



Process Design Basis

1	Design	ABD	BSS	JWT
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1. Introduction

1.1 Purpose

The purpose of this Process Design Basis document is to establish the key technical requirements and philosophies that will form the basis for the Front-End Engineering Design (FEED) of the Blue River Natural Gas Processing Plant. This document will serve as a point of reference for the design of process units, utility systems, and offsites.

1.2 Scope

This document shall cover the following:

- Production capacity and objectives
- Feed gas composition and specifications
- Product specifications for sales gas
- Identifying project scope and battery limits
- Brief Description for major process units including:
 - Inlet separation (Unit 10)
 - Gas sweetening (Unit 20)
 - Gas dehydration
 - Dew Point Control
 - Compression of Sales Gas
- Utility requirements
- Design considerations
- Site Conditions

1.3 Project Overview

Horizon Energy Solutions is developing the Blue River Gas Plant to process 500 MMSCFD of raw natural gas from the Blue River Field. The plant will be located in Westbrook County, [State] approximately 50 miles north of Horizon's existing gathering and transmission infrastructure.

The plant will produce pipeline quality natural gas, mixed natural gas liquids (NGL) product, and stabilized condensate which will be delivered via pipeline to Horizon's Southville Gas Processing Complex for fractionation and sale.

Boostrand Engineering Services has been contracted to perform the FEED study to define the plant configuration and costs to an accuracy of +/- 10%. The FEED package will be used as the basis for detailed engineering and EPC bidding.



How's that? The introduction now clearly states the purpose and scope, provides an overview of the project background, and reads in a more formal tone suitable for an engineering design document. Let me know if you would like me to elaborate on any part of it.

2.0 Project Scope and Process Description

The Blue River Gas Plant will process 500 MMSCFD of raw natural gas using the following main process units:

2.1 Inlet Separation (Unit 10)

The feed gas will enter the plant slug catcher where free liquids will be removed. The separated gas will then flow to the Inlet Separator to remove any carried over liquids. Collected liquids will be sent to the Condensate Stabilizer.

2.2 Gas Sweetening (Unit 20)

The gas from the Inlet Separator will enter the Amine Contactor where it will counter-currently contact a lean amine solution to absorb H₂S and CO₂. Sweet gas from the contactor will flow to the gas dehydration unit. Rich amine from the contactor will be regenerated in the Amine Regenerator and recycled back as lean amine.

2.3 Gas Dehydration (Unit 30)

The sweet gas from the amine absorber will enter the dehydration unit where water is removed. The Dry Gas at Gas Dehydration System battery limit shall meet the most stringent specification between sales gas specification and maximum allowable water content to avoid hydrate formation in the downstream dew point control system.

The TEG absorber will contact the gas with lean glycol at high pressure to absorb the water. The rich TEG will then be regenerated in a reboiler still column under vacuum to remove the water and return lean glycol to the absorber. Gas/glycol heat exchangers and a glycol cooler will be used to maintain the proper lean glycol temperature.

2.4 Dew Point Control (Unit 40)

The dry gas from the TEG absorber will enter a propane refrigeration and plant for deep NGL recovery to meet the hydrocarbon dew point specification.

In a propane system, the gas will be chilled using propane refrigerant in a series of heat exchangers and separators. In a JT system, the gas will be expanded across a valve to a lower pressure and temperature, condensing the NGLs. The recovered liquids will be sent to the existing NGL unit for fractionation.



2.5 Sales Gas Compression (Unit 50)

The residue gas from the dew point control unit will flow to the sales gas compressors where it will be boosted to the final delivery pressure of 800 psig. Centrifugal compressors driven by gas turbines will be used for this service.

The compressors will include suction scrubbers to remove any liquids condensed during cooling and interstage scrubbers for each subsequent stage of compression. The compressed gas will be cooled using air coolers to maintain the proper suction temperature at each stage.

2.6 Interface with Existing NGL Recovery and Stabilization Units

The existing NGL recovery unit will receive additional feed liquids from the new inlet separators, dew point control, and compressor suction/interstage scrubbers in the expanded plant.

The combined liquid will be processed in a depropanizer and debutanizer to produce marketable NGL products meeting RVP and component specifications. The existing condensate stabilizer will process the bottom products to produce on-spec condensate for sale. No modifications to the NGL fractionation unit are anticipated to handle the incremental plant liquids.

The process units will be designed for high reliability and flexibility to handle variations in the feed composition and flow rate while meeting the specified sales gas and product specs. Advanced process control strategies will be employed to optimize plant performance and minimize energy consumption.

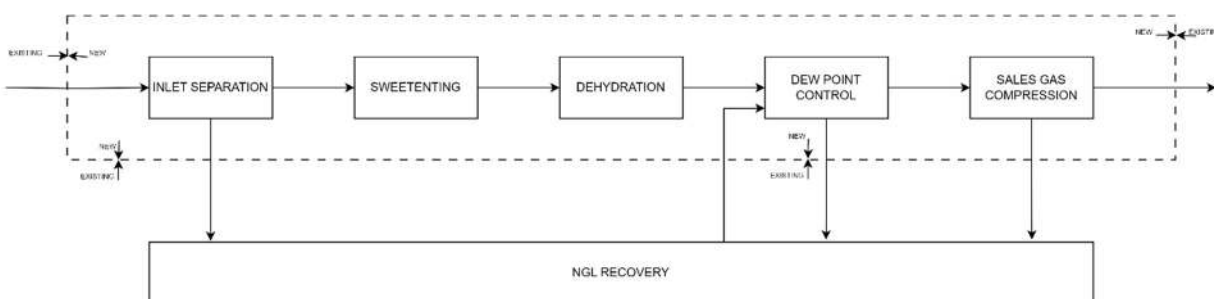


Figure 1 Main Project Scope

3.0 Plant Capacity and Feed Gas Specifications

3.1 Plant Capacity

The Blue River Gas Plant will have the following capacities:

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Design capacity = 10%

Turndown capacity = 50%

Design (Nameplate) Capacity: 500 MMSCFD (design margin)

Normal Operating Capacity: 450 MMSCFD

Minimum Capacity (Turndown): 250 MMSCFD (50% of design) (Tower design, compressor, coolers if overcooling is undesirable)

The plant will be designed for a 20 year operating life. Major equipment will be sized for the design rate of 500 MMSCFD with turndown capability to 50% of design flowrate while maintaining performance and product specifications.

3.2 Feed Gas Composition and Conditions

The plant inlet facilities will be designed to handle the following expected range of feed gas composition. The plant inlet facilities and processing units would be designed to handle the full range of compositions and conditions between these two cases.

The Lean Gas case would result in lower NGL recovery, but may allow for more gas throughput. The gas sweetening and dehydration units would be sized for the lower H₂S, CO₂ and water content.

The Rich Gas case would yield more NGL product revenue but require larger slug catching, condensate stabilization, and NGL recovery units. The gas treating would be sized for the higher H₂S, CO₂ and water dewpoints.

Case 1: Lean Gas

This case represents a relatively dry feed gas with lower heavy hydrocarbon content.

Component Mol%

Methane 88.0

Ethane 6.0

Propane 3.0

Butanes 1.5

Pentanes Plus 0.5

Nitrogen 0.5

Carbon Dioxide 1.5

Hydrogen Sulfide 0.002 (20 ppmv)

Water Saturated

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Feed Gas Conditions

Pressure: 1000 psig

Temperature: 80 °F

Case 2: Rich Gas

This case represents a wetter feed gas with higher NGL content that will yield more marketable liquid products.

Component Mol%

Methane 82.0

Ethane 8.0

Propane 4.0

Butanes 2.0

Pentanes Plus 1.5

Nitrogen 0.5

Carbon Dioxide 3.0

Hydrogen Sulfide 0.02 (200 ppmv)

Water Saturated

Feed Gas Conditions

Pressure: 800 psig

Temperature: 120 °F

4.0 PRODUCT SPECIFICATIONS

The Blue River Gas Plant will be designed to produce three product streams meeting the following specifications:

- H₂S content: < 4 ppmv
- CO₂ content: < 2 mol%
- H₂O content: < 7 lbs/MMSCF (meets -20°F dewpoint spec)
- Hydrocarbon dewpoint: < 15°F at 800 psig
- Gross Heating Value: 950 - 1050 Btu/SCF
- Delivery pressure: 800 psig
- Delivery temperature: 120°F max

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The sales gas must also meet applicable tariff requirements for interchangeability, total inerts, and oxygen/mercury/other contaminant limits to be transported in the XYZ pipeline.

The plant will be designed with sufficient flexibility to ensure the product specifications are met over the full range of feed compositions, operating rates, and ambient conditions.

Online process analyzers, periodic laboratory testing, and custody transfer meters will be utilized to ensure product quality and provide real-time feedback on plant performance.

5.0 UTILITIES AND OFFSITES

Utility system design will incorporate sufficient flexibility and turndown to efficiently support operation over the full range of plant capacity. The following utility and offsite systems will support the Blue River Gas Plant operation:

5.1 Fuel Gas System

The existing fuel gas system supplies 900 psig sweet natural gas for use in fired equipment including heaters, reboilers, and gas turbines. The system capacity is 25 MMSCFD which is sufficient for the additional fuel demand for the new processing units.

5.2 Power Generation

The plant is equipped with two 15 MW gas turbine generators with waste heat recovery providing power and 600 psig steam. A new 15 MW turbine will be added to support the expanded plant electrical load of 40 MW while maintaining N+1 reliability.

5.3 Steam System

High pressure steam at 600 psig is generated from the gas turbine waste heat recovery units and let down to 150 psig and 50 psig levels for use in process heating. Additional waste heat recovery from the new gas turbine will increase 600 psig steam capacity by 50,000 lb/hr to meet the total demand of 200,000 lb/hr.

5.4 Cooling Water

The existing cooling water system consists of a mechanical draft cooling tower and circulation pumps providing 85°F supply water. The system will be expanded from 25,000 gpm to 40,000 gpm to meet the additional cooling duty required by the new process coolers and condensers.



5.5 Refrigeration

A new closed-loop propane refrigeration system will be provided for low-temperature chilling duties in the NGL recovery section. The system will consist of propane compression, condensing, surge storage and evaporation to provide 15°F propane at 200 psig. Total refrigeration duty will be 10 MMBTUH.

5.6 Flare and Relief

Existing HP and LP flare headers and a common elevated flare stack handle collection and safe disposal of emergency relief and blowdown vapors. The flare tip will be replaced and radiation fence expanded to handle the additional relief loads from the new units while ensuring thermal radiation limits are met at grade.

Flare backpressure: 0.5 barg

5.7 Drainage

Pressurized drains will be routed to the existing closed drain drum and pumped to the low pressure separation for recovery. Atmospheric hydrocarbon drains will flow by gravity to the open drain sump for oil-water separation. Drain system piping will be expanded to tie-in the new units. The sump will be resized for 10 minutes of liquid hold-up time.

5.8 Instrument Air for control valves

A central instrument air system will provide clean, dry, oil-free air for pneumatic instruments, valve actuation, and utility stations throughout the plant.

The system consists of oil-flooded rotary screw compressors, pre-filters, air dryers, and receivers. The compressors take suction from a safe, clean outdoor location.

Instrument air will be supplied at the following conditions:

Pressure: 100-125 psig

Dew point: -40°F at line pressure

Particle size: < 3 microns

Oil content: < 1 ppmw

The instrument air demand is estimated at 1000 SCFM based on equipment counts and historical data from similar plants. The compressors will have N+1 sparing to ensure reliability.

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6.0 BATTERY LIMITS

6.1 NGL to Recovery Unit

- Composition: <xx% C1, <xx% C2, xx% C3, xx% C4, xx% C5+
- Flow rate: xx - xx USGPM
- Pressure: xxx - xxx psig
- Temperature: xx - xx °F
- Destination: Existing NGL Fractionation Unit

6.2 Condensate to Stabilization

- Composition: <xx% C1-C4, xx% C5-C8, xx% C9-C12, xx% C13+
- Flow rate: xx - xx USGPM
- Pressure: xxx psig
- Temperature: xx - xx °F
- Destination: Existing Condensate Stabilizer

6.3 Gas from NGL Unit

- Composition: >xx% C1, <xx% C2, <xx% C3+
- Flow rate: xx - xx MMSCFD
- Pressure: xxx - xxx psig
- Temperature: xx - xx °F
- Source: Existing NGL Fractionation Unit

7.0 PROCESS DESIGN CRITERIA

7.1 Equipment Design Conditions Design pressure

Pressure vessels, towers, exchangers and piping systems will be designed in accordance with applicable codes and standards to safely contain process fluids over the full range of operating conditions.

The design pressure will be based on the maximum operating pressure including the effects of control valve failure, tube rupture, and fire exposure where applicable. As a minimum, the design pressure will be the greater of the maximum operating pressure plus 10%, or the maximum operating pressure plus 30 psi.

The design temperature will be based on the maximum and minimum operating temperatures allowing for reasonable safety margins. For systems with a potential for temperature excursions,

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such as compressor discharge or downstream of fired equipment, the design temperature will include an additional 50°F above the maximum operating value.

7.2 Line Sizing and Hydraulics

Process piping will be sized to achieve a balance between capital cost, operating efficiency, and control performance while ensuring stable and safe operation.

Liquid lines will be sized for a maximum velocity of 5-8 ft/s while maintaining a minimum of 1 ft/s to avoid solids settling. Higher velocities up to 15 ft/s may be allowed for non-corrosive and non-abrasive services on a case-by-case basis.

Gas and vapor lines will be sized based on pressure drop and noise limitations. Typical velocity limits are 50-120 ft/s for gases and 150-250 ft/s for steam depending on the line size, fluid properties and allowable pressure drop.

Two-phase lines will be sized to maintain the flow regime necessary for smooth operation and control. Typical design velocities are 20-50 ft/s for dispersed flow and 5-15 ft/s for separated flow.

Detailed hydraulic calculations will be performed to confirm line sizes achieve the required pressure drops, NPSH and flow turndown while avoiding excessive noise, vibration, slugging or erosion.

7.3 Surge and Controllability

Surge vessels will be provided to dampen flow and pressure fluctuations and improve downstream control. Typical design criteria are:

Liquid residence times:

- 1 minute between HHLL and HLL or 150 mm
- 1 minute between LLL and LLLL or 150 mm
- 3 minutes between HLL and LLL for compressor scrubbers
- 15 minutes between HLL and LLL for feed to heaters
- 5 minutes between HLL and LLL for reflux drums
- 30 minutes between HLL and LLL for flare KO drum

7.4 Heat Transfer Equipment

TEMA type heat exchangers will be utilized for process and utility heat transfer services. The TEMA type will be selected based on process conditions, fouling tendency, cleaning and maintenance requirements.

Typical services and TEMA types are:

Process-to-process liquid: AEU

Vaporizing or condensing: AKU, AEU

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BFW preheating: AEU

Air cooled: Fin-fan type

High fouling: AES, CFU

Severe conditions: NEN

Fouling factors and exchanger pressure drops will be based on actual operating experience for the specified fluids. Typical fouling factors range from 0.001-0.003 hr-ft²-°F/BTU for clean streams up to 0.01 for severe fouling services.

Cooling air will be supplied at a design dry bulb temperature of 95°F. A 20°F approach to dry bulb will be used for condensing and cooling services.

7.5 Isolation Philosophy

Equipment and piping systems will be provided with means to safely isolate from the process for maintenance.

Isolation valves will be specified as block and bleed for the following:

Inlet and outlet of rotating equipment

Vessel manways, exchanger channel or floating head

High hazard services (H₂S, HF, NH₃, etc.)

Double block and bleed will be utilized for positive isolation where no leakage can be tolerated, such as exchanger tube sheet maintenance or toxic service.

Spectacle blinds or pancake blinds will provide positive isolation for maintenance of critical valves or equipment without depressurizing the entire circuit.

The plant will be segregated into isolatable sections to allow localized de-inventory and maintenance execution as needed with minimal impact to production.

7.6 Equipment Sparing Philosophy And Design Margins

The following sparing philosophy will be employed for major equipment in the plant design to ensure high availability and reliability of gas processing and delivery:

Rotating Equipment

Compressors: Spared compressors will be provided for the sales gas service. The two 50% compressors will be arranged in parallel, each capable of delivering the full plant throughput.

Pumps: All pumps in critical services (e.g. amine, glycol, condensate) will have an installed spare. The running and spare pumps will each be sized for 100% capacity.

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Heat Transfer Equipment

Air Coolers: Air coolers will be designed with 20% excess area and fans with automatic variable pitch or speed control. This will allow for cooler operation at ambient temperatures above design and fouling over time.

Shell & Tube Exchangers: Critical heat exchangers such as the amine lean/rich exchanger and regenerator feed/bottoms exchanger will have 15-25% excess area. This will accommodate fouling and possible short-term operation at higher than design flows.

Separation Equipment

Slug Catcher: The slug catcher will be sized for a hold up volume of 10 minutes at design gas flow to handle large liquid slugs from pigging.

Inlet Separator: An inlet filter-coalescer will be installed upstream of the inlet separator to reduce entrainment and provide a spare separator in case the main vessel is out of service for maintenance.

Storage Tanks

Amine & Glycol: The amine and glycol systems will each include a 30-day storage tank to hold the total solvent inventory in case of a system shutdown or upset.

7.7 SOFTWARE APPLICATIONS

The following software applications will be utilized for engineering design, analysis, documentation, and project management activities:

- Process simulation: Aspen HYSYS version 12.1 Fluid Package Peng Robinson
- Pipeline Hydraulics: PipeSim
- Flare System Analysis: Aspen Flare Analyzer
- Thermal Design for shell and tube exchangers and air coolers: HTRI version 9.0
- PFD and P&ID drawing: AutoCAD
- General Documents: Microsoft Word

8.0 SITE CONDITIONS

The Blue River Gas Plant will be designed for the following site-specific ambient and meteorological conditions:

8.1 Ambient Temperature

- Maximum design dry bulb: 105°F
- Minimum design dry bulb: -10°F

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- Maximum monthly average: 95°F

- Minimum monthly average: 20°F

8.2 Barometric Pressure

- Design: 14.1 psia

- Operating range: 13.8-14.4 psia

8.3 Relative Humidity

- Maximum: 90%

- Minimum: 20%

- Annual average: 60%

8.4 Wind

- Maximum sustained speed: 60 mph

- Maximum 3-second gust speed: 90 mph

- Prevailing direction: From SW

8.5 Precipitation

- Annual average rainfall: 30 inches

- Maximum 24-hour rainfall: 6 inches

- Annual average snowfall: 10 inches

- Maximum 24-hour snowfall: 12 inches

8.6 Seismic Conditions

- Seismic Zone: 1

- Peak ground acceleration: 0.10g

The plant equipment and structures will be designed in accordance with applicable standards to withstand the specified wind, snow and seismic loads.

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9.0 EQUIPMENT TAGGING PHILOSOPHY

9.1 Unit Identification

Each process unit within the plant will be assigned a unique numeric identifier ranging from 00 to 99.

The unit numbers will be assigned sequentially based on the process flow, starting from the inlet facilities.

Example unit numbers:

- 10 - Inlet Separation
- 20 - Amine Sweetening
- 30 - Glycol Dehydration
- 40 - Refrigeration
- 50 - Sales Gas Compression
- 60 - NGL Recovery

9.2 Equipment Identification

All equipment tags will follow the convention: UUX-YYYY

Where, UU = Unit Number (00-99)

XX = Equipment Type (2-3 letter code)

YYYY = Sequential Number (00001-99999)

Major equipment types and their codes:

- CO - Compressor
- PU - Pump
- HE - Heat Exchanger
- VE - Vessel
- TW - Tower
- TK - Tank
- PK - Package

For multiple identical equipment in the same service, a suffix A, B, C etc. will be added.
e.g. 10-PU-01A/B for parallel pumps in Unit 10

9.3 Instrument Identification (P&ID legend)

All instrument tags will follow the ISA convention: UUX-YYYY

Where, UU = Unit Number (00-99)

XX = ISA Identification Code

YYYY = Loop Number (00001-99999)

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Key ISA identification codes:

FIC - Flow Indicating Controller

LIC - Level Indicating Controller

PIC - Pressure Indicating Controller

TIC - Temperature Indicating Controller

PSV - Pressure Safety Valve

SDV - Shutdown Valve

9.4 Piping Line Identification (P&ID legend)

Process lines will be tagged as: UU-AAAA-BB-CC-DDDDD

Where, UU = Unit Number (00-99)

AAAA = Source Equipment

BB = Destination Equipment

CC = Nominal Pipe Size (in inches)

DDDDD = Sequential Number (00001-99999)

Utility lines will be tagged similarly with the unit number replaced by the utility code.

e.g. IA for Instrument Air, NG for Natural Gas, WA for Water

This tagging philosophy will be implemented in all equipment lists, line lists, P&IDs, datasheets, and 3D model to serve as the common basis for design, procurement, construction and operational activities.

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