

Date: September 30, 2014

Rev.: 2a

**Surface Equipment Design Basis  
East Cat Canyon Field Re-Development  
Brooks Thermal Development**

**GENERAL**

The following parameters and assumptions will be used for sizing and selection of infrastructure equipment for vertical steam flood development of the Brooks reservoir in the East Cat Canyon Field.

**WELLS DESIGN BASIS**

No. of Patterns/Injection Wells	Phase 1: 27 patterns; 107 patterns at Full Development; patterns are 5-acre, inverted 5-spot
Well Pads	well drilling from multi-well surface pads; minimum surface area to accommodate drilling and producing operations
Average Prod/Inject Well Depth	3,000 feet
Well Production Rate	200 to 1,200 BGP/D; average 25 BSP/D steam from casing (maximum 75 BSP/D)
Production Pressure	backpressure production gathering network to maintain up to 250 psig at production flowline; control well casing pressure to maintain minimum reservoir temperature (e.g. 500F, saturation pressure = 680 psia)
Production Temperature	Early production temperature from cyclic steam; peak surface temperature 400°F; (saturated steam at 250 psia flowline/gathering backpressure)

**OIL PRODUCTION DESIGN BASIS**

Design Liquid Production	Phase 1 = 5,000 BOP/D, 18,000 BWPD, 23,000 BGP/D (all values are nominal); Phase 2 = 10,000 BOP/D, 36,000 BWPD, 46,000 BGP/D (all values are nominal)
Produced Oil Gravity	field surface average will range from 9.0 API to 7.6 API
Sand Production	1 LB/BO (5 Tons/day at Phase 2 nominal production rate)

**PRODUCED GAS DESIGN BASIS**

Produced Gas/Oil Ratio	Nominal Design for 100 scf/bbl-bitumen
Produced Gas CO <sub>2</sub> Content	Design range = 10 mole % to 30 mole %
Produced Gas H <sub>2</sub> S Content	Design range = 1.5 mole % to 10.0 mole %
Produced Gas Heating Value (LHV)	Design range = 1000 BTU/scf 1200 BTU/scf

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Design Gas Rate	1,000 MSCFD (nominal) non-condensable plus steam
Sulfur Production	Phase 1 design = 4,200 LB-sulfur/day; (assumes 500 MSCFD @ 10% H <sub>2</sub> S)

**OIL TREATING WITH IMPORTED LIGHT CRUDE OIL**

Target Oil Treating Gravity	12 API
Light Crude Oil (LCO) Gravity	29 API (e.g. Ventura Taylor or Belridge Diatomite)
LCO for treating produced oil	design peak of 0.332 BBL API 29 per BBL cru-bit; nominal import in Phase 1 of 1,666 BBL-LCO/day; nominal import in Phase 2 of 3,320 BBL-LCO/day
LCO for P/L shipped oil	n/a

**STEAM DESIGN BASIS**

Steam injector Rate	maximum 1,000 BSPD @ 70% (target is 800 BSPD)
Steam Injector Pressure	1,900 psig design
Steam Generation Rate	Phase 1 – 18,000 BSPD – cwe; (3) 85 MMBTU/hr OTSGs (average 5,000 BSPD – cwe) plus (1) 62.5 MMBTU/hr OTSG for produced gas (average 3,000 BSPD – cwe); Phase 2 – 33,000 BSPD – cwe; phase 1 plus (3) 85 MMBTU/hr OTSGs (average 5,000 BSPD – cwe)
Steam Generation Quality	70% quality to steam distribution

**WATER SOURCE AND INJECTION**

Fresh Utility Water Wells	Recondition, re-complete or re-drill up to (3) existing water wells, 10 to 50 gpm each
Brackish Source Wells	Up to 7 well locations, 50 to 150 gpm each
Water Injection Wells	9 to 14 well locations, 1,000 to 3,000 BWPD ea @ 1350 psig WH inj.

**DEVELOPMENT PLAN**

- Develop well pad sites for steam injection wells, oil production wells, brackish water source wells, waste water injection wells, and fresh water wells. Develop gathering and

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distribution systems to/from well pads. Well pads, wells, gathering and distribution will be added per the field development plan (e.g. Phase 1 = 27 patterns)

- Build an oilfield thermally enhanced oil recovery (TEOR) steam generation site (SGS) facility and distribution piping system for (TEOR) steam injection at steam injection wells sites. The SGS will be constructed in two phases with start-ups approximately five years apart. Phase 1 will include three (3) 85 MMBTU/hr OTSGs. Phase 2 will add three (3) more 85 MMBTU/hr OTSGs.
- Build a central processing plant (CPP) for oil cleaning, water cleaning, water softening, waste water handling, sand handling, light oil receiving and storage and blend oil storage and shipping. The CPP will be built in two phases with start-ups approximately five years apart. Phase 1 will be a single train configuration designed for a nominal 5,000 BOPD and 18,000 BWPD. Phase 2 will a second train of equal capacity.
- Build a produced gas treating plant, produced gas steam generator and standby flare. The produced gas steam generator will be installed with Phase 1 and will also provide process heat for the CPP. SulfurOx gas sweetening and/or SO<sub>2</sub> scrubbing of OTSG flue gas will be deferred until needed.
- Provide service utilities including 115 KV power line, electric substation and 14-mile natural gas fuel pipeline. The sub-station will be installed as part of Phase 1 and expanded as part of Phase 2. The fuel pipeline will be included in Phase 1. Any connection to area pipelines for production shipping will be deferred pending infrastructure availability and project performance.