.9103-03
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-1.6264+04	-2.0642+04	-2.6749+04	-2.6749+04	-2.6531+04
BTU/LB	-718.3559	-937.6708	-1215.0692	-1215.0693	-1207.4914
MMBTU/HR	-24.3973	-31.8458	-41.2670	-41.2670	-41.0818
ENTROPY:					
BTU/LBMOL-R	15.5901	18.1767	15.0073	15.2351	15.1824
BTU/LB-R	0.6886	0.8257	0.6817	0.6921	0.6910
DENSITY:					
LBMOL/CUFT	1.0399-03	8.6562-04	1.1778-03	1.0502-03	1.0522-03
LB/CUFT	2.3544-02	1.9056-02	2.5928-02	2.3120-02	2.3119-02
AVG MW	22.6406	22.0142	22.0142	22.0142	21.9720

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
N2	28.0135	28.0135	28.0135	28.0135	28.0135
CO2	44.0098	44.0098	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	28.0104	28.0104	28.0104	28.0104	28.0104
O2	31.9988	31.9988	31.9988	MISSING	31.9988
AR	39.9480	39.9480	39.9480	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

SYNGAS-3 SYNGAS-4 SYNGAS-5 SYNGAS-6 SYNG (CONTINUED)

STREAM ID	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
H2O	18.0153	18.0153	18.0153	18.0153	18.0153
H2	2.0159	2.0159	2.0159	2.0159	2.0159
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	16.0428	16.0428	16.0428	16.0428	16.0428
C	12.0110	12.0110	12.0110	MISSING	12.0110
MWMX	22.6406	22.0142	22.0142	22.0142	21.9720
QVALGRS BTU/LB	3092.5215	2958.7016	2958.7016	2958.7016	2975.8073
QVALNET BTU/LB	2811.2079	2677.3881	2677.3881	2677.3881	2693.8191
*** VAPOR PHASE ***					
MUMX LB/FT-HR	0.1065	0.1116	7.7600-02	7.7597-02	7.7574-02
PR	0.5840	0.5216	0.5138	0.5138	0.5132
KMX BTU/HR-FT-R	6.9691-02	8.2841-02	5.4286-02	5.4279-02	5.4372-02
* 68.0000 F *					
VVSTD CUM/SEC					
N2	1.5079	1.5079	1.5079	1.5079	1.5079
CO2	0.1505	0.3184	0.3184	0.3184	0.3184
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	1.1011	1.3007	1.3007	1.3007	1.3007
O2	0.1752	1.7372-16	1.7372-16	MISSING	1.8894-03
AR	1.8165-02	1.8165-02	1.8165-02	1.8165-02	1.8165-02
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	0.5872	0.4023	0.4023	0.4023	0.4023
H2	0.6389	1.1283	1.1283	1.1283	1.1347
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	0.1524	1.1203-04	1.1203-04	1.1203-04	1.1203-04
C	1.0342-15	2.7251-24	2.7251-24	MISSING	3.6019-27
* 68.0000 F *					
VVSTDMX CUFT/MIN	9177.5850	9907.6321	9907.6321	9907.6321	9925.1306

SUBSTREAM: NC STRUCTURE: NON CONVENTIONAL

	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
COMPONENTS: TONS/HR					
CHAR	0.1800	0.1800	0.1800	0.0	0.0
FUEL	8.4304-08	8.4304-08	8.4304-08	0.0	0.0
TAR	2.9856-02	2.9856-02	2.9856-02	2.9856-02	0.0
ASH	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
CHAR	0.8578	0.8578	0.8578	0.0	0.0
FUEL	4.0165-07	4.0165-07	4.0165-07	0.0	0.0
TAR	0.1422	0.1422	0.1422	1.0000	0.0
ASH	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
TONS/HR	0.2099	0.2099	0.2099	2.9856-02	0.0
STATE VARIABLES:					
TEMP F	1652.0000	1742.0000	1000.1855	1000.1897	MISSING
PRES PSI	22.4581	20.4581	18.4581	16.4581	16.4581
VFRAC	0.0	0.0	0.0	0.0	MISSING
LFRAC	0.0	0.0	0.0	0.0	MISSING
SFRAC	1.0000	1.0000	1.0000	1.0000	MISSING

SYNGAS-3 SYNGAS-4 SYNGAS-5 SYNGAS-6 SYNG (CONTINUED)

STREAM ID	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
ENTHALPY:					
BTU/LB	541.2263	541.2263	541.2263	-1200.9214	MISSING
MMBTU/HR	0.2272	0.2272	0.2272	-7.1710-02	MISSING
DENSITY:					
LB/CUFT	112.4329	112.4329	112.4329	75.3300	MISSING
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
MOISTURE	0.0	0.0	0.0	MISSING	MISSING
FC	0.0	0.0	0.0	MISSING	MISSING
VM	0.0	0.0	0.0	MISSING	MISSING
ASH	0.0	0.0	0.0	MISSING	MISSING
ULTANAL					

ASH	0.0	0.0	0.0	MISSING	MISSING
CARBON	94.2164	94.2164	94.2164	MISSING	MISSING
HYDROGEN	0.6269	0.6269	0.6269	MISSING	MISSING
NITROGEN	0.0	0.0	0.0	MISSING	MISSING
CHLORINE	0.0	0.0	0.0	MISSING	MISSING
SULFUR	0.0	0.0	0.0	MISSING	MISSING
OXYGEN	5.1567	5.1567	5.1567	MISSING	MISSING
SULFANAL					
PYRITIC	0.0	0.0	0.0	MISSING	MISSING
SULFATE	0.0	0.0	0.0	MISSING	MISSING
ORGANIC	0.0	0.0	0.0	MISSING	MISSING
FUEL PROXANAL					
MOISTURE	0.0	0.0	0.0	MISSING	MISSING
FC	0.0	0.0	0.0	MISSING	MISSING
VM	0.0	0.0	0.0	MISSING	MISSING
ASH	6.3100	6.3100	6.3100	MISSING	MISSING
ULTANAL					
ASH	6.3100	6.3100	6.3100	MISSING	MISSING
CARBON	44.7400	44.7400	44.7400	MISSING	MISSING
HYDROGEN	5.5000	5.5000	5.5000	MISSING	MISSING
NITROGEN	0.0	0.0	0.0	MISSING	MISSING
CHLORINE	0.0	0.0	0.0	MISSING	MISSING
SULFUR	0.0	0.0	0.0	MISSING	MISSING
OXYGEN	43.4500	43.4500	43.4500	MISSING	MISSING
SULFANAL					
PYRITIC	0.0	0.0	0.0	MISSING	MISSING
SULFATE	0.0	0.0	0.0	MISSING	MISSING
ORGANIC	0.0	0.0	0.0	MISSING	MISSING
TAR PROXANAL					
MOISTURE	0.0	0.0	0.0	0.0	MISSING
FC	0.0	0.0	0.0	0.0	MISSING
VM	0.0	0.0	0.0	0.0	MISSING
ASH	0.0	0.0	0.0	0.0	MISSING
ULTANAL					
ASH	0.0	0.0	0.0	0.0	MISSING
CARBON	59.4990	59.4990	59.4990	59.4990	MISSING
HYDROGEN	7.0942	7.0942	7.0942	7.0942	MISSING
NITROGEN	0.0	0.0	0.0	0.0	MISSING
CHLORINE	0.0	0.0	0.0	0.0	MISSING

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

SYNGAS-3 SYNGAS-4 SYNGAS-5 SYNGAS-6 SYNG (CONTINUED)

STREAM ID	SYNGAS-3	SYNGAS-4	SYNGAS-5	SYNGAS-6	SYNGAS-7
SULFUR	0.0	0.0	0.0	0.0	MISSING
OXYGEN	33.4068	33.4068	33.4068	33.4068	MISSING
SULFANAL					
PYRITIC	0.0	0.0	0.0	0.0	MISSING
SULFATE	0.0	0.0	0.0	0.0	MISSING
ORGANIC	0.0	0.0	0.0	0.0	MISSING
ASH GENANAL					

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

HEAT-DRY HT-CRK HT-CRK-2 TAR-HEAT

STREAM ID	HEAT-DRY	HT-CRK	HT-CRK-2	TAR-HEAT
FROM :	$C-14	TAR-CRK	HEAT-CRK	$C-12
TO :	HEAT-DRY	TAR-CNV	COOL-CRK	TAR-CNV2
CLASS:	HEAT	HEAT	HEAT	HEAT
STREAM ATTRIBUTES:				
HEAT				
Q MMBTU/HR	-16.8918	7.4485	-9.4212	0.2570
TBEG F	104.9298	MISSING	838.3765	2282.0000
TEND F	419.0000	MISSING	1652.0000	1250.0000

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

KILN-AIR NCG-AIR SYNGAS-8 SYNGAS-9 SYNGAS10

STREAM ID	KILN-AIR	NCG-AIR	SYNGAS-8	SYNGAS-9	SYNGAS10
FROM :	----	----	CL-CNG	PIPELOSS	NG-DUP
TO :	$C-8	$C-5	PIPELOSS	NG-DUP	$C-1
SUBSTREAM: MIXED					
PHASE:	VAPOR	VAPOR	MIXED	MIXED	MIXED
COMPONENTS: LBMOL/HR					
N2	1707.1798	100.6929	497.5189	497.5189	497.5189
CO2	0.6564	3.8713-02	105.0396	105.0396	105.0396
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	429.1590	429.1590	429.1590
O2	459.2298	27.0863	0.6234	0.6234	0.6234
AR	20.5658	1.2130	5.9934	5.9934	5.9934
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	2.1879	0.1290	132.7372	132.7372	132.7372
H2	0.2188	1.2904-02	374.3811	374.3811	374.3811
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	3.6964-02	3.6964-02	3.6964-02
C	0.0	0.0	2.9580	2.9580	2.9580
COMPONENTS: MOLE FRAC					
N2	0.7795	0.7795	0.3213	0.3213	0.3213
CO2	2.9970-04	2.9970-04	6.7835-02	6.7835-02	6.7835-02
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.2772	0.2772	0.2772
O2	0.2097	0.2097	4.0260-04	4.0260-04	4.0260-04
AR	9.3906-03	9.3906-03	3.8706-03	3.8706-03	3.8706-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	9.9900-04	9.9900-04	8.5723-02	8.5723-02	8.5723-02
H2	9.9900-05	9.9900-05	0.2418	0.2418	0.2418
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	2.3872-05	2.3872-05	2.3872-05
C	0.0	0.0	1.9103-03	1.9103-03	1.9103-03
COMPONENTS: TONS/HR					
N2	23.9120	1.4104	6.9686	6.9686	6.9686
CO2	1.4443-02	8.5188-04	2.3114	2.3114	2.3114
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	6.0105	6.0105	6.0105
O2	7.3474	0.4334	9.9740-03	9.9740-03	9.9740-03
AR	0.4108	2.4229-02	0.1197	0.1197	0.1197
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1.9707-02	1.1624-03	1.1956	1.1956	1.1956
H2	2.2052-04	1.3007-05	0.3774	0.3774	0.3774
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	2.9650-04	2.9650-04	2.9650-04
C	0.0	0.0	1.7764-02	1.7764-02	1.7764-02
COMPONENTS: MASS FRAC					
N2	0.7542	0.7542	0.4096	0.4096	0.4096

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

KILN-AIR NCG-AIR SYNGAS-8 SYNGAS-9 SYNGA (CONTINUED)

STREAM ID	KILN-AIR	NCG-AIR	SYNGAS-8	SYNGAS-9	SYNGAS10
CO2	4.5555-04	4.5555-04	0.1359	0.1359	0.1359
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.3533	0.3533	0.3533
O2	0.2317	0.2317	5.8632-04	5.8632-04	5.8632-04
AR	1.2957-02	1.2957-02	7.0373-03	7.0373-03	7.0373-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	6.2159-04	6.2159-04	7.0286-02	7.0286-02	7.0286-02
H2	6.9555-06	6.9555-06	2.2183-02	2.2183-02	2.2183-02
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	1.7430-05	1.7430-05	1.7430-05
C	0.0	0.0	1.0443-03	1.0443-03	1.0443-03
TOTAL FLOW:					
LBMOL/HR	2190.0385	129.1729	1548.4476	1548.4476	1548.4476
TONS/HR	31.7046	1.8700	17.0112	17.0112	17.0112
CUFT/HR	8.4348+05	4.9750+04	1.4716+06	1.1016+06	1.1016+06
STATE VARIABLES:					
TEMP F	68.0000	68.0000	1000.1897	600.0000	600.0000
PRES PSI	14.6959	14.6959	16.4581	15.9581	15.9581
VFRAC	1.0000	1.0000	0.9981	0.9981	0.9981
LFRAC	0.0	0.0	1.9103-03	1.9103-03	1.9103-03
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-220.7649	-220.7649	-2.6531+04	-2.9636+04	-2.9636+04
BTU/LB	-7.6248	-7.6248	-1207.4914	-1348.8004	-1348.8004
MMBTU/HR	-0.4835	-2.8517-02	-41.0818	-45.8895	-45.8895
ENTROPY:					
BTU/LBMOL-R	1.0096	1.0096	15.1824	12.7609	12.7609
BTU/LB-R	3.4868-02	3.4868-02	0.6910	0.5808	0.5808
DENSITY:					
LBMOL/CUFT	2.5964-03	2.5964-03	1.0522-03	1.4056-03	1.4056-03
LB/CUFT	7.5176-02	7.5176-02	2.3119-02	3.0884-02	3.0884-02
AVG MW	28.9534	28.9534	21.9720	21.9720	21.9720

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***					
MW UNITLESS					
N2	28.0135	28.0135	28.0135	28.0135	28.0135
CO2	44.0098	44.0098	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	28.0104	28.0104	28.0104
O2	31.9988	31.9988	31.9988	31.9988	31.9988
AR	39.9480	39.9480	39.9480	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	18.0153	18.0153	18.0153	18.0153	18.0153
H2	2.0159	2.0159	2.0159	2.0159	2.0159
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	16.0428	16.0428	16.0428

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

KILN-AIR NCG-AIR SYNGAS-8 SYNGAS-9 SYNGA (CONTINUED)

STREAM ID	KILN-AIR	NCG-AIR	SYNGAS-8	SYNGAS-9	SYNGAS10
C	MISSING	MISSING	12.0110	12.0110	12.0110
MWMX	28.9534	28.9534	21.9720	21.9720	21.9720
QVALGRS BTU/LB	1.0766	1.0766	2975.8073	2975.8073	2975.8073
QVALNET BTU/LB	0.3587	0.3587	2693.8191	2693.8191	2693.8191
*** VAPOR PHASE ***					
MUMX LB/FT-HR	4.5004-02	4.5004-02	7.7574-02	5.9717-02	5.9717-02
PR	0.6983	0.6983	0.5132	0.5068	0.5068
KMX BTU/HR-FT-R	1.5501-02	1.5501-02	5.4372-02	4.0454-02	4.0454-02
* 68.0000 F *					
VVSTD CUM/SEC					
N2	5.1742	0.3052	1.5079	1.5079	1.5079
CO2	1.9893-03	1.1733-04	0.3184	0.3184	0.3184
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	1.3007	1.3007	1.3007
O2	1.3919	8.2094-02	1.8894-03	1.8894-03	1.8894-03
AR	6.2332-02	3.6765-03	1.8165-02	1.8165-02	1.8165-02
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	6.6310-03	3.9111-04	0.4023	0.4023	0.4023
H2	6.6310-04	3.9111-05	1.1347	1.1347	1.1347
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	1.1203-04	1.1203-04	1.1203-04
C	MISSING	MISSING	3.6019-27	0.0	0.0
* 68.0000 F *					
VVSTDMX CUFT/MIN	1.4064+04	829.5480	9925.1306	9925.1306	9925.1306

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION

SYNGAS11

STREAM ID	SYNGAS11
FROM :	NG-DUP
TO :	$C-3
SUBSTREAM: MIXED	
PHASE:	MIXED
COMPONENTS: LBMOL/HR	
N2	497.5189
CO2	105.0396
CACO3	0.0
CAO	0.0
CO	429.1590
O2	0.6234
AR	5.9934
NO2	0.0
NO	0.0
H2O	132.7372
H2	374.3811
H2O-MUD	0.0
CH4	3.6964-02
C	2.9580
COMPONENTS: MOLE FRAC	
N2	0.3213
CO2	6.7835-02
CACO3	0.0
CAO	0.0
CO	0.2772
O2	4.0260-04
AR	3.8706-03
NO2	0.0
NO	0.0

```
  H2O                  8.5723-02
  H2                     0.2418
  H2O-MUD                0.0
  CH4                  2.3872-05
  C                    1.9103-03
COMPONENTS: TONS/HR
  N2                     6.9686
  CO2                    2.3114
  CACO3                  0.0
  CAO                    0.0
  CO                     6.0105
  O2                   9.9740-03
  AR                     0.1197
  NO2                    0.0
  NO                     0.0
  H2O                    1.1956
  H2                     0.3774
  H2O-MUD                0.0
  CH4                  2.9650-04
  C                    1.7764-02
COMPONENTS: MASS FRAC
  N2                     0.4096
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                 HOG FUEL GASIFICATION PROJECT CASE A
                             STREAM SECTION

SYNGAS11 (CONTINUED)

STREAM ID               SYNGAS11

  CO2                    0.1359
  CACO3                  0.0
  CAO                    0.0
  CO                     0.3533
  O2                   5.8632-04
  AR                   7.0373-03
  NO2                    0.0
  NO                     0.0
  H2O                  7.0286-02
  H2                   2.2183-02
  H2O-MUD                0.0
  CH4                  1.7430-05
  C                    1.0443-03
TOTAL FLOW:
  LBMOL/HR             1548.4476
  TONS/HR                17.0112
  CUFT/HR              1.1016+06
STATE VARIABLES:
  TEMP   F              600.0000
  PRES   PSI             15.9581
  VFRAC                   0.9981
  LFRAC                1.9103-03
  SFRAC                  0.0
ENTHALPY:
  BTU/LBMOL           -2.9636+04
  BTU/LB              -1348.8004
  MMBTU/HR              -45.8895
ENTROPY:
  BTU/LBMOL-R            12.7609
  BTU/LB-R                0.5808
DENSITY:
  LBMOL/CUFT           1.4056-03
  LB/CUFT              3.0884-02
AVG MW                   21.9720

MIXED    SUBSTREAM PROPERTIES:
```

```
***  ALL PHASES   ***
MW       UNITLESS
    N2                   28.0135
    CO2                  44.0098
    CACO3                MISSING
    CAO                  MISSING
    CO                   28.0104
    O2                   31.9988
    AR                   39.9480
    NO2                  MISSING
    NO                   MISSING
    H2O                  18.0153
    H2                    2.0159
    H2O-MUD              MISSING
    CH4                  16.0428
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                 HOG FUEL GASIFICATION PROJECT CASE A
                             STREAM SECTION

SYNGAS11 (CONTINUED)

STREAM ID               SYNGAS11

    C                    12.0110
MWMX                     21.9720
QVALGRS  BTU/LB        2975.8073
QVALNET  BTU/LB        2693.8191

*** VAPOR PHASE   ***
MUMX      LB/FT-HR     5.9717-02
PR                        0.5068
KMX       BTU/HR-FT-R  4.0454-02
*   68.0000 F          *
VVSTD     CUM/SEC
    N2                    1.5079
    CO2                   0.3184
    CACO3                MISSING
    CAO                  MISSING
    CO                    1.3007
    O2                   1.8894-03
    AR                   1.8165-02
    NO2                  MISSING
    NO                   MISSING
    H2O                   0.4023
    H2                    1.1347
    H2O-MUD              MISSING
    CH4                  1.1203-04
    C                     0.0
*   68.0000 F          *
VVSTDMX  CUFT/MIN      9925.1306
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                 HOG FUEL GASIFICATION PROJECT CASE A
                             UTILITY SECTION

UTILITY USAGE:  IPS-GEN   (STEAM)
---------------------------------

 INPUT DATA:

   INLET TEMPERATURE                     68.0000  F
   INLET PRESSURE                       170.0000  PSI
   OUTLET PRESSURE                      170.0000  PSI
   OUTLET VAPOR FRACTION                  1.0000
   PRICE                                  0.0     $/LB
   INDEX TYPE                               FUEL
```

```
 RESULT:

   COOLING VALUE                      1158.9080  BTU/LB
   INDEXED PRICE                         0.0     $/LB

 THIS UTILITY IS PURCHASED

 USAGE:

 UOS BLOCK ID     MODEL           USAGE RATE (TONS/H)    COST ($/HR)
 -------------    ------------    -------------------    -------------
 IPSTM            HEATER                     1.5588              0.0
                                       -------------     -------------
                              TOTAL:         1.5588              0.0
                                       =============     =============

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                 HOG FUEL GASIFICATION PROJECT CASE A
                             UTILITY SECTION

UTILITY USAGE:  LPS-GEN   (STEAM)
---------------------------------

 INPUT DATA:

   INLET TEMPERATURE                     68.0000  F
   INLET PRESSURE                        54.0000  PSI
   OUTLET PRESSURE                       54.0000  PSI
   OUTLET VAPOR FRACTION                  1.0000
   PRICE                                  0.0     $/LB
   INDEX TYPE                               FUEL

 RESULT:

   COOLING VALUE                      1138.8674  BTU/LB
   INDEXED PRICE                         0.0     $/LB

 THIS UTILITY IS PURCHASED

 USAGE:

 UOS BLOCK ID     MODEL           USAGE RATE (TONS/H)    COST ($/HR)
 -------------    ------------    -------------------    -------------
 LPSTM            HEATER                     5.9388              0.0
                                       -------------     -------------
                              TOTAL:         5.9388              0.0
                                       =============     =============

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                 HOG FUEL GASIFICATION PROJECT CASE A
               FLOWSHEET SECTION (HIERARCHY: BM-DRYER)

FLOWSHEET CONNECTIVITY BY STREAMS
---------------------------------

FLOWSHEET SECTION KILN
  STREAM     SOURCE     DEST          STREAM     SOURCE     DEST
  BIOMASS    $C-18      MOISTYLD      BIOMASS2   MOISTYLD   SPR-HTR
  STEAM      DISCHRG    STM-SPLT      BIOMASS4   DISCHRG    $C-19
  STM-LK     STM-SPLT   $C-16         DRTY-STM   STM-SPLT   $C-17
  BIOMASS3   SPR-HTR    DISCHRG       HEAT-DRY   SPR-HTR    $C-14

FLOWSHEET CONNECTIVITY BY BLOCKS
--------------------------------
```

```
FLOWSHEET SECTION KILN
  BLOCK       INLETS                                OUTLETS
  MOISTYLD    BIOMASS                               BIOMASS2
  DISCHRG     BIOMASS3                              STEAM BIOMASS4
  STM-SPLT    STEAM                                 STM-LK DRTY-STM
  SPR-HTR     BIOMASS2                              BIOMASS3 HEAT-DRY

CALCULATOR BLOCK:   DRY-FUEL
----------------------------

  SAMPLED VARIABLES:
    WATER    : COMP-ATTR-VA IN STREAM BIOMASS SUBSTREAM NC ID: PROXANAL
    H2OYLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2O IN UOS
               BLOCK MOISTYLD
    FLYLD    : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=FUEL IN UOS BLOCK
               MOISTYLD
    MOIST    : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=1 ID1=1 IN UOS BLOCK
               MOISTYLD
    FLOW     : TOTAL MASSFLOW IN STREAM BIOMASS SUBSTREAM NC

  FORTRAN STATEMENTS:
        REAL MASS
  C ****************************************************************
  C DRY IS THE DESIRED MOISTURE MASS % IN THE DRIED BIOMASS.
  C ****************************************************************

        DRY=10.

  C ****************************************************************
  C YIELD VALUES AND PROXIMATE VALUES FOR WATER ARE SET FOR BLOCK
  C MOISTYLD BELOW.
  C ****************************************************************

        MOIST=DRY
        TOTMAS=FLOW
        DRY=FLOW*(1.-(WATER/100.))
        MASS=DRY/(1.-(MOIST/100.))
        WMASS=TOTMAS-MASS
        H2OYLD=WMASS/TOTMAS
        FLYLD=1-H2OYLD

  EXECUTE BEFORE BLOCK MOISTYLD
 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                    09/27/2007  PAGE 93
                 HOG FUEL GASIFICATION PROJECT CASE A
               FLOWSHEET SECTION (HIERARCHY: BM-DRYER)

CALCULATOR BLOCK:   DRY-FUEL (CONTINUED)

  VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
    VARIABLE         VALUE READ      VALUE WRITTEN     UNITS
    --------         ----------      -------------     -----
    WATER             50.0000          50.0000
    H2OYLD           0.444444         0.444444
    FLYLD            0.555556         0.555556
    MOIST             10.0000          10.0000
    FLOW              15.1748          15.1748         TONS/HR

FLOWSHEET SECTION BALANCE:  KILN
--------------------------------

                     ***  MASS AND ENERGY BALANCE  ***
                                     IN              OUT        RELATIVE DIFF.
   CONVENTIONAL COMPONENTS (LBMOL/HR)
     N2                           0.00000          0.00000          0.00000
     CO2                          0.00000          0.00000          0.00000
     CACO3                        0.00000          0.00000          0.00000
```

CAO	0.00000	0.00000	0.00000
CO	0.00000	0.00000	0.00000
O2	0.00000	0.00000	0.00000
AR	0.00000	0.00000	0.00000
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	0.00000	748.736	-1.00000
H2	0.00000	0.00000	0.00000
H2O-MUD	0.00000	0.00000	0.00000
CH4	0.00000	0.00000	0.00000
C	0.00000	0.00000	0.00000
SUBTOTAL(LBMOL/HR)	0.00000	748.736	-1.00000
(TONS/HR)	0.00000	6.74434	-1.00000
NON-CONVENTIONAL COMPONENTS (TONS/HR)			
CHAR	0.00000	0.00000	0.00000
FUEL	15.1748	8.43043	0.444444
TAR	0.00000	0.00000	0.00000
ASH	0.00000	0.00000	0.00000
SUBTOTAL(TONS/HR)	15.1748	8.43043	0.444444
TOTAL BALANCE			
MASS(TONS/HR)	15.1748	15.1748	0.234120E-15
ENTHALPY(MMBTU/HR)	-132.811	-133.912	0.821940E-02

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HOG FUEL GASIFICATION PROJECT CASE A
U-O-S BLOCK SECTION (HIERARCHY: BM-DRYER)

BLOCK: DISCHRG MODEL: SEP

```
INLET STREAM:          BIOMASS3
OUTLET STREAMS:        STEAM       BIOMASS4
PROPERTY OPTION SET:   PR-BM       PENG-ROBINSON EQUATION OF STATE
```

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)	748.736	748.736	0.00000
(TONS/HR)	6.74434	6.74434	0.00000
NONCONV. COMP(TONS/HR)	8.43043	8.43043	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	15.1748	15.1748	0.00000
ENTHALPY(MMBTU/HR)	-115.920	-117.020	0.940586E-02

*** INPUT DATA ***

```
FLASH SPECS FOR STREAM STEAM
TWO    PHASE  TP  FLASH
SPECIFIED TEMPERATURE F                          302.000
PRESSURE DROP          PSI                         0.0
MAXIMUM NO. ITERATIONS                            30
CONVERGENCE TOLERANCE                              0.000100000

FLASH SPECS FOR STREAM BIOMASS4
TWO    PHASE  TP  FLASH
SPECIFIED TEMPERATURE F                          212.000
SPECIFIED PRESSURE     PSI                        14.6959
MAXIMUM NO. ITERATIONS                            30
CONVERGENCE TOLERANCE                              0.000100000

FRACTION OF FEED
  SUBSTREAM= MIXED
    STREAM= STEAM      CPT= H2O      FRACTION=       1.00000
  SUBSTREAM= NC
    STREAM= STEAM      CPT= FUEL     FRACTION=       0.0
```

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HOG FUEL GASIFICATION PROJECT CASE A
U-O-S BLOCK SECTION (HIERARCHY: BM-DRYER)

BLOCK: DISCHRG MODEL: SEP (CONTINUED)

*** RESULTS ***

```
HEAT DUTY              MMBTU/HR                              -1.1007

COMPONENT = H2O
  STREAM     SUBSTREAM     SPLIT FRACTION
  STEAM      MIXED                1.00000

COMPONENT = FUEL
  STREAM     SUBSTREAM     SPLIT FRACTION
  BIOMASS4   NC                   1.00000
```

BLOCK: MOISTYLD MODEL: RYIELD

```
INLET STREAM:          BIOMASS
OUTLET STREAM:         BIOMASS2
PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE
```

*** MASS AND ENERGY BALANCE ***

	IN	OUT	GENERATION	RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)	0.00000	748.736	748.736	0.00000
(TONS/HR)	0.00000	6.74434		-1.00000
NONCONV COMP(TONS/HR)	15.1748	8.43043		0.444444
TOTAL BALANCE				
MASS(TONS/HR)	15.1748	15.1748		0.117060E-15
ENTHALPY(MMBTU/HR)	-132.811	-132.811		-0.680456E-09

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HOG FUEL GASIFICATION PROJECT CASE A
U-O-S BLOCK SECTION (HIERARCHY: BM-DRYER)

BLOCK: MOISTYLD MODEL: RYIELD (CONTINUED)

*** INPUT DATA ***

```
TWO    PHASE  PQ  FLASH
SPECIFIED PRESSURE     PSI                            58.2073
SPECIFIED HEAT DUTY    MMBTU/HR                        0.0
MAXIMUM NO. ITERATIONS                                30
CONVERGENCE TOLERANCE                                  0.000100000

 MASS-YIELD
  SUBSTREAM MIXED   :
  H2O      0.444
  SUBSTREAM NC      :
  FUEL     0.556
```

*** RESULTS ***

```
OUTLET TEMPERATURE    F                                104.93
OUTLET PRESSURE       PSI                               58.207
HEAT DUTY             MMBTU/HR                          0.0000
VAPOR FRACTION                                          0.0000
```

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HOG FUEL GASIFICATION PROJECT CASE A
U-O-S BLOCK SECTION (HIERARCHY: BM-DRYER)

BLOCK: MOISTYLD MODEL: RYIELD (CONTINUED)

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
H2O	1.0000	1.0000	1.0000	0.17439E-01

BLOCK: SPR-HTR MODEL: HEATER

```
INLET STREAM:          BIOMASS2
OUTLET STREAM:         BIOMASS3
OUTLET HEAT STREAM:    HEAT-DRY
PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE
```

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)	748.736	748.736	0.00000
(TONS/HR)	6.74434	6.74434	0.00000
NONCONV. COMP(TONS/HR)	8.43043	8.43043	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	15.1748	15.1748	0.00000
ENTHALPY(MMBTU/HR)	-132.811	-132.811	0.00000

*** INPUT DATA ***

```
TWO    PHASE  TP  FLASH
SPECIFIED TEMPERATURE                F                419.000
PRESSURE DROP                        PSI                0.0
MAXIMUM NO. ITERATIONS                                 30
CONVERGENCE TOLERANCE                                   0.000100000
```

*** RESULTS ***

```
OUTLET TEMPERATURE    F                                419.00
OUTLET PRESSURE       PSI                               58.207
HEAT DUTY             MMBTU/HR                          16.892
OUTLET VAPOR FRACTION                                   1.0000
PRESSURE-DROP CORRELATION PARAMETER                     0.0000
```

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
H2O	1.0000	1.0000	1.0000	4.8554

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HOG FUEL GASIFICATION PROJECT CASE A
U-O-S BLOCK SECTION (HIERARCHY: BM-DRYER)

BLOCK: STM-SPLT MODEL: FSPLIT

```
INLET STREAM:          STEAM
OUTLET STREAMS:        STM-LK      DRTY-STM
PROPERTY OPTION SET:   PR-BM       PENG-ROBINSON EQUATION OF STATE
```

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)	748.736	748.736	0.00000
(TONS/HR)	6.74434	6.74434	0.131692E-15
NONCONV. COMP(TONS/HR)	0.00000	0.00000	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	6.74434	6.74434	0.131692E-15
ENTHALPY(MMBTU/HR)	-76.5504	-76.5504	0.00000

*** INPUT DATA ***

```
FRACTION OF FLOW               STRM=STM-LK    FRAC=        0.071726
```

*** RESULTS ***

```
STREAM= STM-LK        SPLIT=          0.071726     KEY=  0     STREAM-ORDER=   1
        DRTY-STM                      0.92827            0                     2
```

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: BM-DRYER)

BIOMASS BIOMASS2 BIOMASS3 BIOMASS4 DRTY-STM

STREAM ID	BIOMASS	BIOMASS2	BIOMASS3	BIOMASS4	DRTY-STM
FROM :	$C-18	MOISTYLD	SPR-HTR	DISCHRG	STM-SPLT
TO :	MOISTYLD	SPR-HTR	DISCHRG	$C-19	$C-17
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	15.1748	15.1748	15.1748	8.4304	6.2606
MMBTU/HR	-132.8114	-132.8114	-115.9195	-40.4698	-71.0598
SUBSTREAM: MIXED					
PHASE:	MISSING	LIQUID	VAPOR	MISSING	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	748.7359	748.7359	0.0	695.0322
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	1.0000	1.0000	0.0	1.0000
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	6.7443	6.7443	0.0	6.2606
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: BM-DRYER)

BIOMASS BIOMASS2 BIOMASS3 BIOMASS4 DRTY- (CONTINUED)

STREAM ID	BIOMASS	BIOMASS2	BIOMASS3	BIOMASS4	DRTY-STM

```
  CH4                    0.0        0.0        0.0        0.0        0.0
  C                      0.0        0.0        0.0        0.0        0.0
COMPONENTS: MASS FRAC
  N2                     MISSING    0.0        0.0        MISSING    0.0
  CO2                    MISSING    0.0        0.0        MISSING    0.0
  CACO3                  MISSING    0.0        0.0        MISSING    0.0
  CAO                    MISSING    0.0        0.0        MISSING    0.0
  CO                     MISSING    0.0        0.0        MISSING    0.0
  O2                     MISSING    0.0        0.0        MISSING    0.0
  AR                     MISSING    0.0        0.0        MISSING    0.0
  NO2                    MISSING    0.0        0.0        MISSING    0.0
  NO                     MISSING    0.0        0.0        MISSING    0.0
  H2O                    MISSING    1.0000     1.0000     MISSING    1.0000
  H2                     MISSING    0.0        0.0        MISSING    0.0
  H2O-MUD                MISSING    0.0        0.0        MISSING    0.0
  CH4                    MISSING    0.0        0.0        MISSING    0.0
  C                      MISSING    0.0        0.0        MISSING    0.0
TOTAL FLOW:
  LBMOL/HR               0.0      748.7359   748.7359     0.0      695.0322
  TONS/HR                0.0        6.7443     6.7443     0.0        6.2606
  CUFT/HR                0.0      257.2782   1.1929+05    0.0      9.5177+04
STATE VARIABLES:
  TEMP   F               MISSING  104.9298   419.0000   MISSING   302.0000
  PRES   PSI             14.6959   58.2073    58.2073   14.6959    58.2073
  VFRAC                  MISSING    0.0        1.0000   MISSING     1.0000
  LFRAC                  MISSING    1.0000     0.0      MISSING     0.0
  SFRAC                  MISSING    0.0        0.0      MISSING     0.0
ENTHALPY:
  BTU/LBMOL              MISSING -1.2308+05 -1.0125+05  MISSING -1.0224+05
  BTU/LB                 MISSING -6832.2304 -5620.0792  MISSING -5675.1574
  MMBTU/HR               MISSING   -92.1578   -75.8075  MISSING   -71.0598
ENTROPY:
  BTU/LBMOL-R            MISSING   -39.0370    -9.3642  MISSING   -10.5759
  BTU/LB-R               MISSING    -2.1669    -0.5198  MISSING    -0.5871
DENSITY:
  LBMOL/CUFT             MISSING    2.9102   6.2765-03  MISSING  7.3026-03
  LB/CUFT                MISSING   52.4284     0.1131   MISSING     0.1316
AVG MW                   MISSING   18.0153    18.0153   MISSING    18.0153

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW       UNITLESS
    N2                   MISSING   MISSING   MISSING   MISSING   MISSING
    CO2                  MISSING   MISSING   MISSING   MISSING   MISSING
    CACO3                MISSING   MISSING   MISSING   MISSING   MISSING
    CAO                  MISSING   MISSING   MISSING   MISSING   MISSING
    CO                   MISSING   MISSING   MISSING   MISSING   MISSING
    O2                   MISSING   MISSING   MISSING   MISSING   MISSING
    AR                   MISSING   MISSING   MISSING   MISSING   MISSING
    NO2                  MISSING   MISSING   MISSING   MISSING   MISSING
    NO                   MISSING   MISSING   MISSING   MISSING   MISSING
```



```
BIOMASS BIOMASS2 BIOMASS3 BIOMASS4 DRTY- (CONTINUED)

STREAM ID                BIOMASS   BIOMASS2  BIOMASS3  BIOMASS4  DRTY-STM

    H2O                  MISSING   18.0153   18.0153   MISSING   18.0153
    H2                   MISSING   MISSING   MISSING   MISSING   MISSING
    H2O-MUD              MISSING   MISSING   MISSING   MISSING   MISSING
    CH4                  MISSING   MISSING   MISSING   MISSING   MISSING
    C                    MISSING   MISSING   MISSING   MISSING   MISSING
MWMX                     MISSING   18.0153   18.0153   MISSING   18.0153
QVALGRS  BTU/LB          MISSING 1049.9837 1049.9837   MISSING 1049.9837
QVALNET  BTU/LB          MISSING    0.0       0.0      MISSING    0.0

*** VAPOR PHASE   ***
MUMX      LB/FT-HR       MISSING   MISSING  3.0017-02  MISSING  2.5563-02
PR                       MISSING   MISSING    0.5726   MISSING    0.6008
KMX       BTU/HR-FT-R    MISSING   MISSING  2.4829-02  MISSING  1.9927-02
*   68.0000 F        *
VVSTD     CUM/SEC
    N2                   MISSING   MISSING   MISSING   MISSING   MISSING
    CO2                  MISSING   MISSING   MISSING   MISSING   MISSING
    CACO3                MISSING   MISSING   MISSING   MISSING   MISSING
    CAO                  MISSING   MISSING   MISSING   MISSING   MISSING
    CO                   MISSING   MISSING   MISSING   MISSING   MISSING
    O2                   MISSING   MISSING   MISSING   MISSING   MISSING
    AR                   MISSING   MISSING   MISSING   MISSING   MISSING
    NO2                  MISSING   MISSING   MISSING   MISSING   MISSING
    NO                   MISSING   MISSING   MISSING   MISSING   MISSING
    H2O                  MISSING   MISSING    2.2693   MISSING    2.1065
    H2                   MISSING   MISSING   MISSING   MISSING   MISSING
    H2O-MUD              MISSING   MISSING   MISSING   MISSING   MISSING
    CH4                  MISSING   MISSING   MISSING   MISSING   MISSING
    C                    MISSING   MISSING   MISSING   MISSING   MISSING
*   68.0000 F        *
VVSTDMX  CUFT/MIN        MISSING   MISSING  4808.3803  MISSING  4463.4953

SUBSTREAM: NC            STRUCTURE: NON CONVENTIONAL
COMPONENTS: TONS/HR
  CHAR                    0.0       0.0       0.0       0.0       0.0
  FUEL                   15.1748    8.4304    8.4304    8.4304    0.0
  TAR                     0.0       0.0       0.0       0.0       0.0
  ASH                     0.0       0.0       0.0       0.0       0.0
COMPONENTS: MASS FRAC
  CHAR                    0.0       0.0       0.0       0.0       0.0
  FUEL                    1.0000    1.0000    1.0000    1.0000    0.0
  TAR                     0.0       0.0       0.0       0.0       0.0
  ASH                     0.0       0.0       0.0       0.0       0.0
TOTAL FLOW:
  TONS/HR                15.1748    8.4304    8.4304    8.4304    0.0
STATE VARIABLES:
  TEMP    F              68.0000  104.9298  419.0000  212.0000   MISSING
  PRES    PSI            14.6959   58.2073   58.2073   14.6959   58.2073
  VFRAC                   0.0       0.0       0.0       0.0      MISSING
  LFRAC                   0.0       0.0       0.0       0.0      MISSING
  SFRAC                   1.0000    1.0000    1.0000    1.0000   MISSING
```



```
BIOMASS BIOMASS2 BIOMASS3 BIOMASS4 DRTY- (CONTINUED)

STREAM ID                BIOMASS   BIOMASS2  BIOMASS3  BIOMASS4  DRTY-STM

ENTHALPY:
  BTU/LB              -4376.0584 -2411.1208 -2379.0038 -2400.2212  MISSING
  MMBTU/HR             -132.8114   -40.6536   -40.1120   -40.4698  MISSING
DENSITY:
  LB/CUFT                82.7971   82.7971   82.7971   82.7971   MISSING
AVG MW                    1.0000    1.0000    1.0000    1.0000    1.0000
COMPONENT ATTRIBUTES:
CHAR      PROXANAL
          ULTANAL
          SULFANAL
FUEL      PROXANAL
            MOISTURE     50.0000   10.0000   10.0000   10.0000   MISSING
            FC            0.0       0.0       0.0       0.0      MISSING
            VM            0.0       0.0       0.0       0.0      MISSING
            ASH           6.3100    6.3100    6.3100    6.3100   MISSING
          ULTANAL
            ASH           6.3100    6.3100    6.3100    6.3100   MISSING
            CARBON       44.7400   44.7400   44.7400   44.7400   MISSING
            HYDROGEN      5.5000    5.5000    5.5000    5.5000   MISSING
            NITROGEN      0.0       0.0       0.0       0.0      MISSING
            CHLORINE      0.0       0.0       0.0       0.0      MISSING
            SULFUR        0.0       0.0       0.0       0.0      MISSING
            OXYGEN       43.4500   43.4500   43.4500   43.4500   MISSING
          SULFANAL
            PYRITIC       0.0       0.0       0.0       0.0      MISSING
            SULFATE       0.0       0.0       0.0       0.0      MISSING
            ORGANIC       0.0       0.0       0.0       0.0      MISSING
TAR       PROXANAL
          ULTANAL
          SULFANAL
ASH       GENANAL
```



```
STEAM STM-LK
------------

STREAM ID                STEAM     STM-LK
FROM :                   DISCHRG   STM-SPLT
TO   :                   STM-SPLT  $C-16
CLASS:                   MIXNC     MIXNC
TOTAL STREAM:
  TONS/HR                  6.7443    0.4837
  MMBTU/HR               -76.5504   -5.4906
SUBSTREAM: MIXED
PHASE:                   VAPOR     VAPOR
COMPONENTS: LBMOL/HR
  N2                       0.0       0.0
  CO2                      0.0       0.0
  CACO3                    0.0       0.0
  CAO                      0.0       0.0
  CO                       0.0       0.0
  O2                       0.0       0.0
  AR                       0.0       0.0
  NO2                      0.0       0.0
  NO                       0.0       0.0
  H2O                    748.7359   53.7037
  H2                       0.0       0.0
  H2O-MUD                  0.0       0.0
  CH4                      0.0       0.0
  C                        0.0       0.0
COMPONENTS: MOLE FRAC
  N2                       0.0       0.0
  CO2                      0.0       0.0
  CACO3                    0.0       0.0
  CAO                      0.0       0.0
  CO                       0.0       0.0
  O2                       0.0       0.0
  AR                       0.0       0.0
  NO2                      0.0       0.0
  NO                       0.0       0.0
  H2O                      1.0000    1.0000
  H2                       0.0       0.0
  H2O-MUD                  0.0       0.0
  CH4                      0.0       0.0
  C                        0.0       0.0
COMPONENTS: TONS/HR
  N2                       0.0       0.0
  CO2                      0.0       0.0
  CACO3                    0.0       0.0
  CAO                      0.0       0.0
  CO                       0.0       0.0
  O2                       0.0       0.0
  AR                       0.0       0.0
  NO2                      0.0       0.0
  NO                       0.0       0.0
  H2O                      6.7443    0.4837
  H2                       0.0       0.0
  H2O-MUD                  0.0       0.0
```



```
STEAM STM-LK (CONTINUED)

STREAM ID                STEAM     STM-LK

  CH4                      0.0       0.0
  C                        0.0       0.0
COMPONENTS: MASS FRAC
  N2                       0.0       0.0
  CO2                      0.0       0.0
  CACO3                    0.0       0.0
  CAO                      0.0       0.0
  CO                       0.0       0.0
  O2                       0.0       0.0
  AR                       0.0       0.0
  NO2                      0.0       0.0
  NO                       0.0       0.0
  H2O                      1.0000    1.0000
  H2                       0.0       0.0
  H2O-MUD                  0.0       0.0
  CH4                      0.0       0.0
  C                        0.0       0.0
TOTAL FLOW:
  LBMOL/HR               748.7359   53.7037
  TONS/HR                  6.7443    0.4837
  CUFT/HR                1.0253+05 7354.0988
STATE VARIABLES:
  TEMP    F              302.0000  302.0000
  PRES    PSI             58.2073   58.2073
  VFRAC                    1.0000    1.0000
  LFRAC                    0.0       0.0
  SFRAC                    0.0       0.0
ENTHALPY:
  BTU/LBMOL             -1.0224+05 -1.0224+05
  BTU/LB                -5675.1574 -5675.1574
  MMBTU/HR                -76.5504   -5.4906
ENTROPY:
  BTU/LBMOL-R             -10.5759  -10.5759
  BTU/LB-R                 -0.5871   -0.5871
DENSITY:
  LBMOL/CUFT             7.3026-03 7.3026-03
  LB/CUFT                  0.1316    0.1316
AVG MW                    18.0153   18.0153

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW       UNITLESS
    N2                   MISSING   MISSING
    CO2                  MISSING   MISSING
    CACO3                MISSING   MISSING
```

```
    CAO                     MISSING    MISSING
    CO                      MISSING    MISSING
    O2                      MISSING    MISSING
    AR                      MISSING    MISSING
    NO2                     MISSING    MISSING
    NO                      MISSING    MISSING
```



```
STEAM STM-LK (CONTINUED)

STREAM ID               STEAM      STM-LK

    H2O                 18.0153    18.0153
    H2                  MISSING    MISSING
    H2O-MUD             MISSING    MISSING
    CH4                 MISSING    MISSING
    C                   MISSING    MISSING
MWMX                    18.0153    18.0153
QVALGRS  BTU/LB       1049.9837  1049.9837
QVALNET  BTU/LB          0.0        0.0

*** VAPOR PHASE   ***
MUMX     LB/FT-HR      2.5563-02  2.5563-02
PR                       0.6008     0.6008
KMX      BTU/HR-FT-R  1.9927-02  1.9927-02
*  68.0000 F        *
VVSTD    CUM/SEC
    N2                  MISSING    MISSING
    CO2                 MISSING    MISSING
    CACO3               MISSING    MISSING
    CAO                 MISSING    MISSING
    CO                  MISSING    MISSING
    O2                  MISSING    MISSING
    AR                  MISSING    MISSING
    NO2                 MISSING    MISSING
    NO                  MISSING    MISSING
    H2O                  2.2693     0.1628
    H2                  MISSING    MISSING
    H2O-MUD             MISSING    MISSING
    CH4                 MISSING    MISSING
    C                   MISSING    MISSING
*  68.0000 F        *
VVSTDMX  CUFT/MIN      4808.3803   344.8850
```



```
HEAT-DRY
--------

STREAM ID               HEAT-DRY
FROM :                  SPR-HTR
TO   :                  $C-14
CLASS:                  HEAT

STREAM ATTRIBUTES:
HEAT
Q        MMBTU/HR       -16.8918
TBEG     F              104.9298
TEND     F              419.0000
```



```
FLOWSHEET CONNECTIVITY BY STREAMS
---------------------------------

FLOWSHEET SECTION GLOBAL
  STREAM     SOURCE     DEST          STREAM     SOURCE     DEST
  FUEL       $C-15      STP-COOL      O2         ----       BURN
  STP        STP-COOL   DECOMP        POC        BURN       DUP
  ELEMENTS   DECOMP     BURN          HEAT       DECOMP     BURN
  HHV-POC    DUP        HHV-COND      LHV-POC    DUP        LHV-COND
  LHV-LIQ    LHV-COND   ----          LHV-GAS    LHV-COND   ----
  HHV-LIQ    HHV-COND   ----          HHV-GAS    HHV-COND   ----

FLOWSHEET CONNECTIVITY BY BLOCKS
--------------------------------

FLOWSHEET SECTION GLOBAL
  BLOCK      INLETS                       OUTLETS
  STP-COOL   FUEL                         STP
  BURN       ELEMENTS O2 HEAT             POC
  DECOMP     STP                          ELEMENTS HEAT
  DUP        POC                          HHV-POC LHV-POC
  LHV-COND   LHV-POC                      LHV-LIQ LHV-GAS
  HHV-COND   HHV-POC                      HHV-LIQ HHV-GAS

CALCULATOR BLOCK:   DECOMP
--------------------------

  SAMPLED VARIABLES:
    ULTA     : COMPONENT-AT VEC IN STREAM FUEL SUBSTREAM NC ID: ULTANAL
    PROX     : COMPONENT-AT VEC IN STREAM FUEL SUBSTREAM NC ID: PROXANAL
    SULF     : COMPONENT-AT VEC IN STREAM FUEL SUBSTREAM NC ID: SULFANAL
    H2O      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2O IN UOS
               BLOCK DECOMP
    C        : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=C IN UOS BLOCK
               DECOMP
    H2       : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2 IN UOS
               BLOCK DECOMP
    N2       : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=N2 IN UOS
               BLOCK DECOMP
    O2       : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=O2 IN UOS
               BLOCK DECOMP
    ASH      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=ASH IN UOS BLOCK
               DECOMP
    FUEL     : FUEL MASSFLOW IN STREAM FUEL SUBSTREAM NC

  FORTRAN STATEMENTS:
        DOUBLE PRECISION N2HF
  C *******************************************************************
  C CALCULATES THE MASS YIELD FOR THE DECOMPOSITION OF THE FUEL.
  C NOTE THIS BLOCK CAN ACCOMADATE MULTIPLE FUEL COMBINATIONS.
  C
  C THE ELEMENTAL AND ASH YIELDS ARE DETERMINED BASED ON
  C THE ELEMENTAL COMPOSTION SPECIFIED IN THE ULTIMATE ANALYSIS.
  C *******************************************************************
```



```
CALCULATOR BLOCK:   DECOMP (CONTINUED)

        ASH=ULTA(1)/100.
        C=ULTA(2)/100.
        H2=ULTA(3)/100.
        N2=ULTA(4)/100.
        CL2=ULTA(5)/100.
        O2=ULTA(7)/100.

  C *******************************************************************
  C THE SULFUR YIELD CALCULATION IS BASED ON THE SULFUR ANALYSIS.
  C *******************************************************************

        S=(SULF(1)+SULF(2)+SULF(3))/100.0

  C *******************************************************************
  C FINALLY, THE FINAL YIELDS ARE CALCULATED BY AVERAGING THE
  C YIELDS FOR EACH FUEL IN THE FEED.
  C *******************************************************************

        H2O=PROX(1)/100.
        ASH=(1-H2O)*(ASH*FUEL)/(FUEL)
        C=(1-H2O)*(C*FUEL)/(FUEL)
        H2=(1-H2O)*(H2*FUEL)/(FUEL)
        N2=(1-H2O)*(N2*FUEL)/(FUEL)
        CL2=(1-H2O)*(CL2*FUEL)/(FUEL)
        O2=(1-H2O)*(O2*FUEL)/(FUEL)
        S=(1-H2O)*(S*FUEL)/(FUEL)

  EXECUTE BEFORE BLOCK DECOMP

  VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
    VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
    --------        ----------      -------------    -----
    ULTA(1)         6.31000         6.31000
    ULTA(2)         44.7400         44.7400
    ULTA(3)         5.50000         5.50000
    ULTA(4)         0.00000         0.00000
    ULTA(5)         0.00000         0.00000
    ULTA(6)         0.00000         0.00000
    ULTA(7)         43.4500         43.4500
    PROX(1)         50.0000         50.0000
    PROX(2)         0.00000         0.00000
    PROX(3)         0.00000         0.00000
    PROX(4)         6.31000         6.31000
    SULF(1)         0.00000         0.00000
    SULF(2)         0.00000         0.00000
    SULF(3)         0.00000         0.00000
    H2O             1.00000         0.500000
    C               1.00000         0.223700
    H2              1.00000         0.275000E-01
    N2              1.00000         0.00000
    O2              1.00000         0.217250
    ASH             1.00000         0.315500E-01
    FUEL            30349.5         30349.5          LB/HR
```



```
CALCULATOR BLOCK:   O2
----------------------

  SAMPLED VARIABLES:
    O2FLOW   : TOTAL MOLEFLOW IN STREAM O2 SUBSTREAM MIXED
    C        : C MOLEFLOW IN STREAM ELEMENTS SUBSTREAM MIXED
    H2       : H2 MOLEFLOW IN STREAM ELEMENTS SUBSTREAM MIXED
    N2       : N2 MOLEFLOW IN STREAM ELEMENTS SUBSTREAM MIXED
    O2       : O2 MOLEFLOW IN STREAM ELEMENTS SUBSTREAM MIXED

  FORTRAN STATEMENTS:
  C *******************************************************************
  C CALCULATES THE AMOUNT (FLOW) OF OXYGEN REQUIRED TO
  C COMPLETELY COMBUST THE FUEL FOR THE HHV CACULATION.
  C *******************************************************************

        O2FLOW=C+S+(1./2.*(H2-CL2))+(2*N2)-O2

  EXECUTE BEFORE BLOCK BURN

  VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:
    VARIABLE        VALUE READ      VALUE WRITTEN    UNITS
    --------        ----------      -------------    -----
    O2FLOW          100.000         566.205          LBMOL/HR
    C               565.248         565.248          LBMOL/HR
    H2              414.019         414.019          LBMOL/HR
    N2              0.00000         0.00000          LBMOL/HR
    O2              206.053         206.053          LBMOL/HR

FLOWSHEET SECTION BALANCE:  GLOBAL
----------------------------------

                     ***  MASS AND ENERGY BALANCE  ***
                                     IN              OUT        RELATIVE DIFF.
   CONVENTIONAL COMPONENTS (LBMOL/HR)
      N2                           0.00000         0.00000         0.00000
      CO2                          0.00000         1130.50        -1.00000
      CACO3                        0.00000         0.00000         0.00000
      CAO                          0.00000         0.00000         0.00000
      CO                           0.00000         0.00000         0.00000
      O2                           566.205         0.00000         1.00000
      AR                           0.00000         0.00000         0.00000
      NO2                          0.00000         0.00000         0.00000
      NO                           0.00000         0.00000         0.00000
      H2O                          0.00000         2512.69        -1.00000
      H2                           0.00000         0.00000         0.00000
      H2O-MUD                      0.00000         0.00000         0.00000
      CH4                          0.00000         0.00000         0.00000
      C                            0.00000         0.00000         0.00000
   SUBTOTAL(LBMOL/HR)              566.205         3643.19        -0.844585
           (TONS/HR )              9.05894         47.5099        -0.809325
```



```
FLOWSHEET SECTION BALANCE:  GLOBAL (CONTINUED)
   NON-CONVENTIONAL COMPONENTS (TONS/HR )
      CHAR                         0.00000         0.00000         0.00000
      FUEL                         15.1748         0.00000         1.00000
      TAR                          0.00000         0.00000         0.00000
      ASH                          0.00000         0.957528       -1.00000
   SUBTOTAL(TONS/HR )              15.1748         0.957528        0.936900
   TOTAL BALANCE
      MASS(TONS/HR )               24.2337         48.4674        -0.500000
      ENTHALPY(MMBTU/HR)          -132.850        -477.666         0.721878
```



```
BLOCK:  BURN     MODEL: RSTOIC
------------------------------
  INLET STREAMS:          ELEMENTS    O2
  INLET HEAT STREAM:      HEAT
  OUTLET STREAM:          POC
  PROPERTY OPTION SET:    PR-BM     PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                              IN          OUT       GENERATION    RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)     2593.85      1821.59      -772.257       0.175317E-15
           (TONS/HR )     23.7549      23.7549                    -0.149557E-15
NONCONV COMP(TONS/HR )    0.478764     0.478764                    0.00000
```

```
 TOTAL BALANCE
    MASS(TONS/HR )      24.2337        24.2337                          -0.146602E-15
    ENTHALPY(MMBTU/HR) -132.850       -132.850                           0.482722E-09

                         ***  INPUT DATA  ***
 STOICHIOMETRY MATRIX:

  REACTION #   1:
   SUBSTREAM MIXED    :
   CO2        1.00    O2        -1.00    C          -1.00
   SUBSTREAM NC       :
   NO PARTICIPATING COMPONENTS

  REACTION #   4:
   SUBSTREAM MIXED    :
   O2        -1.00    H2O        2.00    H2         -2.00
   SUBSTREAM NC       :
   NO PARTICIPATING COMPONENTS

  REACTION #   5:
   SUBSTREAM MIXED    :
   N2        -1.00    O2        -2.00    NO2         2.00
   SUBSTREAM NC       :
   NO PARTICIPATING COMPONENTS


 REACTION CONVERSION SPECS: NUMBER=    3
   REACTION #   1:
   SUBSTREAM:MIXED    KEY COMP:C        CONV FRAC:  1.000
   REACTION #   4:
   SUBSTREAM:MIXED    KEY COMP:H2       CONV FRAC:  1.000
   REACTION #   5:
   SUBSTREAM:MIXED    KEY COMP:O2       CONV FRAC:  1.000

 TWO    PHASE  PQ  FLASH
 SPECIFIED PRESSURE    PSI                                    14.6959
 DUTY FROM INLET HEAT STREAM(S)  MMBTU/HR                    -63.2909
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 112
                      HOG FUEL GASIFICATION PROJECT CASE A
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  BURN     MODEL: RSTOIC (CONTINUED)
 SERIES REACTIONS
 GENERATE COMBUSTION REACTIONS FOR FEED SPECIES           NO

                         ***  RESULTS  ***
 OUTLET TEMPERATURE    F                                      4402.6
 OUTLET PRESSURE       PSI                                    14.696
 VAPOR FRACTION                                               1.0000


 REACTION EXTENTS:

    REACTION          REACTION
    NUMBER            EXTENT
                      LBMOL/HR
    1                  565.25
    4                  207.01
    5                  0.0000

 V-L PHASE EQUILIBRIUM :

    COMP              F(I)           X(I)           Y(I)           K(I)
```

```
    CO2              0.31030        0.16877E-04    0.31030         3448.1
    H2O              0.68970        0.99998        0.68970         3142.8

BLOCK:  DECOMP   MODEL: RYIELD
------------------------------
 INLET STREAM:            STP
 OUTLET STREAM:           ELEMENTS
 OUTLET HEAT STREAM:      HEAT
 PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                             IN             OUT        GENERATION    RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)      0.00000        2027.65        2027.65        0.00000
            (TONS/HR )     0.00000        14.6960                      -1.00000
NONCONV COMP(TONS/HR )     15.1748        0.478764                      0.968450
 TOTAL BALANCE
    MASS(TONS/HR )         15.1748        15.1748                      -0.234120E-15
    ENTHALPY(MMBTU/HR) -132.811         -132.811                        0.00000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 113
                      HOG FUEL GASIFICATION PROJECT CASE A
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  DECOMP   MODEL: RYIELD (CONTINUED)

                         ***  INPUT DATA  ***
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE F                                      68.0000
 SPECIFIED PRESSURE    PSI                                    14.6959
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

   MASS-YIELD
    SUBSTREAM MIXED    :
    O2        0.217        H2O        0.500        H2         0.275E-01
    C         0.224
    SUBSTREAM NC       :
    ASH       0.316E-01
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 114
                      HOG FUEL GASIFICATION PROJECT CASE A
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  DECOMP   MODEL: RYIELD (CONTINUED)

                         ***  RESULTS  ***
 OUTLET TEMPERATURE    F                                      68.000
 OUTLET PRESSURE       PSI                                    14.696
 HEAT DUTY             MMBTU/HR                               63.291
 VAPOR FRACTION                                               0.72123


 V-L PHASE EQUILIBRIUM :

    COMP              F(I)           X(I)           Y(I)           K(I)
    O2               0.10162        0.14106E-20    0.14090        0.99888E+20
    H2O              0.41542        0.56784E-20    0.57599        0.10144E+21
    H2               0.20419        0.28450E-20    0.28311        0.99513E+20
    C                0.27877         1.0000        0.80648E-98    0.80648E-98

BLOCK:  DUP      MODEL: DUPL
----------------------------
 INLET STREAM:            POC
 OUTLET STREAMS:          HHV-POC      LHV-POC

BLOCK:  HHV-COND MODEL: SEP
---------------------------
```

```
 INLET STREAM:            HHV-POC
 OUTLET STREAMS:          HHV-LIQ      HHV-GAS
 PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                  IN             OUT         RELATIVE DIFF.
    CONV. COMP.(LBMOL/HR)      1821.59        1821.59         0.00000
                (TONS/HR )     23.7549        23.7549         0.149557E-15
    NONCONV. COMP(TONS/HR )  0.478764       0.478764         0.00000
  TOTAL BALANCE
    MASS(TONS/HR )             24.2337        24.2337         0.146602E-15
    ENTHALPY(MMBTU/HR)        -132.850       -251.226         0.471194
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 115
                      HOG FUEL GASIFICATION PROJECT CASE A
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  HHV-COND MODEL: SEP (CONTINUED)

                         ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM HHV-LIQ
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  LIQUID
 SPECIFIED TEMPERATURE F                                      68.0000
 SPECIFIED PRESSURE    PSI                                    14.6959
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FLASH SPECS FOR STREAM HHV-GAS
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  VAPOR
 SPECIFIED TEMPERATURE F                                      68.0000
 SPECIFIED PRESSURE    PSI                                    14.6959
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= HHV-LIQ   CPT= H2O       FRACTION=              1.00000
                            C                                1.00000
   SUBSTREAM= NC
     STREAM= HHV-LIQ   CPT= ASH       FRACTION=              1.00000

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                              -118.38

COMPONENT = CO2
  STREAM     SUBSTREAM    SPLIT FRACTION
  HHV-GAS    MIXED               1.00000

COMPONENT = H2O
  STREAM     SUBSTREAM    SPLIT FRACTION
  HHV-LIQ    MIXED               1.00000

COMPONENT = ASH
  STREAM     SUBSTREAM    SPLIT FRACTION
  HHV-LIQ    NC                  1.00000

BLOCK:  LHV-COND MODEL: SEP
---------------------------
 INLET STREAM:            LHV-POC
 OUTLET STREAMS:          LHV-LIQ      LHV-GAS
 PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 116
                      HOG FUEL GASIFICATION PROJECT CASE A
```

```
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  LHV-COND MODEL: SEP (CONTINUED)

                    ***  MASS AND ENERGY BALANCE  ***
                                  IN             OUT         RELATIVE DIFF.
    CONV. COMP.(LBMOL/HR)      1821.59        1821.59         0.00000
                (TONS/HR )     23.7549        23.7549         0.00000
    NONCONV. COMP(TONS/HR )  0.478764       0.478764         0.00000
  TOTAL BALANCE
    MASS(TONS/HR )             24.2337        24.2337         0.00000
    ENTHALPY(MMBTU/HR)        -132.850       -226.441         0.413314

                         ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM LHV-LIQ
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  LIQUID
 SPECIFIED TEMPERATURE F                                      68.0000
 SPECIFIED PRESSURE    PSI                                    14.6959
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FLASH SPECS FOR STREAM LHV-GAS
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  VAPOR
 SPECIFIED TEMPERATURE F                                      68.0000
 SPECIFIED PRESSURE    PSI                                    14.6959
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= LHV-LIQ   CPT= C         FRACTION=              1.00000
   SUBSTREAM= NC
     STREAM= LHV-LIQ   CPT= ASH       FRACTION=              1.00000

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                              -93.591

COMPONENT = CO2
  STREAM     SUBSTREAM    SPLIT FRACTION
  LHV-GAS    MIXED               1.00000

COMPONENT = H2O
  STREAM     SUBSTREAM    SPLIT FRACTION
  LHV-GAS    MIXED               1.00000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                     09/27/2007  PAGE 117
                      HOG FUEL GASIFICATION PROJECT CASE A
                    U-O-S BLOCK SECTION (HIERARCHY: FUEL-HHV)

BLOCK:  LHV-COND MODEL: SEP (CONTINUED)

COMPONENT = ASH
  STREAM     SUBSTREAM    SPLIT FRACTION
  LHV-LIQ    NC                  1.00000

BLOCK:  STP-COOL MODEL: HEATER
------------------------------
 INLET STREAM:            FUEL
 OUTLET STREAM:           STP
 PROPERTY OPTION SET:     PR-BM      PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                  IN             OUT         RELATIVE DIFF.
```

CONV. COMP.(LBMOL/HR)	0.00000	0.00000	0.00000
(TONS/HR)	0.00000	0.00000	0.00000
NONCONV. COMP(TONS/HR)	15.1748	15.1748	0.00000
TOTAL BALANCE			
MASS(TONS/HR)	15.1748	15.1748	0.00000
ENTHALPY(MMBTU/HR)	-132.811	-132.811	0.00000

*** INPUT DATA ***

TWO PHASE TP FLASH		
SPECIFIED TEMPERATURE	F	68.0000
SPECIFIED PRESSURE	PSI	14.6959
MAXIMUM NO. ITERATIONS		30
CONVERGENCE TOLERANCE		0.000100000

*** RESULTS ***

OUTLET TEMPERATURE	F	68.000
OUTLET PRESSURE	PSI	14.696
HEAT DUTY	MMBTU/HR	0.0000
OUTLET VAPOR FRACTION		0.0000

ELEMENTS FUEL HHV-GAS HHV-LIQ HHV-POC

STREAM ID	ELEMENTS	FUEL	HHV-GAS	HHV-LIQ	HHV-POC
FROM :	DECOMP	$C-15	HHV-COND	HHV-COND	DUP
TO :	BURN	STP-COOL	----	----	HHV-COND
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	15.1748	15.1748	12.4382	11.7955	24.2337
MMBTU/HR	-69.5205	-132.8114	-95.6835	-155.5421	-132.8495
SUBSTREAM: MIXED					
PHASE:	MIXED	MISSING	VAPOR	LIQUID	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	565.2480	0.0	565.2480
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	206.0527	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	842.3279	0.0	0.0	1256.3469	1256.3469
H2	414.0189	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	565.2480	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	1.0000	0.0	0.3103
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.1016	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.4154	0.0	0.0	1.0000	0.6897
H2	0.2042	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.2788	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	12.4382	0.0	12.4382
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	3.2967	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	7.5874	0.0	0.0	11.3167	11.3167
H2	0.4173	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0

ELEMENTS FUEL HHV-GAS HHV-LIQ HHV-POC (CONTINUED)

STREAM ID	ELEMENTS	FUEL	HHV-GAS	HHV-LIQ	HHV-POC
CH4	0.0	0.0	0.0	0.0	0.0
C	3.3946	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	MISSING	0.0	0.0	0.0
CO2	0.0	MISSING	1.0000	0.0	0.5236
CACO3	0.0	MISSING	0.0	0.0	0.0
CAO	0.0	MISSING	0.0	0.0	0.0
CO	0.0	MISSING	0.0	0.0	0.0
O2	0.2243	MISSING	0.0	0.0	0.0
AR	0.0	MISSING	0.0	0.0	0.0
NO2	0.0	MISSING	0.0	0.0	0.0
NO	0.0	MISSING	0.0	0.0	0.0
H2O	0.5163	MISSING	0.0	1.0000	0.4764
H2	2.8396-02	MISSING	0.0	0.0	0.0
H2O-MUD	0.0	MISSING	0.0	0.0	0.0
CH4	0.0	MISSING	0.0	0.0	0.0
C	0.2310	MISSING	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	2027.6475	0.0	565.2480	1256.3469	1821.5948
TONS/HR	14.6960	0.0	12.4382	11.3167	23.7549
CUFT/HR	5.5990+05	0.0	2.1653+05	425.8305	6.4683+06
STATE VARIABLES:					
TEMP F	68.0000	MISSING	68.0000	68.0000	4402.6116
PRES PSI	14.6959	MISSING	14.6959	14.6959	14.6959
VFRAC	0.7212	MISSING	1.0000	0.0	1.0000
LFRAC	0.2788	MISSING	0.0	1.0000	0.0
SFRAC	0.0	MISSING	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-3.4285+04	MISSING	-1.6928+05	-1.2380+05	-7.3612+04
BTU/LB	-2365.1960	MISSING	-3846.3489	-6872.1091	-2822.4042
MMBTU/HR	-69.5179	MISSING	-95.6835	-155.5395	-134.0921
ENTROPY:					
BTU/LBMOL-R	-13.7106	MISSING	0.5157	-40.3480	17.7241
BTU/LB-R	-0.9458	MISSING	1.1718-02	-2.2397	0.6796
DENSITY:					
LBMOL/CUFT	3.6214-03	MISSING	2.6105-03	2.9503	2.8162-04
LB/CUFT	5.2495-02	MISSING	0.1149	53.1513	7.3450-03
AVG MW	14.4956	MISSING	44.0098	18.0153	26.0815

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	MISSING	MISSING	44.0098	MISSING	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	31.9988	MISSING	MISSING	MISSING	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

ELEMENTS FUEL HHV-GAS HHV-LIQ HHV-POC (CONTINUED)

STREAM ID	ELEMENTS	FUEL	HHV-GAS	HHV-LIQ	HHV-POC
H2O	18.0153	MISSING	MISSING	18.0153	18.0153
H2	2.0159	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	12.0110	MISSING	MISSING	MISSING	MISSING
MWMX	14.4956	MISSING	44.0098	18.0153	26.0815
QVALGRS BTU/LB	5526.5510	MISSING	0.0	1049.9837	500.2062
QVALNET BTU/LB	4718.0068	MISSING	0.0	0.0	0.0
*** VAPOR PHASE ***					
MUMX LB/FT-HR	2.2766-02	MISSING	3.4810-02	MISSING	0.1795
PR	0.4558	MISSING	0.6583	MISSING	0.5818
KMX BTU/HR-FT-R	2.4549-02	MISSING	1.0679-02	MISSING	0.1607
* 68.0000 F *					
VVSTD CUM/SEC					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	MISSING	MISSING	1.7132	MISSING	1.7132
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	0.6245	MISSING	MISSING	MISSING	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	2.5530	MISSING	MISSING	MISSING	3.8078
H2	1.2548	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	0.0	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	9391.5268	MISSING	3630.0212	MISSING	1.1698+04
SUBSTREAM: NC	STRUCTURE: NON CONVENTIONAL				
COMPONENTS: TONS/HR					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	15.1748	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.4788	0.0	0.0	0.4788	0.4788
COMPONENTS: MASS FRAC					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	1.0000	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	1.0000	0.0	0.0	1.0000	1.0000
TOTAL FLOW:					
TONS/HR	0.4788	15.1748	0.0	0.4788	0.4788
STATE VARIABLES:					
TEMP F	68.0000	68.0000	MISSING	68.0000	4402.6116
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959
VFRAC	0.0	0.0	MISSING	0.0	0.0
LFRAC	0.0	0.0	MISSING	0.0	0.0
SFRAC	1.0000	1.0000	MISSING	1.0000	1.0000

ELEMENTS FUEL HHV-GAS HHV-LIQ HHV-POC (CONTINUED)

STREAM ID	ELEMENTS	FUEL	HHV-GAS	HHV-LIQ	HHV-POC
ENTHALPY:					
BTU/LB	-2.7000	-4376.0584	MISSING	-2.7000	1297.6835
MMBTU/HR	-2.5853-03	-132.8114	MISSING	-2.5853-03	1.2426
DENSITY:					
LB/CUFT	187.2839	82.7971	MISSING	187.2839	187.2839
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
ULTANAL					
SULFANAL					
FUEL PROXANAL					
MOISTURE	MISSING	50.0000	MISSING	MISSING	MISSING
FC	MISSING	0.0	MISSING	MISSING	MISSING
VM	MISSING	0.0	MISSING	MISSING	MISSING
ASH	MISSING	6.3100	MISSING	MISSING	MISSING
ULTANAL					
ASH	MISSING	6.3100	MISSING	MISSING	MISSING
CARBON	MISSING	44.7400	MISSING	MISSING	MISSING
HYDROGEN	MISSING	5.5000	MISSING	MISSING	MISSING
NITROGEN	MISSING	0.0	MISSING	MISSING	MISSING
CHLORINE	MISSING	0.0	MISSING	MISSING	MISSING
SULFUR	MISSING	0.0	MISSING	MISSING	MISSING
OXYGEN	MISSING	43.4500	MISSING	MISSING	MISSING
SULFANAL					
PYRITIC	MISSING	0.0	MISSING	MISSING	MISSING
SULFATE	MISSING	0.0	MISSING	MISSING	MISSING
ORGANIC	MISSING	0.0	MISSING	MISSING	MISSING
TAR PROXANAL					
ULTANAL					
SULFANAL					
ASH GENANAL					
ELEM1	100.0000	MISSING	MISSING	100.0000	100.0000
ELEM2	0.0	MISSING	MISSING	0.0	0.0
ELEM3	0.0	MISSING	MISSING	0.0	0.0
ELEM4	0.0	MISSING	MISSING	0.0	0.0
ELEM5	0.0	MISSING	MISSING	0.0	0.0
ELEM6	0.0	MISSING	MISSING	0.0	0.0
ELEM7	0.0	MISSING	MISSING	0.0	0.0
ELEM8	0.0	MISSING	MISSING	0.0	0.0
ELEM9	0.0	MISSING	MISSING	0.0	0.0
ELEM10	0.0	MISSING	MISSING	0.0	0.0
ELEM11	0.0	MISSING	MISSING	0.0	0.0
ELEM12	0.0	MISSING	MISSING	0.0	0.0
ELEM13	0.0	MISSING	MISSING	0.0	0.0
ELEM14	0.0	MISSING	MISSING	0.0	0.0
ELEM15	0.0	MISSING	MISSING	0.0	0.0
ELEM16	0.0	MISSING	MISSING	0.0	0.0
ELEM17	0.0	MISSING	MISSING	0.0	0.0
ELEM18	0.0	MISSING	MISSING	0.0	0.0
ELEM19	0.0	MISSING	MISSING	0.0	0.0
ELEM20	0.0	MISSING	MISSING	0.0	0.0

LHV-GAS LHV-LIQ LHV-POC O2 POC

STREAM ID	LHV-GAS	LHV-LIQ	LHV-POC	O2	POC
FROM :	LHV-COND	LHV-COND	DUP	----	BURN
TO :	----	----	LHV-COND	BURN	DUP
CLASS:	MIXNC	MIXNC	MIXNC	MIXNC	MIXNC
TOTAL STREAM:					
TONS/HR	23.7549	0.4788	24.2337	9.0589	24.2337
MMBTU/HR	-226.4382	-2.5853-03	-132.8495	-3.8161-02	-132.8495
SUBSTREAM: MIXED					
PHASE:	VAPOR	MISSING	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	565.2480	0.0	565.2480	0.0	565.2480
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	566.2048	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1256.3469	0.0	1256.3469	0.0	1256.3469
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.3103	0.0	0.3103	0.0	0.3103
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	1.0000	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.6897	0.0	0.6897	0.0	0.6897
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	12.4382	0.0	12.4382	0.0	12.4382
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	9.0589	0.0
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	11.3167	0.0	11.3167	0.0	11.3167
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0

LHV-GAS LHV-LIQ LHV-POC O2 POC (CONTINUED)

STREAM ID	LHV-GAS	LHV-LIQ	LHV-POC	O2	POC
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	MISSING	0.0	0.0	0.0
CO2	0.5236	MISSING	0.5236	0.0	0.5236
CACO3	0.0	MISSING	0.0	0.0	0.0
CAO	0.0	MISSING	0.0	0.0	0.0
CO	0.0	MISSING	0.0	0.0	0.0
O2	0.0	MISSING	0.0	1.0000	0.0
AR	0.0	MISSING	0.0	0.0	0.0
NO2	0.0	MISSING	0.0	0.0	0.0
NO	0.0	MISSING	0.0	0.0	0.0
H2O	0.4764	MISSING	0.4764	0.0	0.4764
H2	0.0	MISSING	0.0	0.0	0.0
H2O-MUD	0.0	MISSING	0.0	0.0	0.0
CH4	0.0	MISSING	0.0	0.0	0.0
C	0.0	MISSING	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	1821.5948	0.0	1821.5948	566.2048	1821.5948
TONS/HR	23.7549	0.0	23.7549	9.0589	23.7549
CUFT/HR	6.9306+05	0.0	6.4683+06	2.1797+05	6.4683+06
STATE VARIABLES:					
TEMP F	68.0000	MISSING	4402.6116	68.0000	4402.6116
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959
VFRAC	1.0000	MISSING	1.0000	1.0000	1.0000
LFRAC	0.0	MISSING	0.0	0.0	0.0
SFRAC	0.0	MISSING	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-1.2431+05	MISSING	-7.3612+04	-67.3973	-7.3612+04
BTU/LB	-4766.1265	MISSING	-2822.4042	-2.1062	-2822.4042
MMBTU/HR	-226.4382	MISSING	-134.0921	-3.8161-02	-134.0921
ENTROPY:					
BTU/LBMOL-R	-6.0433	MISSING	17.7241	-0.1249	17.7241
BTU/LB-R	-0.2317	MISSING	0.6796	-3.9044-03	0.6796
DENSITY:					
LBMOL/CUFT	2.6284-03	MISSING	2.8162-04	2.5976-03	2.8162-04
LB/CUFT	6.8551-02	MISSING	7.3450-03	8.3119-02	7.3450-03
AVG MW	26.0815	MISSING	26.0815	31.9988	26.0815

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	44.0098	MISSING	44.0098	MISSING	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	MISSING	MISSING	MISSING	31.9988	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING

LHV-GAS LHV-LIQ LHV-POC O2 POC (CONTINUED)

STREAM ID	LHV-GAS	LHV-LIQ	LHV-POC	O2	POC
H2O	18.0153	MISSING	18.0153	MISSING	18.0153
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	26.0815	MISSING	26.0815	31.9988	26.0815
QVALGRS BTU/LB	500.2062	MISSING	500.2062	0.0	500.2062
QVALNET BTU/LB	0.0	MISSING	0.0	0.0	0.0
*** VAPOR PHASE ***					
MUMX LB/FT-HR	2.0583-02	MISSING	0.1795	4.9854-02	0.1795
PR	0.5864	MISSING	0.5818	0.6946	0.5818
KMX BTU/HR-FT-R	1.1254-02	MISSING	0.1607	1.5744-02	0.1607
* 68.0000 F *					
VVSTD CUM/SEC					
N2	MISSING	MISSING	MISSING	MISSING	MISSING
CO2	1.7132	MISSING	1.7132	MISSING	1.7132
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	MISSING	MISSING	MISSING	1.7161	MISSING
AR	MISSING	MISSING	MISSING	MISSING	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	3.8078	MISSING	3.8078	MISSING	3.8078
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *					
VVSTDMX CUFT/MIN	1.1698+04	MISSING	1.1698+04	3636.1657	1.1698+04
SUBSTREAM: NC	STRUCTURE: NON CONVENTIONAL				
COMPONENTS: TONS/HR					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	0.0	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	0.4788	0.4788	0.0	0.4788
COMPONENTS: MASS FRAC					
CHAR	0.0	0.0	0.0	0.0	0.0
FUEL	0.0	0.0	0.0	0.0	0.0
TAR	0.0	0.0	0.0	0.0	0.0
ASH	0.0	1.0000	1.0000	0.0	1.0000
TOTAL FLOW:					
TONS/HR	0.0	0.4788	0.4788	0.0	0.4788
STATE VARIABLES:					
TEMP F	MISSING	68.0000	4402.6116	MISSING	4402.6116
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959
VFRAC	MISSING	0.0	0.0	MISSING	0.0
LFRAC	MISSING	0.0	0.0	MISSING	0.0
SFRAC	MISSING	1.0000	1.0000	MISSING	1.0000

LHV-GAS LHV-LIQ LHV-POC O2 POC (CONTINUED)

STREAM ID	LHV-GAS	LHV-LIQ	LHV-POC	O2	POC
ENTHALPY:					
BTU/LB	MISSING	-2.7000	1297.6835	MISSING	1297.6835
MMBTU/HR	MISSING	-2.5853-03	1.2426	MISSING	1.2426
DENSITY:					
LB/CUFT	MISSING	187.2839	187.2839	MISSING	187.2839
AVG MW	1.0000	1.0000	1.0000	1.0000	1.0000
COMPONENT ATTRIBUTES:					
CHAR PROXANAL					
ULTANAL					
SULFANAL					
FUEL PROXANAL					
ULTANAL					
SULFANAL					
TAR PROXANAL					
ULTANAL					
SULFANAL					
ASH GENANAL					
ELEM1	MISSING	100.0000	100.0000	MISSING	100.0000
ELEM2	MISSING	0.0	0.0	MISSING	0.0
ELEM3	MISSING	0.0	0.0	MISSING	0.0
ELEM4	MISSING	0.0	0.0	MISSING	0.0
ELEM5	MISSING	0.0	0.0	MISSING	0.0
ELEM6	MISSING	0.0	0.0	MISSING	0.0
ELEM7	MISSING	0.0	0.0	MISSING	0.0
ELEM8	MISSING	0.0	0.0	MISSING	0.0
ELEM9	MISSING	0.0	0.0	MISSING	0.0
ELEM10	MISSING	0.0	0.0	MISSING	0.0
ELEM11	MISSING	0.0	0.0	MISSING	0.0
ELEM12	MISSING	0.0	0.0	MISSING	0.0
ELEM13	MISSING	0.0	0.0	MISSING	0.0
ELEM14	MISSING	0.0	0.0	MISSING	0.0
ELEM15	MISSING	0.0	0.0	MISSING	0.0
ELEM16	MISSING	0.0	0.0	MISSING	0.0
ELEM17	MISSING	0.0	0.0	MISSING	0.0
ELEM18	MISSING	0.0	0.0	MISSING	0.0
ELEM19	MISSING	0.0	0.0	MISSING	0.0
ELEM20	MISSING	0.0	0.0	MISSING	0.0

STP

STREAM ID	STP
FROM :	STP-COOL
TO :	DECOMP
CLASS:	MIXNC
TOTAL STREAM:	
TONS/HR	15.1748
MMBTU/HR	-132.8114
SUBSTREAM: NC	STRUCTURE: NON CONVENTIONAL
COMPONENTS: TONS/HR	
CHAR	0.0
FUEL	15.1748
TAR	0.0
ASH	0.0
COMPONENTS: MASS FRAC	
CHAR	0.0
FUEL	1.0000
TAR	0.0
ASH	0.0
TOTAL FLOW:	
TONS/HR	15.1748
STATE VARIABLES:	
TEMP F	68.0000
PRES PSI	14.6959
VFRAC	0.0
LFRAC	0.0
SFRAC	1.0000
ENTHALPY:	
BTU/LB	-4376.0584
MMBTU/HR	-132.8114
DENSITY:	
LB/CUFT	82.7971
AVG MW	1.0000
COMPONENT ATTRIBUTES:	
CHAR PROXANAL	
ULTANAL	
SULFANAL	
FUEL PROXANAL	

```
          MOISTURE     50.0000
          FC            0.0
          VM            0.0
          ASH           6.3100
        ULTANAL
          ASH           6.3100
          CARBON       44.7400
          HYDROGEN      5.5000
          NITROGEN      0.0
          CHLORINE      0.0
          SULFUR        0.0
          OXYGEN       43.4500
        SULFANAL
          PYRITIC       0.0
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                   HOG FUEL GASIFICATION PROJECT CASE A
                    STREAM SECTION (HIERARCHY: FUEL-HHV)

STP (CONTINUED)

STREAM ID               STP

          SULFATE       0.0
          ORGANIC       0.0
TAR     PROXANAL
        ULTANAL
        SULFANAL
ASH     GENANAL
 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                     09/27/2007  PAGE 128
                   HOG FUEL GASIFICATION PROJECT CASE A
                    STREAM SECTION (HIERARCHY: FUEL-HHV)

HEAT
----

STREAM ID               HEAT
FROM :                  DECOMP
TO   :                  BURN
CLASS:                  HEAT

STREAM ATTRIBUTES:
HEAT
Q       MMBTU/HR       -63.2909
TBEG     F              68.0000
TEND     F              68.0000
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                   HOG FUEL GASIFICATION PROJECT CASE A
                   FLOWSHEET SECTION (HIERARCHY: GAS-HHV)

FLOWSHEET CONNECTIVITY BY STREAMS
---------------------------------

FLOWSHEET SECTION GAS-HHV
  STREAM     SOURCE     DEST           STREAM     SOURCE     DEST
  O2-DRY     ----       BURN-DRY       GAS        $C-1       STP-COOL
  O2-WET     ----       BURN-WET       POC-LHVD   DUP-DRY    LHVCONDD
  POC-HHVD   DUP-DRY    HHVCONDD       HHV-LIQD   HHVCONDD   ----
  HHV-GASD   HHVCONDD   ----           POC-DRY    BURN-DRY   DUP-DRY
  GAS-H2O    H2O-SEP    ----           DRY-GAS    H2O-SEP    BURN-DRY
  WETGAS-1   DUP-MAIN   BURN-WET       WETGAS-2   DUP-MAIN   H2O-SEP
  STP-GAS    STP-COOL   DUP-MAIN       POC-WET    BURN-WET   DUP-WET
  POC-HHVW   DUP-WET    HHVCONDW       POC-LHVW   DUP-WET    LHVCONDW
  HHV-LIQW   HHVCONDW   ----           HHV-GASW   HHVCONDW   ----
  LHV-GASD   LHVCONDD   ----           LHV-GASW   LHVCONDW   ----

FLOWSHEET CONNECTIVITY BY BLOCKS
```

```
--------------------------------

FLOWSHEET SECTION GAS-HHV
  BLOCK      INLETS                                OUTLETS
  DUP-DRY    POC-DRY                               POC-LHVD POC-HHVD
  HHVCONDD   POC-HHVD                              HHV-LIQD HHV-GASD
  BURN-DRY   DRY-GAS O2-DRY                        POC-DRY
  H2O-SEP    WETGAS-2                              GAS-H2O DRY-GAS
  DUP-MAIN   STP-GAS                               WETGAS-1 WETGAS-2
  STP-COOL   GAS                                   STP-GAS
  BURN-WET   O2-WET WETGAS-1                       POC-WET
  DUP-WET    POC-WET                               POC-HHVW POC-LHVW
  HHVCONDW   POC-HHVW                              HHV-LIQW HHV-GASW
  LHVCONDD   POC-LHVD                              LHV-GASD
  LHVCONDW   POC-LHVW                              LHV-GASW

DESIGN-SPEC:  O2-DRY
--------------------

  SAMPLED VARIABLES:
    O2NEED   : PROPERTY STRMPROP COMB-O2 IN STREAM WETGAS-1
    O2FLOW   : O2 MOLEFLOW IN STREAM O2-WET SUBSTREAM MIXED

  SPECIFICATION:
    MAKE O2FLOW APPROACH 1.00001*O2NEED
    WITHIN          0.100000-04

  MANIPULATED VARIABLES:
    VARY     : TOTAL MOLEFLOW IN STREAM O2-WET SUBSTREAM MIXED
    LOWER LIMIT =           100.000                      LBMOL/HR
    UPPER LIMIT =       900,000.                         LBMOL/HR
    FINAL VALUE =           404.183                      LBMOL/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE       VALUE AT START      FINAL VALUE     UNITS
                      OF LOOP
    --------      -------------       -----------     -----
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                   HOG FUEL GASIFICATION PROJECT CASE A
                   FLOWSHEET SECTION (HIERARCHY: GAS-HHV)

DESIGN-SPEC:  O2-DRY (CONTINUED)
    O2NEED         404.179            404.179         LBMOL/HR
    O2FLOW         23438.4            404.183         LBMOL/HR

DESIGN-SPEC:  O2-WET
--------------------

  SAMPLED VARIABLES:
    O2NEED   : PROPERTY STRMPROP COMB-O2 IN STREAM DRY-GAS
    O2FLOW   : O2 MOLEFLOW IN STREAM O2-DRY SUBSTREAM MIXED

  SPECIFICATION:
    MAKE O2FLOW APPROACH 1.00001*O2NEED
    WITHIN          0.100000-04

  MANIPULATED VARIABLES:
    VARY     : TOTAL MOLEFLOW IN STREAM O2-DRY SUBSTREAM MIXED
    LOWER LIMIT =           100.000                      LBMOL/HR
    UPPER LIMIT =       900,000.                         LBMOL/HR
    FINAL VALUE =           404.183                      LBMOL/HR

  VALUES OF ACCESSED FORTRAN VARIABLES:
    VARIABLE       VALUE AT START      FINAL VALUE     UNITS
                      OF LOOP
    --------      -------------       -----------     -----
```

```
    O2NEED         404.179            404.179         LBMOL/HR
    O2FLOW         23438.4            404.183         LBMOL/HR

FLOWSHEET SECTION BALANCE:  GAS-HHV
-----------------------------------

                     ***  MASS AND ENERGY BALANCE  ***
                                     IN            OUT          RELATIVE DIFF.
   CONVENTIONAL COMPONENTS (LBMOL/HR)
       N2                         497.519        1990.08         -0.750000
       CO2                        105.040        2148.77         -0.951116
       CACO3                      0.00000        0.00000          0.00000
       CAO                        0.00000        0.00000          0.00000
       CO                         429.159        0.00000          1.00000
       O2                         808.989      0.161671E-01       0.999980
       AR                         5.99344        23.9737         -0.750000
       NO2                        0.00000        0.00000          0.00000
       NO                         0.00000        0.00000          0.00000
       H2O                        132.737        1896.03         -0.929992
       H2                         374.381        0.00000          1.00000
       H2O-MUD                    0.00000        0.00000          0.00000
       CH4                      0.369641E-01     0.00000          1.00000
       C                          2.95798        0.00000          1.00000
   TOTAL BALANCE
       MOLE(LBMOL/HR)             2356.81        6058.87         -0.611015
       MASS(TONS/HR  )            29.9446        92.7159         -0.677029
       ENTHALPY(MMBTU/HR)        -45.9407       -581.201          0.920956
 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                     09/27/2007  PAGE 131
                   HOG FUEL GASIFICATION PROJECT CASE A
                  U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  BURN-DRY MODEL: RSTOIC
------------------------------
   INLET STREAMS:          DRY-GAS      O2-DRY
   OUTLET STREAM:          POC-DRY
   PROPERTY OPTION SET:    PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                              IN           OUT      GENERATION   RELATIVE DIFF.
   TOTAL BALANCE
   MOLE(LBMOL/HR)          1819.89       1415.16     -404.728      0.124938E-15
   MASS(TONS/HR )          22.2822       22.2822                    0.00000
   ENTHALPY(MMBTU/HR)     -38.1897      -38.1897                    0.00000

                          ***  INPUT DATA  ***


   TWO    PHASE  PQ  FLASH
   SPECIFIED PRESSURE    PSI                                   14.6959
   SPECIFIED HEAT DUTY   MMBTU/HR                               0.0
   MAXIMUM NO. ITERATIONS                                      30
   CONVERGENCE TOLERANCE                                        0.000100000
   SIMULTANEOUS REACTIONS
   GENERATE COMBUSTION REACTIONS FOR FEED SPECIES              YES
   COMBUSTION PRODUCT FOR CHEMICALLY BOUND NITROGEN            NO2

                          ***  RESULTS  ***
   OUTLET TEMPERATURE    F                                       5851.1
   OUTLET PRESSURE       PSI                                     14.696
   VAPOR FRACTION                                                1.0000

 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                     09/27/2007  PAGE 132
                   HOG FUEL GASIFICATION PROJECT CASE A
                  U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)
```

```
BLOCK:  BURN-DRY MODEL: RSTOIC (CONTINUED)

  COMBUSTION REACTIONS:

     RXN NO    STOICHIOMETRY

     C1        CO + 0.5 O2 --> CO2
     C2        0.5 O2 + NO --> NO2
     C3        0.5 O2 + H2 --> H2O
     C4        2 O2 + CH4 --> CO2 + 2 H2O
     C5        O2 + C --> CO2


  REACTION EXTENTS:

     REACTION          REACTION
     NUMBER            EXTENT
                       LBMOL/HR
     C1                 429.16
     C3                 374.38
     C4                 0.36964E-01
     C5                 2.9580

  V-L PHASE EQUILIBRIUM :

     COMP            F(I)           X(I)           Y(I)            K(I)
     N2              0.35156        0.35156        0.35156         MISSING
     CO2             0.37960        0.37960        0.37960         MISSING
     O2              0.28561E-05    0.28561E-05    0.28561E-05     MISSING
     AR              0.42351E-02    0.42351E-02    0.42351E-02     MISSING
     H2O             0.26460        0.26460        0.26460         MISSING
BLOCK:  BURN-WET MODEL: RSTOIC
------------------------------
   INLET STREAMS:          O2-WET       WETGAS-1
   OUTLET STREAM:          POC-WET
   PROPERTY OPTION SET:    PR-BM      PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                              IN           OUT      GENERATION   RELATIVE DIFF.
   TOTAL BALANCE
   MOLE(LBMOL/HR)          1952.63       1547.90     -404.728      0.116445E-15
   MASS(TONS/HR )          23.4779       23.4779                    0.00000
   ENTHALPY(MMBTU/HR)     -53.6129      -53.6129                    0.00000

                          ***  INPUT DATA  ***

 ASPEN PLUS   PLAT: WIN32    VER: 20.0 1                     09/27/2007  PAGE 133
                   HOG FUEL GASIFICATION PROJECT CASE A
                  U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  BURN-WET MODEL: RSTOIC (CONTINUED)
   TWO    PHASE  PQ  FLASH
   SPECIFIED PRESSURE    PSI                                   14.6959
   SPECIFIED HEAT DUTY   MMBTU/HR                               0.0
   MAXIMUM NO. ITERATIONS                                      30
   CONVERGENCE TOLERANCE                                        0.000100000
   SIMULTANEOUS REACTIONS
   GENERATE COMBUSTION REACTIONS FOR FEED SPECIES              YES
   COMBUSTION PRODUCT FOR CHEMICALLY BOUND NITROGEN            NO2

                          ***  RESULTS  ***
   OUTLET TEMPERATURE    F                                       5309.0
   OUTLET PRESSURE       PSI                                     14.696
```

```
 VAPOR FRACTION                                               1.0000


 COMBUSTION REACTIONS:

    RXN NO    STOICHIOMETRY

    C1        CO + 0.5 O2 --> CO2
    C2        0.5 O2 + NO --> NO2
    C3        0.5 O2 + H2 --> H2O
    C4        2 O2 + CH4 --> CO2 + 2 H2O
    C5        O2 + C --> CO2


 REACTION EXTENTS:

    REACTION           REACTION
    NUMBER             EXTENT
                       LBMOL/HR
    C1                  429.16
    C3                  374.38
    C4                 0.36964E-01
    C5                  2.9580

 V-L PHASE EQUILIBRIUM :

    COMP              F(I)          X(I)          Y(I)          K(I)
    N2              0.32141       0.32141       0.32141       MISSING
    CO2             0.34705       0.34705       0.34705       MISSING
    O2              0.26111E-05   0.26111E-05   0.26111E-05   MISSING
    AR              0.38720E-02   0.38720E-02   0.38720E-02   MISSING
    H2O             0.32766       0.32766       0.32766       MISSING
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                09/27/2007  PAGE 134
                  HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  DUP-DRY  MODEL: DUPL
----------------------------
 INLET STREAM:            POC-DRY
 OUTLET STREAMS:          POC-LHVD    POC-HHVD

BLOCK:  DUP-MAIN MODEL: DUPL
----------------------------
 INLET STREAM:            STP-GAS
 OUTLET STREAMS:          WETGAS-1    WETGAS-2

BLOCK:  DUP-WET  MODEL: DUPL
----------------------------
 INLET STREAM:            POC-WET
 OUTLET STREAMS:          POC-HHVW    POC-LHVW

BLOCK:  H2O-SEP  MODEL: SEP
---------------------------
 INLET STREAM:            WETGAS-2
 OUTLET STREAMS:          GAS-H2O     DRY-GAS
 PROPERTY OPTION SET:     PR-BM       PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                     IN              OUT        RELATIVE DIFF.
   TOTAL BALANCE
     MOLE(LBMOL/HR)              1548.45          1548.45         0.00000
     MASS(TONS/HR )              17.0112          17.0112         0.208845E-15
     ENTHALPY(MMBTU/HR)         -53.5873         -54.5974         0.185009E-01
```

```
                         ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM GAS-H2O
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  LIQUID
 SPECIFIED TEMPERATURE F                                       68.0000
 SPECIFIED PRESSURE    PSI                                     14.6959
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000
ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                  09/27/2007  PAGE 135
                  HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  H2O-SEP  MODEL: SEP (CONTINUED)

 FLASH SPECS FOR STREAM DRY-GAS
 TWO    PHASE  TP  FLASH
 PRESSURE DROP         PSI                                      0.0
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= GAS-H2O   CPT= H2O       FRACTION=                1.00000
                            H2                                 0.0
                            O2                                 0.0
                            AR                                 0.0
                            N2                                 0.0
                            NO                                 0.0
                            NO2                                0.0
                            CO                                 0.0
                            CO2                                0.0

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                              -1.0101

 COMPONENT = N2
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = CO2
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = CO
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = O2
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = AR
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = H2O
   STREAM     SUBSTREAM    SPLIT FRACTION
   GAS-H2O    MIXED                1.00000

 COMPONENT = H2
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                  09/27/2007  PAGE 136
```

```
                  HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  H2O-SEP  MODEL: SEP (CONTINUED)

 COMPONENT = CH4
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

 COMPONENT = C
   STREAM     SUBSTREAM    SPLIT FRACTION
   DRY-GAS    MIXED                1.00000

BLOCK:  HHVCONDD MODEL: SEP
---------------------------
 INLET STREAM:            POC-HHVD
 OUTLET STREAMS:          HHV-LIQD    HHV-GASD
 PROPERTY OPTION SET:     PR-BM       PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                     IN              OUT        RELATIVE DIFF.
   TOTAL BALANCE
     MOLE(LBMOL/HR)              1415.16          1415.16         0.00000
     MASS(TONS/HR )              22.2822          22.2822         0.159441E-15
     ENTHALPY(MMBTU/HR)         -38.1897         -137.325         0.721903

                         ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM HHV-LIQD
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  LIQUID
 SPECIFIED TEMPERATURE F                                  68.0000
 SPECIFIED PRESSURE    PSI                                14.6959
 MAXIMUM NO. ITERATIONS                                   30
 CONVERGENCE TOLERANCE                                     0.000100000

 FLASH SPECS FOR STREAM HHV-GASD
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  VAPOR
 SPECIFIED TEMPERATURE F                                  68.0000
 SPECIFIED PRESSURE    PSI                                14.6959
 MAXIMUM NO. ITERATIONS                                   30
 CONVERGENCE TOLERANCE                                     0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= HHV-LIQD  CPT= H2O       FRACTION=           1.00000
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                09/27/2007  PAGE 137
                  HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  HHVCONDD MODEL: SEP (CONTINUED)

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                          -99.135

 COMPONENT = N2
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASD   MIXED                1.00000

 COMPONENT = CO2
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASD   MIXED                1.00000

 COMPONENT = O2
```

```
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASD   MIXED                1.00000

 COMPONENT = AR
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASD   MIXED                1.00000

 COMPONENT = H2O
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-LIQD   MIXED                1.00000

BLOCK:  HHVCONDW MODEL: SEP
---------------------------
 INLET STREAM:            POC-HHVW
 OUTLET STREAMS:          HHV-LIQW    HHV-GASW
 PROPERTY OPTION SET:     PR-BM       PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                     IN              OUT        RELATIVE DIFF.
   TOTAL BALANCE
     MOLE(LBMOL/HR)              1547.90          1547.90         0.00000
     MASS(TONS/HR )              23.4779          23.4779         0.00000
     ENTHALPY(MMBTU/HR)         -53.6129         -153.758         0.651317
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                  HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GAS-HHV)

BLOCK:  HHVCONDW MODEL: SEP (CONTINUED)

                         ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM HHV-LIQW
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  LIQUID
 SPECIFIED TEMPERATURE F                                       68.0000
 SPECIFIED PRESSURE    PSI                                     14.6959
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FLASH SPECS FOR STREAM HHV-GASW
 ONE    PHASE  TP  FLASH   SPECIFIED PHASE IS  VAPOR
 SPECIFIED TEMPERATURE F                                       68.0000
 SPECIFIED PRESSURE    PSI                                     14.6959
 MAXIMUM NO. ITERATIONS                                        30
 CONVERGENCE TOLERANCE                                          0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= HHV-LIQW  CPT= H2O       FRACTION=                1.00000

                          ***  RESULTS  ***

 HEAT DUTY              MMBTU/HR                              -100.15

 COMPONENT = N2
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASW   MIXED                1.00000

 COMPONENT = CO2
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASW   MIXED                1.00000

 COMPONENT = O2
   STREAM     SUBSTREAM    SPLIT FRACTION
   HHV-GASW   MIXED                1.00000
```

COMPONENT = AR

STREAM	SUBSTREAM	SPLIT FRACTION
HHV-GASW	MIXED	1.00000

COMPONENT = H2O

STREAM	SUBSTREAM	SPLIT FRACTION
HHV-LIQW	MIXED	1.00000

BLOCK: LHVCONDD MODEL: HEATER

INLET STREAM: POC-LHVD
OUTLET STREAM: LHV-GASD
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	1415.16	1415.16	0.00000
MASS(TONS/HR)	22.2822	22.2822	0.00000
ENTHALPY(MMBTU/HR)	-38.1897	-129.935	0.706087

*** INPUT DATA ***

ONE PHASE TP FLASH SPECIFIED PHASE IS VAPOR
SPECIFIED TEMPERATURE F 68.0000
SPECIFIED PRESSURE PSI 14.6959
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 68.000
OUTLET PRESSURE PSI 14.696
HEAT DUTY MMBTU/HR -91.746

PRESSURE-DROP CORRELATION PARAMETER 0.0000

BLOCK: LHVCONDW MODEL: HEATER

INLET STREAM: POC-LHVW
OUTLET STREAM: LHV-GASW
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	1547.90	1547.90	0.00000
MASS(TONS/HR)	23.4779	23.4779	0.00000
ENTHALPY(MMBTU/HR)	-53.6129	-143.749	0.627039

BLOCK: LHVCONDW MODEL: HEATER (CONTINUED)

*** INPUT DATA ***

ONE PHASE TP FLASH SPECIFIED PHASE IS VAPOR
SPECIFIED TEMPERATURE F 68.0000
SPECIFIED PRESSURE PSI 14.6959
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

*** RESULTS ***

OUTLET TEMPERATURE F 68.000
OUTLET PRESSURE PSI 14.696
HEAT DUTY MMBTU/HR -90.137

PRESSURE-DROP CORRELATION PARAMETER 0.0000

BLOCK: STP-COOL MODEL: HEATER

INLET STREAM: GAS
OUTLET STREAM: STP-GAS
PROPERTY OPTION SET: PR-BM PENG-ROBINSON EQUATION OF STATE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
TOTAL BALANCE			
MOLE(LBMOL/HR)	1548.45	1548.45	0.00000
MASS(TONS/HR)	17.0112	17.0112	0.00000
ENTHALPY(MMBTU/HR)	-45.8895	-53.5873	0.143650

*** INPUT DATA ***

TWO PHASE TP FLASH
SPECIFIED TEMPERATURE F 68.0000
SPECIFIED PRESSURE PSI 14.6959
MAXIMUM NO. ITERATIONS 30
CONVERGENCE TOLERANCE 0.000100000

BLOCK: STP-COOL MODEL: HEATER (CONTINUED)

*** RESULTS ***

OUTLET TEMPERATURE F 68.000
OUTLET PRESSURE PSI 14.696
HEAT DUTY MMBTU/HR -7.6978
OUTLET VAPOR FRACTION 0.93222
PRESSURE-DROP CORRELATION PARAMETER 311.40

V-L PHASE EQUILIBRIUM :

COMP	F(I)	X(I)	Y(I)	K(I)
N2	0.32130	0.12889E-08	0.34466	0.26741E+09
CO2	0.67835E-01	0.68574E-06	0.72767E-01	0.10612E+06
CO	0.27715	0.11467E-08	0.29730	0.25927E+09
O2	0.40260E-03	0.95899E-10	0.43187E-03	0.45033E+07
AR	0.38706E-02	0.84400E-09	0.41520E-02	0.49195E+07
H2O	0.85723E-01	0.97181	0.21299E-01	0.21917E-01
H2	0.24178	0.65272E-08	0.25936	0.39735E+08
CH4	0.23872E-04	0.11983E-11	0.25607E-04	0.21370E+08
C	0.19103E-02	0.28185E-01	0.92700E-42	0.33128E-40

DRY-GAS GAS GAS-H2O HHV-GASD HHV-GASW

STREAM ID	DRY-GAS	GAS	GAS-H2O	HHV-GASD	HHV-GASW
FROM :	H2O-SEP	$C-1	H2O-SEP	HHVCONDD	HHVCONDW
TO :	BURN-DRY	STP-COOL	----	----	----
SUBSTREAM: MIXED					
PHASE:	MIXED	MIXED	LIQUID	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	497.5189	497.5189	0.0	497.5189	497.5189
CO2	105.0396	105.0396	0.0	537.1936	537.1936
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	429.1590	429.1590	0.0	0.0	0.0
O2	0.6234	0.6234	0.0	4.0418-03	4.0418-03
AR	5.9934	5.9934	0.0	5.9934	5.9934
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	132.7372	132.7372	0.0	0.0
H2	374.3811	374.3811	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	3.6964-02	3.6964-02	0.0	0.0	0.0
C	2.9580	2.9580	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.3514	0.3213	0.0	0.4781	0.4781
CO2	7.4196-02	6.7835-02	0.0	0.5162	0.5162
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.3031	0.2772	0.0	0.0	0.0
O2	4.4034-04	4.0260-04	0.0	3.8837-06	3.8837-06
AR	4.2335-03	3.8706-03	0.0	5.7590-03	5.7590-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	8.5723-02	1.0000	0.0	0.0
H2	0.2644	0.2418	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	2.6110-05	2.3872-05	0.0	0.0	0.0
C	2.0894-03	1.9103-03	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	6.9686	6.9686	0.0	6.9686	6.9686
CO2	2.3114	2.3114	0.0	11.8209	11.8209
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	6.0105	6.0105	0.0	0.0	0.0
O2	9.9740-03	9.9740-03	0.0	6.4666-05	6.4666-05
AR	0.1197	0.1197	0.0	0.1197	0.1197
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	1.1956	1.1956	0.0	0.0
H2	0.3774	0.3774	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	2.9650-04	2.9650-04	0.0	0.0	0.0
C	1.7764-02	1.7764-02	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.4406	0.4096	0.0	0.3685	0.3685

DRY-GAS GAS GAS-H2O HHV-GASD HHV-GASW (CONTINUED)

STREAM ID	DRY-GAS	GAS	GAS-H2O	HHV-GASD	HHV-GASW
CO2	0.1461	0.1359	0.0	0.6251	0.6251
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.3800	0.3533	0.0	0.0	0.0
O2	6.3065-04	5.8632-04	0.0	3.4198-06	3.4198-06
AR	7.5693-03	7.0373-03	0.0	6.3309-03	6.3309-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	7.0286-02	1.0000	0.0	0.0
H2	2.3860-02	2.2183-02	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	1.8748-05	1.7430-05	0.0	0.0	0.0
C	1.1232-03	1.0443-03	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	1415.7104	1548.4476	132.7372	1040.7099	1040.7099
TONS/HR	15.8156	17.0112	1.1956	18.9093	18.9093
CUFT/HR	5.4416+05	1.1016+06	44.9904	3.9995+05	3.9995+05
STATE VARIABLES:					
TEMP F	68.0000	600.0000	68.0000	68.0000	68.0000
PRES PSI	14.6959	15.9581	14.6959	14.6959	14.6959
VFRAC	0.9979	0.9981	0.0	1.0000	1.0000
LFRAC	2.0894-03	1.9103-03	1.0000	0.0	0.0
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-2.6958+04	-2.9636+04	-1.2380+05	-8.7408+04	-8.7408+04
BTU/LB	-1206.5361	-1348.8004	-6872.1091	-2405.3345	-2405.3345
MMBTU/HR	-38.1641	-45.8895	-16.4333	-90.9663	-90.9663
ENTROPY:					
BTU/LBMOL-R	8.8908	12.7609	-40.3480	1.6456	1.6456
BTU/LB-R	0.3979	0.5808	-2.2397	4.5286-02	4.5286-02
DENSITY:					
LBMOL/CUFT	2.6016-03	1.4056-03	2.9503	2.6021-03	2.6021-03
LB/CUFT	5.8128-02	3.0884-02	53.1513	9.4558-02	9.4558-02
AVG MW	22.3429	21.9720	18.0153	36.3392	36.3392

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	28.0135	28.0135	MISSING	28.0135	28.0135
CO2	44.0098	44.0098	MISSING	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	28.0104	28.0104	MISSING	MISSING	MISSING
O2	31.9988	31.9988	MISSING	31.9988	31.9988
AR	39.9480	39.9480	MISSING	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	MISSING	18.0153	18.0153	MISSING	MISSING
H2	2.0159	2.0159	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	16.0428	16.0428	MISSING	MISSING	MISSING

DRY-GAS GAS GAS-H2O HHV-GASD HHV-GASW (CONTINUED)

STREAM ID	DRY-GAS	GAS	GAS-H2O	HHV-GASD	HHV-GASW
C	12.0110	12.0110	MISSING	MISSING	MISSING
MWMX	22.3429	21.9720	18.0153	36.3392	36.3392

HHV-LIQD HHV-LIQW LHV-GASD LHV-GASW O2-DRY

STREAM ID	HHV-LIQD	HHV-LIQW	LHV-GASD	LHV-GASW	O2-DRY
FROM :	HHVCONDD	HHVCONDW	LHVCONDD	LHVCONDW	----
TO :	----	----	----	----	BURN-DRY
SUBSTREAM: MIXED					
PHASE:	LIQUID	LIQUID	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	497.5189	497.5189	0.0
CO2	0.0	0.0	537.1936	537.1936	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	4.0418-03	4.0418-03	404.1826
AR	0.0	0.0	5.9934	5.9934	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	374.4550	507.1922	374.4550	507.1922	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.3516	0.3214	0.0
CO2	0.0	0.0	0.3796	0.3470	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	2.8561-06	2.6111-06	1.0000
AR	0.0	0.0	4.2351-03	3.8720-03	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1.0000	1.0000	0.2646	0.3277	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	6.9686	6.9686	0.0
CO2	0.0	0.0	11.8209	11.8209	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	6.4666-05	6.4666-05	6.4667
AR	0.0	0.0	0.1197	0.1197	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	3.3730	4.5686	3.3730	4.5686	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	0.0	0.3127	0.2968	0.0

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: GAS-HHV)

HHV-LIQD HHV-LIQW LHV-GASD LHV-GASW O2-D (CONTINUED)

STREAM ID	HHV-LIQD	HHV-LIQW	LHV-GASD	LHV-GASW	O2-DRY
CO2	0.0	0.0	0.5305	0.5035	0.0
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	0.0	0.0	2.9021-06	2.7543-06	1.0000
AR	0.0	0.0	5.3726-03	5.0990-03	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1.0000	1.0000	0.1514	0.1946	0.0
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	374.4550	507.1922	1415.1649	1547.9021	404.1826
TONS/HR	3.3730	4.5686	22.2822	23.4779	6.4667
CUFT/HR	126.9191	171.9095	5.4241+05	5.9285+05	2.2886+06
STATE VARIABLES:					
TEMP F	68.0000	68.0000	68.0000	68.0000	68.0000
PRES PSI	14.6959	14.6959	14.6959	14.6959	1.0000
VFRAC	0.0	0.0	1.0000	1.0000	1.0000
LFRAC	1.0000	1.0000	0.0	0.0	0.0
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-1.2380+05	-1.2380+05	-9.1816+04	-9.2867+04	-63.3549
BTU/LB	-6872.1091	-6872.1091	-2915.6693	-3061.3784	-1.9799
MMBTU/HR	-46.3586	-62.7919	-129.9353	-143.7494	-2.5607-02
ENTROPY:					
BTU/LBMOL-R	-40.3480	-40.3480	-0.4923	-1.1669	5.2182
BTU/LB-R	-2.2397	-2.2397	-1.5632-02	-3.8467-02	0.1631
DENSITY:					
LBMOL/CUFT	2.9503	2.9503	2.6090-03	2.6110-03	1.7661-04
LB/CUFT	53.1513	53.1513	8.2160-02	7.9204-02	5.6512-03
AVG MW	18.0153	18.0153	31.4907	30.3351	31.9988

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	MISSING	MISSING	28.0135	28.0135	MISSING
CO2	MISSING	MISSING	44.0098	44.0098	MISSING
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	MISSING	MISSING	31.9988	31.9988	31.9988
AR	MISSING	MISSING	39.9480	39.9480	MISSING
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	18.0153	18.0153	18.0153	18.0153	MISSING
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: GAS-HHV)

HHV-LIQD HHV-LIQW LHV-GASD LHV-GASW O2-D (CONTINUED)

STREAM ID	HHV-LIQD	HHV-LIQW	LHV-GASD	LHV-GASW	O2-DRY
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	18.0153	18.0153	31.4907	30.3351	31.9988

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: GAS-HHV)

O2-WET POC-DRY POC-HHVD POC-HHVW POC-LHVD

STREAM ID	O2-WET	POC-DRY	POC-HHVD	POC-HHVW	POC-LHVD
FROM :	----	BURN-DRY	DUP-DRY	DUP-WET	DUP-DRY
TO :	BURN-WET	DUP-DRY	HHVCONDD	HHVCONDW	LHVCONDD
SUBSTREAM: MIXED					
PHASE:	VAPOR	VAPOR	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	497.5189	497.5189	497.5189	497.5189
CO2	0.0	537.1936	537.1936	537.1936	537.1936
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	404.1826	4.0418-03	4.0418-03	4.0418-03	4.0418-03
AR	0.0	5.9934	5.9934	5.9934	5.9934
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	374.4550	374.4550	507.1922	374.4550
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.3516	0.3516	0.3214	0.3516
CO2	0.0	0.3796	0.3796	0.3470	0.3796
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	1.0000	2.8561-06	2.8561-06	2.6111-06	2.8561-06
AR	0.0	4.2351-03	4.2351-03	3.8720-03	4.2351-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.2646	0.2646	0.3277	0.2646
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	6.9686	6.9686	6.9686	6.9686
CO2	0.0	11.8209	11.8209	11.8209	11.8209
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	6.4667	6.4666-05	6.4666-05	6.4666-05	6.4666-05
AR	0.0	0.1197	0.1197	0.1197	0.1197
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	3.3730	3.3730	4.5686	3.3730
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	0.3127	0.3127	0.2968	0.3127

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: GAS-HHV)

O2-WET POC-DRY POC-HHVD POC-HHVW POC-LHV (CONTINUED)

STREAM ID	O2-WET	POC-DRY	POC-HHVD	POC-HHVW	POC-LHVD
CO2	0.0	0.5305	0.5305	0.5035	0.5305
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.0
O2	1.0000	2.9021-06	2.9021-06	2.7543-06	2.9021-06
AR	0.0	5.3726-03	5.3726-03	5.0990-03	5.3726-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.1514	0.1514	0.1946	0.1514
H2	0.0	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
TOTAL FLOW:					
LBMOL/HR	404.1826	1415.1649	1415.1649	1547.9021	1415.1649
TONS/HR	6.4667	22.2822	22.2822	23.4779	22.2822
CUFT/HR	2.2886+06	6.5220+06	6.5220+06	6.5210+06	6.5220+06
STATE VARIABLES:					
TEMP F	68.0000	5851.0816	5851.0816	5308.9799	5851.0816
PRES PSI	1.0000	14.6959	14.6959	14.6959	14.6959
VFRAC	1.0000	1.0000	1.0000	1.0000	1.0000
LFRAC	0.0	0.0	0.0	0.0	0.0
SFRAC	0.0	0.0	0.0	0.0	0.0
ENTHALPY:					
BTU/LBMOL	-63.3549	-2.6986+04	-2.6986+04	-3.4636+04	-2.6986+04
BTU/LB	-1.9799	-856.9538	-856.9538	-1141.7734	-856.9538
MMBTU/HR	-2.5607-02	-38.1897	-38.1897	-53.6129	-38.1897
ENTROPY:					
BTU/LBMOL-R	5.2182	25.0586	25.0586	23.2674	25.0586
BTU/LB-R	0.1631	0.7957	0.7957	0.7670	0.7957
DENSITY:					
LBMOL/CUFT	1.7661-04	2.1698-04	2.1698-04	2.3737-04	2.1698-04
LB/CUFT	5.6512-03	6.8329-03	6.8329-03	7.2007-03	6.8329-03
AVG MW	31.9988	31.4907	31.4907	30.3351	31.4907

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***

MW UNITLESS					
N2	MISSING	28.0135	28.0135	28.0135	28.0135
CO2	MISSING	44.0098	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING	MISSING
CO	MISSING	MISSING	MISSING	MISSING	MISSING
O2	31.9988	31.9988	31.9988	31.9988	31.9988
AR	MISSING	39.9480	39.9480	39.9480	39.9480
NO2	MISSING	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING	MISSING
H2O	MISSING	18.0153	18.0153	18.0153	18.0153
H2	MISSING	MISSING	MISSING	MISSING	MISSING
H2O-MUD	MISSING	MISSING	MISSING	MISSING	MISSING
CH4	MISSING	MISSING	MISSING	MISSING	MISSING

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STREAM SECTION (HIERARCHY: GAS-HHV)

O2-WET POC-DRY POC-HHVD POC-HHVW POC-LHV (CONTINUED)

STREAM ID	O2-WET	POC-DRY	POC-HHVD	POC-HHVW	POC-LHVD
C	MISSING	MISSING	MISSING	MISSING	MISSING
MWMX	31.9988	31.4907	31.4907	30.3351	31.4907

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HOG FUEL GASIFICATION PROJECT CASE A
STREAM SECTION (HIERARCHY: GAS-HHV)

POC-LHVW POC-WET STP-GAS WETGAS-1 WETGAS-2

```
STREAM ID                POC-LHVW   POC-WET    STP-GAS    WETGAS-1   WETGAS-2
FROM :                   DUP-WET    BURN-WET   STP-COOL   DUP-MAIN   DUP-MAIN
TO   :                   LHVCONDW   DUP-WET    DUP-MAIN   BURN-WET   H2O-SEP

SUBSTREAM: MIXED
PHASE:                   VAPOR      VAPOR      MIXED      MIXED      MIXED
COMPONENTS: LBMOL/HR
  N2                     497.5189   497.5189   497.5189   497.5189   497.5189
  CO2                    537.1936   537.1936   105.0396   105.0396   105.0396
  CACO3                    0.0        0.0        0.0        0.0        0.0
  CAO                      0.0        0.0        0.0        0.0        0.0
  CO                       0.0        0.0      429.1590   429.1590   429.1590
  O2                     4.0418-03  4.0418-03    0.6234     0.6234     0.6234
  AR                       5.9934     5.9934     5.9934     5.9934     5.9934
  NO2                      0.0        0.0        0.0        0.0        0.0
  NO                       0.0        0.0        0.0        0.0        0.0
  H2O                    507.1922   507.1922   132.7372   132.7372   132.7372
  H2                       0.0        0.0      374.3811   374.3811   374.3811
  H2O-MUD                  0.0        0.0        0.0        0.0        0.0
  CH4                      0.0        0.0      3.6964-02  3.6964-02  3.6964-02
  C                        0.0        0.0        2.9580     2.9580     2.9580
COMPONENTS: MOLE FRAC
  N2                       0.3214     0.3214     0.3213     0.3213     0.3213
  CO2                      0.3470     0.3470   6.7835-02  6.7835-02  6.7835-02
  CACO3                    0.0        0.0        0.0        0.0        0.0
  CAO                      0.0        0.0        0.0        0.0        0.0
  CO                       0.0        0.0        0.2772     0.2772     0.2772
  O2                     2.6111-06  2.6111-06  4.0260-04  4.0260-04  4.0260-04
  AR                     3.8720-03  3.8720-03  3.8706-03  3.8706-03  3.8706-03
  NO2                      0.0        0.0        0.0        0.0        0.0
  NO                       0.0        0.0        0.0        0.0        0.0
  H2O                      0.3277     0.3277   8.5723-02  8.5723-02  8.5723-02
  H2                       0.0        0.0        0.2418     0.2418     0.2418
  H2O-MUD                  0.0        0.0        0.0        0.0        0.0
  CH4                      0.0        0.0      2.3872-05  2.3872-05  2.3872-05
  C                        0.0        0.0      1.9103-03  1.9103-03  1.9103-03
COMPONENTS: TONS/HR
  N2                       6.9686     6.9686     6.9686     6.9686     6.9686
  CO2                     11.8209    11.8209     2.3114     2.3114     2.3114
  CACO3                    0.0        0.0        0.0        0.0        0.0
  CAO                      0.0        0.0        0.0        0.0        0.0
  CO                       0.0        0.0        6.0105     6.0105     6.0105
  O2                     6.4666-05  6.4666-05  9.9740-03  9.9740-03  9.9740-03
  AR                       0.1197     0.1197     0.1197     0.1197     0.1197
  NO2                      0.0        0.0        0.0        0.0        0.0
  NO                       0.0        0.0        0.0        0.0        0.0
  H2O                      4.5686     4.5686     1.1956     1.1956     1.1956
  H2                       0.0        0.0        0.3774     0.3774     0.3774
  H2O-MUD                  0.0        0.0        0.0        0.0        0.0
  CH4                      0.0        0.0      2.9650-04  2.9650-04  2.9650-04
  C                        0.0        0.0      1.7764-02  1.7764-02  1.7764-02
COMPONENTS: MASS FRAC
  N2                       0.2968     0.2968     0.4096     0.4096     0.4096
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                     HOG FUEL GASIFICATION PROJECT CASE A
                      STREAM SECTION (HIERARCHY: GAS-HHV)

POC-LHVW POC-WET STP-GAS WETGAS-1 WETGAS (CONTINUED)

STREAM ID                POC-LHVW   POC-WET    STP-GAS    WETGAS-1   WETGAS-2

  CO2                      0.5035     0.5035     0.1359     0.1359     0.1359
  CACO3                    0.0        0.0        0.0        0.0        0.0
  CAO                      0.0        0.0        0.0        0.0        0.0
  CO                       0.0        0.0        0.3533     0.3533     0.3533
  O2                     2.7543-06  2.7543-06  5.8632-04  5.8632-04  5.8632-04
```

```
  AR                     5.0990-03  5.0990-03  7.0373-03  7.0373-03  7.0373-03
  NO2                      0.0        0.0        0.0        0.0        0.0
  NO                       0.0        0.0        0.0        0.0        0.0
  H2O                      0.1946     0.1946   7.0286-02  7.0286-02  7.0286-02
  H2                       0.0        0.0      2.2183-02  2.2183-02  2.2183-02
  H2O-MUD                  0.0        0.0        0.0        0.0        0.0
  CH4                      0.0        0.0      1.7430-05  1.7430-05  1.7430-05
  C                        0.0        0.0      1.0443-03  1.0443-03  1.0443-03
TOTAL FLOW:
  LBMOL/HR               1547.9021  1547.9021  1548.4476  1548.4476  1548.4476
  TONS/HR                  23.4779    23.4779    17.0112    17.0112    17.0112
  CUFT/HR                6.5210+06  6.5210+06  5.5595+05  5.5595+05  5.5595+05
STATE VARIABLES:
  TEMP   F               5308.9799  5308.9799    68.0000    68.0000    68.0000
  PRES   PSI               14.6959    14.6959    14.6959    14.6959    14.6959
  VFRAC                    1.0000     1.0000     0.9322     0.9322     0.9322
  LFRAC                    0.0        0.0      6.7778-02  6.7778-02  6.7778-02
  SFRAC                    0.0        0.0        0.0        0.0        0.0
ENTHALPY:
  BTU/LBMOL             -3.4636+04 -3.4636+04 -3.4607+04 -3.4607+04 -3.4607+04
  BTU/LB                -1141.7734 -1141.7734 -1575.0570 -1575.0570 -1575.0570
  MMBTU/HR                -53.6129   -53.6129   -53.5873   -53.5873   -53.5873
ENTROPY:
  BTU/LBMOL-R              23.2674    23.2674     5.4391     5.4391     5.4391
  BTU/LB-R                 0.7670     0.7670     0.2475     0.2475     0.2475
DENSITY:
  LBMOL/CUFT             2.3737-04  2.3737-04  2.7852-03  2.7852-03  2.7852-03
  LB/CUFT                7.2007-03  7.2007-03  6.1196-02  6.1196-02  6.1196-02
AVG MW                     30.3351    30.3351    21.9720    21.9720    21.9720

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW       UNITLESS
    N2                     28.0135    28.0135    28.0135    28.0135    28.0135
    CO2                    44.0098    44.0098    44.0098    44.0098    44.0098
    CACO3                  MISSING    MISSING    MISSING    MISSING    MISSING
    CAO                    MISSING    MISSING    MISSING    MISSING    MISSING
    CO                     MISSING    MISSING    28.0104    28.0104    28.0104
    O2                     31.9988    31.9988    31.9988    31.9988    31.9988
    AR                     39.9480    39.9480    39.9480    39.9480    39.9480
    NO2                    MISSING    MISSING    MISSING    MISSING    MISSING
    NO                     MISSING    MISSING    MISSING    MISSING    MISSING
    H2O                    18.0153    18.0153    18.0153    18.0153    18.0153
    H2                     MISSING    MISSING     2.0159     2.0159     2.0159
    H2O-MUD                MISSING    MISSING    MISSING    MISSING    MISSING
    CH4                    MISSING    MISSING    16.0428    16.0428    16.0428
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                     HOG FUEL GASIFICATION PROJECT CASE A
                      STREAM SECTION (HIERARCHY: GAS-HHV)

POC-LHVW POC-WET STP-GAS WETGAS-1 WETGAS (CONTINUED)

STREAM ID                POC-LHVW   POC-WET    STP-GAS    WETGAS-1   WETGAS-2

    C                      MISSING    MISSING    12.0110    12.0110    12.0110
MWMX                       30.3351    30.3351    21.9720    21.9720    21.9720
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 154
                     HOG FUEL GASIFICATION PROJECT CASE A
                    FLOWSHEET SECTION (HIERARCHY: GASIFIER)

FLOWSHEET CONNECTIVITY BY STREAMS
---------------------------------

FLOWSHEET SECTION GASIFIER
  STREAM     SOURCE     DEST           STREAM     SOURCE     DEST
```

```
  AIR        $C-10      FEED-MIX       BIOMASS    $C-11      EVP-DEVL
  GFRQLOSS   ----       HEATMIX        MIX-FEED   FEED-MIX   FD-SPLT
  SYNGAS-1   GFR        ASH-SEP        SYNGAS-3   DVL-EXCH   $C-9
  DEVOLPRD   EVP-DEVL   FEED-MIX       HEAT-1     EVP-DEVL   HEATMIX
  HEAT-2     HEATMIX    DVL-EXCH       ASH        ASH-SEP    $C-13
  SYNGAS-2   ASH-SEP    DVL-EXCH       FEED-1     FD-SPLT    GFR
  FEED-2     FD-SPLT    GFR-2          SYNGAS-5   GFR-2      ASH-SEP

FLOWSHEET CONNECTIVITY BY BLOCKS
--------------------------------

FLOWSHEET SECTION GASIFIER
  BLOCK        INLETS                         OUTLETS
  FEED-MIX     DEVOLPRD AIR                   MIX-FEED
  GFR          FEED-1                         SYNGAS-1
  DVL-EXCH     SYNGAS-2 HEAT-2                SYNGAS-3
  EVP-DEVL     BIOMASS                        DEVOLPRD HEAT-1
  HEATMIX      HEAT-1 GFRQLOSS                HEAT-2
  ASH-SEP      SYNGAS-1 SYNGAS-5              ASH SYNGAS-2
  FD-SPLT      MIX-FEED                       FEED-1 FEED-2
  GFR-2        FEED-2                         SYNGAS-5

CALCULATOR BLOCK:   EVPDVL
--------------------------

  SAMPLED VARIABLES:
    FLOW     : TOTAL MASSFLOW IN STREAM BIOMASS SUBSTREAM NC
    WATER    : COMP-ATTR-VA IN STREAM BIOMASS SUBSTREAM NC ID: PROXANAL
    MOIST    : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=1 ID1=1 IN UOS BLOCK
                EVP-DEVL
    YLD      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=FUEL IN UOS BLOCK
                EVP-DEVL
    WYLD     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2O IN UOS
                BLOCK EVP-DEVL
    CH4YLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CH4 IN UOS
                BLOCK EVP-DEVL
    COYLD    : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CO IN UOS
                BLOCK EVP-DEVL
    CO2YLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CO2 IN UOS
                BLOCK EVP-DEVL
    H2YLD    : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2 IN UOS
                BLOCK EVP-DEVL
    CHRYLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=CHAR IN UOS BLOCK
                EVP-DEVL
    TARYLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=TAR IN UOS BLOCK
                EVP-DEVL
    ASHYLD   : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=ASH IN UOS BLOCK
                EVP-DEVL
    ASH      : COMP-ATTR-VA IN STREAM BIOMASS SUBSTREAM NC ID: ULTANAL
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 155
                     HOG FUEL GASIFICATION PROJECT CASE A
                    FLOWSHEET SECTION (HIERARCHY: GASIFIER)

CALCULATOR BLOCK:   EVPDVL (CONTINUED)
    TOTAL    : LOCAL-PARAM
    FUELU    : COMPONENT-AT VEC IN STREAM BIOMASS SUBSTREAM NC ID: ULTANAL
    TARUC    : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=2 ID1=8 IN UOS BLOCK
                EVP-DEVL
    TARUH    : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=3 ID1=8 IN UOS BLOCK
                EVP-DEVL
    TARUO    : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=7 ID1=8 IN UOS BLOCK
                EVP-DEVL
    CHARUC   : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=2 ID1=3 IN UOS BLOCK
                EVP-DEVL
    CHARUH   : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=3 ID1=3 IN UOS BLOCK
                EVP-DEVL
```

```
    CHARUO   : SENTENCE=COMP-ATTR VARIABLE=VALUE ELEMENT=7 ID1=3 IN UOS BLOCK
                EVP-DEVL
    CIN      : LOCAL-PARAM
    COUT     : LOCAL-PARAM
    HIN      : LOCAL-PARAM
    HOUT     : LOCAL-PARAM
    OIN      : LOCAL-PARAM
    OOUT     : LOCAL-PARAM
    COM      : LOCAL-PARAM
    CO2M     : LOCAL-PARAM
    CH4M     : LOCAL-PARAM
    H2M      : LOCAL-PARAM
    HHVT     : PROPERTY PARAMETER HCOMB, DATA SET 1
    HHVC     : PROPERTY PARAMETER HCOMB, DATA SET 1

  FORTRAN STATEMENTS:
        REAL MASS
        REAL MWH
        REAL MWC
        REAL MWO
        REAL MWFUEL
  C ********************************************************************
  C DRY IS THE DESIRED MOISTURE MASS % IN THE DRIED BIOMASS.
  C ********************************************************************

        DRY=0.

  C ********************************************************************
  C YIELD VALUES AND PROXIMATE VALUES FOR WATER ARE SET FOR BLOCK
  C EVP-DEVL BELOW.
  C ********************************************************************

        MOIST=DRY
        TOTMAS=FLOW
        DRY=FLOW*(1.-(WATER/100.))
        MASS=DRY/(1.-(MOIST/100.))
        WMASS=TOTMAS-MASS
        WYIELD=WMASS/TOTMAS

  C ********************************************************************
  C MOLECULAR WEIGHTS FOR CARBON, HYDROGEN, AND OXYGEN USED IN
  C DEVOLATILIZATION CALCULATIONS.
  C ********************************************************************
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                      09/27/2007  PAGE 156
                     HOG FUEL GASIFICATION PROJECT CASE A
                    FLOWSHEET SECTION (HIERARCHY: GASIFIER)

CALCULATOR BLOCK:   EVPDVL (CONTINUED)

        MWH=1.00794
        MWO=15.9994
        MWC=12.011

  C ********************************************************************
  C GAS VOLUME YIELDS FOR CO, CO2, H2, AND CH4 FROM FAGBEMI AT 900 C.
  C NOTE THAT C2HX WAS ADDED TO CH4 YIELD.  MASS YIELDS OF CO, CO2,
  C H2, AND CH4 CALCULATED FROM VOLUME YIELD DATA.  YIELD DATA FROM
  C FAGBEMI (298).
  C ********************************************************************

        COV=53.5
        CO2V=5
        H2V=25.3
        CH4V=12.1+4.1

        COM=COV*(MWC+MWO)
```

```
      CO2M=CO2V*(MWC+2.*MWO)
      H2M=H2V*(2.*MWH)
      CH4M=CH4V*(MWC+4.*MWH)

      TOTGMSS=COM+CO2M+H2M+CH4M

C **********************************************************************
C GAS VOLUME YIELDS FOR CO, CO2, H2, AND CH4 FROM FAGBEMI AT 900C.
C NOTE THAT C2HX WAS ADDED TO CH4 YIELD.  MASS YIELDS OF CO, CO2,
C H2, AND CH4 CALCULATED FROM VOLUME YIELD DATA.
C **********************************************************************

      GAS=0.47
      CHAR=0.22
      H2O=0.205
      TAR=0.105


      YLD=1.*(10.**-8.)
      ASHYLD=ASH/100.*(1-WYIELD-YLD)
      CH4YLD=CH4M/TOTGMSS*GAS*(1-WYIELD-ASHYLD-YLD)
      COYLD=COM/TOTGMSS*GAS*(1-WYIELD-ASHYLD-YLD)
      CO2YLD=CO2M/TOTGMSS*GAS*(1-WYIELD-ASHYLD-YLD)
      WYLD=H2O*(1-WYIELD-ASHYLD-YLD)+WYIELD
      H2YLD=H2M/TOTGMSS*GAS*(1-WYIELD-ASHYLD-YLD)
      CHRYLD=CHAR*(1-WYIELD-ASHYLD-YLD)
      TARYLD=TAR*(1-WYIELD-ASHYLD-YLD)

C **********************************************************************
C CALCULATION CHECK TO ENSURE YIELDS ADD TO 1.
C **********************************************************************

      TOTAL=ASHYLD+CH4YLD+COYLD+CO2YLD+WYLD+H2YLD+CHRYLD+TARYLD+YLD

C **********************************************************************
C CALCULATION OF CABORN, HYDROGEN, AND OXYGEN MASS FLOW INTO THE
C SYSTEM.
```


CALCULATOR BLOCK: EVPDVL (CONTINUED)

```
C **********************************************************************

      CIN=DRY*FUELU(2)/100.
      HIN=DRY*FUELU(3)/100.+WMASS*2.*MWH/(2.*MWH+MWO)
      OIN=DRY*FUELU(7)/100.+WMASS*MWO/(2.*MWH+MWO)

C **********************************************************************
C CALCULATION TAR CARBON, HYDROGEN, AND OXYGEN FLOWS BY DIFFERENCE.
C **********************************************************************

      TARC=CIN-(FLOW*(CHRYLD*(CHARUC/100.)+CH4YLD*(MWC/(MWC+4.*MWH))
     ++COYLD*(MWC/(MWC+MWO))+CO2YLD*(MWC/(MWC+2.*MWO))+YLD*(FUELU(2)
     +/100.)))

      TARH=HIN-(FLOW*(CHRYLD*(CHARUH/100.)+CH4YLD*(4.*MWH/(MWC+4.*MWH))
     ++WYLD*(2.*MWH/(2.*MWH+MWO))+H2YLD*(2.*MWH/(2.*MWH))+YLD*(FUELU(3)
     +/100.)))

      TARO=OIN-(FLOW*(CHRYLD*(CHARUO/100.)+CO2YLD*(2.*MWO/(MWC+2.*MWO))+
     +WYLD*(MWO/(2.*MWH+MWO))+COYLD*(MWO/(MWC+MWO))+YLD*(FUELU(7)/
     +100.)))

C **********************************************************************
C CALCULATION OF TAR ULIMATE ANALYSIS.
C **********************************************************************

      TARUC=TARC/(TARC+TARH+TARO)*100.
      TARUH=TARH/(TARC+TARH+TARO)*100.
      TARUO=TARO/(TARC+TARH+TARO)*100.

C **********************************************************************
C CALCULATION OF CABORN, HYDROGEN, AND OXYGEN MASS FLOW OUT OF THE
C SYSTEM, USED TO ENSURE CONTINUITY OF SPECIES MASS FLOW.
C **********************************************************************

      COUT=FLOW*(CHRYLD*(CHARUC/100.)+TARYLD*(TARUC/100.)+CH4YLD*(
     +MWC/(MWC+4.*MWH))+COYLD*(MWC/(MWC+MWO))+CO2YLD*(MWC/(MWC+2.*MWO))
     ++YLD*(FUELU(2)/100.))

      HOUT=FLOW*(CHRYLD*(CHARUH/100.)+TARYLD*(TARUH/100.)+CH4YLD*(
     +4.*MWH/(MWC+4.*MWH))+WYLD*(2.*MWH/(2.*MWH+MWO))+H2YLD*(2.*MWH/
     +(2.*MWH))+YLD*(FUELU(3)/100.))

      OOUT=FLOW*(CHRYLD*(CHARUO/100.)+TARYLD*(TARUO/100.)+CO2YLD*(
     +2.*MWO/(MWC+2.*MWO))+WYLD*(MWO/(2.*MWH+MWO))+COYLD*(MWO/
     +(MWC+MWO))+YLD*(FUELU(7)/100.))

C **********************************************************************
C CALCULATION OF HEATING VALUE OF TAR AND CHAR (HHV) BASED ON IGT
C EQUATION PRESENTED IN FAGBEMI (297).
C **********************************************************************

      HHVT=(354.68*TARUC+1376.29*TARUH+71.26-124.69*TARUO)*1000.
      HHVC=(354.68*CHARUC+1376.29*CHARUH+71.26-124.69*CHARUO)*1000.
```

EXECUTE BEFORE BLOCK EVP-DEVL

CALCULATOR BLOCK: EVPDVL (CONTINUED)

VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:

VARIABLE	VALUE READ	VALUE WRITTEN	UNITS
FLOW	2.12443		KG/SEC
WATER	10.0000		
MOIST	0.00000	0.00000	
YLD	0.100000E-07	0.100000E-07	
WYLD	0.272858	0.272858	
CH4YLD	0.507503E-01	0.507503E-01	
COYLD	0.292629	0.292629	
CO2YLD	0.429699E-01	0.429699E-01	
H2YLD	0.995932E-02	0.995932E-02	
CHRYLD	0.185506	0.185506	
TARYLD	0.885370E-01	0.885370E-01	
ASHYLD	0.567900E-01	0.567900E-01	
ASH	6.31000		
TOTAL	1.00000	1.00000	
FUELU(1)	6.31000		
FUELU(2)	44.7400		
FUELU(3)	5.50000		
FUELU(4)	0.00000		
FUELU(5)	0.00000		
FUELU(6)	0.00000		
FUELU(7)	43.4500		
TARUC	59.4990	59.4990	
TARUH	7.09419	7.09419	
TARUO	33.4068	33.4068	
CHARUC	94.2164		
CHARUH	0.626896		
CHARUO	5.15672		
CIN	0.855424	0.855424	
COUT	0.855424	0.855424	
HIN	0.128931	0.128931	
HOUT	0.128931	0.128931	
OIN	1.01943	1.01943	
OOUT	1.01943	1.01943	
COM	1498.56	1498.56	
CO2M	220.049	220.049	
CH4M	259.893	259.893	
H2M	51.0018	51.0018	
HHVT	0.267725E+08	0.267725E+08	
HHVC	0.337077E+08	0.337077E+08	

CALCULATOR BLOCK: GFRQLOSS

SAMPLED VARIABLES:

```
QLOSS    : INFO-VAR IN STREAM GFRQLOSS ID: HEAT
FUEL     : TOTAL MASSFLOW IN STREAM BIOMASS SUBSTREAM NC
AIR      : TOTAL MASSFLOW IN STREAM AIR SUBSTREAM MIXED
FUELE    : MOLE ENTHALPY IN STREAM BIOMASS SUBSTREAM NC
AIRE     : MASS ENTHALPY IN STREAM AIR SUBSTREAM MIXED
```


CALCULATOR BLOCK: GFRQLOSS (CONTINUED)

FORTRAN STATEMENTS:

```
C **********************************************************************
C CALCULATES THE HEAT LOSS FROM THE GASIFIER, WHICH IS 1% OF THE HEAT
C CONTENT OF THE STREAMS ENTERING THE GASIFIER (EMERY).
C **********************************************************************

      QLOSS=((AIR*AIRE)+(FUEL*FUELE))*1./100.
```

EXECUTE BEFORE BLOCK HEATMIX

VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:

VARIABLE	VALUE READ	VALUE WRITTEN	UNITS
QLOSS	-119060.	-117824.	WATT
FUEL	2.12443	2.12443	KG/SEC
AIR	1.58302	1.58302	KG/SEC
FUELE	-0.558291E+07	-0.558291E+07	J/KG
AIRE	49329.3	49329.3	J/KG

CALCULATOR BLOCK: RXN-2

SAMPLED VARIABLES:

```
MFCONV   : TOTAL MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFNC     : TOTAL MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM NC
YCH4     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CH4 IN UOS
           BLOCK GFR-2
YCO2     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CO2 IN UOS
           BLOCK GFR-2
YCO      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=CO IN UOS
           BLOCK GFR-2
YO2      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=O2 IN UOS
           BLOCK GFR-2
YH2O     : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2O IN UOS
           BLOCK GFR-2
YH2      : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=MIXED ID2=H2 IN UOS
           BLOCK GFR-2
YCHAR    : SENTENCE=MASS-YIELD VARIABLE=YIELD ID1=NC ID2=CHAR IN UOS BLOCK
           GFR-2
MFCH4    : CH4 MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFCO2    : CO2 MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFCO     : CO MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFO2     : O2 MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFH2O    : H2O MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFH2     : H2 MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFCHAR   : CHAR MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM NC
MFFUEL   : FUEL MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM NC
MFTAR    : TAR MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM NC
MFASH    : ASH MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM NC
MFN2     : N2 MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
MFAR     : AR MASSFLOW IN STREAM SYNGAS-1 SUBSTREAM MIXED
```

FORTRAN STATEMENTS:

CALCULATOR BLOCK: RXN-2 (CONTINUED)

```
C **********************************************************************
C CALCULATES THE MASS YIELD FOR THE SECOND REACTOR BASED ON THE YIELD
C OF THE FIRST REACTOR BLOCK.
C **********************************************************************
      FLOW=MFCONV+MFNC-MFFUEL-MFTAR-MFASH-MFN2-MFAR

      YCH4=MFCH4/FLOW
      YCO2=MFCO2/FLOW
      YCO=MFCO/FLOW
      YO2=MFO2/FLOW
      YH2O=MFH2O/FLOW
      YH2=MFH2/FLOW
      YCHAR=MFCHAR/FLOW
```

EXECUTE AFTER BLOCK GFR

VALUES OF ACCESSED FORTRAN VARIABLES ON MOST RECENT SIMULATION PASS:

VARIABLE	VALUE READ	VALUE WRITTEN	UNITS
MFCONV	6.65359	6.65359	TONS/HR
MFNC	0.702605	0.702605	TONS/HR
YCH4	0.465313E-01	0.465313E-01	
YCO2	0.125937	0.125937	
YCO	0.586994	0.586994	
YO2	0.00000	0.00000	
YH2O	0.201123	0.201123	
YH2	0.186443E-01	0.186443E-01	
YCHAR	0.207709E-01	0.207709E-01	
MFCH4	0.201664	0.201664	TONS/HR
MFCO2	0.545803	0.545803	TONS/HR
MFCO	2.54400	2.54400	TONS/HR
MFO2	0.00000	0.00000	TONS/HR
MFH2O	0.871655	0.871655	TONS/HR
MFH2	0.808032E-01	0.808032E-01	TONS/HR
MFCHAR	0.900202E-01	0.900202E-01	TONS/HR
MFFUEL	0.421521E-07	0.421521E-07	TONS/HR
MFTAR	0.373203	0.373203	TONS/HR
MFASH	0.239382	0.239382	TONS/HR
MFN2	2.36897	2.36897	TONS/HR
MFAR	0.406961E-01	0.406961E-01	TONS/HR

FLOWSHEET SECTION BALANCE: GASIFIER

```
             ***  MASS AND ENERGY BALANCE  ***
                          IN              OUT          RELATIVE DIFF.
  CONVENTIONAL COMPONENTS (LBMOL/HR)
     N2                  338.261         338.261         0.00000
     CO2                 0.130050        49.6074        -0.997378
     CACO3               0.00000         0.00000         0.00000
     CAO                 0.00000         0.00000         0.00000
     CO                  0.00000         363.294        -1.00000
     O2                  90.9919         0.00000         1.00000
     AR                  4.07491         4.07491         0.00000
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                   HOG FUEL GASIFICATION PROJECT CASE A
                  FLOWSHEET SECTION (HIERARCHY: GASIFIER)

FLOWSHEET SECTION BALANCE:  GASIFIER (CONTINUED)

             ***  MASS AND ENERGY BALANCE  ***
                          IN              OUT          RELATIVE DIFF.
  CONVENTIONAL COMPONENTS (LBMOL/HR)
     NO2                 0.00000         0.00000         0.00000
     NO                  0.00000         0.00000         0.00000
     H2O                 0.433501        193.537        -0.997760
     H2                  0.433501E-01    160.333        -0.999730
     H2O-MUD             0.00000         0.00000         0.00000
     CH4                 0.00000         50.2817        -1.00000
     C                   0.00000         0.00000         0.00000
   SUBTOTAL(LBMOL/HR)    433.935         1159.39        -0.625721
           (TONS/HR )    6.28195         13.3072        -0.527928
  NON-CONVENTIONAL COMPONENTS (TONS/HR )
     CHAR                0.00000         0.180040       -1.00000
     FUEL                8.43043         0.843043E-07    1.00000
     TAR                 0.00000         0.746405       -1.00000
     ASH                 0.00000         0.478764       -1.00000
   SUBTOTAL(TONS/HR )    8.43043         1.40521         0.833317
  TOTAL BALANCE
     MASS(TONS/HR )      14.7124         14.7124        -0.399640E-06
     ENTHALPY(MMBTU/HR)  -40.6054        -40.6054       -0.688787E-08
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  ASH-SEP  MODEL: SEP
----------------------------
   INLET STREAMS:         SYNGAS-1    SYNGAS-5
   OUTLET STREAMS:        ASH         SYNGAS-2
   PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

             ***  MASS AND ENERGY BALANCE  ***
                          IN              OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)     1159.39       1159.39       0.196115E-15
                (TONS/HR )     13.3072       13.3072       0.133489E-15
     NONCONV. COMP(TONS/HR )   1.40521       1.40521       0.00000
  TOTAL BALANCE
     MASS(TONS/HR )            14.7124       14.7124       0.120739E-15
     ENTHALPY(MMBTU/HR)        -29.7299      -29.7299      0.641713E-13

                    ***  INPUT DATA  ***

   INLET PRESSURE:  MINIMUM OF INLET STREAM PRESSURES

   FLASH SPECS FOR STREAM ASH
   TWO    PHASE  TP  FLASH
   PRESSURE DROP            PSI                        0.0
   MAXIMUM NO. ITERATIONS                              30
   CONVERGENCE TOLERANCE                               0.000100000
```

```
   FLASH SPECS FOR STREAM SYNGAS-2
   TWO    PHASE  TP  FLASH
   PRESSURE DROP            PSI                        0.0
   MAXIMUM NO. ITERATIONS                              30
   CONVERGENCE TOLERANCE                               0.000100000

   FRACTION OF FEED
     SUBSTREAM= MIXED
       STREAM= ASH        CPT= O2        FRACTION=       0.0
     SUBSTREAM= NC
       STREAM= ASH        CPT= ASH       FRACTION=       1.00000
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  ASH-SEP  MODEL: SEP (CONTINUED)

                      ***  RESULTS  ***

   HEAT DUTY             MMBTU/HR                      -0.19067E-11

  COMPONENT = N2
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = CO2
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = CO
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = AR
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = H2O
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = H2
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = CH4
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   MIXED                1.00000

  COMPONENT = CHAR
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   NC                   1.00000

  COMPONENT = FUEL
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   NC                   1.00000

  COMPONENT = TAR
    STREAM     SUBSTREAM    SPLIT FRACTION
    SYNGAS-2   NC                   1.00000

  COMPONENT = ASH
    STREAM     SUBSTREAM    SPLIT FRACTION
    ASH        NC                   1.00000
```

```
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  DVL-EXCH MODEL: HEATER
------------------------------
   INLET STREAM:          SYNGAS-2
   INLET HEAT STREAM:     HEAT-2
   OUTLET STREAM:         SYNGAS-3
   PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

             ***  MASS AND ENERGY BALANCE  ***
                          IN              OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)     1159.39       1159.39       0.00000
                (TONS/HR )     13.3072       13.3072       0.00000
     NONCONV. COMP(TONS/HR )   0.926446      0.926446      0.00000
  TOTAL BALANCE
     MASS(TONS/HR )            14.2336       14.2336       0.00000
     ENTHALPY(MMBTU/HR)        -41.1577      -41.1577      0.576051E-08

                    ***  INPUT DATA  ***
   TWO    PHASE  PQ  FLASH
   PRESSURE DROP                        PSI                0.0
   DUTY FROM INLET HEAT STREAM(S)       MMBTU/HR          -10.8754
   MAXIMUM NO. ITERATIONS                                  30
   CONVERGENCE TOLERANCE                                   0.000100000


                    ***  RESULTS  ***
   OUTLET TEMPERATURE     F                            940.06
   OUTLET PRESSURE        PSI                          24.458
   OUTLET VAPOR FRACTION                               1.0000
   PRESSURE-DROP CORRELATION PARAMETER                 0.0000


   V-L PHASE EQUILIBRIUM :

      COMP            F(I)          X(I)          Y(I)          K(I)
      N2              0.29176       0.36765E-07   0.29176       523.44
      CO2             0.42788E-01   0.27059E-05   0.42788E-01   470.65
      CO              0.31335       0.41648E-07   0.31335       524.64
      AR              0.35147E-02   0.79988E-08   0.35147E-02   482.96
      H2O             0.16693       1.0000        0.16693       344.18
      H2              0.13829       0.59333E-07   0.13829       472.55
      CH4             0.43369E-01   0.50644E-07   0.43369E-01   493.88
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  EVP-DEVL MODEL: RYIELD
------------------------------
   INLET STREAM:          BIOMASS
   OUTLET STREAM:         DEVOLPRD
   OUTLET HEAT STREAM:    HEAT-1
   PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

             ***  MASS AND ENERGY BALANCE  ***
                          IN          OUT        GENERATION   RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)    0.00000     584.622      584.622       0.00000
           (TONS/HR )    0.00000     5.64136                   -1.00000
NONCONV COMP(TONS/HR )   8.43043     2.78907                    0.669167
  TOTAL BALANCE
     MASS(TONS/HR )      8.43043     8.43043                    0.00000
     ENTHALPY(MMBTU/HR) -40.4698    -40.4698                    0.00000
```

```
 ASPEN PLUS    PLAT: WIN32    VER: 20.0 1              09/27/2007  PAGE 166
                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  EVP-DEVL MODEL: RYIELD (CONTINUED)

                     ***  INPUT DATA  ***
   TWO    PHASE  TP  FLASH
   SPECIFIED TEMPERATURE F                           1,652.00
   SPECIFIED PRESSURE    PSI                           25.0000
   MAXIMUM NO. ITERATIONS                              30
   CONVERGENCE TOLERANCE                               0.000100000

    MASS-YIELD
     SUBSTREAM MIXED    :
     CO2      0.430E-01     CO         0.293         H2O        0.273
     H2       0.996E-02     CH4        0.508E-01
     SUBSTREAM NC       :
     CHAR     0.186         FUEL       0.100E-07     TAR        0.885E-01
     ASH      0.568E-01

   INERTS:        O2        N2
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  EVP-DEVL MODEL: RYIELD (CONTINUED)

                    ***  RESULTS  ***
   OUTLET TEMPERATURE     F                               1652.0
   OUTLET PRESSURE        PSI                             25.000
   HEAT DUTY              MMBTU/HR                        10.473
   VAPOR FRACTION                                         1.0000


   V-L PHASE EQUILIBRIUM :

      COMP            F(I)          X(I)          Y(I)          K(I)
      CO2             0.28159E-01   0.24854E-01   0.28159E-01   841.40
      CO              0.30130       0.25652       0.30130       872.30
      H2O             0.43682       0.50103       0.43682       647.40
      H2              0.14249       0.13808       0.14249       766.35
      CH4             0.91236E-01   0.79514E-01   0.91236E-01   852.11

BLOCK:  FD-SPLT  MODEL: FSPLIT
------------------------------
   INLET STREAM:          MIX-FEED
   OUTLET STREAMS:        FEED-1      FEED-2
   PROPERTY OPTION SET:   PR-BM      PENG-ROBINSON EQUATION OF STATE

             ***  MASS AND ENERGY BALANCE  ***
                          IN              OUT          RELATIVE DIFF.
     CONV. COMP.(LBMOL/HR)     1018.56       1018.56       0.00000
                (TONS/HR )     11.9233       11.9233       0.00000
     NONCONV. COMP(TONS/HR )   2.78907       2.78907       0.00000
  TOTAL BALANCE
     MASS(TONS/HR )            14.7124       14.7124       0.00000
     ENTHALPY(MMBTU/HR)        -29.7299      -29.7299      0.00000

                     ***  INPUT DATA  ***

  FRACTION OF FLOW              STRM=FEED-1    FRAC=        0.50000
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                   HOG FUEL GASIFICATION PROJECT CASE A
                 U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)
```

```
BLOCK:  FD-SPLT  MODEL: FSPLIT (CONTINUED)

                         ***  RESULTS  ***

 STREAM= FEED-1         SPLIT=          0.50000     KEY=  0    STREAM-ORDER=   1
         FEED-2                         0.50000           0                    2

BLOCK:  FEED-MIX MODEL: MIXER
-----------------------------
  INLET STREAMS:          DEVOLPRD    AIR
  OUTLET STREAM:          MIX-FEED
  PROPERTY OPTION SET:    PR-BM     PENG-ROBINSON EQUATION OF STATE

                      ***  MASS AND ENERGY BALANCE  ***
                                  IN              OUT         RELATIVE DIFF.
      CONV. COMP.(LBMOL/HR)     1018.56         1018.56         0.00000
               (TONS/HR )       11.9233         11.9233         0.148982E-15
      NONCONV. COMP(TONS/HR )   2.78907         2.78907         0.00000
    TOTAL BALANCE
      MASS(TONS/HR )            14.7124         14.7124         0.00000
      ENTHALPY(MMBTU/HR)       -29.7299        -29.7299        -0.187482E-07

                           ***  INPUT DATA  ***
  TWO    PHASE      FLASH
  MAXIMUM NO. ITERATIONS                                      30
  CONVERGENCE TOLERANCE                                        0.000100000
  OUTLET PRESSURE:  MINIMUM OF INLET STREAM PRESSURES

BLOCK:  GFR      MODEL: RPLUG
-----------------------------
  INLET STREAM:           FEED-1
  OUTLET STREAM:          SYNGAS-1
  PROPERTY OPTION SET:    PR-BM     PENG-ROBINSON EQUATION OF STATE

                      ***  MASS AND ENERGY BALANCE  ***
                             IN           OUT        GENERATION   RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)     509.278       579.695       70.4163      -0.392230E-15
          (TONS/HR )      5.96166       6.65359                    -0.103994
NONCONV COMP(TONS/HR )    1.39453       0.702605                    0.496172
  TOTAL BALANCE
     MASS(TONS/HR )       7.35619       7.35620                    -0.799280E-06
     ENTHALPY(MMBTU/HR) -14.8650      -14.8650                      0.271976E-08
```



```
BLOCK:  GFR      MODEL: RPLUG (CONTINUED)

                           ***  INPUT DATA  ***

  REACTOR TYPE:
    ADIABATIC
    VAPOR FLUID PHASE
  REACTOR TUBE LENGTH                         FT                    4.2133
  REACTOR DIAMETER                            FT                    7.5000
  REACTOR RISE                                FT                    0.0000
  NUMBER OF REACTOR TUBES                                           1
  REACTOR VOLUME                              CUFT                  186.14
  PRESSURE DROP OPTION:                                             SPECIFIED

  LIQUID HOLDUP OPTION:                                             NO-SLIP

  ERROR TOLERANCE                                                   0.25000E-04
  INTEGRATION METHOD                                                GEAR
  CORRECTOR METHOD                                                  NEWTON
```

```
  INITIAL STEP SIZE FACTOR                                          0.10000E-01
  CORRECTOR TOLERANCE FACTOR                                        0.10000
  MAXIMUM NUMBER OF STEPS                                            1000


   REACTION PARAGRAPH             ID:  CHAR1          TYPE:  USER
   SUBROUTINE NAME                                           CHAR1
   GLOBAL BASES:
   KBASIS                                                    MOLE-GAMMA
   CBASIS                                                    MOLARITY
   SBASIS                                                    LOCAL

                            ***  RESULTS  ***

   REACTOR DUTY                   MMBTU/HR                  -0.40429E-07
   RESIDENCE TIME                 HR                         0.30000E-03
   REACTOR MINIMUM TEMPERATURE F                             1144.2
   REACTOR MAXIMUM TEMPERATURE F                             3189.7


        *** RESULTS PROFILE (PROCESS SUBSTREAM MIXED) ***

     LENGTH         PRESSURE       TEMPERATURE   VAPOR FRAC     RES-TIME
     FT             PSI            F                            HR

      0.0000         25.000         1144.2        1.0000         0.0000
     0.42133         24.946         2003.3        1.0000        0.29813E-04
     0.84267         24.892         2002.8        1.0000        0.60078E-04
      1.2640         24.837         2002.5        1.0000        0.90282E-04
      1.6853         24.783         2002.1        1.0000        0.12042E-03
      2.1067         24.729         2001.7        1.0000        0.15051E-03
      2.5280         24.675         2001.3        1.0000        0.18053E-03
      2.9493         24.621         2000.9        1.0000        0.21049E-03
      3.3707         24.566         2000.6        1.0000        0.24038E-03
      3.7920         24.512         2000.2        1.0000        0.27022E-03
      4.2133         24.458         1999.9        1.0000        0.30000E-03

     LENGTH         LIQUID HOLDUP
     FT
      0.0000         0.0000
     0.42133         0.0000
     0.84267         0.0000
      1.2640         0.0000
      1.6853         0.0000
      2.1067         0.0000
      2.5280         0.0000
      2.9493         0.0000
      3.3707         0.0000
      3.7920         0.0000
      4.2133         0.0000
```



```
BLOCK:  GFR      MODEL: RPLUG (CONTINUED)

        ***  TOTAL MOLE FRACTION PROFILE (PROCESS SUBSTREAM MIXED) ***

     LENGTH         N2             CO2            CO             O2
     FT

      0.0000        0.33210        0.16290E-01   0.17294        0.89334E-01
     0.42133        0.29176        0.45224E-01   0.31091         0.0000
     0.84267        0.29176        0.44932E-01   0.31120         0.0000
```

```
      1.2640        0.29176        0.44646E-01   0.31149         0.0000
      1.6853        0.29176        0.44365E-01   0.31177         0.0000
      2.1067        0.29176        0.44089E-01   0.31205         0.0000
      2.5280        0.29176        0.43819E-01   0.31232         0.0000
      2.9493        0.29176        0.43554E-01   0.31258         0.0000
      3.3707        0.29176        0.43294E-01   0.31284         0.0000
      3.7920        0.29176        0.43038E-01   0.31310         0.0000
      4.2133        0.29176        0.42788E-01   0.31335         0.0000

     LENGTH         AR             H2O            H2             CH4
     FT

      0.0000        0.40007E-02    0.25115        0.81825E-01    0.52367E-01
     0.42133        0.35147E-02    0.16449        0.14073        0.43369E-01
     0.84267        0.35147E-02    0.16479        0.14044        0.43369E-01
      1.2640        0.35147E-02    0.16507        0.14015        0.43369E-01
      1.6853        0.35147E-02    0.16535        0.13987        0.43369E-01
      2.1067        0.35147E-02    0.16563        0.13959        0.43369E-01
      2.5280        0.35147E-02    0.16590        0.13932        0.43369E-01
      2.9493        0.35147E-02    0.16616        0.13906        0.43369E-01
      3.3707        0.35147E-02    0.16642        0.13880        0.43369E-01
      3.7920        0.35147E-02    0.16668        0.13854        0.43369E-01
      4.2133        0.35147E-02    0.16693        0.13829        0.43369E-01

        ***  TOTAL  MASS FRACTION PROFILE (PROCESS SUBSTREAM MIXED) ***

     LENGTH         N2             CO2            CO             O2
     FT

      0.0000        0.39737        0.30622E-01   0.20690        0.12210
     0.42133        0.35604        0.86703E-01   0.37938         0.0000
     0.84267        0.35604        0.86143E-01   0.37973         0.0000
      1.2640        0.35604        0.85594E-01   0.38008         0.0000
      1.6853        0.35604        0.85056E-01   0.38043         0.0000
      2.1067        0.35604        0.84527E-01   0.38076         0.0000
      2.5280        0.35604        0.84009E-01   0.38109         0.0000
      2.9493        0.35604        0.83501E-01   0.38142         0.0000
      3.3707        0.35604        0.83002E-01   0.38173         0.0000
      3.7920        0.35604        0.82512E-01   0.38204         0.0000
      4.2133        0.35604        0.82031E-01   0.38235         0.0000
```



```
BLOCK:  GFR      MODEL: RPLUG (CONTINUED)

        ***  TOTAL  MASS FRACTION PROFILE (PROCESS SUBSTREAM MIXED) ***

     LENGTH         AR             H2O            H2             CH4
     FT

      0.0000        0.68263E-02    0.19325        0.70454E-02    0.35883E-01
     0.42133        0.61164E-02    0.12909        0.12358E-01    0.30309E-01
     0.84267        0.61164E-02    0.12932        0.12333E-01    0.30309E-01
      1.2640        0.61164E-02    0.12955        0.12307E-01    0.30309E-01
      1.6853        0.61164E-02    0.12977        0.12283E-01    0.30309E-01
      2.1067        0.61164E-02    0.12998        0.12259E-01    0.30309E-01
      2.5280        0.61164E-02    0.13020        0.12235E-01    0.30309E-01
      2.9493        0.61164E-02    0.13040        0.12212E-01    0.30309E-01
      3.3707        0.61164E-02    0.13061        0.12189E-01    0.30309E-01
      3.7920        0.61164E-02    0.13081        0.12166E-01    0.30309E-01
      4.2133        0.61164E-02    0.13101        0.12144E-01    0.30309E-01
```

```
        *** RESULTS PROFILE (PROCESS SUBSTREAM NC) ***

     LENGTH         PRESSURE       TEMPERATURE   RES-TIME
     FT             PSI            F             HR

      0.0000         25.000         1144.2        0.0000
     0.42133         24.946         2003.3       0.29813E-04
     0.84267         24.892         2002.8       0.60078E-04
      1.2640         24.837         2002.5       0.90282E-04
      1.6853         24.783         2002.1       0.12042E-03
      2.1067         24.729         2001.7       0.15051E-03
      2.5280         24.675         2001.3       0.18053E-03
      2.9493         24.621         2000.9       0.21049E-03
      3.3707         24.566         2000.6       0.24038E-03
      3.7920         24.512         2000.2       0.27022E-03
      4.2133         24.458         1999.9       0.30000E-03
```



```
BLOCK:  GFR      MODEL: RPLUG (CONTINUED)

        *** MASS FRACTION PROFILE (PROCESS SUBSTREAM NC) ***

     LENGTH         CHAR           FUEL          TAR            ASH
     FT

      0.0000        0.56072        0.30227E-07   0.26762        0.17166
     0.42133        0.12812        0.59994E-07   0.53117        0.34071
     0.84267        0.12812        0.59994E-07   0.53117        0.34071
      1.2640        0.12812        0.59994E-07   0.53117        0.34071
      1.6853        0.12812        0.59994E-07   0.53117        0.34071
      2.1067        0.12812        0.59994E-07   0.53117        0.34071
      2.5280        0.12812        0.59994E-07   0.53117        0.34071
      2.9493        0.12812        0.59994E-07   0.53117        0.34071
      3.3707        0.12812        0.59994E-07   0.53117        0.34071
      3.7920        0.12812        0.59994E-07   0.53117        0.34071
      4.2133        0.12812        0.59994E-07   0.53117        0.34071



     LENGTH         CHAR           FUEL          TAR            ASH
     FT

BLOCK:  GFR-2    MODEL: RYIELD
-----------------------------
  INLET STREAM:           FEED-2
  OUTLET STREAM:          SYNGAS-5
  PROPERTY OPTION SET:    PR-BM     PENG-ROBINSON EQUATION OF STATE

                      ***  MASS AND ENERGY BALANCE  ***
                             IN           OUT        GENERATION   RELATIVE DIFF.
CONV. COMP.(LBMOL/HR)     509.278       579.694       70.4157       0.00000
          (TONS/HR )      5.96166       6.65359                    -0.103993
NONCONV COMP(TONS/HR )    1.39453       0.702605                    0.496172
```



```
BLOCK:  GFR-2    MODEL: RYIELD (CONTINUED)
  TOTAL BALANCE
     MASS(TONS/HR )       7.35619       7.35619                    -0.241478E-15
     ENTHALPY(MMBTU/HR) -14.8650      -14.8650                      0.119375E-10
```

```
                        ***  INPUT DATA  ***
  TWO    PHASE  PQ  FLASH
  PRESSURE DROP          PSI                                  0.54191
  SPECIFIED HEAT DUTY   MMBTU/HR                              0.0
  MAXIMUM NO. ITERATIONS                                     30
  CONVERGENCE TOLERANCE                                       0.000100000

   MASS-YIELD
    SUBSTREAM MIXED    :
    CO2        0.126         CO         0.587         H2O         0.201
    H2         0.186E-01     CH4        0.465E-01
    SUBSTREAM NC       :
    CHAR       0.208E-01

  INERTS:          N2          CACO3       CAO         AR          NO2
                   NO          H2O-MUD     FUEL        TAR         ASH
                   C
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 174
                       HOG FUEL GASIFICATION PROJECT CASE A
                     U-O-S BLOCK SECTION (HIERARCHY: GASIFIER)

BLOCK:  GFR-2    MODEL: RYIELD (CONTINUED)

                         ***  RESULTS  ***
  OUTLET TEMPERATURE    F                                      1999.9
  OUTLET PRESSURE       PSI                                    24.458
  HEAT DUTY             MMBTU/HR                               0.0000
  VAPOR FRACTION                                               1.0000


  V-L PHASE EQUILIBRIUM :

     COMP                F(I)           X(I)           Y(I)           K(I)
     N2                  0.29176        0.36765E-07    0.29176        949.71
     CO2                 0.42788E-01    0.27059E-05    0.42788E-01    964.27
     CO                  0.31335        0.41648E-07    0.31335        955.32
     AR                  0.35147E-02    0.79988E-08    0.35147E-02    903.86
     H2O                 0.16693         1.0000        0.16693        846.26
     H2                  0.13829        0.59333E-07    0.13829        864.60
     CH4                 0.43369E-01    0.50644E-07    0.43369E-01    966.87

BLOCK:  HEATMIX  MODEL: MIXER
-----------------------------
  INLET STREAMS:          HEAT-1      GFRQLOSS
  OUTLET STREAM:          HEAT-2
  PROPERTY OPTION SET:    PR-BM     PENG-ROBINSON EQUATION OF STATE

                     ***  MASS AND ENERGY BALANCE  ***
                                   IN              OUT          RELATIVE DIFF.
   TOTAL BALANCE
      ENTHALPY(MMBTU/HR)      -10.8754        -10.8754          0.00000
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 175
                       HOG FUEL GASIFICATION PROJECT CASE A
                        STREAM SECTION (HIERARCHY: GASIFIER)

AIR ASH BIOMASS DEVOLPRD FEED-1
-------------------------------

STREAM ID                 AIR         ASH         BIOMASS     DEVOLPRD    FEED-1
FROM :                    $C-10       ASH-SEP     $C-11       EVP-DEVL    FD-SPLT
TO   :                    FEED-MIX    $C-13       EVP-DEVL    FEED-MIX    GFR
CLASS:                    MIXNC       MIXNC       MIXNC       MIXNC       MIXNC
TOTAL STREAM:
  TONS/HR                  6.2820      0.4788      8.4304      8.4304      7.3562
```

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  MMBTU/HR                 0.2665      0.5524    -40.4698    -29.9964    -14.8650
SUBSTREAM: MIXED
PHASE:                    VAPOR       MISSING     MISSING     VAPOR       VAPOR
COMPONENTS: LBMOL/HR
  N2                     338.2609     0.0         0.0         0.0       169.1305
  CO2                      0.1301     0.0         0.0        16.4624      8.2962
  CACO3                    0.0        0.0         0.0         0.0         0.0
  CAO                      0.0        0.0         0.0         0.0         0.0
  CO                       0.0        0.0         0.0       176.1481     88.0741
  O2                      90.9919     0.0         0.0         0.0        45.4959
  AR                       4.0749     0.0         0.0         0.0         2.0375
  NO2                      0.0        0.0         0.0         0.0         0.0
  NO                       0.0        0.0         0.0         0.0         0.0
  H2O                      0.4335     0.0         0.0       255.3733    127.9034
  H2                     4.3350-02    0.0         0.0        83.3000     41.6717
  H2O-MUD                  0.0        0.0         0.0         0.0         0.0
  CH4                      0.0        0.0         0.0        53.3383     26.6692
  C                        0.0        0.0         0.0         0.0         0.0
COMPONENTS: MOLE FRAC
  N2                       0.7795     0.0         0.0         0.0         0.3321
  CO2                    2.9970-04    0.0         0.0       2.8159-02   1.6290-02
  CACO3                    0.0        0.0         0.0         0.0         0.0
  CAO                      0.0        0.0         0.0         0.0         0.0
  CO                       0.0        0.0         0.0         0.3013      0.1729
  O2                       0.2097     0.0         0.0         0.0       8.9334-02
  AR                     9.3906-03    0.0         0.0         0.0       4.0007-03
  NO2                      0.0        0.0         0.0         0.0         0.0
  NO                       0.0        0.0         0.0         0.0         0.0
  H2O                    9.9900-04    0.0         0.0         0.4368      0.2511
  H2                     9.9900-05    0.0         0.0         0.1425    8.1825-02
  H2O-MUD                  0.0        0.0         0.0         0.0         0.0
  CH4                      0.0        0.0         0.0       9.1236-02   5.2367-02
  C                        0.0        0.0         0.0         0.0         0.0
COMPONENTS: TONS/HR
  N2                       4.7379     0.0         0.0         0.0         2.3690
  CO2                    2.8617-03    0.0         0.0         0.3623      0.1826
  CACO3                    0.0        0.0         0.0         0.0         0.0
  CAO                      0.0        0.0         0.0         0.0         0.0
  CO                       0.0        0.0         0.0         2.4670      1.2335
  O2                       1.4558     0.0         0.0         0.0         0.7279
  AR                     8.1392-02    0.0         0.0         0.0       4.0696-02
  NO2                      0.0        0.0         0.0         0.0         0.0
  NO                       0.0        0.0         0.0         0.0         0.0
  H2O                    3.9048-03    0.0         0.0         2.3003      1.1521
  H2                     4.3694-05    0.0         0.0       8.3961-02   4.2003-02
  H2O-MUD                  0.0        0.0         0.0         0.0         0.0
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 176
                       HOG FUEL GASIFICATION PROJECT CASE A
                        STREAM SECTION (HIERARCHY: GASIFIER)

AIR ASH BIOMASS DEVOLPRD FEED-1 (CONTINUED)

STREAM ID                 AIR         ASH         BIOMASS     DEVOLPRD    FEED-1

  CH4                      0.0        0.0         0.0         0.4278      0.2139
  C                        0.0        0.0         0.0         0.0         0.0
COMPONENTS: MASS FRAC
  N2                       0.7542     MISSING     MISSING     0.0         0.3974
  CO2                    4.5555-04    MISSING     MISSING   6.4214-02   3.0622-02
  CACO3                    0.0        MISSING     MISSING     0.0         0.0
  CAO                      0.0        MISSING     MISSING     0.0         0.0
  CO                       0.0        MISSING     MISSING     0.4373      0.2069
  O2                       0.2317     MISSING     MISSING     0.0         0.1221
  AR                     1.2957-02    MISSING     MISSING     0.0       6.8263-03
  NO2                      0.0        MISSING     MISSING     0.0         0.0
  NO                       0.0        MISSING     MISSING     0.0         0.0
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  H2O                    6.2159-04    MISSING     MISSING     0.4078      0.1933
  H2                     6.9555-06    MISSING     MISSING   1.4883-02   7.0454-03
  H2O-MUD                  0.0        MISSING     MISSING     0.0         0.0
  CH4                      0.0        MISSING     MISSING   7.5841-02   3.5883-02
  C                        0.0        MISSING     MISSING     0.0         0.0
TOTAL FLOW:
  LBMOL/HR               433.9346     0.0         0.0       584.6221    509.2784
  TONS/HR                  6.2820     0.0         0.0         5.6414      5.9617
  CUFT/HR                1.2064+05    0.0         0.0       5.3006+05   3.5075+05
STATE VARIABLES:
  TEMP   F               187.9075     MISSING     MISSING  1652.0000   1144.2167
  PRES   PSI              25.0000    24.4581     14.6959     25.0000     25.0000
  VFRAC                    1.0000     MISSING     MISSING     1.0000      1.0000
  LFRAC                    0.0        MISSING     MISSING     0.0         0.0
  SFRAC                    0.0        MISSING     MISSING     0.0         0.0
ENTHALPY:
  BTU/LBMOL              614.0381     MISSING     MISSING -5.3458+04  -3.0278+04
  BTU/LB                  21.2078     MISSING     MISSING -2769.9462  -1293.2741
  MMBTU/HR                 0.2665     MISSING     MISSING   -31.2525    -15.4201
ENTROPY:
  BTU/LBMOL-R              1.3802     MISSING     MISSING    13.3686     10.8806
  BTU/LB-R               4.7668-02    MISSING     MISSING     0.6927      0.4647
DENSITY:
  LBMOL/CUFT             3.5971-03    MISSING     MISSING   1.1029-03   1.4520-03
  LB/CUFT                  0.1041     MISSING     MISSING   2.1286-02   3.3994-02
AVG MW                    28.9534     MISSING     MISSING    19.2992     23.4122

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW       UNITLESS
    N2                    28.0135     MISSING     MISSING     MISSING     28.0135
    CO2                   44.0098     MISSING     MISSING    44.0098     44.0098
    CACO3                 MISSING     MISSING     MISSING     MISSING     MISSING
    CAO                   MISSING     MISSING     MISSING     MISSING     MISSING
    CO                    MISSING     MISSING     MISSING    28.0104     28.0104
    O2                    31.9988     MISSING     MISSING     MISSING     31.9988
    AR                    39.9480     MISSING     MISSING     MISSING     39.9480
    NO2                   MISSING     MISSING     MISSING     MISSING     MISSING
    NO                    MISSING     MISSING     MISSING     MISSING     MISSING
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 177
                       HOG FUEL GASIFICATION PROJECT CASE A
                        STREAM SECTION (HIERARCHY: GASIFIER)

AIR ASH BIOMASS DEVOLPRD FEED-1 (CONTINUED)

STREAM ID                 AIR         ASH         BIOMASS     DEVOLPRD    FEED-1

    H2O                   18.0153     MISSING     MISSING    18.0153     18.0153
    H2                     2.0159     MISSING     MISSING     2.0159      2.0159
    H2O-MUD               MISSING     MISSING     MISSING     MISSING     MISSING
    CH4                   MISSING     MISSING     MISSING    16.0428     16.0428
    C                     MISSING     MISSING     MISSING     MISSING     MISSING
MWMX                      28.9534     MISSING     MISSING    19.2992     23.4122
QVALGRS  BTU/LB            1.0766     MISSING     MISSING  5044.9759   2387.5329
QVALNET  BTU/LB            0.3587     MISSING     MISSING  4298.3366   2033.8919

*** VAPOR PHASE   ***
MUMX     LB/FT-HR       5.2368-02     MISSING     MISSING   8.5170-02   8.0274-02
PR                         0.6992     MISSING     MISSING     0.5785      0.6026
KMX      BTU/HR-FT-R    1.8099-02     MISSING     MISSING   7.7404-02   4.9319-02
*   68.0000 F        *
VVSTD    CUM/SEC
    N2                     1.0252     MISSING     MISSING     MISSING     0.5126
    CO2                  3.9416-04    MISSING     MISSING   4.9895-02   2.5145-02
    CACO3                 MISSING     MISSING     MISSING     MISSING     MISSING
```

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    CAO                   MISSING     MISSING     MISSING     MISSING     MISSING
    CO                    MISSING     MISSING     MISSING     0.5339      0.2669
    O2                     0.2758     MISSING     MISSING     MISSING     0.1379
    AR                   1.2350-02    MISSING     MISSING     MISSING   6.1752-03
    NO2                   MISSING     MISSING     MISSING     MISSING     MISSING
    NO                    MISSING     MISSING     MISSING     MISSING     MISSING
    H2O                  1.3139-03    MISSING     MISSING     0.7740      0.3877
    H2                   1.3139-04    MISSING     MISSING     0.2525      0.1263
    H2O-MUD               MISSING     MISSING     MISSING     MISSING     MISSING
    CH4                   MISSING     MISSING     MISSING     0.1617    8.0830-02
    C                     MISSING     MISSING     MISSING     MISSING     MISSING
*   68.0000 F        *
VVSTDMX  CUFT/MIN        2786.7270    MISSING     MISSING  3754.4419   3270.5845

SUBSTREAM: NC             STRUCTURE: NON CONVENTIONAL
COMPONENTS: TONS/HR
  CHAR                     0.0        0.0         0.0         1.5639      0.7819
  FUEL                     0.0        0.0         8.4304    8.4304-08   4.2152-08
  TAR                      0.0        0.0         0.0         0.7464      0.3732
  ASH                      0.0        0.4788      0.0         0.4788      0.2394
COMPONENTS: MASS FRAC
  CHAR                     0.0        0.0         0.0         0.5607      0.5607
  FUEL                     0.0        0.0         1.0000    3.0227-08   3.0227-08
  TAR                      0.0        0.0         0.0         0.2676      0.2676
  ASH                      0.0        1.0000      0.0         0.1717      0.1717
TOTAL FLOW:
  TONS/HR                  0.0        0.4788      8.4304      2.7891      1.3945
STATE VARIABLES:
  TEMP   F                MISSING  1999.8616    212.0000   1652.0000   1144.2167
  PRES   PSI              25.0000    24.4581     14.6959     25.0000     25.0000
  VFRAC                   MISSING     0.0         0.0         0.0         0.0
  LFRAC                   MISSING     0.0         0.0         0.0         0.0
  SFRAC                   MISSING     1.0000      1.0000      1.0000      1.0000
 ASPEN PLUS   PLAT: WIN32     VER: 20.0 1                   09/27/2007  PAGE 178
                       HOG FUEL GASIFICATION PROJECT CASE A
                        STREAM SECTION (HIERARCHY: GASIFIER)

AIR ASH BIOMASS DEVOLPRD FEED-1 (CONTINUED)

STREAM ID                 AIR         ASH         BIOMASS     DEVOLPRD    FEED-1

ENTHALPY:
  BTU/LB                  MISSING    576.8585  -2400.2212    225.1929    199.0434
  MMBTU/HR                MISSING      0.5524    -40.4698      1.2562      0.5551
DENSITY:
  LB/CUFT                 MISSING    187.2839     82.7971    110.5092    110.5092
AVG MW                     1.0000      1.0000      1.0000      1.0000      1.0000
COMPONENT ATTRIBUTES:
CHAR      PROXANAL
            MOISTURE      MISSING     MISSING     MISSING     0.0         0.0
            FC            MISSING     MISSING     MISSING     0.0         0.0
            VM            MISSING     MISSING     MISSING     0.0         0.0
            ASH           MISSING     MISSING     MISSING     0.0         0.0
          ULTANAL
            ASH           MISSING     MISSING     MISSING     0.0         0.0
            CARBON        MISSING     MISSING     MISSING    94.2164     94.2164
            HYDROGEN      MISSING     MISSING     MISSING     0.6269      0.6269
            NITROGEN      MISSING     MISSING     MISSING     0.0         0.0
            CHLORINE      MISSING     MISSING     MISSING     0.0         0.0
            SULFUR        MISSING     MISSING     MISSING     0.0         0.0
            OXYGEN        MISSING     MISSING     MISSING     5.1567      5.1567
          SULFANAL
            PYRITIC       MISSING     MISSING     MISSING     0.0         0.0
            SULFATE       MISSING     MISSING     MISSING     0.0         0.0
            ORGANIC       MISSING     MISSING     MISSING     0.0         0.0
FUEL      PROXANAL
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            MOISTURE     MISSING    MISSING    10.0000     0.0         0.0
            FC           MISSING    MISSING     0.0        0.0         0.0
            VM           MISSING    MISSING     0.0        0.0         0.0
            ASH          MISSING    MISSING     6.3100     6.3100      6.3100
          ULTANAL
            ASH          MISSING    MISSING     6.3100     6.3100      6.3100
            CARBON       MISSING    MISSING    44.7400    44.7400     44.7400
            HYDROGEN     MISSING    MISSING     5.5000     5.5000      5.5000
            NITROGEN     MISSING    MISSING     0.0        0.0         0.0
            CHLORINE     MISSING    MISSING     0.0        0.0         0.0
            SULFUR       MISSING    MISSING     0.0        0.0         0.0
            OXYGEN       MISSING    MISSING    43.4500    43.4500     43.4500
          SULFANAL
            PYRITIC      MISSING    MISSING     0.0        0.0         0.0
            SULFATE      MISSING    MISSING     0.0        0.0         0.0
            ORGANIC      MISSING    MISSING     0.0        0.0         0.0
 TAR      PROXANAL
            MOISTURE     MISSING    MISSING    MISSING     0.0         0.0
            FC           MISSING    MISSING    MISSING     0.0         0.0
            VM           MISSING    MISSING    MISSING     0.0         0.0
            ASH          MISSING    MISSING    MISSING     0.0         0.0
          ULTANAL
            ASH          MISSING    MISSING    MISSING     0.0         0.0
            CARBON       MISSING    MISSING    MISSING    59.4990     59.4990
            HYDROGEN     MISSING    MISSING    MISSING     7.0942      7.0942
            NITROGEN     MISSING    MISSING    MISSING     0.0         0.0
            CHLORINE     MISSING    MISSING    MISSING     0.0         0.0
 ASPEN PLUS    PLAT: WIN32     VER: 20.0 1               09/27/2007  PAGE 179
                         HOG FUEL GASIFICATION PROJECT CASE A
                          STREAM SECTION (HIERARCHY: GASIFIER)

AIR ASH BIOMASS DEVOLPRD FEED-1 (CONTINUED)

STREAM ID                AIR        ASH        BIOMASS    DEVOLPRD   FEED-1

            SULFUR       MISSING    MISSING    MISSING     0.0         0.0
            OXYGEN       MISSING    MISSING    MISSING    33.4068     33.4068
          SULFANAL
            PYRITIC      MISSING    MISSING    MISSING     0.0         0.0
            SULFATE      MISSING    MISSING    MISSING     0.0         0.0
            ORGANIC      MISSING    MISSING    MISSING     0.0         0.0
 ASH      GENANAL
            ELEM1        MISSING   100.0000    MISSING   100.0000    100.0000
            ELEM2        MISSING     0.0       MISSING     0.0         0.0
            ELEM3        MISSING     0.0       MISSING     0.0         0.0
            ELEM4        MISSING     0.0       MISSING     0.0         0.0
            ELEM5        MISSING     0.0       MISSING     0.0         0.0
            ELEM6        MISSING     0.0       MISSING     0.0         0.0
            ELEM7        MISSING     0.0       MISSING     0.0         0.0
            ELEM8        MISSING     0.0       MISSING     0.0         0.0
            ELEM9        MISSING     0.0       MISSING     0.0         0.0
            ELEM10       MISSING     0.0       MISSING     0.0         0.0
            ELEM11       MISSING     0.0       MISSING     0.0         0.0
            ELEM12       MISSING     0.0       MISSING     0.0         0.0
            ELEM13       MISSING     0.0       MISSING     0.0         0.0
            ELEM14       MISSING     0.0       MISSING     0.0         0.0
            ELEM15       MISSING     0.0       MISSING     0.0         0.0
            ELEM16       MISSING     0.0       MISSING     0.0         0.0
            ELEM17       MISSING     0.0       MISSING     0.0         0.0
            ELEM18       MISSING     0.0       MISSING     0.0         0.0
            ELEM19       MISSING     0.0       MISSING     0.0         0.0
            ELEM20       MISSING     0.0       MISSING     0.0         0.0
 ASPEN PLUS    PLAT: WIN32     VER: 20.0 1               09/27/2007  PAGE 180
                         HOG FUEL GASIFICATION PROJECT CASE A
                          STREAM SECTION (HIERARCHY: GASIFIER)
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FEED-2 MIX-FEED SYNGAS-1 SYNGAS-2 SYNGAS-3
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STREAM ID                FEED-2      MIX-FEED    SYNGAS-1    SYNGAS-2    SYNGAS-3
FROM :                   FD-SPLT     FEED-MIX    GFR         ASH-SEP     DVL-EXCH
TO   :                   GFR-2       FD-SPLT     ASH-SEP     DVL-EXCH    $C-9
CLASS:                   MIXNC       MIXNC       MIXNC       MIXNC       MIXNC
TOTAL STREAM:
  TONS/HR                  7.3562     14.7124      7.3562     14.2336     14.2336
  MMBTU/HR               -14.8650    -29.7299    -14.8650    -30.2823    -41.1577
SUBSTREAM: MIXED
PHASE:                   VAPOR       VAPOR       VAPOR       VAPOR       VAPOR
COMPONENTS: LBMOL/HR
  N2                     169.1305    338.2609    169.1305    338.2609    338.2609
  CO2                      8.2962     16.5925     24.8037     49.6074     49.6074
  CACO3                    0.0         0.0         0.0         0.0         0.0
  CAO                      0.0         0.0         0.0         0.0         0.0
  CO                      88.0741    176.1481    181.6470    363.2938    363.2938
  O2                      45.4959     90.9919      0.0         0.0         0.0
  AR                       2.0375      4.0749      2.0375      4.0749      4.0749
  NO2                      0.0         0.0         0.0         0.0         0.0
  NO                       0.0         0.0         0.0         0.0         0.0
  H2O                    127.9034    255.8068     96.7684    193.5367    193.5367
  H2                      41.6717     83.3433     80.1667    160.3333    160.3333
  H2O-MUD                  0.0         0.0         0.0         0.0         0.0
  CH4                     26.6692     53.3383     25.1409     50.2817     50.2817
  C                        0.0         0.0         0.0         0.0         0.0
COMPONENTS: MOLE FRAC
  N2                       0.3321      0.3321      0.2918      0.2918      0.2918
  CO2                    1.6290-02   1.6290-02   4.2788-02   4.2788-02   4.2788-02
  CACO3                    0.0         0.0         0.0         0.0         0.0
  CAO                      0.0         0.0         0.0         0.0         0.0
  CO                       0.1729      0.1729      0.3133      0.3133      0.3133
  O2                     8.9334-02   8.9334-02     0.0         0.0         0.0
  AR                     4.0007-03   4.0007-03   3.5147-03   3.5147-03   3.5147-03
  NO2                      0.0         0.0         0.0         0.0         0.0
  NO                       0.0         0.0         0.0         0.0         0.0
  H2O                      0.2511      0.2511      0.1669      0.1669      0.1669
  H2                     8.1825-02   8.1825-02     0.1383      0.1383      0.1383
  H2O-MUD                  0.0         0.0         0.0         0.0         0.0
  CH4                    5.2367-02   5.2367-02   4.3369-02   4.3369-02   4.3369-02
  C                        0.0         0.0         0.0         0.0         0.0
COMPONENTS: TONS/HR
  N2                       2.3690      4.7379      2.3690      4.7379      4.7379
  CO2                      0.1826      0.3651      0.5458      1.0916      1.0916
  CACO3                    0.0         0.0         0.0         0.0         0.0
  CAO                      0.0         0.0         0.0         0.0         0.0
  CO                       1.2335      2.4670      2.5440      5.0880      5.0880
  O2                       0.7279      1.4558      0.0         0.0         0.0
  AR                     4.0696-02   8.1392-02   4.0696-02   8.1392-02   8.1392-02
  NO2                      0.0         0.0         0.0         0.0         0.0
  NO                       0.0         0.0         0.0         0.0         0.0
  H2O                      1.1521      2.3042      0.8717      1.7433      1.7433
  H2                     4.2003-02   8.4005-02   8.0803-02     0.1616      0.1616
  H2O-MUD                  0.0         0.0         0.0         0.0         0.0
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                         HOG FUEL GASIFICATION PROJECT CASE A
                          STREAM SECTION (HIERARCHY: GASIFIER)

FEED-2 MIX-FEED SYNGAS-1 SYNGAS-2 SYNGAS (CONTINUED)

STREAM ID                FEED-2      MIX-FEED    SYNGAS-1    SYNGAS-2    SYNGAS-3

  CH4                      0.2139      0.4278      0.2017      0.4033      0.4033
  C                        0.0         0.0         0.0         0.0         0.0
COMPONENTS: MASS FRAC
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  N2                       0.3974      0.3974      0.3560      0.3560      0.3560
  CO2                    3.0622-02   3.0622-02   8.2031-02   8.2031-02   8.2031-02
  CACO3                    0.0         0.0         0.0         0.0         0.0
  CAO                      0.0         0.0         0.0         0.0         0.0
  CO                       0.2069      0.2069      0.3824      0.3824      0.3824
  O2                       0.1221      0.1221      0.0         0.0         0.0
  AR                     6.8263-03   6.8263-03   6.1164-03   6.1164-03   6.1164-03
  NO2                      0.0         0.0         0.0         0.0         0.0
  NO                       0.0         0.0         0.0         0.0         0.0
  H2O                      0.1933      0.1933      0.1310      0.1310      0.1310
  H2                     7.0454-03   7.0454-03   1.2144-02   1.2144-02   1.2144-02
  H2O-MUD                  0.0         0.0         0.0         0.0         0.0
  CH4                    3.5883-02   3.5883-02   3.0309-02   3.0309-02   3.0309-02
  C                        0.0         0.0         0.0         0.0         0.0
TOTAL FLOW:
  LBMOL/HR               509.2784   1018.5567    579.6946   1159.3887   1159.3887
  TONS/HR                  5.9617     11.9233      6.6536     13.3072     13.3072
  CUFT/HR                3.5075+05   7.0149+05   6.2578+05   1.2516+06   7.1233+05
STATE VARIABLES:
  TEMP    F             1144.2167   1144.2167   1999.8636   1999.8616    940.0563
  PRES    PSI             25.0000     25.0000     24.4581     24.4581     24.4581
  VFRAC                    1.0000      1.0000      1.0000      1.0000      1.0000
  LFRAC                    0.0         0.0         0.0         0.0         0.0
  SFRAC                    0.0         0.0         0.0         0.0         0.0
ENTHALPY:
  BTU/LBMOL             -3.0278+04  -3.0278+04  -2.4831+04  -2.4831+04  -3.4211+04
  BTU/LB                -1293.2741  -1293.2741  -1081.6888  -1081.6892  -1490.3197
  MMBTU/HR                -15.4201    -30.8402    -14.3942    -28.7885    -39.6639
ENTROPY:
  BTU/LBMOL-R             10.8806     10.8806     18.5310     18.5310     13.5715
  BTU/LB-R                 0.4647      0.4647      0.8073      0.8073      0.5912
DENSITY:
  LBMOL/CUFT             1.4520-03   1.4520-03   9.2635-04   9.2635-04   1.6276-03
  LB/CUFT                3.3994-02   3.3994-02   2.1265-02   2.1265-02   3.7363-02
AVG MW                    23.4122     23.4122     22.9555     22.9555     22.9555

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW        UNITLESS
    N2                    28.0135     28.0135     28.0135     28.0135     28.0135
    CO2                   44.0098     44.0098     44.0098     44.0098     44.0098
    CACO3                 MISSING     MISSING     MISSING     MISSING     MISSING
    CAO                   MISSING     MISSING     MISSING     MISSING     MISSING
    CO                    28.0104     28.0104     28.0104     28.0104     28.0104
    O2                    31.9988     31.9988     MISSING     MISSING     MISSING
    AR                    39.9480     39.9480     39.9480     39.9480     39.9480
    NO2                   MISSING     MISSING     MISSING     MISSING     MISSING
    NO                    MISSING     MISSING     MISSING     MISSING     MISSING
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                         HOG FUEL GASIFICATION PROJECT CASE A
                          STREAM SECTION (HIERARCHY: GASIFIER)

FEED-2 MIX-FEED SYNGAS-1 SYNGAS-2 SYNGAS (CONTINUED)

STREAM ID                FEED-2      MIX-FEED    SYNGAS-1    SYNGAS-2    SYNGAS-3

    H2O                   18.0153     18.0153     18.0153     18.0153     18.0153
    H2                     2.0159      2.0159      2.0159      2.0159      2.0159
    H2O-MUD               MISSING     MISSING     MISSING     MISSING     MISSING
    CH4                   16.0428     16.0428     16.0428     16.0428     16.0428
    C                     MISSING     MISSING     MISSING     MISSING     MISSING
MWMX                      23.4122     23.4122     22.9555     22.9555     22.9555
QVALGRS   BTU/LB        2387.5329   2387.5329   3262.0196   3262.0188   3262.0188
QVALNET   BTU/LB        2033.8919   2033.8919   2939.0378   2939.0371   2939.0371
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*** VAPOR PHASE    ***
MUMX      LB/FT-HR       8.0274-02   8.0274-02     0.1181      0.1181    7.2800-02
PR                         0.6026      0.6026      0.5963      0.5963      0.5781
KMX       BTU/HR-FT-R    4.9319-02   4.9319-02   8.0780-02   8.0780-02   4.5255-02
*   68.0000 F       *
VVSTD     CUM/SEC
    N2                     0.5126      1.0252      0.5126      1.0252      1.0252
    CO2                  2.5145-02   5.0289-02   7.5176-02     0.1504      0.1504
    CACO3                 MISSING     MISSING     MISSING     MISSING     MISSING
    CAO                   MISSING     MISSING     MISSING     MISSING     MISSING
    CO                     0.2669      0.5339      0.5505      1.1011      1.1011
    O2                     0.1379      0.2758     MISSING     MISSING     MISSING
    AR                   6.1752-03   1.2350-02   6.1752-03   1.2350-02   1.2350-02
    NO2                   MISSING     MISSING     MISSING     MISSING     MISSING
    NO                    MISSING     MISSING     MISSING     MISSING     MISSING
    H2O                    0.3877      0.7753      0.2933      0.5866      0.5866
    H2                     0.1263      0.2526      0.2430      0.4859      0.4859
    H2O-MUD               MISSING     MISSING     MISSING     MISSING     MISSING
    CH4                  8.0830-02     0.1617    7.6198-02     0.1524      0.1524
    C                     MISSING     MISSING     MISSING     MISSING     MISSING
*   68.0000 F       *
VVSTDMX   CUFT/MIN       3270.5845   6541.1690   3722.7975   7445.5914   7445.5914

SUBSTREAM: NC            STRUCTURE: NON CONVENTIONAL
COMPONENTS: TONS/HR
  CHAR                     0.7819      1.5639    9.0020-02     0.1800      0.1800
  FUEL                   4.2152-08   8.4304-08   4.2152-08   8.4304-08   8.4304-08
  TAR                      0.3732      0.7464      0.3732      0.7464      0.7464
  ASH                      0.2394      0.4788      0.2394      0.0         0.0
COMPONENTS: MASS FRAC
  CHAR                     0.5607      0.5607      0.1281      0.1943      0.1943
  FUEL                   3.0227-08   3.0227-08   5.9994-08   9.0998-08   9.0998-08
  TAR                      0.2676      0.2676      0.5312      0.8057      0.8057
  ASH                      0.1717      0.1717      0.3407      0.0         0.0
TOTAL FLOW:
  TONS/HR                  1.3945      2.7891      0.7026      0.9264      0.9264
STATE VARIABLES:
  TEMP    F             1144.2167   1144.2167   1999.8636   1999.8616    940.0563
  PRES    PSI             25.0000     25.0000     24.4581     24.4581     24.4581
  VFRAC                    0.0         0.0         0.0         0.0         0.0
  LFRAC                    0.0         0.0         0.0         0.0         0.0
  SFRAC                    1.0000      1.0000      1.0000      1.0000      1.0000
 ASPEN PLUS    PLAT: WIN32     VER: 20.0 1               09/27/2007  PAGE 183
                         HOG FUEL GASIFICATION PROJECT CASE A
                          STREAM SECTION (HIERARCHY: GASIFIER)

FEED-2 MIX-FEED SYNGAS-1 SYNGAS-2 SYNGAS (CONTINUED)

STREAM ID                FEED-2      MIX-FEED    SYNGAS-1    SYNGAS-2    SYNGAS-3

ENTHALPY:
  BTU/LB                 199.0434    199.0434   -334.9949   -806.2184   -806.2184
  MMBTU/HR                 0.5551      1.1103     -0.4707     -1.4938     -1.4938
DENSITY:
  LB/CUFT                110.5092    110.5092    100.8377     81.4171     81.4171
AVG MW                     1.0000      1.0000      1.0000      1.0000      1.0000
COMPONENT ATTRIBUTES:
CHAR      PROXANAL
            MOISTURE       0.0         0.0         0.0         0.0         0.0
            FC             0.0         0.0         0.0         0.0         0.0
            VM             0.0         0.0         0.0         0.0         0.0
            ASH            0.0         0.0         0.0         0.0         0.0
          ULTANAL
            ASH            0.0         0.0         0.0         0.0         0.0
            CARBON        94.2164     94.2164     94.2164     94.2164     94.2164
            HYDROGEN       0.6269      0.6269      0.6269      0.6269      0.6269
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          NITROGEN     0.0        0.0        0.0        0.0        0.0
          CHLORINE     0.0        0.0        0.0        0.0        0.0
          SULFUR       0.0        0.0        0.0        0.0        0.0
          OXYGEN       5.1567     5.1567     5.1567     5.1567     5.1567
        SULFANAL
          PYRITIC      0.0        0.0        0.0        0.0        0.0
          SULFATE      0.0        0.0        0.0        0.0        0.0
          ORGANIC      0.0        0.0        0.0        0.0        0.0
FUEL    PROXANAL
          MOISTURE     0.0        0.0        0.0        0.0        0.0
          FC           0.0        0.0        0.0        0.0        0.0
          VM           0.0        0.0        0.0        0.0        0.0
          ASH          6.3100     6.3100     6.3100     6.3100     6.3100
        ULTANAL
          ASH          6.3100     6.3100     6.3100     6.3100     6.3100
          CARBON      44.7400    44.7400    44.7400    44.7400    44.7400
          HYDROGEN     5.5000     5.5000     5.5000     5.5000     5.5000
          NITROGEN     0.0        0.0        0.0        0.0        0.0
          CHLORINE     0.0        0.0        0.0        0.0        0.0
          SULFUR       0.0        0.0        0.0        0.0        0.0
          OXYGEN      43.4500    43.4500    43.4500    43.4500    43.4500
        SULFANAL
          PYRITIC      0.0        0.0        0.0        0.0        0.0
          SULFATE      0.0        0.0        0.0        0.0        0.0
          ORGANIC      0.0        0.0        0.0        0.0        0.0
TAR     PROXANAL
          MOISTURE     0.0        0.0        0.0        0.0        0.0
          FC           0.0        0.0        0.0        0.0        0.0
          VM           0.0        0.0        0.0        0.0        0.0
          ASH          0.0        0.0        0.0        0.0        0.0
        ULTANAL
          ASH          0.0        0.0        0.0        0.0        0.0
          CARBON      59.4990    59.4990    59.4990    59.4990    59.4990
          HYDROGEN     7.0942     7.0942     7.0942     7.0942     7.0942
          NITROGEN     0.0        0.0        0.0        0.0        0.0
          CHLORINE     0.0        0.0        0.0        0.0        0.0
```



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FEED-2 MIX-FEED SYNGAS-1 SYNGAS-2 SYNGAS (CONTINUED)

STREAM ID              FEED-2     MIX-FEED   SYNGAS-1   SYNGAS-2   SYNGAS-3

          SULFUR       0.0        0.0        0.0        0.0        0.0
          OXYGEN      33.4068    33.4068    33.4068    33.4068    33.4068
        SULFANAL
          PYRITIC      0.0        0.0        0.0        0.0        0.0
          SULFATE      0.0        0.0        0.0        0.0        0.0
          ORGANIC      0.0        0.0        0.0        0.0        0.0
ASH     GENANAL
          ELEM1      100.0000   100.0000   100.0000    MISSING    MISSING
          ELEM2        0.0        0.0        0.0       MISSING    MISSING
          ELEM3        0.0        0.0        0.0       MISSING    MISSING
          ELEM4        0.0        0.0        0.0       MISSING    MISSING
          ELEM5        0.0        0.0        0.0       MISSING    MISSING
          ELEM6        0.0        0.0        0.0       MISSING    MISSING
          ELEM7        0.0        0.0        0.0       MISSING    MISSING
          ELEM8        0.0        0.0        0.0       MISSING    MISSING
          ELEM9        0.0        0.0        0.0       MISSING    MISSING
          ELEM10       0.0        0.0        0.0       MISSING    MISSING
          ELEM11       0.0        0.0        0.0       MISSING    MISSING
          ELEM12       0.0        0.0        0.0       MISSING    MISSING
          ELEM13       0.0        0.0        0.0       MISSING    MISSING
          ELEM14       0.0        0.0        0.0       MISSING    MISSING
          ELEM15       0.0        0.0        0.0       MISSING    MISSING
          ELEM16       0.0        0.0        0.0       MISSING    MISSING
          ELEM17       0.0        0.0        0.0       MISSING    MISSING
          ELEM18       0.0        0.0        0.0       MISSING    MISSING
          ELEM19       0.0        0.0        0.0       MISSING    MISSING
          ELEM20       0.0        0.0        0.0       MISSING    MISSING
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SYNGAS-5
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STREAM ID               SYNGAS-5
FROM :                  GFR-2
TO   :                  ASH-SEP
CLASS:                  MIXNC
TOTAL STREAM:
  TONS/HR                 7.3562
  MMBTU/HR              -14.8650
SUBSTREAM: MIXED
PHASE:                  VAPOR
COMPONENTS: LBMOL/HR
  N2                    169.1305
  CO2                    24.8037
  CACO3                   0.0
  CAO                     0.0
  CO                    181.6468
  O2                      0.0
  AR                      2.0375
  NO2                     0.0
  NO                      0.0
  H2O                    96.7683
  H2                     80.1666
  H2O-MUD                 0.0
  CH4                    25.1408
  C                       0.0
COMPONENTS: MOLE FRAC
  N2                      0.2918
  CO2                   4.2788-02
  CACO3                   0.0
  CAO                     0.0
  CO                      0.3133
  O2                      0.0
  AR                    3.5147-03
  NO2                     0.0
  NO                      0.0
  H2O                     0.1669
  H2                      0.1383
  H2O-MUD                 0.0
  CH4                   4.3369-02
  C                       0.0
COMPONENTS: TONS/HR
  N2                      2.3690
  CO2                     0.5458
  CACO3                   0.0
  CAO                     0.0
  CO                      2.5440
  O2                      0.0
  AR                    4.0696-02
  NO2                     0.0
  NO                      0.0
  H2O                     0.8717
  H2                    8.0803-02
  H2O-MUD                 0.0
```



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SYNGAS-5 (CONTINUED)

STREAM ID               SYNGAS-5

  CH4                     0.2017
  C                       0.0
COMPONENTS: MASS FRAC
  N2                      0.3560
  CO2                   8.2031-02
  CACO3                   0.0
  CAO                     0.0
  CO                      0.3824
  O2                      0.0
  AR                    6.1164-03
  NO2                     0.0
  NO                      0.0
  H2O                     0.1310
  H2                    1.2144-02
  H2O-MUD                 0.0
  CH4                   3.0309-02
  C                       0.0
TOTAL FLOW:
  LBMOL/HR              579.6941
  TONS/HR                 6.6536
  CUFT/HR               6.2578+05
STATE VARIABLES:
  TEMP    F            1999.8596
  PRES    PSI            24.4581
  VFRAC                   1.0000
  LFRAC                   0.0
  SFRAC                   0.0
ENTHALPY:
  BTU/LBMOL            -2.4831+04
  BTU/LB              -1081.6897
  MMBTU/HR              -14.3942
ENTROPY:
  BTU/LBMOL-R            18.5310
  BTU/LB-R                0.8073
DENSITY:
  LBMOL/CUFT            9.2635-04
  LB/CUFT               2.1265-02
AVG MW                   22.9555

MIXED    SUBSTREAM PROPERTIES:

***   ALL PHASES   ***
MW         UNITLESS
    N2                   28.0135
    CO2                  44.0098
    CACO3                MISSING
    CAO                  MISSING
    CO                   28.0104
    O2                   MISSING
    AR                   39.9480
    NO2                  MISSING
    NO                   MISSING
```



```
SYNGAS-5 (CONTINUED)

STREAM ID               SYNGAS-5

    H2O                  18.0153
    H2                    2.0159
    H2O-MUD              MISSING
    CH4                  16.0428
    C                    MISSING
MWMX                     22.9555
QVALGRS  BTU/LB        3262.0180
QVALNET  BTU/LB        2939.0364

*** VAPOR PHASE   ***
MUMX      LB/FT-HR        0.1181
PR                        0.5963
KMX       BTU/HR-FT-R  8.0780-02
*   68.0000 F         *
VVSTD     CUM/SEC
    N2                    0.5126
    CO2                 7.5176-02
    CACO3                MISSING
    CAO                  MISSING
    CO                    0.5505
    O2                   MISSING
    AR                  6.1752-03
    NO2                  MISSING
    NO                   MISSING
    H2O                   0.2933
    H2                    0.2430
    H2O-MUD              MISSING
    CH4                 7.6198-02
    C                    MISSING
*   68.0000 F         *
VVSTDMX  CUFT/MIN      3722.7939

SUBSTREAM: NC           STRUCTURE: NON CONVENTIONAL
COMPONENTS: TONS/HR
  CHAR                  9.0020-02
  FUEL                  4.2152-08
  TAR                     0.3732
  ASH                     0.2394
COMPONENTS: MASS FRAC
  CHAR                    0.1281
  FUEL                  5.9994-08
  TAR                     0.5312
  ASH                     0.3407
TOTAL FLOW:
  TONS/HR                 0.7026
STATE VARIABLES:
  TEMP    F            1999.8596
  PRES    PSI            24.4581
  VFRAC                   0.0
  LFRAC                   0.0
  SFRAC                   1.0000
```



```
SYNGAS-5 (CONTINUED)

STREAM ID               SYNGAS-5

ENTHALPY:
  BTU/LB               -334.9955
  MMBTU/HR               -0.4707
DENSITY:
  LB/CUFT               100.8377
AVG MW                    1.0000
COMPONENT ATTRIBUTES:
```

CHAR	PROXANAL		
		MOISTURE	0.0
		FC	0.0
		VM	0.0
		ASH	0.0
	ULTANAL		
		ASH	0.0
		CARBON	94.2164
		HYDROGEN	0.6269
		NITROGEN	0.0
		CHLORINE	0.0
		SULFUR	0.0
		OXYGEN	5.1567
	SULFANAL		
		PYRITIC	0.0
		SULFATE	0.0
		ORGANIC	0.0
FUEL	PROXANAL		
		MOISTURE	0.0
		FC	0.0
		VM	0.0
		ASH	6.3100
	ULTANAL		
		ASH	6.3100
		CARBON	44.7400
		HYDROGEN	5.5000
		NITROGEN	0.0
		CHLORINE	0.0
		SULFUR	0.0
		OXYGEN	43.4500
	SULFANAL		
		PYRITIC	0.0
		SULFATE	0.0
		ORGANIC	0.0
TAR	PROXANAL		
		MOISTURE	0.0
		FC	0.0
		VM	0.0
		ASH	0.0
	ULTANAL		
		ASH	0.0
		CARBON	59.4990
		HYDROGEN	7.0942
		NITROGEN	0.0
		CHLORINE	0.0

SYNGAS-5 (CONTINUED)

STREAM ID			SYNGAS-5
		SULFUR	0.0
		OXYGEN	33.4068
	SULFANAL		
		PYRITIC	0.0
		SULFATE	0.0
		ORGANIC	0.0
ASH	GENANAL		
		ELEM1	100.0000
		ELEM2	0.0
		ELEM3	0.0
		ELEM4	0.0
		ELEM5	0.0
		ELEM6	0.0
		ELEM7	0.0
		ELEM8	0.0
		ELEM9	0.0
		ELEM10	0.0
		ELEM11	0.0
		ELEM12	0.0
		ELEM13	0.0
		ELEM14	0.0
		ELEM15	0.0
		ELEM16	0.0
		ELEM17	0.0
		ELEM18	0.0
		ELEM19	0.0
		ELEM20	0.0

GFRQLOSS HEAT-1 HEAT-2

STREAM ID		GFRQLOSS	HEAT-1	HEAT-2
FROM :		----	EVP-DEVL	HEATMIX
TO :		HEATMIX	HEATMIX	DVL-EXCH
CLASS:		HEAT	HEAT	HEAT
STREAM ATTRIBUTES:				
HEAT				
Q	MMBTU/HR	-0.4020	-10.4734	-10.8754
TBEG	F	MISSING	212.0000	MISSING
TEND	F	MISSING	1652.0000	MISSING

FLOWSHEET CONNECTIVITY BY STREAMS

FLOWSHEET SECTION GLOBAL

STREAM	SOURCE	DEST	STREAM	SOURCE	DEST
FUEL	$C-3	BURNER	AIR	$C-8	BURNER
TG-BNR	BURNER	CL-CNG			

FLOWSHEET SECTION KILN

STREAM	SOURCE	DEST	STREAM	SOURCE	DEST
KLN-DUST	$C-4	REACTOR	CACO3	$C-7	REACTOR
HEATLOSS	----	HT-MIX	NCG-AIR	$C-5	NCG-HT
KLN-PROD	REACTOR	SEP	HEAT-4	REACTOR	BURNER
CAO	SEP	CAO-TADJ	KLN-TG	SEP	KLN-TADJ
TG	TG-MIX	H2O-CON	TG-BNR-2	CL-CNG	TG-MIX
KLN-TG-2	KLN-TADJ	TG-MIX	HEAT-3	KLN-TADJ	HT-SPLT
CAO-2	CAO-TADJ	$C-6	HEAT	CAO-TADJ	HT-MIX
HEAT-2	HT-MIX	REACTOR	TG-2	H2O-CON	$C-2
NCG-AIR2	NCG-HT	TG-MIX	HEAT-5	NCG-HT	BURNER
HEAT-6	HT-SPLT	HT-MIX	HEAT-7	HT-SPLT	$C-12

FLOWSHEET CONNECTIVITY BY BLOCKS

FLOWSHEET SECTION GLOBAL

BLOCK	INLETS	OUTLETS
BURNER	AIR FUEL HEAT-5 HEAT-4	TG-BNR

FLOWSHEET SECTION KILN

BLOCK	INLETS	OUTLETS
REACTOR	CACO3 KLN-DUST HEAT-2	KLN-PROD HEAT-4
SEP	KLN-PROD	CAO KLN-TG
TG-MIX	TG-BNR-2 KLN-TG-2 NCG-AIR2	TG
CL-CNG	TG-BNR	TG-BNR-2
KLN-TADJ	KLN-TG	KLN-TG-2 HEAT-3
CAO-TADJ	CAO	CAO-2 HEAT
HT-MIX	HEATLOSS HEAT HEAT-6	HEAT-2
H2O-CON	TG	TG-2
NCG-HT	NCG-AIR	NCG-AIR2 HEAT-5
HT-SPLT	HEAT-3	HEAT-6 HEAT-7

FLOWSHEET SECTION BALANCE: GLOBAL

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	2204.70	2204.70	0.00000
CO2	105.696	537.850	-0.803484
CACO3	0.00000	0.00000	0.00000
CAO	0.00000	0.00000	0.00000
CO	429.159	0.00000	1.00000
O2	459.853	54.9419	0.880523
AR	26.5592	26.5592	0.00000

FLOWSHEET SECTION BALANCE: GLOBAL (CONTINUED)

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	134.925	509.599	-0.735233
H2	374.600	0.00000	1.00000
H2O-MUD	0.00000	0.00000	0.00000
CH4	0.369641E-01	0.00000	1.00000
C	2.95798	0.00000	1.00000
TOTAL BALANCE			
MOLE(LBMOL/HR)	3738.49	3333.65	0.108289
MASS(TONS/HR)	48.7158	48.7158	-0.145855E-15
ENTHALPY(MMBTU/HR)	-112.222	-112.222	-0.126631E-15

FLOWSHEET SECTION BALANCE: KILN

*** MASS AND ENERGY BALANCE ***

	IN	OUT	RELATIVE DIFF.
CONVENTIONAL COMPONENTS (LBMOL/HR)			
N2	2305.39	2305.39	0.00000
CO2	537.889	1063.71	-0.494329
CACO3	526.061	0.00000	1.00000
CAO	47.7590	573.820	-0.916770
CO	0.00000	0.237845	-1.00000
O2	82.0282	82.1471	-0.144768E-02
AR	27.7722	27.7722	0.00000
NO2	0.00000	0.00000	0.00000
NO	0.00000	0.00000	0.00000
H2O	509.728	509.728	-0.950383E-08
H2	0.129044E-01	0.129044E-01	-0.317309E-07
H2O-MUD	0.484478E-05	0.00000	1.00000
CH4	0.00000	0.00000	0.00000
C	0.00000	0.00000	0.00000
TOTAL BALANCE			
MOLE(LBMOL/HR)	4036.64	4562.82	-0.115319
MASS(TONS/HR)	78.2509	78.2509	0.544819E-15
ENTHALPY(MMBTU/HR)	-406.860	-406.860	-0.504626E-06

BLOCK: BURNER MODEL: RSTOIC

INLET STREAMS:	AIR	FUEL
INLET HEAT STREAMS:	HEAT-5	HEAT-4
OUTLET STREAM:	TG-BNR	
PROPERTY OPTION SET:	PR-BM	PENG-ROBINSON EQUATION OF STATE

*** MASS AND ENERGY BALANCE ***

	IN	OUT	GENERATION	RELATIVE DIFF.
TOTAL BALANCE				
MOLE(LBMOL/HR)	3738.49	3333.65	-404.837	-0.121639E-15
MASS(TONS/HR)	48.7158	48.7158		-0.145855E-15
ENTHALPY(MMBTU/HR)	-112.222	-112.222		-0.126631E-15

*** INPUT DATA ***

TWO PHASE PQ FLASH		
SPECIFIED PRESSURE	PSI	14.6959
DUTY FROM INLET HEAT STREAM(S)	MMBTU/HR	-65.8494
MAXIMUM NO. ITERATIONS		30
CONVERGENCE TOLERANCE		0.000100000
SIMULTANEOUS REACTIONS		
GENERATE COMBUSTION REACTIONS FOR FEED SPECIES		YES
COMBUSTION PRODUCT FOR CHEMICALLY BOUND NITROGEN		NO

*** RESULTS ***

OUTLET TEMPERATURE	F	1249.0
OUTLET PRESSURE	PSI	14.696
VAPOR FRACTION		1.0000

BLOCK: BURNER MODEL: RSTOIC (CONTINUED)

COMBUSTION REACTIONS:

RXN NO	STOICHIOMETRY
C1	CO + 0.5 O2 --> CO2
C2	NO2 --> 0.5 O2 + NO
C3	0.5 O2 + H2 --> H2O
C4	2 O2 + CH4 --> CO2 + 2 H2O
C5	O2 + C --> CO2

REACTION EXTENTS:

REACTION NUMBER	REACTION EXTENT LBMOL/HR
C1	429.16
C3	374.60
C4	0.36964E-01
C5	2.9580

```
 V-L PHASE EQUILIBRIUM :

    COMP           F(I)          X(I)          Y(I)           K(I)
    N2             0.66135       0.66135       0.66135        679.86
    CO2            0.16134       0.16134       0.16134        569.68
    O2             0.16481E-01   0.16481E-01   0.16481E-01    623.54
    AR             0.79670E-02   0.79670E-02   0.79670E-02    620.51
    H2O            0.15287       0.15287       0.15287        389.33

BLOCK:  CAO-TADJ MODEL: HEATER
------------------------------
 INLET STREAM:          CAO
 OUTLET STREAM:         CAO-2
 OUTLET HEAT STREAM:    HEAT
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)            526.061         526.061         0.00000
     MASS(TONS/HR )            14.7501         14.7501         0.00000
     ENTHALPY(MMBTU/HR)       -128.978        -128.978         0.00000
```



```
BLOCK:  CAO-TADJ MODEL: HEATER (CONTINUED)

                        ***  INPUT DATA  ***
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE                   F                        1,300.00
 PRESSURE DROP                           PSI                          0.0
 MAXIMUM NO. ITERATIONS                                              30
 CONVERGENCE TOLERANCE                                                0.000100000


                        ***  RESULTS  ***
 OUTLET TEMPERATURE     F                                        1300.0
 OUTLET PRESSURE        PSI                                      14.696
 HEAT DUTY              MMBTU/HR                                 -6.7680
 OUTLET VAPOR FRACTION                                           0.0000


BLOCK:  CL-CNG   MODEL: CLCHNG
------------------------------
 INLET STREAM:          TG-BNR
 OUTLET STREAM:         TG-BNR-2
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)            3333.65         3333.65         0.00000
     MASS(TONS/HR )            48.7158         48.7158         0.00000
     ENTHALPY(MMBTU/HR)       -112.222        -112.222         0.00000

BLOCK:  H2O-CON  MODEL: RSTOIC
------------------------------
 INLET STREAM:          TG
 OUTLET STREAM:         TG-2
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE
```



```
BLOCK:  H2O-CON  MODEL: RSTOIC (CONTINUED)

                   ***  MASS AND ENERGY BALANCE  ***
                          IN            OUT        GENERATION   RELATIVE DIFF.
 TOTAL BALANCE
 MOLE(LBMOL/HR)         4036.76        4036.76       0.00000        0.00000
 MASS(TONS/HR )         63.5008        63.5008                      0.00000
 ENTHALPY(MMBTU/HR)    -205.522       -205.522                      0.180192E-12

                        ***  INPUT DATA  ***
 STOICHIOMETRY MATRIX:

  REACTION #   1:
   SUBSTREAM MIXED    :
   H2O        1.00    H2O-MUD   -1.00
   SUBSTREAM CISOLID :
   NO PARTICIPATING COMPONENTS


 REACTION CONVERSION SPECS: NUMBER=     1
   REACTION #   1:
   SUBSTREAM:MIXED     KEY COMP:H2O-MUD  CONV FRAC:  1.000



 TWO    PHASE  PQ  FLASH
 PRESSURE DROP               PSI                                    0.0
 SPECIFIED HEAT DUTY    MMBTU/HR                                    0.0
 MAXIMUM NO. ITERATIONS                                            30
 CONVERGENCE TOLERANCE                                              0.000100000
 SIMULTANEOUS REACTIONS
 GENERATE COMBUSTION REACTIONS FOR FEED SPECIES                   NO

                        ***  RESULTS  ***
 OUTLET TEMPERATURE     F                                          1249.2
 OUTLET PRESSURE        PSI                                        14.696
 VAPOR FRACTION                                                    1.0000
```



```
BLOCK:  H2O-CON  MODEL: RSTOIC (CONTINUED)

 REACTION EXTENTS:

    REACTION          REACTION
    NUMBER            EXTENT
                      LBMOL/HR
    1                 0.24222E-05

 V-L PHASE EQUILIBRIUM :

    COMP           F(I)          X(I)          Y(I)           K(I)
    N2             0.57794       0.45158E-07   0.57794        1000.2
    CO2            0.26666       0.13857E-04   0.26666        964.63
    CO             0.59625E-04   0.49427E-11   0.59625E-04    1004.4
    O2             0.20593E-01   0.33656E-07   0.20593E-01    943.46
    AR             0.69622E-02   0.10818E-07   0.69622E-02    941.39
    H2O            0.12778       0.99999       0.12778        781.63
    H2             0.32350E-05   0.82357E-12   0.32350E-05    908.00

BLOCK:  HT-MIX   MODEL: MIXER
------------------------------
 INLET STREAMS:         HEATLOSS    HEAT        HEAT-6
 OUTLET STREAM:         HEAT-2
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     ENTHALPY(MMBTU/HR)       -1.15410        -1.15410         0.00000

BLOCK:  HT-SPLT  MODEL: FSPLIT
------------------------------
 INLET STREAM:          HEAT-3
 OUTLET STREAMS:        HEAT-6      HEAT-7
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     ENTHALPY(MMBTU/HR)        7.97489         7.97489         0.00000

                        ***  INPUT DATA  ***
```



```
BLOCK:  HT-SPLT  MODEL: FSPLIT (CONTINUED)

 FRACTION OF FLOW                   STRM=HEAT-7   FRAC=          0.032221

                        ***  RESULTS  ***

 STREAM= HEAT-6           SPLIT=            0.96778
         HEAT-7                             0.032221

BLOCK:  KLN-TADJ MODEL: HEATER
------------------------------
 INLET STREAM:          KLN-TG
 OUTLET STREAM:         KLN-TG-2
 OUTLET HEAT STREAM:    HEAT-3
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)            573.939         573.939         0.00000
     MASS(TONS/HR )            12.9150         12.9150         0.00000
     ENTHALPY(MMBTU/HR)       -86.4166        -86.4166        -0.164446E-15

                        ***  INPUT DATA  ***
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE                   F                        1,250.00
 PRESSURE DROP                           PSI                          0.0
 MAXIMUM NO. ITERATIONS                                              30
 CONVERGENCE TOLERANCE                                                0.000100000


                        ***  RESULTS  ***
 OUTLET TEMPERATURE     F                                        1250.0
 OUTLET PRESSURE        PSI                                      14.696
 HEAT DUTY              MMBTU/HR                                 -7.9749
 OUTLET VAPOR FRACTION                                           1.0000
 PRESSURE-DROP CORRELATION PARAMETER                             0.0000
```



```
BLOCK:  KLN-TADJ MODEL: HEATER (CONTINUED)

 V-L PHASE EQUILIBRIUM :

    COMP           F(I)          X(I)          Y(I)           K(I)
    CO2            0.99932       0.99934       0.99932        831.01
    CO             0.45202E-03   0.43046E-03   0.45202E-03    872.66
    O2             0.22601E-03   0.22830E-03   0.22601E-03    822.70
    H2O            0.46033E-08   0.57118E-08   0.46033E-08    669.73
    H2             0.77819E-12   0.81399E-12   0.77819E-12    794.48
    H2O-MUD        0.46033E-08   0.57118E-08   0.46033E-08    669.73

BLOCK:  NCG-HT   MODEL: HEATER
------------------------------
 INLET STREAM:          NCG-AIR
 OUTLET STREAM:         NCG-AIR2
 OUTLET HEAT STREAM:    HEAT-5
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN              OUT          RELATIVE DIFF.
  TOTAL BALANCE
     MOLE(LBMOL/HR)            129.173         129.173         0.00000
     MASS(TONS/HR )            1.87000         1.87000         0.00000
     ENTHALPY(MMBTU/HR)     -0.285168E-01   -0.285168E-01   -0.352823E-14

                        ***  INPUT DATA  ***
 TWO    PHASE  TP  FLASH
 SPECIFIED TEMPERATURE                   F                        1,250.00
 PRESSURE DROP                           PSI                          0.0
 MAXIMUM NO. ITERATIONS                                              30
 CONVERGENCE TOLERANCE                                                0.000100000


                        ***  RESULTS  ***
 OUTLET TEMPERATURE     F                                        1250.0
 OUTLET PRESSURE        PSI                                      14.696
 HEAT DUTY              MMBTU/HR                                 1.1200
 OUTLET VAPOR FRACTION                                           1.0000
 PRESSURE-DROP CORRELATION PARAMETER                             0.0000
```



```
BLOCK:  NCG-HT   MODEL: HEATER (CONTINUED)

 V-L PHASE EQUILIBRIUM :

    COMP           F(I)          X(I)          Y(I)           K(I)
    N2             0.77952       0.77952       0.77952        MISSING
    CO2            0.29970E-03   0.29970E-03   0.29970E-03    MISSING
    O2             0.20969       0.20969       0.20969        MISSING
    AR             0.93906E-02   0.93906E-02   0.93906E-02    MISSING
    H2O            0.99900E-03   0.99900E-03   0.99900E-03    MISSING
    H2             0.99900E-04   0.99900E-04   0.99900E-04    MISSING

BLOCK:  REACTOR  MODEL: RGIBBS
------------------------------
 INLET STREAMS:         CACO3       KLN-DUST
```

```
 INLET HEAT STREAM:     HEAT-2
 OUTLET STREAM:         KLN-PROD
 OUTLET HEAT STREAM:    HEAT-4
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                              IN          OUT        GENERATION   RELATIVE DIFF.
 TOTAL BALANCE
 MOLE(LBMOL/HR)         573.820        1100.00        526.180        0.00000
 MASS(TONS/HR )         27.6651        27.6651                       0.154102E-14
 ENTHALPY(MMBTU/HR)    -280.124       -280.124                       0.00000

                        ***  INPUT DATA  ***

 EQUILIBRIUM SPECIFICATIONS:
   ONLY CHEMICAL EQUILIBRIUM IS CONSIDERED, THE FLUID PHASE IS VAPOR
   SYSTEM TEMPERATURE     F                                    2282.0
   TEMPERATURE FOR FREE ENERGY EVALUATION    F                 2282.0
   SYSTEM PRESSURE DROP  PSI                                   0.0000

 FLUID PHASE SPECIES IN PRODUCT LIST:
   N2 CO2 CO O2 AR NO2 NO H2O H2 H2O-MUD CH4 C

 SOLIDS IN PRODUCT LIST:
   CACO3 CAO
```



```
BLOCK:  REACTOR  MODEL: RGIBBS (CONTINUED)

 ATOM MATRIX:
 ELEMENT      H    C    N    O    AR   CA
   N2       0.00 0.00 2.00 0.00 0.00 0.00
   CO2      0.00 1.00 0.00 2.00 0.00 0.00
   CACO3    0.00 1.00 0.00 3.00 0.00 1.00
   CAO      0.00 0.00 0.00 1.00 0.00 1.00
   CO       0.00 1.00 0.00 1.00 0.00 0.00
   O2       0.00 0.00 0.00 2.00 0.00 0.00
   AR       0.00 0.00 0.00 0.00 1.00 0.00
   NO2      0.00 0.00 1.00 2.00 0.00 0.00
   NO       0.00 0.00 1.00 1.00 0.00 0.00
   H2O      2.00 0.00 0.00 1.00 0.00 0.00
   H2       2.00 0.00 0.00 0.00 0.00 0.00
   H2O-MUD  2.00 0.00 0.00 1.00 0.00 0.00
   CH4      4.00 1.00 0.00 0.00 0.00 0.00
   C        0.00 1.00 0.00 0.00 0.00 0.00

                       ***  RESULTS  ***
 TEMPERATURE            F                                      2282.0
 PRESSURE               PSI                                    14.696
 HEAT DUTY              MMBTU/HR                               63.575
 NET DUTY               MMBTU/HR                               64.729
 VAPOR FRACTION                                                1.0000
 NUMBER OF FLUID PHASES                                               1

 FLUID PHASE MOLE FRACTIONS:

 PHASE                 VAPOR
 OF TYPE               VAPOR
 PHASE FRACTION        1.000000
 PLACED IN STREAM      KLN-PROD
   CO2                 0.9993220
   CO                  0.4520228E-03
   O2                  0.2260114E-03
   H2O                 0.4603334E-08
   H2                  0.7781884E-12
   H2O-MUD             0.4603334E-08
   CH4                  0.000000
   C                    0.000000

 LBMOL/HR              526.1802

 SOLIDS PRESENT AT EQUILIBRIUM, PLACED IN STREAM KLN-PROD

 SOLID FLOW RATES    (LBMOL/HR) :

   CAO                 573.8202
```



```
BLOCK:  SEP      MODEL: SEP
---------------------------
 INLET STREAM:           KLN-PROD
 OUTLET STREAMS:         CAO          KLN-TG
 PROPERTY OPTION SET:    PR-BM      PENG-ROBINSON EQUATION OF STATE

                   ***  MASS AND ENERGY BALANCE  ***
                                IN             OUT         RELATIVE DIFF.
   TOTAL BALANCE
     MOLE(LBMOL/HR)           1100.00        1100.00          0.00000
     MASS(TONS/HR )           27.6651        27.6651         -0.128419E-15
     ENTHALPY(MMBTU/HR)      -215.394       -215.394          0.115618E-08

                       ***  INPUT DATA  ***

 FLASH SPECS FOR STREAM CAO
 TWO    PHASE  TP  FLASH
 PRESSURE DROP           PSI                                   0.0
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FLASH SPECS FOR STREAM KLN-TG
 TWO    PHASE  TP  FLASH
 PRESSURE DROP           PSI                                   0.0
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000

 FRACTION OF FEED
   SUBSTREAM= MIXED
     STREAM= CAO        CPT= CAO       FRACTION=         0.0
   SUBSTREAM= CISOLID
     STREAM= CAO        CPT= CAO       FRACTION=         0.91677

                        ***  RESULTS  ***

 HEAT DUTY               MMBTU/HR                          -0.24903E-06

COMPONENT = CO2
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000
```



```
BLOCK:  SEP      MODEL: SEP (CONTINUED)

COMPONENT = CAO
  STREAM     SUBSTREAM    SPLIT FRACTION
  CAO        CISOLID            0.91677
  KLN-TG     CISOLID            0.083230

COMPONENT = CO
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000

COMPONENT = O2
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000

COMPONENT = H2O
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000

COMPONENT = H2
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000

COMPONENT = H2O-MUD
  STREAM     SUBSTREAM    SPLIT FRACTION
  KLN-TG     MIXED              1.00000

BLOCK:  TG-MIX   MODEL: MIXER
------------------------------
 INLET STREAMS:         TG-BNR-2    KLN-TG-2    NCG-AIR2
 OUTLET STREAM:         TG
 PROPERTY OPTION SET:   PR-BM     PENG-ROBINSON EQUATION OF STATE

                    ***  MASS AND ENERGY BALANCE  ***
                                 IN            OUT        RELATIVE DIFF.
   TOTAL BALANCE
     MOLE(LBMOL/HR)            4036.76        4036.76        0.225303E-15
     MASS(TONS/HR )            63.5008        63.5008        0.00000
     ENTHALPY(MMBTU/HR)       -205.522       -205.522       -0.100019E-05

                        ***  INPUT DATA  ***
 TWO    PHASE     FLASH
 MAXIMUM NO. ITERATIONS                                       30
 CONVERGENCE TOLERANCE                                         0.000100000
 OUTLET PRESSURE:  MINIMUM OF INLET STREAM PRESSURES
```


CACO3 CAO CAO-2 KLN-DUST KLN-PROD

STREAM ID	CACO3	CAO	CAO-2	KLN-DUST	KLN-PROD
FROM :	$C-7	SEP	CAO-TADJ	$C-4	REACTOR
TO :	REACTOR	CAO-TADJ	$C-6	REACTOR	SEP
CLASS:	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD	MIXCISLD
TOTAL STREAM:					
TONS/HR	26.3260	14.7501	14.7501	1.3391	27.6651
MMBTU/HR	-266.3454	-128.9777	-135.7456	-12.6242	-215.3943
SUBSTREAM: MIXED					
PHASE:	VAPOR	MISSING	MISSING	MISSING	VAPOR
COMPONENTS: LBMOL/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	525.8234
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	0.2378
O2	0.0	0.0	0.0	0.0	0.1189
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	2.4222-06
H2	0.0	0.0	0.0	0.0	4.0947-10
H2O-MUD	4.8448-06	0.0	0.0	0.0	2.4222-06
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	0.9993
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	4.5202-04
O2	0.0	0.0	0.0	0.0	2.2601-04
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	4.6033-09
H2	0.0	0.0	0.0	0.0	7.7819-13
H2O-MUD	1.0000	0.0	0.0	0.0	4.6033-09
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	0.0	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0	11.5707
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.0	0.0	0.0	3.3311-03
O2	0.0	0.0	0.0	0.0	1.9027-03
AR	0.0	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0	2.1818-08
H2	0.0	0.0	0.0	0.0	4.1272-13
H2O-MUD	4.3640-08	0.0	0.0	0.0	2.1818-08

CACO3 CAO CAO-2 KLN-DUST KLN-PROD (CONTINUED)

STREAM ID	CACO3	CAO	CAO-2	KLN-DUST	KLN-PROD
CH4	0.0	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.0	MISSING	MISSING	MISSING	0.0
CO2	0.0	MISSING	MISSING	MISSING	0.9995
CACO3	0.0	MISSING	MISSING	MISSING	0.0
CAO	0.0	MISSING	MISSING	MISSING	0.0
CO	0.0	MISSING	MISSING	MISSING	2.8776-04
O2	0.0	MISSING	MISSING	MISSING	1.6437-04
AR	0.0	MISSING	MISSING	MISSING	0.0
NO2	0.0	MISSING	MISSING	MISSING	0.0
NO	0.0	MISSING	MISSING	MISSING	0.0
H2O	0.0	MISSING	MISSING	MISSING	1.8848-09
H2	0.0	MISSING	MISSING	MISSING	3.5653-14
H2O-MUD	1.0000	MISSING	MISSING	MISSING	1.8848-09
CH4	0.0	MISSING	MISSING	MISSING	0.0
C	0.0	MISSING	MISSING	MISSING	0.0
TOTAL FLOW:					
LBMOL/HR	4.8448-06	0.0	0.0	0.0	526.1802
TONS/HR	4.3640-08	0.0	0.0	0.0	11.5759
CUFT/HR	3.8645-03	0.0	0.0	0.0	1.0537+06
STATE VARIABLES:					
TEMP F	635.0000	MISSING	MISSING	MISSING	2282.0000
PRES PSI	14.6959	14.6959	14.6959	14.6959	14.6959

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  VFRAC                     1.0000     MISSING    MISSING    MISSING      1.0000
  LFRAC                     0.0        MISSING    MISSING    MISSING      0.0
  SFRAC                     0.0        MISSING    MISSING    MISSING      0.0
ENTHALPY:
  BTU/LBMOL             -9.9334+04     MISSING    MISSING    MISSING -1.4198+05
  BTU/LB                -5513.8944     MISSING    MISSING    MISSING -3226.8379
  MMBTU/HR              -4.8125-07     MISSING    MISSING    MISSING   -74.7073
ENTROPY:
  BTU/LBMOL-R              -4.7023     MISSING    MISSING    MISSING    19.6557
  BTU/LB-R                 -0.2610     MISSING    MISSING    MISSING     0.4467
DENSITY:
  LBMOL/CUFT             1.2537-03     MISSING    MISSING    MISSING  4.9938-04
  LB/CUFT                2.2585-02     MISSING    MISSING    MISSING  2.1973-02
AVG MW                     18.0153     MISSING    MISSING    MISSING    43.9999

MIXED    SUBSTREAM PROPERTIES:

***  ALL PHASES   ***
MW        UNITLESS
    N2                     MISSING     MISSING    MISSING    MISSING    MISSING
    CO2                    MISSING     MISSING    MISSING    MISSING    44.0098
    CACO3                  MISSING     MISSING    MISSING    MISSING    MISSING
    CAO                    MISSING     MISSING    MISSING    MISSING    MISSING
    CO                     MISSING     MISSING    MISSING    MISSING    28.0104
    O2                     MISSING     MISSING    MISSING    MISSING    31.9988
    AR                     MISSING     MISSING    MISSING    MISSING    MISSING
    NO2                    MISSING     MISSING    MISSING    MISSING    MISSING
    NO                     MISSING     MISSING    MISSING    MISSING    MISSING
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CACO3 CAO CAO-2 KLN-DUST KLN-PROD (CONTINUED)

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STREAM ID                  CACO3      CAO        CAO-2      KLN-DUST   KLN-PROD

    H2O                    MISSING     MISSING    MISSING    MISSING    18.0153
    H2                     MISSING     MISSING    MISSING    MISSING     2.0159
    H2O-MUD                18.0153     MISSING    MISSING    MISSING    18.0153
    CH4                    MISSING     MISSING    MISSING    MISSING    MISSING
    C                      MISSING     MISSING    MISSING    MISSING    MISSING
MWMX                       18.0153     MISSING    MISSING    MISSING    43.9999
QVALGRS  BTU/LB          1049.9837     MISSING    MISSING    MISSING     1.2499
QVALNET  BTU/LB             0.0        MISSING    MISSING    MISSING     1.2499

*** VAPOR PHASE   ***
MUMX      LB/FT-HR       3.8532-02     MISSING    MISSING    MISSING     0.1508
PR                          0.5448     MISSING    MISSING    MISSING     0.7077
KMX       BTU/HR-FT-R    3.4243-02     MISSING    MISSING    MISSING  6.7943-02
*   68.0000 F         *
VVSTD     CUM/SEC
    N2                     MISSING     MISSING    MISSING    MISSING    MISSING
    CO2                    MISSING     MISSING    MISSING    MISSING     1.5937
    CACO3                  MISSING     MISSING    MISSING    MISSING    MISSING
    CAO                    MISSING     MISSING    MISSING    MISSING    MISSING
    CO                     MISSING     MISSING    MISSING    MISSING  7.2087-04
    O2                     MISSING     MISSING    MISSING    MISSING  3.6044-04
    AR                     MISSING     MISSING    MISSING    MISSING    MISSING
    NO2                    MISSING     MISSING    MISSING    MISSING    MISSING
    NO                     MISSING     MISSING    MISSING    MISSING    MISSING
    H2O                    MISSING     MISSING    MISSING    MISSING  7.3413-09
    H2                     MISSING     MISSING    MISSING    MISSING  1.2410-12
    H2O-MUD              1.4684-08     MISSING    MISSING    MISSING  7.3413-09
    CH4                    MISSING     MISSING    MISSING    MISSING    MISSING
    C                      MISSING     MISSING    MISSING    MISSING    MISSING
*   68.0000 F         *
VVSTDMX  CUFT/MIN        3.1113-05     MISSING    MISSING    MISSING  3379.1280

SUBSTREAM: CISOLID       STRUCTURE: CONVENTIONAL
COMPONENTS: LBMOL/HR
  N2                      0.0         0.0        0.0        0.0        0.0
  CO2                     0.0         0.0        0.0        0.0        0.0
  CACO3                 526.0613      0.0        0.0        0.0        0.0
  CAO                     0.0       526.0613   526.0613    47.7590   573.8202
  CO                      0.0         0.0        0.0        0.0        0.0
  O2                      0.0         0.0        0.0        0.0        0.0
  AR                      0.0         0.0        0.0        0.0        0.0
  NO2                     0.0         0.0        0.0        0.0        0.0
  NO                      0.0         0.0        0.0        0.0        0.0
  H2O                     0.0         0.0        0.0        0.0        0.0
  H2                      0.0         0.0        0.0        0.0        0.0
  H2O-MUD                 0.0         0.0        0.0        0.0        0.0
  CH4                     0.0         0.0        0.0        0.0        0.0
  C                       0.0         0.0        0.0        0.0        0.0
COMPONENTS: MOLE FRAC
  N2                      0.0         0.0        0.0        0.0        0.0
  CO2                     0.0         0.0        0.0        0.0        0.0
  CACO3                   1.0000      0.0        0.0        0.0        0.0
```


CACO3 CAO CAO-2 KLN-DUST KLN-PROD (CONTINUED)

```
STREAM ID                CACO3      CAO        CAO-2      KLN-DUST   KLN-PROD

  CAO                     0.0         1.0000     1.0000     1.0000     1.0000
  CO                      0.0         0.0        0.0        0.0        0.0
  O2                      0.0         0.0        0.0        0.0        0.0
  AR                      0.0         0.0        0.0        0.0        0.0
  NO2                     0.0         0.0        0.0        0.0        0.0
  NO                      0.0         0.0        0.0        0.0        0.0
  H2O                     0.0         0.0        0.0        0.0        0.0
  H2                      0.0         0.0        0.0        0.0        0.0
  H2O-MUD                 0.0         0.0        0.0        0.0        0.0
  CH4                     0.0         0.0        0.0        0.0        0.0
  C                       0.0         0.0        0.0        0.0        0.0
COMPONENTS: TONS/HR
  N2                      0.0         0.0        0.0        0.0        0.0
  CO2                     0.0         0.0        0.0        0.0        0.0
  CACO3                  26.3260      0.0        0.0        0.0        0.0
  CAO                     0.0        14.7501    14.7501     1.3391    16.0892
  CO                      0.0         0.0        0.0        0.0        0.0
  O2                      0.0         0.0        0.0        0.0        0.0
  AR                      0.0         0.0        0.0        0.0        0.0
  NO2                     0.0         0.0        0.0        0.0        0.0
  NO                      0.0         0.0        0.0        0.0        0.0
  H2O                     0.0         0.0        0.0        0.0        0.0
  H2                      0.0         0.0        0.0        0.0        0.0
  H2O-MUD                 0.0         0.0        0.0        0.0        0.0
  CH4                     0.0         0.0        0.0        0.0        0.0
  C                       0.0         0.0        0.0        0.0        0.0
COMPONENTS: MASS FRAC
  N2                      0.0         0.0        0.0        0.0        0.0
  CO2                     0.0         0.0        0.0        0.0        0.0
  CACO3                   1.0000      0.0        0.0        0.0        0.0
  CAO                     0.0         1.0000     1.0000     1.0000     1.0000
  CO                      0.0         0.0        0.0        0.0        0.0
  O2                      0.0         0.0        0.0        0.0        0.0
  AR                      0.0         0.0        0.0        0.0        0.0
  NO2                     0.0         0.0        0.0        0.0        0.0
  NO                      0.0         0.0        0.0        0.0        0.0
  H2O                     0.0         0.0        0.0        0.0        0.0
  H2                      0.0         0.0        0.0        0.0        0.0
  H2O-MUD                 0.0         0.0        0.0        0.0        0.0
  CH4                     0.0         0.0        0.0        0.0        0.0
  C                       0.0         0.0        0.0        0.0        0.0
TOTAL FLOW:
  LBMOL/HR              526.0613    526.0613   526.0613    47.7590   573.8202
  TONS/HR                26.3260     14.7501    14.7501     1.3391    16.0892
  CUFT/HR               312.8851    143.2989   143.2989    13.0095   156.3084
STATE VARIABLES:
  TEMP    F             635.0000   2282.0000  1300.0000   798.9216  2282.0000
  PRES    PSI            14.6959     14.6959    14.6959    14.6959    14.6959
  VFRAC                   0.0         0.0        0.0        0.0        0.0
  LFRAC                   0.0         0.0        0.0        0.0        0.0
  SFRAC                   1.0000      1.0000     1.0000     1.0000     1.0000
```


CACO3 CAO CAO-2 KLN-DUST KLN-PROD (CONTINUED)

```
STREAM ID                CACO3      CAO        CAO-2      KLN-DUST   KLN-PROD

ENTHALPY:
  BTU/LBMOL            -5.0630+05 -2.4518+05 -2.5804+05 -2.6433+05 -2.4518+05
  BTU/LB               -5058.5993 -4372.1024 -4601.5238 -4713.6739 -4372.1024
  MMBTU/HR              -266.3454  -128.9777  -135.7456   -12.6242  -140.6870
ENTROPY:
  BTU/LBMOL-R            -46.8325    -5.0683   -10.8664   -15.0691    -5.0683
  BTU/LB-R                -0.4679 -9.0381-02   -0.1938    -0.2687 -9.0381-02
DENSITY:
  LBMOL/CUFT               1.6813     3.6711     3.6711     3.6711     3.6711
  LB/CUFT                168.2790   205.8644   205.8644   205.8644   205.8644
AVG MW                   100.0872    56.0774    56.0774    56.0774    56.0774
```


KLN-TG KLN-TG-2 TG TG-2

```
STREAM ID                KLN-TG     KLN-TG-2   TG         TG-2
FROM :                   SEP        KLN-TADJ   TG-MIX     H2O-CON
TO   :                   KLN-TADJ   TG-MIX     H2O-CON    $C-2
CLASS:                   MIXCISLD   MIXCISLD   MIXCISLD   MIXCISLD

MAX CONV. ERROR:           0.0        0.0     -1.0471-06    0.0
TOTAL STREAM:
  TONS/HR                12.9150    12.9150    63.5008    63.5008
  MMBTU/HR              -86.4166   -94.3915  -205.5221  -205.5221
SUBSTREAM: MIXED
PHASE:                   VAPOR      VAPOR      VAPOR      VAPOR
COMPONENTS: LBMOL/HR
  N2                      0.0        0.0      2305.3916  2305.3916
  CO2                   525.8234   525.8234   1063.7121  1063.7121
  CACO3                   0.0        0.0        0.0        0.0
  CAO                     0.0        0.0        0.0        0.0
  CO                      0.2378     0.2378     0.2378     0.2378
  O2                      0.1189     0.1189    82.1471    82.1471
  AR                      0.0        0.0       27.7722    27.7722
  NO2                     0.0        0.0        0.0        0.0
  NO                      0.0        0.0        0.0        0.0
  H2O                   2.4222-06  2.4222-06  509.7279   509.7279
  H2                    4.0947-10  4.0947-10  1.2904-02  1.2904-02
  H2O-MUD               2.4222-06  2.4222-06  2.4222-06    0.0
  CH4                     0.0        0.0        0.0        0.0
  C                       0.0        0.0        0.0        0.0
COMPONENTS: MOLE FRAC
  N2                      0.0        0.0        0.5779     0.5779
  CO2                     0.9993     0.9993     0.2667     0.2667
  CACO3                   0.0        0.0        0.0        0.0
  CAO                     0.0        0.0        0.0        0.0
  CO                    4.5202-04  4.5202-04  5.9625-05  5.9625-05
  O2                    2.2601-04  2.2601-04  2.0593-02  2.0593-02
  AR                      0.0        0.0      6.9622-03  6.9622-03
  NO2                     0.0        0.0        0.0        0.0
  NO                      0.0        0.0        0.0        0.0
  H2O                   4.6033-09  4.6033-09    0.1278     0.1278
  H2                    7.7819-13  7.7819-13  3.2350-06  3.2350-06
  H2O-MUD               4.6033-09  4.6033-09  6.0722-10    0.0
  CH4                     0.0        0.0        0.0        0.0
  C                       0.0        0.0        0.0        0.0
COMPONENTS: TONS/HR
  N2                      0.0        0.0       32.2910    32.2910
  CO2                    11.5707    11.5707    23.4069    23.4069
  CACO3                   0.0        0.0        0.0        0.0
  CAO                     0.0        0.0        0.0        0.0
  CO                    3.3311-03  3.3311-03  3.3311-03  3.3311-03
  O2                    1.9027-03  1.9027-03    1.3143     1.3143
  AR                      0.0        0.0        0.5547     0.5547
  NO2                     0.0        0.0        0.0        0.0
  NO                      0.0        0.0        0.0        0.0
  H2O                   2.1818-08  2.1818-08    4.5914     4.5914
```


KLN-TG KLN-TG-2 TG TG-2 (CONTINUED)

```
STREAM ID                KLN-TG     KLN-TG-2   TG         TG-2

  H2                    4.1272-13  4.1272-13  1.3007-05  1.3007-05
  H2O-MUD               2.1818-08  2.1818-08  2.1818-08    0.0
  CH4                     0.0        0.0        0.0        0.0
  C                       0.0        0.0        0.0        0.0
COMPONENTS: MASS FRAC
  N2                      0.0        0.0        0.5195     0.5195
  CO2                     0.9995     0.9995     0.3765     0.3765
  CACO3                   0.0        0.0        0.0        0.0
  CAO                     0.0        0.0        0.0        0.0
  CO                    2.8776-04  2.8776-04  5.3587-05  5.3587-05
  O2                    1.6437-04  1.6437-04  2.1143-02  2.1143-02
  AR                      0.0        0.0      8.9239-03  8.9239-03
  NO2                     0.0        0.0        0.0        0.0
  NO                      0.0        0.0        0.0        0.0
  H2O                   1.8848-09  1.8848-09  7.3863-02  7.3863-02
  H2                    3.5653-14  3.5653-14  2.0924-07  2.0924-07
  H2O-MUD               1.8848-09  1.8848-09  3.5099-10    0.0
  CH4                     0.0        0.0        0.0        0.0
  C                       0.0        0.0        0.0        0.0
TOTAL FLOW:
  LBMOL/HR              526.1802   526.1802   3989.0017  3989.0017
  TONS/HR                11.5759    11.5759    62.1617    62.1617
  CUFT/HR               1.0537+06  6.5707+05  4.9791+06  4.9791+06
STATE VARIABLES:
  TEMP    F             2282.0000  1250.0000  1249.2256  1249.2310
  PRES    PSI            14.6959    14.6959    14.6959    14.6959
  VFRAC                   1.0000     1.0000     1.0000     1.0000
  LFRAC                   0.0        0.0        0.0        0.0
  SFRAC                   0.0        0.0        0.0        0.0
ENTHALPY:
  BTU/LBMOL            -1.4198+05 -1.5591+05 -4.8425+04 -4.8425+04
```

BTU/LB	-3226.8380	-3543.4463	-1553.7493	-1553.7493
MMBTU/HR	-74.7073	-82.0373	-193.1675	-193.1675
ENTROPY:				
BTU/LBMOL-R	19.6557	13.3038	10.5776	10.5776
BTU/LB-R	0.4467	0.3024	0.3394	0.3394
DENSITY:				
LBMOL/CUFT	4.9938-04	8.0080-04	8.0115-04	8.0115-04
LB/CUFT	2.1973-02	3.5235-02	2.4969-02	2.4969-02
AVG MW	43.9999	43.9999	31.1666	31.1666

MIXED SUBSTREAM PROPERTIES:

*** ALL PHASES ***				
MW UNITLESS				
N2	MISSING	MISSING	28.0135	28.0135
CO2	44.0098	44.0098	44.0098	44.0098
CACO3	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING
CO	28.0104	28.0104	28.0104	28.0104
O2	31.9988	31.9988	31.9988	31.9988
AR	MISSING	MISSING	39.9480	39.9480

KLN-TG KLN-TG-2 TG TG-2 (CONTINUED)

STREAM ID	KLN-TG	KLN-TG-2	TG	TG-2
NO2	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING
H2O	18.0153	18.0153	18.0153	18.0153
H2	2.0159	2.0159	2.0159	2.0159
H2O-MUD	18.0153	18.0153	18.0153	MISSING
CH4	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING
MWMX	43.9999	43.9999	31.1666	31.1666
QVALGRS BTU/LB	1.2499	1.2499	77.8004	77.8004
QVALNET BTU/LB	1.2499	1.2499	0.2436	0.2436
*** VAPOR PHASE ***				
MUMX LB/FT-HR	0.1508	0.1054	9.6723-02	9.6723-02
PR	0.7077	0.7028	0.6934	0.6934
KMX BTU/HR-FT-R	6.7943-02	4.3562-02	4.1740-02	4.1740-02
* 68.0000 F *				
VVSTD CUM/SEC				
N2	MISSING	MISSING	6.9873	6.9873
CO2	1.5937	1.5937	3.2239	3.2239
CACO3	MISSING	MISSING	MISSING	MISSING
CAO	MISSING	MISSING	MISSING	MISSING
CO	7.2087-04	7.2087-04	7.2087-04	7.2087-04
O2	3.6044-04	3.6044-04	0.2490	0.2490
AR	MISSING	MISSING	8.4173-02	8.4173-02
NO2	MISSING	MISSING	MISSING	MISSING
NO	MISSING	MISSING	MISSING	MISSING
H2O	7.3413-09	7.3413-09	1.5449	1.5449
H2	1.2410-12	1.2410-12	3.9111-05	3.9111-05
H2O-MUD	7.3413-09	7.3413-09	7.3413-09	MISSING
CH4	MISSING	MISSING	MISSING	MISSING
C	MISSING	MISSING	MISSING	MISSING
* 68.0000 F *				
VVSTDMX CUFT/MIN	3379.1280	3379.1280	2.5617+04	2.5617+04

SUBSTREAM: CISOLID STRUCTURE: CONVENTIONAL

COMPONENTS: LBMOL/HR				
N2	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0
CAO	47.7590	47.7590	47.7590	47.7590
CO	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0
COMPONENTS: MOLE FRAC				
N2	0.0	0.0	0.0	0.0

KLN-TG KLN-TG-2 TG TG-2 (CONTINUED)

STREAM ID	KLN-TG	KLN-TG-2	TG	TG-2
CO2	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0
CAO	1.0000	1.0000	1.0000	1.0000
CO	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0
COMPONENTS: TONS/HR				
N2	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0
CAO	1.3391	1.3391	1.3391	1.3391
CO	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0
COMPONENTS: MASS FRAC				
N2	0.0	0.0	0.0	0.0
CO2	0.0	0.0	0.0	0.0
CACO3	0.0	0.0	0.0	0.0
CAO	1.0000	1.0000	1.0000	1.0000
CO	0.0	0.0	0.0	0.0
O2	0.0	0.0	0.0	0.0
AR	0.0	0.0	0.0	0.0
NO2	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0
H2O	0.0	0.0	0.0	0.0
H2	0.0	0.0	0.0	0.0
H2O-MUD	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0
C	0.0	0.0	0.0	0.0
TOTAL FLOW:				
LBMOL/HR	47.7590	47.7590	47.7590	47.7590
TONS/HR	1.3391	1.3391	1.3391	1.3391
CUFT/HR	13.0095	13.0095	13.0095	13.0095

KLN-TG KLN-TG-2 TG TG-2 (CONTINUED)

STREAM ID	KLN-TG	KLN-TG-2	TG	TG-2
STATE VARIABLES:				
TEMP F	2282.0000	1250.0000	1249.2256	1249.2310
PRES PSI	14.6959	14.6959	14.6959	14.6959
VFRAC	0.0	0.0	0.0	0.0
LFRAC	0.0	0.0	0.0	0.0
SFRAC	1.0000	1.0000	1.0000	1.0000
ENTHALPY:				
BTU/LBMOL	-2.4518+05	-2.5868+05	-2.5869+05	-2.5869+05
BTU/LB	-4372.1024	-4612.8696	-4613.0439	-4613.0439
MMBTU/HR	-11.7094	-12.3542	-12.3546	-12.3546
ENTROPY:				
BTU/LBMOL-R	-5.0683	-11.2332	-11.2390	-11.2390
BTU/LB-R	-9.0381-02	-0.2003	-0.2004	-0.2004
DENSITY:				
LBMOL/CUFT	3.6711	3.6711	3.6711	3.6711
LB/CUFT	205.8644	205.8644	205.8644	205.8644
AVG MW	56.0774	56.0774	56.0774	56.0774

HEAT HEAT-2 HEAT-3 HEAT-4 HEAT-5

STREAM ID	HEAT	HEAT-2	HEAT-3	HEAT-4	HEAT-5
FROM :	CAO-TADJ	HT-MIX	KLN-TADJ	REACTOR	NCG-HT
TO :	HT-MIX	REACTOR	HT-SPLT	BURNER	BURNER
CLASS:	HEAT	HEAT	HEAT	HEAT	HEAT
STREAM ATTRIBUTES:					
HEAT					
Q MMBTU/HR	6.7680	-1.1541	7.9749	-64.7293	-1.1200
TBEG F	2282.0000	MISSING	2282.0000	MISSING	68.0000
TEND F	1300.0000	MISSING	1250.0000	MISSING	1250.0000

HEAT-6 HEAT-7 HEATLOSS

STREAM ID	HEAT-6	HEAT-7	HEATLOSS
FROM :	HT-SPLT	HT-SPLT	----
TO :	HT-MIX	$C-12	HT-MIX
CLASS:	HEAT	HEAT	HEAT
STREAM ATTRIBUTES:			
HEAT			
Q MMBTU/HR	7.7179	0.2570	-15.6400
TBEG F	2282.0000	2282.0000	MISSING
TEND F	1250.0000	1250.0000	MISSING

AIR FUEL NCG-AIR NCG-AIR2 TG-BNR

STREAM ID	AIR	FUEL	NCG-AIR	NCG-AIR2	TG-BNR
FROM :	$C-8	$C-3	$C-5	NCG-HT	BURNER
TO :	BURNER	BURNER	NCG-HT	TG-MIX	CL-CNG
SUBSTREAM: MIXED					
PHASE:	VAPOR	MIXED	VAPOR	VAPOR	VAPOR
COMPONENTS: LBMOL/HR					
N2	1707.1798	497.5189	100.6929	100.6929	2204.6987
CO2	0.6564	105.0396	3.8713-02	3.8713-02	537.8499
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	429.1590	0.0	0.0	0.0
O2	459.2298	0.6234	27.0863	27.0863	54.9419
AR	20.5658	5.9934	1.2130	1.2130	26.5592
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	2.1879	132.7372	0.1290	0.1290	509.5988
H2	0.2188	374.3811	1.2904-02	1.2904-02	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	3.6964-02	0.0	0.0	0.0
C	0.0	2.9580	0.0	0.0	0.0
COMPONENTS: MOLE FRAC					
N2	0.7795	0.3213	0.7795	0.7795	0.6613
CO2	2.9970-04	6.7835-02	2.9970-04	2.9970-04	0.1613
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	0.2772	0.0	0.0	0.0
O2	0.2097	4.0260-04	0.2097	0.2097	1.6481-02
AR	9.3906-03	3.8706-03	9.3906-03	9.3906-03	7.9670-03
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	9.9900-04	8.5723-02	9.9900-04	9.9900-04	0.1529
H2	9.9900-05	0.2418	9.9900-05	9.9900-05	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	2.3872-05	0.0	0.0	0.0
C	0.0	1.9103-03	0.0	0.0	0.0
COMPONENTS: TONS/HR					
N2	23.9120	6.9686	1.4104	1.4104	30.8806
CO2	1.4443-02	2.3114	8.5188-04	8.5188-04	11.8353
CACO3	0.0	0.0	0.0	0.0	0.0
CAO	0.0	0.0	0.0	0.0	0.0
CO	0.0	6.0105	0.0	0.0	0.0
O2	7.3474	9.9740-03	0.4334	0.4334	0.8790
AR	0.4108	0.1197	2.4229-02	2.4229-02	0.5305
NO2	0.0	0.0	0.0	0.0	0.0
NO	0.0	0.0	0.0	0.0	0.0
H2O	1.9707-02	1.1956	1.1624-03	1.1624-03	4.5903
H2	2.2052-04	0.3774	1.3007-05	1.3007-05	0.0
H2O-MUD	0.0	0.0	0.0	0.0	0.0
CH4	0.0	2.9650-04	0.0	0.0	0.0
C	0.0	1.7764-02	0.0	0.0	0.0
COMPONENTS: MASS FRAC					
N2	0.7542	0.4096	0.7542	0.7542	0.6339

AIR FUEL NCG-AIR NCG-AIR2 TG-BNR (CONTINUED)

STREAM ID	AIR	FUEL	NCG-AIR	NCG-AIR2	TG-BNR
CO2	4.5555-04	0.1359	4.5555-04	4.5555-04	0.2429

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   CACO3                      0.0         0.0         0.0         0.0         0.0
   CAO                        0.0         0.0         0.0         0.0         0.0
   CO                         0.0         0.3533      0.0         0.0         0.0
   O2                         0.2317   5.8632-04      0.2317      0.2317   1.8044-02
   AR                      1.2957-02   7.0373-03   1.2957-02   1.2957-02   1.0890-02
   NO2                        0.0         0.0         0.0         0.0         0.0
   NO                         0.0         0.0         0.0         0.0         0.0
   H2O                     6.2159-04   7.0286-02   6.2159-04   6.2159-04   9.4226-02
   H2                      6.9555-06   2.2183-02   6.9555-06   6.9555-06      0.0
   H2O-MUD                    0.0         0.0         0.0         0.0         0.0
   CH4                        0.0      1.7430-05      0.0         0.0         0.0
   C                          0.0      1.0443-03      0.0         0.0         0.0
 TOTAL FLOW:
   LBMOL/HR                2190.0385   1548.4476    129.1729    129.1729   3333.6486
   TONS/HR                   31.7046     17.0112      1.8700      1.8700     48.7158
   CUFT/HR                 8.4348+05   1.1016+06   4.9750+04   1.6131+05   4.1605+06
 STATE VARIABLES:
   TEMP   F                  68.0000    600.0000     68.0000   1250.0000   1249.0101
   PRES   PSI                14.6959     15.9581     14.6959     14.6959     14.6959
   VFRAC                      1.0000      0.9981      1.0000      1.0000      1.0000
   LFRAC                      0.0      1.9103-03      0.0         0.0         0.0
   SFRAC                      0.0         0.0         0.0         0.0         0.0
 ENTHALPY:
   BTU/LBMOL               -220.7649  -2.9636+04   -220.7649   8450.0846  -3.3664+04
   BTU/LB                    -7.6248  -1348.8004     -7.6248    291.8508  -1151.8062
   MMBTU/HR                  -0.4835    -45.8895  -2.8517-02      1.0915   -112.2223
 ENTROPY:
   BTU/LBMOL-R                1.0096     12.7609      1.0096      9.5311      9.6535
   BTU/LB-R                3.4868-02      0.5808   3.4868-02      0.3292      0.3303
 DENSITY:
   LBMOL/CUFT              2.5964-03   1.4056-03   2.5964-03   8.0076-04   8.0125-04
   LB/CUFT                 7.5176-02   3.0884-02   7.5176-02   2.3185-02   2.3418-02
 AVG MW                      28.9534     21.9720     28.9534     28.9534     29.2267

 MIXED   SUBSTREAM PROPERTIES:

 ***  ALL PHASES   ***
 MW       UNITLESS
     N2                      28.0135     28.0135     28.0135     28.0135     28.0135
     CO2                     44.0098     44.0098     44.0098     44.0098     44.0098
     CACO3                   MISSING     MISSING     MISSING     MISSING     MISSING
     CAO                     MISSING     MISSING     MISSING     MISSING     MISSING
     CO                      MISSING     28.0104     MISSING     MISSING     MISSING
     O2                      31.9988     31.9988     31.9988     31.9988     31.9988
     AR                      39.9480     39.9480     39.9480     39.9480     39.9480
     NO2                     MISSING     MISSING     MISSING     MISSING     MISSING
     NO                      MISSING     MISSING     MISSING     MISSING     MISSING
     H2O                     18.0153     18.0153     18.0153     18.0153     18.0153
     H2                       2.0159      2.0159      2.0159      2.0159     MISSING
     H2O-MUD                 MISSING     MISSING     MISSING     MISSING     MISSING
     CH4                     MISSING     16.0428     MISSING     MISSING     MISSING
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 AIR FUEL NCG-AIR NCG-AIR2 TG-BNR (CONTINUED)

 STREAM ID                      AIR        FUEL      NCG-AIR     NCG-AIR2     TG-BNR

     C                       MISSING     12.0110     MISSING     MISSING     MISSING
 MWMX                        28.9534     21.9720     28.9534     28.9534     29.2267
 QVALGRS  BTU/LB              1.0766   2975.8073      1.0766      1.0766     98.9355
 QVALNET  BTU/LB              0.3587   2693.8191      0.3587      0.3587      0.0

 *** VAPOR PHASE   ***
 MUMX      LB/FT-HR        4.5004-02   5.9717-02   4.5004-02      0.1116   9.5265-02
 PR                           0.6983      0.5068      0.6983      0.7080      0.6846
 KMX       BTU/HR-FT-R     1.5501-02   4.0454-02   1.5501-02   4.2598-02   4.2081-02
 *   68.0000 F          *
 VVSTD    CUM/SEC
     N2                       5.1742      1.5079      0.3052      0.3052      6.6821
     CO2                   1.9893-03      0.3184   1.1733-04   1.1733-04      1.6301
     CACO3                   MISSING     MISSING     MISSING     MISSING     MISSING
     CAO                     MISSING     MISSING     MISSING     MISSING     MISSING
     CO                      MISSING      1.3007     MISSING     MISSING     MISSING
     O2                       1.3919   1.8894-03   8.2094-02   8.2094-02      0.1665
     AR                    6.2332-02   1.8165-02   3.6765-03   3.6765-03   8.0497-02
     NO2                     MISSING     MISSING     MISSING     MISSING     MISSING
     NO                      MISSING     MISSING     MISSING     MISSING     MISSING
     H2O                   6.6310-03      0.4023   3.9111-04   3.9111-04      1.5445
     H2                    6.6310-04      1.1347   3.9111-05   3.9111-05     MISSING
     H2O-MUD                 MISSING     MISSING     MISSING     MISSING     MISSING
     CH4                     MISSING   1.1203-04     MISSING     MISSING     MISSING
     C                       MISSING      0.0        MISSING     MISSING     MISSING
 *   68.0000 F          *
 VVSTDMX  CUFT/MIN         1.4064+04   9925.1306    829.5480    829.5480   2.1409+04
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 TG-BNR-2
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 STREAM ID                  TG-BNR-2
 FROM :                     CL-CNG
 TO   :                     TG-MIX

 SUBSTREAM: MIXED
 PHASE:                     VAPOR
 COMPONENTS: LBMOL/HR
   N2                       2204.6987
   CO2                       537.8499
   CACO3                       0.0
   CAO                         0.0
   CO                          0.0
   O2                         54.9419
   AR                         26.5592
   NO2                         0.0
   NO                          0.0
   H2O                       509.5988
   H2                          0.0
   H2O-MUD                     0.0
   CH4                         0.0
   C                           0.0
 COMPONENTS: MOLE FRAC
   N2                          0.6613
   CO2                         0.1613
   CACO3                       0.0
   CAO                         0.0
   CO                          0.0
   O2                       1.6481-02
   AR                       7.9670-03
   NO2                         0.0
   NO                          0.0
   H2O                         0.1529
   H2                          0.0
   H2O-MUD                     0.0
   CH4                         0.0
   C                           0.0
 COMPONENTS: TONS/HR
   N2                         30.8806
   CO2                        11.8353
   CACO3                       0.0
   CAO                         0.0
   CO                          0.0
   O2                          0.8790
   AR                          0.5305
   NO2                         0.0
   NO                          0.0
   H2O                         4.5903
   H2                          0.0
   H2O-MUD                     0.0
   CH4                         0.0
   C                           0.0
 COMPONENTS: MASS FRAC
   N2                          0.6339
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 TG-BNR-2 (CONTINUED)

 STREAM ID                  TG-BNR-2

   CO2                         0.2429
   CACO3                       0.0
   CAO                         0.0
   CO                          0.0
   O2                       1.8044-02
   AR                       1.0890-02
   NO2                         0.0
   NO                          0.0
   H2O                      9.4226-02
   H2                          0.0
   H2O-MUD                     0.0
   CH4                         0.0
   C                           0.0
 TOTAL FLOW:
   LBMOL/HR                 3333.6486
   TONS/HR                    48.7158
   CUFT/HR                  4.1605+06
 STATE VARIABLES:
   TEMP   F                 1249.0101
   PRES   PSI                 14.6959
   VFRAC                       1.0000
   LFRAC                       0.0
   SFRAC                       0.0
 ENTHALPY:
   BTU/LBMOL               -3.3664+04
   BTU/LB                  -1151.8062
   MMBTU/HR                 -112.2223
 ENTROPY:
   BTU/LBMOL-R                 9.6535
   BTU/LB-R                    0.3303
 DENSITY:
   LBMOL/CUFT               8.0125-04
   LB/CUFT                  2.3418-02
 AVG MW                       29.2267

 MIXED   SUBSTREAM PROPERTIES:

 ***  ALL PHASES   ***
 MW       UNITLESS
     N2                       28.0135
     CO2                      44.0098
     CACO3                    MISSING
     CAO                      MISSING
     CO                       MISSING
     O2                       31.9988
     AR                       39.9480
     NO2                      MISSING
     NO                       MISSING
     H2O                      18.0153
     H2                       MISSING
     H2O-MUD                  MISSING
     CH4                      MISSING
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```
 TG-BNR-2 (CONTINUED)

 STREAM ID                  TG-BNR-2

     C                        MISSING
 MWMX                         29.2267
 QVALGRS  BTU/LB              98.9355
 QVALNET  BTU/LB               0.0

 *** VAPOR PHASE   ***
 MUMX      LB/FT-HR         9.5265-02
 PR                            0.6846
 KMX       BTU/HR-FT-R      4.2081-02
 *   68.0000 F          *
 VVSTD    CUM/SEC
     N2                        6.6821
     CO2                       1.6301
     CACO3                    MISSING
     CAO                      MISSING
     CO                       MISSING
     O2                        0.1665
     AR                     8.0497-02
     NO2                      MISSING
     NO                       MISSING
     H2O                       1.5445
     H2                       MISSING
     H2O-MUD                  MISSING
     CH4                      MISSING
     C                        MISSING
 *   68.0000 F          *
 VVSTDMX  CUFT/MIN          2.1409+04
```

```
 BLOCK STATUS
 ------------

 ****************************************************************************
 *                                                                          *
 * Calculations were completed normally                                     *
 *                                                                          *
 * All Unit Operation blocks were completed normally                        *
 *                                                                          *
 * All streams were flashed normally                                        *
 *                                                                          *
 * All Utility blocks were completed normally                               *
 *                                                                          *
 * All Convergence blocks were completed normally                           *
 *                                                                          *
 * All Calculator blocks were completed normally                            *
 *                                                                          *
 ****************************************************************************
```

Appendix C

Fortran User Kinetic Subroutine

```
C=================================================================================
C           Aspen Fortran subroutine for an updraft biomass gasifier.
C            Created by Anastasia Gribik, Idaho National Laboratory
C                              on July 24, 2007
C               for the DOE EERE Hog Fuel Gasification Project
C
C The code currently assumes immediate devolatilization, which is handled by
C a YIELD block in Aspen.  The yield block also creates the correct amount
C of tars generated in an updraft gasifier (~50 g/Nm3); thus, there is no
C predictive capability for tar generation.  In addition, carbon conversion is
C hard coded into the subroutine, currently at 95%.  Despite the fact that
C carbon conversion and tar production must be hardcoded into the program the
C prediction for gas composition is predictive based upon moisture content of
C the fuel, air or oxygen flow into the gasifier, and the fuel devolatilization
C products.  Given the complexity of devolatilization, it is necessary to
C determine the appropriate devolatilization yields and products for the fuel
C type desired, which should then be programmed into the YIELD block.  Thus,
C the current model is specifically designed for wood chips (hog fuel).
C=================================================================================

      SUBROUTINE CHAR1  (SOUT,     NSUBS,    IDXSUB,   ITYPE,    NINT,
     +                   INT,      NREAL,    REAL,     IDS,      NPO,
     +                   NBOPST,   NIWORK,   IWORK,    NWORK,    WORK,
     +                   NC,       NR,       STOIC,    RATES,    FLUXM,
     +                   FLUXS,    XCURR,    NTCAT,    RATCAT,   NTSSAT,
     +                   RATSSA,   KCALL,    KFAIL,    KFLASH,   NCOMP,
     +                   IDX,      Y,        X,        X1,       X2,
     +                   NRALL,    RATALL,   NUSERV,   USERV,    NINTR,
     +                   INTR,     NREALR,   REALR,    NIWR,     IWR,
     +                   NWR,      WR)

      IMPLICIT NONE

C=================================================================================
C Declare variables used in dimensioning.
C=================================================================================

      INTEGER NSUBS,  NINT,   NPO,    NIWORK, NWORK,
     +        NC,     NR,     NTCAT,  NTSSAT, NCOMP,
     +        NRALL,  NUSERV, NINTR,  NREALR, NIWR,
     +        NWR

C=================================================================================
C Labeled commons to pass data for RPLUG.
C=================================================================================

#include "rplg_rplugi.cmn"
      EQUIVALENCE (NTUBE, RPLUGI_NTUBE)

#include "rplg_rplugr.cmn"
      EQUIVALENCE (XLEN, RPLUGR_UXLONG)
      EQUIVALENCE (DIAM, RPLUGR_UDIAM)

C=================================================================================
C General labeled commons to pass physical property data.
C=================================================================================

#include "rxn_rprops.cmn"
      EQUIVALENCE (TEMP, RPROPS_UTEMP)
      EQUIVALENCE (PRES, RPROPS_UPRES)
      EQUIVALENCE (VFRAC, RPROPS_UVFRAC)
      EQUIVALENCE (BETA, RPROPS_UBETA)
      EQUIVALENCE (VVAP, RPROPS_UVVAP)
      EQUIVALENCE (VLIQ, RPROPS_UVLIQ)
      EQUIVALENCE (VLIQS, RPROPS_UVLIQS)

#include "pputl_ppglob.cmn"

#include "dms_ncomp.cmn"
```

```
C===============================================================================
C General user common for all user-specified routines.
C===============================================================================

#include "ppexec user.cmn"
      EQUIVALENCE (RMISS, USER_RUMISS)
      EQUIVALENCE (IMISS, USER_IUMISS)

C===============================================================================
C Declarations
C===============================================================================

      INTEGER IDXSUB(NSUBS),  ITYPE(NSUBS),   INT(NINT),
     +        IDS(2),         NBOPST(6,NPO),  IWORK(NIWORK),
     +        IDX(NCOMP),     INTR(NINTR),    IWR(NIWR),
     +        NREAL,          KCALL,          KFAIL,
     +        KFLASH

      DOUBLE PRECISION        SOUT(1),        STOIC(NC,NSUBS,NR),
     +        WORK(NWORK),    RATES(NC),      FLUXM(1),
     +        FLUXS(1),       RATCAT(NTCAT),  RATSSA(NTSSAT),
     +        Y(NCOMP),       X(NCOMP),       X1(NCOMP),
     +        X2(NCOMP),      REAL(NREAL),    RATALL(NRALL),
     +        USERV(NUSERV),  REALR(NREALR),  WR(NWR),
     +        XCURR

C===============================================================================
C Declare local variables
C===============================================================================

      INTEGER DMS KFORMC, DMS KNCIDC, I,          ICH4,
     +        ICHAR,      ICO,        ICO2,       IFUEL,
     +        IH2,        IH2O,       IMISS,      IN2,
     +        IO2,        IPROG(2),   ITAR,       NTUBE

      DOUBLE PRECISION    ACH4,       ACHCO2,     ACHH2,
     +        ACHH2O,     ACHO2,      ACO,        ACO2,

     +        AH2,        AH2O,       ALPHA,      AREACONV,
     +        BETA,       BETAA,      CARBON,     CARBONc,
     +        CARBONo,    CHARUC,     CHARUH,     CHARUO,
     +        CHI,        CONCCH4,    CONCCO,     CONCCO2,
     +        CONCH2,     CONCH2O,    CONCO2,     DIAM,
     +        ECH4,       ECHCO2,     ECHH2,      ECHH2O,

     +        ECHO2,      ECO,        ECO2,       EH2,
     +        EH2O,       EPSILON,    FUELH,      FUELO,

     +        FUELUC,     FUELUH,     FUELUO,     GAMMA,

     +        GAMMAP,     HYDROGEN,   HYDROGENo,  kCHCO2,
     +        kCHH2,      kCHH2O,     kCHO2,      km,
     +        MFTARo,     MWC,        MWCHAR,     MWFUEL,
     +        MWH,        MWO,        MWTAR,      NUp,
     +        OXYGEN,     OXYGENo,    PI,         PRES,
     +        R,          Rc,         RCH4,       RCH4CO2,
     +        RCH4H2O,    RCH4O2,     RCHCO2,     RCHCO2CO,
     +        RCHCO2CO2,  RCHCO2H2,   RCHCO2H2O,  RCHH2,

     +        RCHH2CH4,   RCHH2H2,    RCHH2H2O,   RCHH2O,
     +        RCHH2OCO,   RCHH2OH2,   RCHH2OH2O,  RCHO2,
     +        RCHO2CO,    RCHO2CO2,   RCHO2H2O,   RCHO2O2,

     +        RCO,        RCO2,       RCO2CO,     RCO2H2,
     +        RCO2H2O,    RCOCO2,     RCOO2,      RH2,

     +        RH2H2O,     RH2O,       RH2O2,      RH2OCO,
     +        RH2OCO2,    RH2OH2,     RMISS,      Ro,
     +        TARH,       TARO,       TARRAT,     TARUC,
     +        TARUH,      TARUO,      TEMP,       Urat,
```

```
     +        Us,         Uso,        VFRAC,      VLIQ,
     +        VLIQS,      VOLFLOW,    VVAP,       XLEN,
     +        YCH4,       YCO,        YCO2,       YH2,
     +        YH2O,       YN2,        YO2

C===============================================================================
C Opens file(s) for debugging the code
C===============================================================================

      open(unit=1,name='output.out',access='append',type='unknown')

C===============================================================================
C Initialize rates vector.
C This vector is used to specify the rate of change for each component.
C
C BEGIN EXECUTABLE CODE
C===============================================================================

      DO I = 1., NC
          RATES(I) = 0.
      END DO

C===============================================================================
C Locate component indices used in this routine based on formula name for
C conventional components and the component name for nonconventional components.
C
C These indices correspond to the order that each component is declared in the
C Components paragraph of the simulation input file or on the Components
C Specifications Selection sheet.  This section of code is optional. It enables
C the user routine to automatically use the correct indices if the component
C order is changed, or if components are inserted or deleted from the components
C paragraph.
C
C     The component index will be obtained for:
C
C     Component       CID      Formula
C     ---------       ---      -------
C     OXYGEN          O2       O2
C     CARBON MONOXIDE CO       CO
C     CARBON DIOXIDE  CO2      CO2
C     WATER           H2O      H2O
C     METHANE         CH4      CH4
C     HYDROGEN        H2       H2
C     CHAR            CHAR     NONCONVENTIONAL
C     FUEL            FUEL     NONCONVENTIONAL
C     TAR             TAR      NONCONVENTIONAL
C===============================================================================

      IO2=DMS_KFORMC('O2')
      ICO=DMS_KFORMC('CO')
      ICO2=DMS_KFORMC('CO2')
      IH2O=DMS_KFORMC('H2O')
      ICH4=DMS_KFORMC('CH4')
      IH2=DMS_KFORMC('H2')
      IN2=DMS_KFORMC('N2')
      ICHAR=NCOMP_NCC+DMS_KNCIDC('CHAR')
      IFUEL=NCOMP_NCC+DMS_KNCIDC('FUEL')
      ITAR=NCOMP_NCC+DMS_KNCIDC('TAR')

C===============================================================================
C The mass fractions of carbon, hydrogen, and oxygen are passed from the
C ultimate analysis for calculation of the molar fuel composition.
C
C The values for the hydrogen and oxygen in the fuel (which are used to balance
C the reaction equations) are determined from the ultimate analysis of the fuel.
C Molecular weight has units of kg/kmol.
C===============================================================================

      IF (XCURR.EQ.0.) THEN
```

```
          FUELUC=SOUT(NCOMP_NCC+9+NCOMP_NNCC+15+14)   !Fuel carbon content
          FUELUH=SOUT(NCOMP_NCC+9+NCOMP_NNCC+16+14)   !Fuel hydrogen content
          FUELUO=SOUT(NCOMP_NCC+9+NCOMP_NNCC+20+14)   !Fuel oxygen content

          MWH=1.00794                         !Molecular weight of hydrogen
          MWO=15.9994                         !Molecular weight of oxygen
          MWC=12.011                          !Molecular weight of carbon

          FUELH=(FUELUH/MWH)/(FUELUC/MWC)     !Calculation for hydrogen in fuel
          FUELO=(FUELUO/MWO)/(FUELUC/MWC)     !Calculation for oxygen in fuel
          MWFUEL=MWC+(FUELH*MWH)+(FUELO*MWO)  !Molecular weight of fuel

C===============================================================================
C The mass fractions of carbon, hydrogen, and oxygen are passed from the
C ultimate analysis for calculation of the molar char composition.
C
C The values for alpha and beta (which are used to balance the reaction
C equations) are determined from the ultimate analysis of the char.  The value
C for gamma is set to be equal to one.
C Molecular weight has units of kg/kmol.
C===============================================================================

          CHARUC=SOUT(NCOMP_NCC+9+NCOMP_NNCC+15)      !Char carbon content
          CHARUH=SOUT(NCOMP_NCC+9+NCOMP_NNCC+16)      !Char hydrogen content
          CHARUO=SOUT(NCOMP_NCC+9+NCOMP_NNCC+20)      !Char oxygen content

          ALPHA=(CHARUH/MWH)/(CHARUC/MWC)     !Calculation for ALPHA (hydrogen)
          BETAA=(CHARUO/MWO)/(CHARUC/MWC)     !Calculation for BETAA (oxygen)
          MWCHAR=MWC+(ALPHA*MWH)+(BETAA*MWO)  !Molecular weight of char

C===============================================================================
C The mass fractions of carbon, hydrogen, and oxygen are passed from the
C ultimate analysis for calculation of the molar tar composition.
C
C The values for the hydrogen and oxygen in the tar (which are used to balance
C the reaction equations) are determined from the ultimate analysis of the tar.
C Molecular weight has units of kg/kmol.
C===============================================================================

          TARUC=SOUT(NCOMP_NCC+9+NCOMP_NNCC+15+14+14) !Tar carbon content
          TARUH=SOUT(NCOMP_NCC+9+NCOMP_NNCC+16+14+14) !Tar hydrogen content
          TARUO=SOUT(NCOMP_NCC+9+NCOMP_NNCC+20+14+14) !Tar oxygen content

          TARH=(TARUH/MWH)/(TARUC/MWC)        !Calculation for hydrogen in tar
          TARO=(TARUO/MWO)/(TARUC/MWC)        !Calculation for oxygen in tar
          MWTAR=MWC+(TARH*MWH)+(TARO*MWO)     !Molecular weight of tar

C===============================================================================
C Calculation of mass flow of initial carbon, hydrogen, and oxygen in system.
C===============================================================================

          CARBONo=(SOUT(ICO)+SOUT(ICO2)+SOUT(ICH4)+(SOUT(ICHAR+9)/
     +        MWCHAR)+(SOUT(IFUEL+9)/MWFUEL)+(SOUT(ITAR+9)/MWTAR))*MWC
          HYDROGENo=(2.*SOUT(IH2O)+4.*SOUT(ICH4)+2.*SOUT(IH2)+
     +        (SOUT(ICHAR+9)/MWCHAR)*ALPHA+(SOUT(IFUEL+9)/MWFUEL)*
     +        FUELH+(SOUT(ITAR+9)/MWTAR)*TARH)*MWH
          OXYGENo=(2.*SOUT(IO2)+SOUT(ICO)+2.*SOUT(ICO2)+SOUT(IH2O)+
     +        (SOUT(ICHAR+9)/MWCHAR)*BETAA+(SOUT(IFUEL+9)/MWFUEL)*
     +        FUELO+(SOUT(ITAR+9)/MWTAR)*TARO)*MWO

      END IF

C===============================================================================
C Calculation of quantities used for reaction expressions.  The following
C information is taken from Di Blasi (2004).  Note that it is assumed that the
C particle velocity is equivalent to the particle flow for the char, since
C density and area are constant and would cancel in the ratio equation. Also the
C mass transfer coefficient used in the reaction rate equation is km*, or the
C maximum value for mass transfer.
C===============================================================================
```

```
      PI=3.14159265359    !PI constant
      Rc=8.314            !R constant [=] J/mol-K
      km=0.15             !Maximum value for mass transfer coefficient [=] m/s
      CHI=0.0569          !Ash content of the fuel (mass percent)
      EPSILON=0.5         !Bed porosity (unitless)
      R=0.005/2.          !Initial particle radius [=] m

      IF (XCURR.EQ.0.) THEN

          Uso=SOUT(ICHAR+9)   !Initial char flow after devolatilization [=] kg/s
          MFTARo=SOUT(ITAR+9) !Initial tar flow after devolatilization [=] kg/s

          !Erases the previous output file(s)
          REWIND(unit=1)

          !Writes the header for the output file(s)
          write(1,5)
    5     FORMAT('-------------------------------------------------------',
     +        '-------------------------------------------------------')

          write(1,10)
   10     FORMAT('    XCUR,     TEMP,      YO2,     YCO,      YCO2,',
     +        '     YH2O,     YCH4,     YH2,      YN2,   TARRAT,'
     +        ' CARBONc,')

          write(1,15)
   15     FORMAT('-------------------------------------------------------',
     +        '-------------------------------------------------------')

      END IF

      Us=SOUT(ICHAR+9)                !Current char flow [=] kg/s

      Urat=Us/Uso                     !Ratio of current to initial char velocity

      Ro=(((1.-CHI)*Urat+CHI)**(1./3.))*R !Current particle radius [=] m

      NUp=3.*(1.-EPSILON)/Ro              !Particle density number [=] 1/m

      CARBONc=1.-Us*(CHARUC/100.)/CARBONo !Current carbon fraction

C================================================================================
C Calculate the vapor concentration of each component and the current grams
C of tar per standard cubic meter.
C
C The rate expression in this example is based on molar concentration. The
C component concentration can be calculated by dividing the molar flow of the
C species (kmol/s) by the current volumetric flowrate (m3/s).  Note that the
C volumetric flow includes the volume flow of the tar species.
C================================================================================

      !Calculation of current volumetric gas flow, including tar [=] m3/s
      VOLFLOW=SOUT(NCOMP_NCC+1)*SOUT(NCOMP_NCC+9)/SOUT(NCOMP_NCC+8)+
     +    ((SOUT(ITAR+9)/MWTAR)*Rc*1000.*TEMP/SOUT(NCOMP_NCC+3))

      CONCO2=SOUT(IO2)/VOLFLOW                !Concentration of O2 [=] kmol/m3
      CONCCO=SOUT(ICO)/VOLFLOW                !Concentration of CO [=] kmol/m3
      CONCCO2=SOUT(ICO2)/VOLFLOW              !Concentration of CO2 [=] kmol/m3
      CONCH2O=SOUT(IH2O)/VOLFLOW              !Concentration of H2O [=] kmol/m3
      CONCCH4=SOUT(ICH4)/VOLFLOW              !Concentration of CH4 [=] kmol/m3
      CONCH2=SOUT(IH2)/VOLFLOW                !Concentration of H2 [=] kmol/m3

      !g of Tar/Nm3
      TARRAT=SOUT(ITAR+9)/((VOLFLOW/(TEMP*101325.))*(298.15*PRES))*1000.

C================================================================================
C================================================================================
C
C CALCULATION OF GAS PHASE REACTION RATES
```

```
C
C=========================================================================
C=========================================================================

C=========================================================================
C Reaction rates for the gas phase reactions of the devolatilization products
C are described in the following sections.  The reactions include the reaction
C of tar and oxygen, methane and oxygen, CO and oxygen, hydrogen and oxygen,
C and the water gas shift reaction.  The kinetic parameters are taken from
C Di Blasi (2004), Souza-Santos (2004), Tingey (1966), and NETL (2005).
C=========================================================================

C=========================================================================
C Reaction rate calculation for reaction of methane with oxygen.  The rate
C expression and constants are taken from Souza-Santos (2004).  The rate
C of CH4 consumption takes the following form:
C
C     Rate = epsilon*A*(T**-1)*exp(-E/T)*[CH4]*[O2]
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C     CH4 + 2O2 -> CO2 + 2H2O
C=========================================================================

      ACH4=3.552*(10.**14.)           !Frequency factor [=] K-m3/kmol-s

      ECH4=15700.                     !Activation energy [=] K

      !Rate of CH4 consumption [=] kmol/m3-s
      RCH4=EPSILON*ACH4*(TEMP**-1)*DEXP(-ECH4/TEMP)*CONCCH4*CONCO2

      RCH4O2=2.*RCH4                  !Rate of O2 consumption [=] kmol/m3-s

      RCH4CO2=RCH4                    !Rate of CO2 production [=] kmol/m3-s

      RCH4H2O=2.*RCH4                 !Rate of H2O production [=] kmol/m3-s

C=========================================================================
C Reaction rate calculation for reaction of carbon monoxide with oxygen.  The
C rate expression and constants are taken from Souza-Santos (2004).  The rate
C of carbon monoxide consumption takes the following form:
C
C     Rate = epsilon*2*A*exp(-E/T)*[CO]*[O2]**0.25*[H2O]**0.5
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C    2CO + O2 -> 2CO2
C=========================================================================

      ACO=1.3*(10.**17.)                  !Frequency factor [=] m2.25/s-kmol0.75

      ECO=34740.                          !Activation energy [=] K

      !Rate of CO consumption [=] kmol/m3-s
      RCO=EPSILON*2.*ACO*DEXP(-ECO/TEMP)*CONCCO*(CONCO2**0.25)*
     +    (CONCH2O**0.5)

      RCOO2=RCO/2.                        !Rate of O2 consumption [=] kmol/m3-s

      RCOCO2=RCO                          !Rate of CO2 production [=] kmol/m3-s

C=========================================================================
C Reaction rate calculation for reaction of hydrogen with oxygen.  The
C rate expression and constants are taken from Souza-Santos (2004).  The rate
C of hydrogen consumption takes the following form:
C
C     Rate = epsilon*2*A*(T**-1.5)*exp(-E/T)*[H2]**1.5*[O2]
C
```

```
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C    2H2 + O2 -> 2H2O
C===============================================================================

      AH2=5.159*(10.**13.)            !Frequency factor [=] m4.5-K1.5/s-kmol1.5

      EH2=3430.                       !Activation energy [=] K

      !Rate of H2 consumption [=] kmol/m3-s
      RH2=EPSILON*2.*AH2*(TEMP**-1.5)*DEXP(-EH2/TEMP)*CONCO2*
     +    (CONCH2**1.5)

      RH2O2=RH2/2.                        !Rate of O2 consumption [=] kmol/m3-s

      RH2H2O=RH2                          !Rate of H2O production [=] kmol/m3-s

C===============================================================================
C Reaction rate calculation for the water gas shift reaction.  The forward and
C reverse gas shift reactions are handled separately as the general chemical
C equilibrium equation is not satisfactory when large amounts of moisture are
C fed in with the fuel.  Forward rates are taken from a recent NETL study (2005)
C and reverse reaction rates are broken down for temperature ranges based on
C rates from Tingey (1966).
C
C The rate for the forward reaction takes the following form:
C
C     Rate = epsilon*A*exp(-E/RT)*[H2O]*[CO]**0.5
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction for the forward reaction:
C
C     CO + H2O -> CO2 + H2
C
C The rate for the reverse reaction takes the following form:
C
C     Rate = epsilon*A*exp(-E/RT)*[CO2]*[H2]**0.5
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction for the reverse reaction:
C
C     CO2 + H2 -> CO + H2O
C===============================================================================

      !Forward Reaction

      !Frequency factor [=] m1.5/kmol0.5-s
      AH2O=7.40*(10.**11.)*(0.01**1.5)*(1000**0.5)

      EH2O=288300.                        !Activation energy [=] J/mol

      !Rate of H2O consumption [=] kmol/m3-s
      RH2O=EPSILON*AH2O*DEXP(-EH2O/(Rc*TEMP))*CONCH2O*(CONCCO**0.5)

      RH2OCO=RH2O                         !Rate of CO consumption [=] kmol/m3-s

      RH2OCO2=RH2O                        !Rate of CO2 production [=] kmol/m3-s

      RH2OH2=RH2O                         !Rate of H2 production [=] kmol/m3-s

      !Reverse Reaction

      IF (TEMP.LT.1073.) THEN

          ACO2=7.6*(10.**4.)              !Frequency factor [=] m1.5/kmol0.333-s

          ECO2=39200.*4.1868              !Activation energy [=] J/mol

          !Rate of CO2 consumption [=] kmol/m3-s
```

```
          RCO2=EPSILON*ACO2*DEXP(-ECO2/(Rc*TEMP))*(CONCH2**(1./3.))
     +        *CONCCO2

      ELSE

          ACO2=1.2*(10.**13.)             !Frequency factor [=] m1.5/kmol0.5-s

          ECO2=78000.*4.1868              !Activation energy [=] J/mol

          !Rate of CO2 consumption [=] kmol/m3-s
          RCO2=EPSILON*ACO2*DEXP(-ECO2/(Rc*TEMP))*(CONCH2**(1./2.))
     +        *CONCCO2

      END IF

      RCO2H2=RCO2                         !Rate of H2 consumption [=] kmol/m3-s

      RCO2CO=RCO2                         !Rate of CO production [=] kmol/m3-s

      RCO2H2O=RCO2                        !Rate of H2O production [=] kmol/m3-s

C================================================================================
C================================================================================
C
C CALCULATION OF CHAR REACTION RATES
C
C================================================================================
C================================================================================

C================================================================================
C Calculation of rate expression for reaction of char with oxygen.  The rate
C expressions and constants are taken from Di Blasi (2004) and Hobbs (1992).
C The rate of char consumption takes the following form:
C
C     Rate = NUp*[O2]/((1/km)+(1/k)) with k = A*T*exp(-E/Ts)
C
C It is assumed that the temperature of the solid is equal to the temperature
C of the gas.
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C     CHaOb + gO2 -> (2-2g-b+a/2)CO + (2g+b-a/2-1)CO2 + a/2H2O
C================================================================================

      ! Calculation of distribution between CO and CO2 for char oxidation
      ! reaction.  Taken from Souza-Santos (2004) pg. 157.
      GAMMAP=2500.*DEXP(-6240./TEMP)
      GAMMA=(2.+GAMMAP)/(2.+2.*GAMMAP)

      ACHO2=2.3                               !Frequency factor [=] m/s-K

      ECHO2=11100.                            !Activation energy [=] K

      kCHO2=ACHO2*TEMP*DEXP(-ECHO2/TEMP)      !Rate constant [=] m/s

      RCHO2=NUp*CONCO2/((1./km)+(1./kCHO2))   !Char consumption [=] kmol/m3-s

      RCHO2O2=GAMMA*RCHO2                     !O2 consumption [=] kmol/m3-s

      RCHO2CO=(2.-(2.*GAMMA)-BETAA+(ALPHA/2.))*RCHO2  !CO prod. [=] kmol/m3-s

      RCHO2CO2=((2.*GAMMA)+BETAA-(ALPHA/2.)-1.)*RCHO2 !CO2 prod. [=] kmol/m3-s

      RCHO2H2O=(ALPHA/2.)*RCHO2               !H2O production [=] kmol/m3-s

      IF (CARBONc.GT.0.95) THEN   !Sets rates to zero at 95% carbon conversion
          RCHO2=0.
          RCHO2O2=0.
          RCHO2CO=0.
```

```
          RCHO2CO2=0.
          RCHO2H2O=0.
      ELSE

      END IF

C================================================================================
C Calculation of rate expression for reaction of char with carbon dioxide.  The
C rate expressions and constants are taken from Di Blasi (2004) and Hobbs (1992).
C The rate of char consumption takes the following form:
C
C     Rate = NUp*[CO2]/((1/km)+(1/k)) with k = A*T*exp(-E/Ts)
C
C It is assumed that the temperature of the solid is equal to the temperature
C of the gas.
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C     CHaOb + CO2 -> 2CO + bH2O + (a/2-b)H2
C================================================================================

      ACHCO2=589.                            !Frequency factor [=] m/s-K

      ECHCO2=26800.                          !Activation energy [=] J/mol

      kCHCO2=ACHCO2*TEMP*DEXP(-ECHCO2/TEMP)   !Rate constant [=] m/s

      RCHCO2=NUp*CONCCO2/((1./km)+(1./kCHCO2))!Char consumption [=] kmol/m3-s

      RCHCO2CO2=RCHCO2                       !CO2 consumption [=] kmol/m3-s

      RCHCO2CO=2.*RCHCO2                     !CO production [=] kmol/m3-s

      RCHCO2H2O=BETAA*RCHCO2                 !H2O production [=] kmol/m3-s

      RCHCO2H2=((ALPHA/2.)-BETAA)*RCHCO2      !H2 production [=] kmol/m3-s

      IF (CARBONc.GT.0.95) THEN   !Sets rates to zero at 95% carbon conversion
          RCHCO2=0.
          RCHCO2CO2=0.
          RCHCO2CO=0.
          RCHCO2H2O=0.
          RCHCO2H2=0.
      ELSE

      END IF

C================================================================================
C Calculation of rate expression for reaction of char with hydrogen.  The rate
C expressions and constants are taken from Di Blasi (2004) and Hobbs (1992).
C The rate of char consumption takes the following form:
C
C     Rate = NUp*[H2]/((1/km)+(1/k)) with k = A*T*exp(-E/Ts)
C
C It is assumed that the temperature of the solid is equal to the temperature
C of the gas.
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C     CHaOb + (2-a/2+b)H2 -> CH4 + bH2O
C================================================================================

      ACHH2=0.589                            !Frequency factor [=] m/s-K

      ECHH2=26800.                           !Activation energy [=] J/mol

      kCHH2=ACHH2*TEMP*DEXP(-ECHH2/TEMP)      !Rate constant [=] m/s
```

```
      RCHH2=NUp*CONCH2/((1./km)+(1./kCHH2))   !Char consumption [=] kmol/m3-s

      RCHH2H2=(2.-(ALPHA/2.)+BETAA)*RCHH2     !H2 consumption [=] kmol/m3-s

      RCHH2CH4=RCHH2                          !CH4 production [=] kmol/m3-s

      RCHH2H2O=BETAA*RCHH2                    !H2O production [=] kmol/m3-s

      IF (CARBONc.GT.0.95) THEN   !Sets rates to zero at 95% carbon conversion
          RCHH2=0.
          RCHH2H2=0.
          RCHH2CH4=0.
          RCHH2H2O=0.
      ELSE

      END IF

C================================================================================
C Calculation of rate expression for reaction of char with water.  The rate
C expressions and constants are taken from Di Blasi (2004) and Hobbs (1992).
C The rate of char consumption takes the following form:
C
C     Rate = NUp*[H2O]/((1/km)+(1/k)) with k = A*T*exp(-E/Ts)
C
C It is assumed that the temperature of the solid is equal to the temperature
C of the gas.
C
C Rates for the consumption or generation of reactants is governed by the
C following chemical reaction:
C
C     CHaOb + (1-b)H2O -> CO + (1-b+a/2)H2
C================================================================================

      ACHH2O=589.                             !Frequency factor [=] m/s-K

      ECHH2O=26800.                           !Activation energy [=] J/mol

      kCHH2O=ACHH2O*TEMP*DEXP(-ECHH2O/TEMP)   !Rate constant [=] m/s

      RCHH2O=NUp*CONCH2O/((1./km)+(1./kCHH2O))!Char consumption [=] kmol/m3-s

      RCHH2OH2O=(1.-BETAA)*RCHH2O             !H2O consumption [=] kmol/m3-s

      RCHH2OCO=RCHH2O                         !CO production [=] kmol/m3-s

      RCHH2OH2=(1.-BETAA+(ALPHA/2.))*RCHH2O   !H2 production [=] kmol/m3-s

      IF (CARBONc.GT.0.95) THEN   !Sets rates to zero at 95% carbon conversion
          RCHH2O=0.
          RCHH2OH2O=0.
          RCHH2OCO=0.
          RCHH2OH2=0.
      ELSE

      END IF

C================================================================================
C Convert the rates to kmol/m-s by multiplying by the reactor cross sectional
C area (or kg/m-s for nonconventional components).
C================================================================================

      AREACONV=(PI/4.)*(DIAM**2.)     !Reactor cross sectional area [=] m2

      !Rate of change of O2 [=] kmol/m3-s
      RATES(IO2)=(-RCH4O2-RCOO2-RH2O2-RCHO2O2)*AREACONV

      !Rate of change of CO [=] kmol/m3-s
      RATES(ICO)=(-RCO-RH2OCO+RCO2CO+RCHO2CO+RCHCO2CO+RCHH2OCO)*AREACONV

      !Rate of change of CO2 [=] kmol/m3-s
```

```
      RATES(ICO2)=(RCH4CO2+RCOCO2+RH2OCO2-RCO2+RCHO2CO2-RCHCO2CO2)*
     +    AREACONV

      !Rate of change of H2O [=] kmol/m3-s
      RATES(IH2O)=(RCH4H2O+RH2H2O-RH2O+RCO2H2O+RCHO2H2O+RCHCO2H2O+
     +    RCHH2H2O-RCHH2OH2O)*AREACONV

      !Rate of change of CH4 [=] kmol/m3-s
      RATES(ICH4)=(-RCH4+RCHH2CH4)*AREACONV

      !Rate of change of H2 [=] kmol/m3-s
      RATES(IH2)=(-RH2+RH2OH2-RCO2H2+RCHCO2H2-RCHH2H2+RCHH2OH2)*AREACONV

      !Rate of change of CHAR [=] kg/m3-s
      RATES(ICHAR)=(-RCHO2-RCHCO2-RCHH2-RCHH2O)*MWCHAR*AREACONV

C================================================================================
C Calculate the mole fraction of each species in the gas
C================================================================================

      YCH4=SOUT(ICH4)/SOUT(NCOMP NCC+1.)      !Mole fraction of CH4
      YCO=SOUT(ICO)/SOUT(NCOMP NCC+1.)        !Mole fraction of CO
      YCO2=SOUT(ICO2)/SOUT(NCOMP NCC+1.)      !Mole fraction of CO2
      YH2=SOUT(IH2)/SOUT(NCOMP NCC+1.)        !Mole fraction of H2
      YH2O=SOUT(IH2O)/SOUT(NCOMP NCC+1.)      !Mole fraction of H2O
      YO2=SOUT(IO2)/SOUT(NCOMP NCC+1.)        !Mole fraction of O2
      YN2=SOUT(IN2)/SOUT(NCOMP_NCC+1.)        !Mole fraction of N2

C================================================================================
C Calculation of mass flow of current carbon, hydrogen, and oxygen in system.
C================================================================================

      CARBON=(SOUT(ICO)+SOUT(ICO2)+SOUT(ICH4)+(SOUT(ICHAR+9.)/MWCHAR)+
     +    (SOUT(IFUEL+9.)/MWFUEL)+(SOUT(ITAR+9.)/MWTAR))*MWC
      HYDROGEN=(2.*SOUT(IH2O)+4.*SOUT(ICH4)+2.*SOUT(IH2)+(SOUT(ICHAR+9.)
     +    /MWCHAR)*ALPHA+(SOUT(IFUEL+9.)/MWFUEL)*FUELH+(SOUT(ITAR+9.)/
     +    MWTAR)*TARH)*MWH
      OXYGEN=(2.*SOUT(IO2)+SOUT(ICO)+2.*SOUT(ICO2)+SOUT(IH2O)+
     +    (SOUT(ICHAR+9.)/MWCHAR)*BETAA+(SOUT(IFUEL+9.)/MWFUEL)*
     +    FUELO+(SOUT(ITAR+9.)/MWTAR)*TARO)*MWO

C================================================================================
C Create output file
C================================================================================

      write(1,30)XCURR, TEMP, YO2, YCO, YCO2, YH2O, YCH4, YH2, YN2,
     +    TARRAT,CARBONc

   30 FORMAT(2x,F7.5,',',2x,F7.2,',',2x,F7.5,',',2x,F7.5,',',2x,F7.5,','
     +    ,2x,F7.5,',',2x,F7.5,',',2x,F7.5,',',2x,F7.5,',',2x,F4.1,',',
     +    2x,F7.5,',')

C================================================================================
C END PROGRAM
C================================================================================

      close(unit=1)

      RETURN
      END
```