July 5, 2016

SUBJECT

Bakken – Three Forks Pool (01 62A)

Daly Sinclair Field, Manitoba

Carbon Dioxide (CO_2) Enhanced Oil Recovery (EOR) Project

Sinclair Unit No. 1 - Application for Expansion of the CO_2 Enhanced Oil Recovery Project

Tundra has been operating a CO_2 flood in the SE ¼ of Section 4 within the Sinclair Unit 1 waterflood, since August 2008. The original CO_2 flood consisted of injecting CO_2 into one well. Due to quick breakthrough by 2009 this project was changed to be a "WAG" (Water Alternating Gas) process, alternating injecting water and gas into the one injection well. The impact of CO_2 WAG injection on the 4 offsetting vertical wells within the SE ¼ of Section 4 has been closely monitored. The results to date have been documented in the annual progress reports submitted to the Petroleum Branch.

Tundra is committed to maximizing oil recovery from this field beyond secondary recovery methods (waterflood) and believe that a commercial scale CO_2 WAG flood (tertiary) can also be a part of the solution for reducing overall industrial CO_2 emissions. Expanding the CO_2 flood to include all of Section 4 Twp 8 Rge 29 is the natural next step towards implementing a CO_2 flood on a commercial scale as learnings of both the feasibility and the recovery potential of this enhanced oil recovery method are progressed. Below in Figure 1 is a map that illustrates our plan for this expansion.

Figure 1 – Proposed CO_2 Pilot Expansion

Table 1 is a list of wells, all of which are currently water injectors, which are being proposed to convert to CO_2 WAG injectors.

Table 1 – List of injection wells proposed to be added to the CO_2 Enhanced Oil Recovery Order

UWI	*Surface Hole Location*	*Operator*	*License Number*	*Fluid*	*Mode*	*Type*	*Pool Name*
102/04-04-008-29W1/0	100070400829W100	TUNDRA OIL & GAS LIMITED	006355	Water Injection	Injection	Horizontal	BAKKEN-THREE FORKS B
102/12-04-008-29W1/0	100050300829W100	TUNDRA OIL & GAS LIMITED	006356	Water Injection	Injection	Horizontal	BAKKEN-THREE FORKS B
103/13-04-008-29W1/0	100120300829W100	TUNDRA OIL & GAS LIMITED	006357	Water Injection	Injection	Horizontal	BAKKEN-THREE FORKS B

Below are two of the key reasons to move forward with the expansion:

1. **Capture and Re-injection of CO_2**

Tundra is committed to continue to operate the existing CO_2 WAG flood but also wants to take the initiative to reduce our CO_2 emissions. Currently, the gas produced (high CO_2 content) from the offset vertical producers within the CO_2 flood is not being re-captured. Tundra would like to implement a re-injection facility in order to capture this produced gas for re-injection into the reservoir, along with makeup CO_2 gas to meet reservoir voidage.

A capture and re-injection facility was not part of the CO_2/CO_2 WAG pilot due to a few factors: initial uncertainty around the duration of the pilot, appropriate sizing of equipment for uncertain timelines, operational problems associated with only one well being the injector and ultimately the total cost associated with installation and operating of such facility. To elaborate, currently we only have approval to inject CO_2 into one well which is under WAG operations. While this injection well is on the water cycle, it would not be possible to operate the re-injection facility as there would not be a well available to inject the re-captured gas. Therefore, the produced gas would have to be sent to flare during every water cycle. This issue negatively affects both the emissions impact and the economics of the re-injection facility. By expanding the CO_2 flood and adding more injection wells to the CO_2 WAG pilot, we expect to be able to operate the re-injection facility with greater than 90% runtime, since at least one well will always be on the “gas” cycle of WAG, therefore the produced gas can always be re-injected to that well. This strategy will help minimize CO_2 emissions from this project, which is one of the key operating goals for Tundra.

2. **Confirm Reservoir Knowledge Prior to Development of Commercial Scale Project**

Since the implementation of WAG operations in the middle of 2013, positive results have been observed as we have been able to increase the reservoir pressure back to miscible conditions. In doing so, oil production has increased while producing Gas-Oil Ratios (GOR) have been reduced. These results have provided encouragement that a CO_2 WAG operation can be operated under miscible conditions.

Tundra would like to invest a significant amount of capital in progressing these learnings by adding more wells into the CO_2 flood which should result in an overall increase in oil recovery. This expansion would provide a larger sample set of results and data to help make a good long term decision on moving towards commercial development of this operation in the future.

Reservoir Discussion

Tundra's strategy to prevent gas channeling is to operate the CO_2 flood at or above miscible pressures all the time. Learning from the first CO_2 injection project, we plan to switch from injecting CO_2 over to injecting water to help prevent early breakthrough at the offset producers, which is commonly referred to as the Water Alternating Gas (WAG) process. WAG is commonly used in CO_2 EOR floods and has proven to be effective in controlling CO_2 breakthrough within Tundra's CO_2 pilot operations.

Tundra's strategy to prevent injection out of the targeted formation will be to ensure that the wellhead injection pressures are maintained below the least value of either:

- the area specific known and calculated fracture gradient, or
- the licensed surface injection Maximum Allowable Pressure (MOP)

Tundra has a thorough understanding of area fracture gradients. A management program will be utilized to set and routinely review injection target rates and pressures vs. surface MOP and the known area formation fracture pressures. All injection wells are surface equipped with injection volume metering and rate/pressure control.

It is shown on the map of the proposed expansion (Figure 1) that there will be a horizontal water injection well along each of the four borders of Section 4. These water injection wells will act as a flow barrier preventing any CO_2 from migrating outside of Section 4, the proposed CO_2 project area.

Tundra will also utilize various surveillance techniques to monitor for injection out of the pool and gas channeling which will consist of the following:

- Regular well production testing for oil, water, and gas
- Daily injection rate and pressure monitoring vs target
- Reservoir pressure surveys
- Pattern VRR calculations
- Use of some or all of: Water Oil Ratio (WOR) and Gas Oil Ratio (GOR) trends, Hydrocarbon Pore Volumes Injected, Conformance Plots
- Gas compositional analysis measurements of producing wells within and offsetting Section 4

Facilities Discussion

Tundra will be installing a new separator to split all producing wells in Section 4 off from the rest of the field. To maintain the highest purity of CO_2 in the produced gas it is important that this production is not blended with the rest of the field. All associated surface piping will be converted from carbon steel pipe to stainless steel or internally coated pipe for corrosion control as required.

A CO_2 capture and re-injection facility will be installed at Tundra's 3-4-8-29 battery. This facility will consist of a group separator, re-injection compressor and gas de-hydrator. Tundra will invest significant capital in ensuring all wetted components will use the appropriate metallurgies and coatings to protect against CO2 induced corrosion. Tundra has elected to install a de-hydrator as the last step of this re-injection facility to remove 98% of the remaining water content. This will greatly reduce the potential for corrosion related issues and also the formation of hydrates downstream of the re-injection facility.

There is the potential as this project matures to see increased surface pressure at all producing wells, which offset CO_2 injectors, if they are shut in for an extended period of time. Tundra will be replacing the existing wellheads and adding a second pressure switch to all sixteen producing wells in Section 4. The new wellhead has a higher pressure rating, better corrosion control and will be a flanged connection which has better resistance to leaks.

Proposed Pilot Expansion Schedule

2016 Q4 - Convert the 102/04-04-008-29W1/0 well to CO_2 WAG injector

2016 Q4 - Convert the 102/01-05-008-29Q1/0 well to water injection

2017 Q1 - Commission re-injection facility

2017 Q1 - Drill the horizontal water injection well bordering the eastern boundary of Section 4 in a north-south orientation and convert to water injection

2017 Q3 - Convert the 102/12-04-008-29W1/0 and 103/13-04-008-29W1/0 wells to CO_2 WAG injector

Project Economics

The proposed CO_2 pilot expansion project is not expected to be an economic project primarily due to the high costs of transporting CO_2 by truck and a large upfront capital investment needed for the custom made re-injection facilities required for this expansion project. However, Tundra believes that the field wide implementation of a CO_2 flood could be commercially economic depending on a number of factors including: better understanding of incremental oil recovery due to CO_2 flooding, reduction in supply costs of CO_2 by utilizing a pipeline, as well as the level of financial commitment from federal and provincial governments. The purpose of this pilot is to attain scalable results from a CO2 flood to understand field wide incremental oil recovery potential.

The economic limits of a CO_2 enhanced oil recovery operation will be reached when the net oil revenue stream becomes less than the producing operating cost. The producing GOR is a key variable when considering the economic limits for a CO_2 flood since produced gas is not sold but rather re-injected, requiring compression costs. This causes operating costs per barrel of oil to increase as GOR's increase. The implementation of WAG operations can control and reduce GORs thus extending the economic life of a CO_2 flood.

Tundra continues to have access to the same CO_2 source as our existing one well pilot, and has secured the necessary volumes required for this project expansion.

Operations

At the request of the Petroleum Branch, the following information pertaining to operations have been included in the Appendix:

- Preliminary process flow diagrams illustrating the additions required for the project including the ANSI ratings of the piping equipment (Appendix 1). We note that all equipment will be constructed in accordance with the Boiler's Branch standards.
- Corrosion control program for the area of operations affected by the CO_2 flood (Appendix 2)
- CO_2 WAG operation procedure (Appendix 3)

Landowner Notifications

At the request of the Petroleum Branch all land owners within 0.5km of the project area have been notified. Proof of service of the notices and the copy of notices are included as Appendix 4.

Should the Petroleum Branch have further questions or require more information, please contact Abhy Pandey at 403.767.1247 or by email at abhy.pandey@tundraoilandgas.com.

TUNDRA OIL & GAS

Original Signed by Abhy Pandey, P.Eng, July 5, 2016, in Calgary, AB

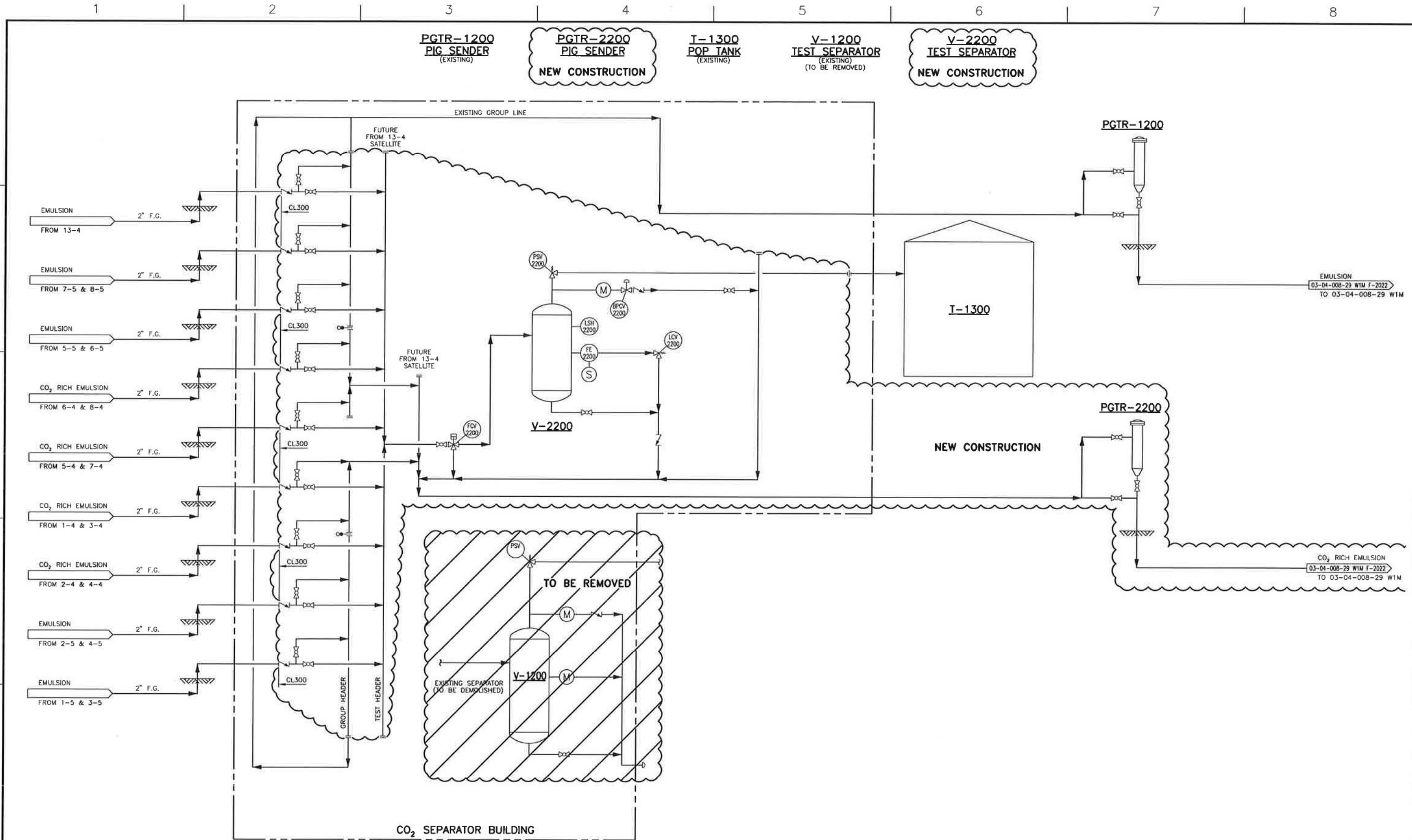
Sinclair Unit No. 1 CO_2 Enhanced Oil Recovery (EOR) Project

Application for Expansion of the CO_2 Enhanced Oil Recovery Project

LIST OF APPENDICES

Appendix 1

CO_2 Injection Process Flow Diagrams



NOTES	REFERENCE DRAWINGS		REVISIONS						
	NUMBER	TITLE	NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
			A	ISSUED FOR REVIEW	2016.FEB.29	CEM			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED DATE APPROVED DATE

ASHER ENGINEERING LTD

PROJ. NO.	2033
SCALE	NTS

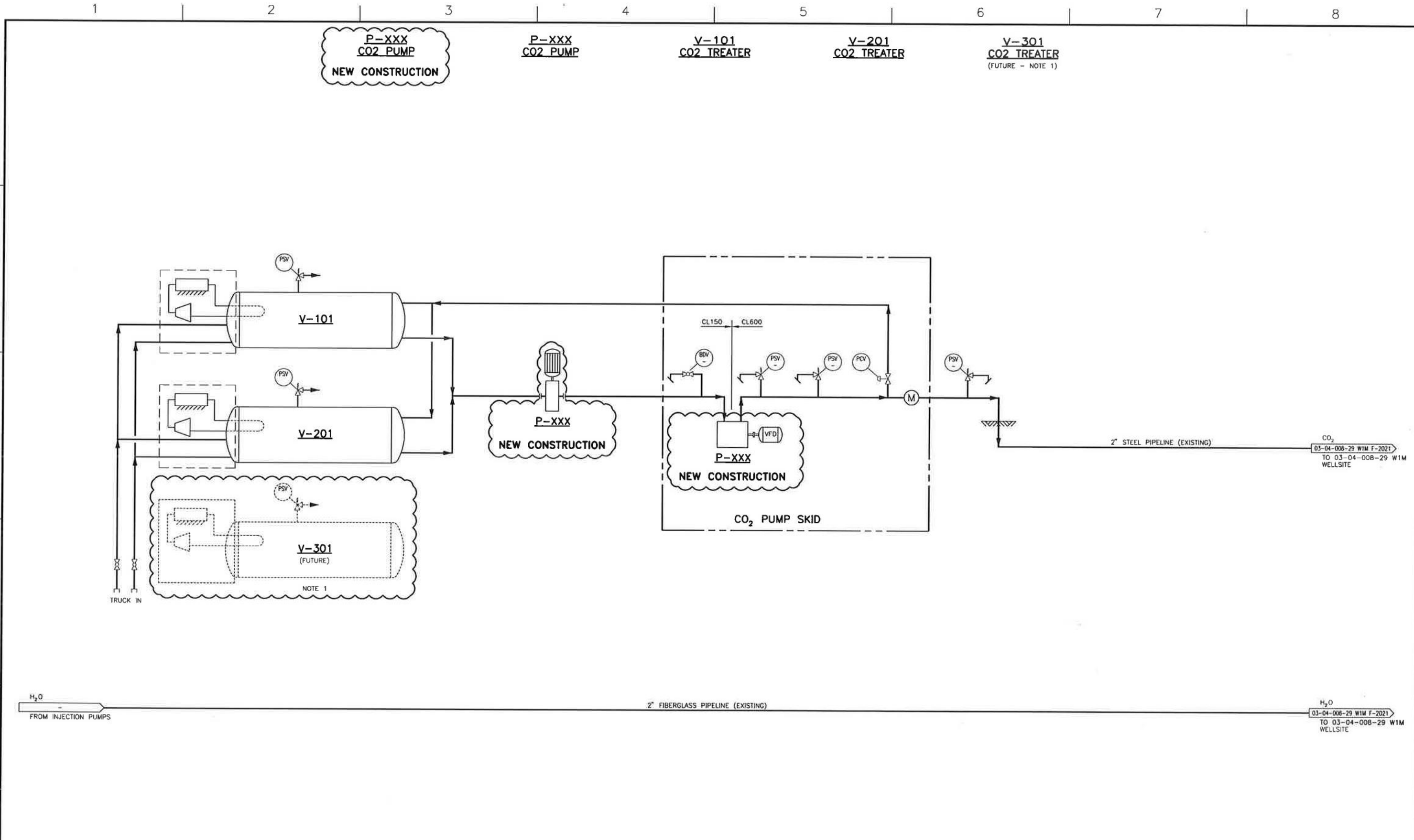
TUNDRA OIL & GAS

LSD: 05–04–008–29 W1M

SINCLAIR
SEPARATORS & POP TANK
PROCESS FLOW DIAGRAM

CADFILE	05–04–008–29W1M_F–2011.DWG	
DRAWING NO.	05–04–008–29W1M_F–2011	REV. A

S:\LOCATIONS\FACILITIES\MB\03–04–008–29 W1M\DRAWINGS\05–04–008–29W1M_F–2011.DWG, Wednesday, 2016–Jun–01, 2:17 PM
LAST SAVED: Wednesday, 2016–Jun–01, 10:32 AM BY: K.MANKOVETSKIY



NOTES

1. THE NEED FOR A THIRD VESSEL IS UNDER REVIEW.

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
A	ISSUED FOR REVIEW	2016.FEB.29	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED DATE APPROVED DATE

ASHER ENGINEERING LTD

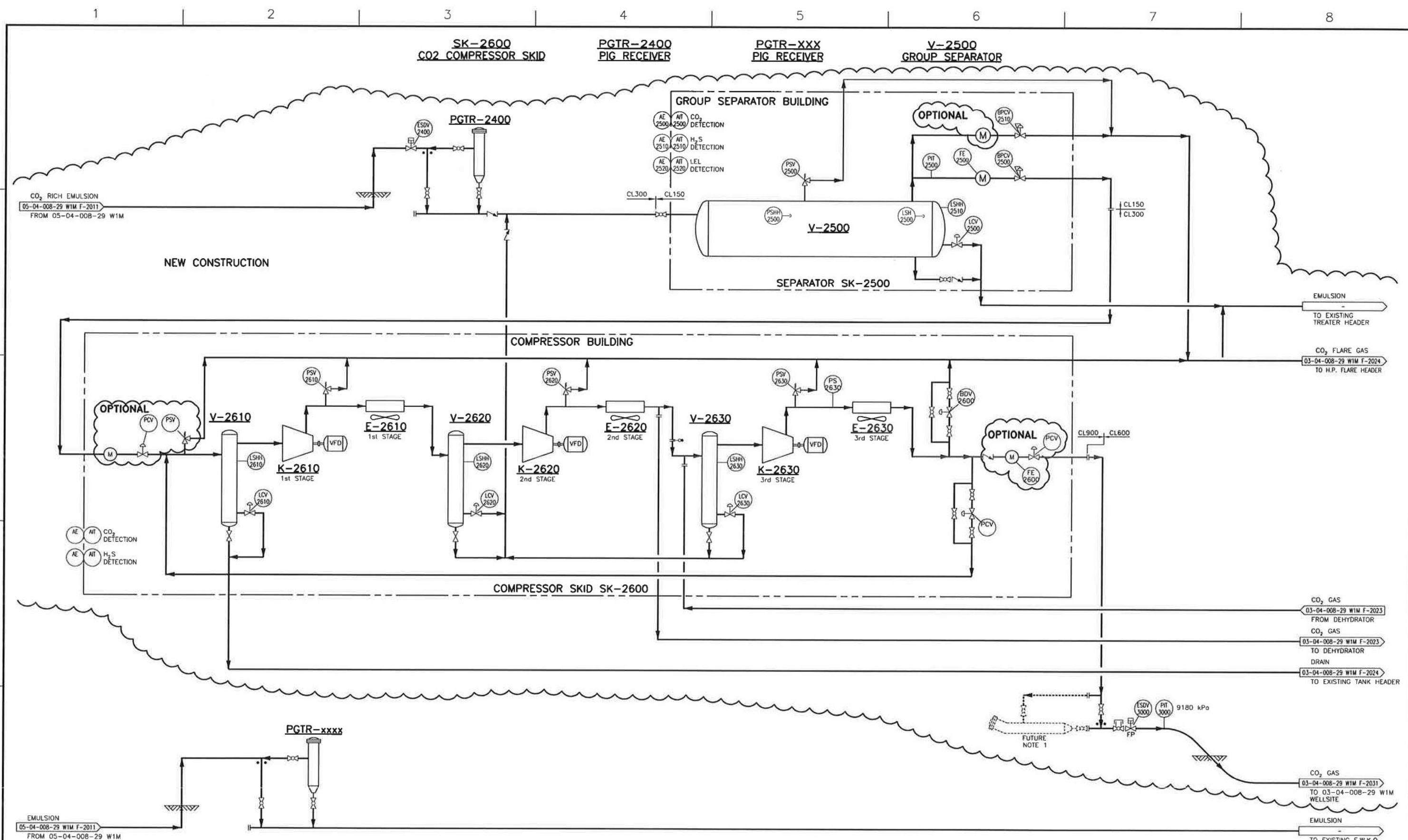
TUNDRA OIL & GAS

LSD: 03-04-008-29 W1M

SINCLAIR
03-04-008-29 W1M BATTERY
PROCESS FLOW DIAGRAM

PROJ. NO.	2033
SCALE	NTS
CADFILE	03-04-008-29W1M_F-2021.DWG
DRAWING NO.	03-04-008-29W1M_F-2021
REV.	A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2021.DWG, Wednesday, 2016-Jun-01, 8:51 AM
LAST SAVED: Monday, 2016-Feb-29, 12:31 PM BY: G.SHEPHERD



NOTES
1. ARGUS PIG VALVE WITH CONNECTIONS FOR FUTURE SMART PIGGING.

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
A	ISSUED FOR REVIEW	2016.FEB.29	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED DATE APPROVED DATE

ASHER ENGINEERING LTD.

PROJ. NO.	2033
SCALE	NTS

TUNDRA OIL & GAS

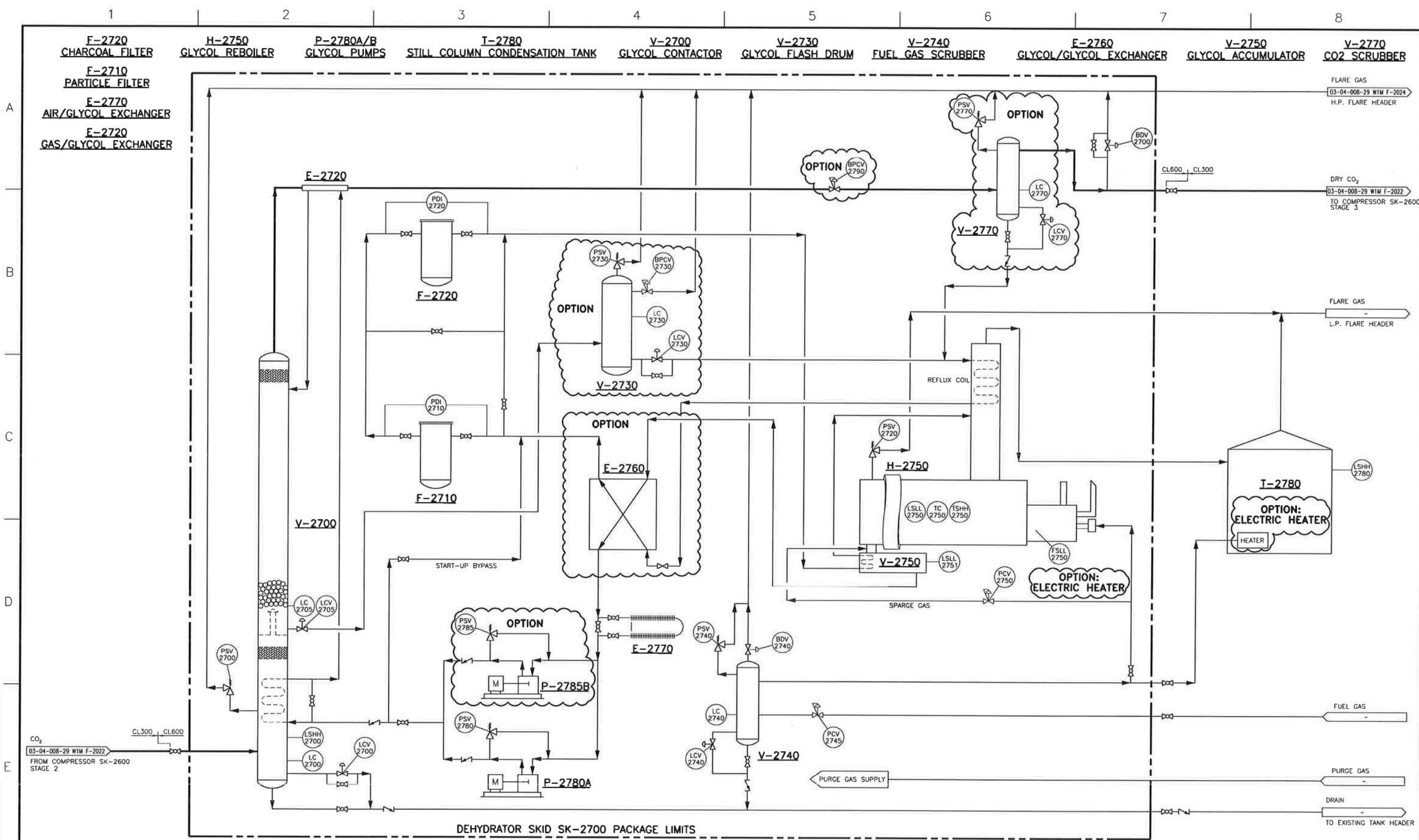
LSD: 03-04-008-29 W1M

SINCLAIR
03-04-008-29 W1M BATTERY
PROCESS FLOW DIAGRAM

CADFILE 03-04-008-29W1M_F-2022.DWG

DRAWING NO. 03-04-008-29W1M_F-2022 REV. A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2022.DWG, Wednesday, 2016-Jun-01, 10:20 AM
LAST SAVED: Wednesday, 2016-Jun-01, 10:19 AM BY: K.MANKOVETSKIY



NOTES	REFERENCE DRAWINGS		REVISIONS						
	NUMBER	TITLE	NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
			A	ISSUED FOR REVIEW	2016.FEB.29	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED DATE APPROVED DATE

ASHER ENGINEERING LTD.

PROJ. NO.	2033
SCALE	NTS

TUNDRA OIL & GAS

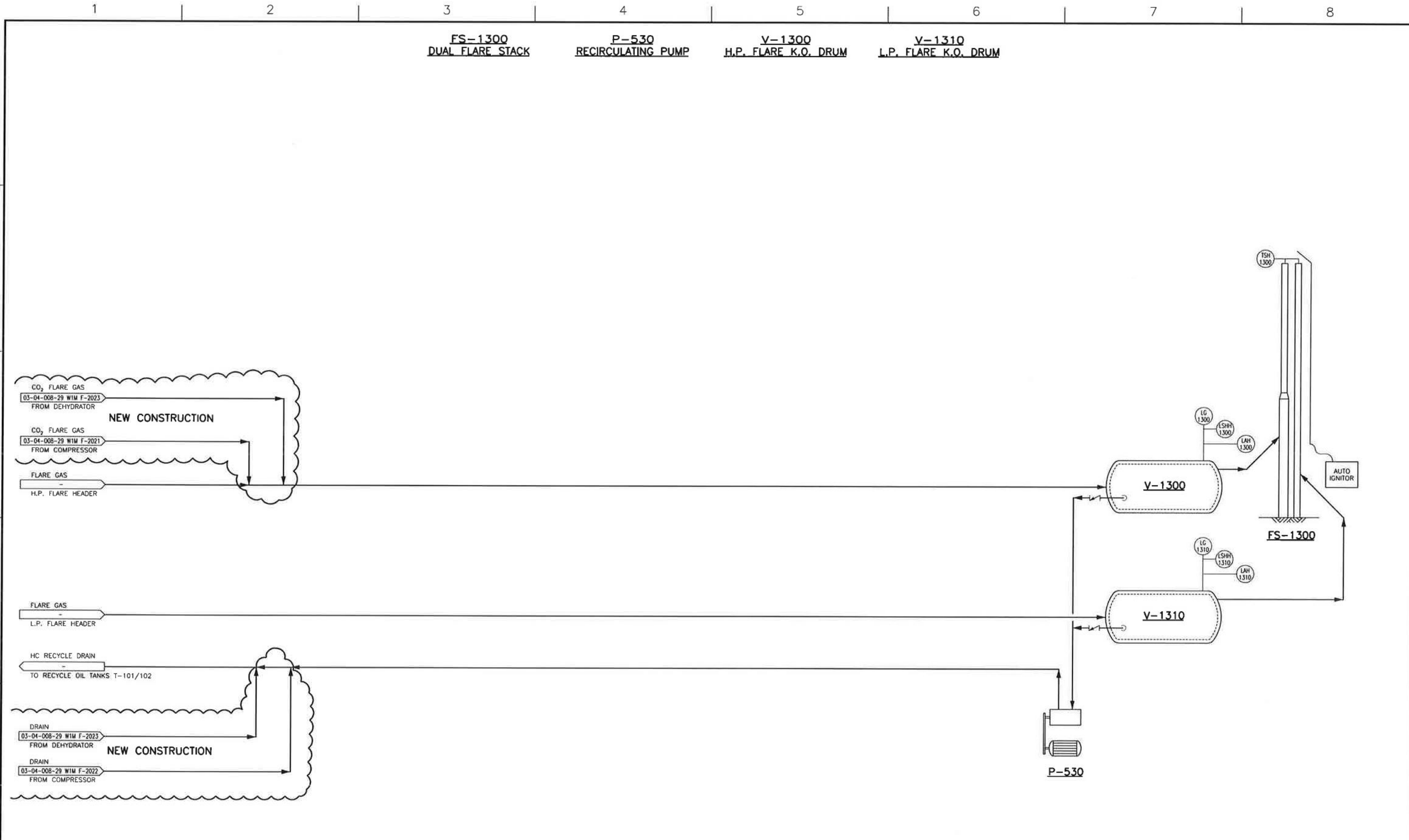
LSD: 03-04-008-29 W1M

SINCLAIR
03-04-008-29 W1M BATTERY
PROCESS FLOW DIAGRAM

CADFILE 03-04-008-29W1M_F-2023.DWG

DRAWING NO. 03-04-008-29W1M_F-2023 REV. A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2023.DWG, Wednesday, 2016-Jun-01, 10:31 AM
LAST SAVED: Wednesday, 2016-Jun-01, 10:30 AM BY: K.MANKOVETSKIY



NOTES	REFERENCE DRAWINGS		REVISIONS						
	NUMBER	TITLE	NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
			A	ISSUED FOR REVIEW	2016.FEB.29	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED	DATE	APPROVED	DATE

ASHER ENGINEERING LTD.

PROJ. NO.	2033
SCALE	NTS

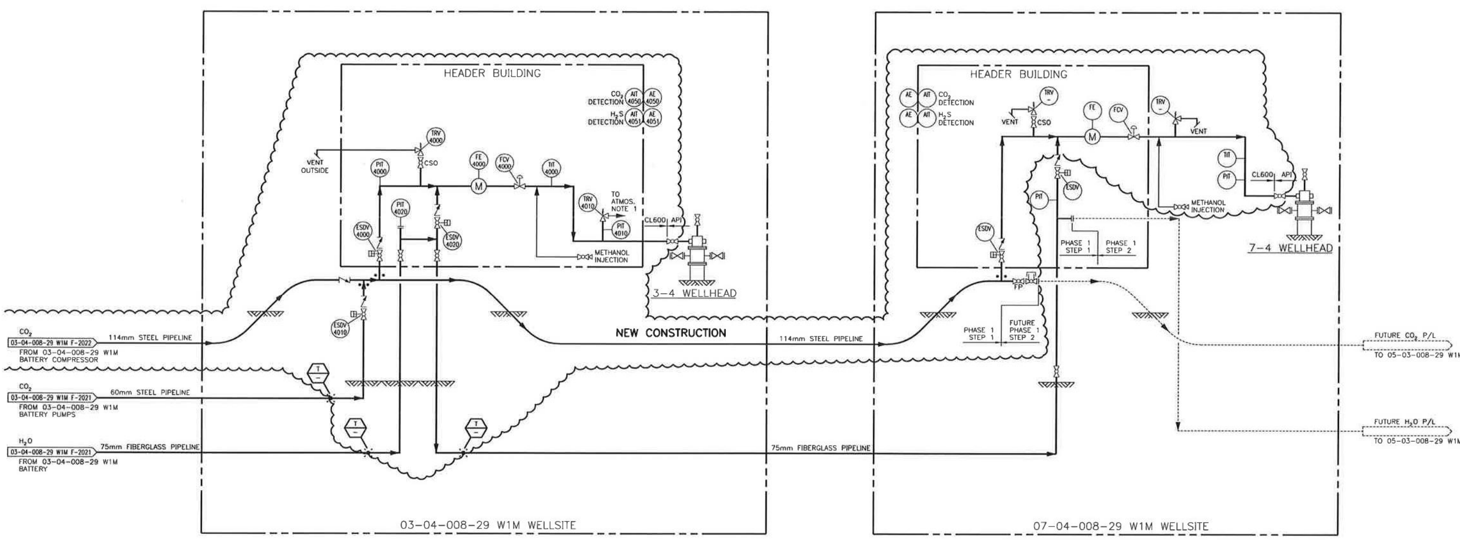
TUNDRA OIL & GAS

LSD: 03-04-008-29 W1M

SINCLAIR
K.O. DRUMS & FLARE STACK
PROCESS FLOW DIAGRAM

CADFILE	03-04-008-29W1M_F-2024.DWG	
DRAWING NO.	03-04-008-29W1M_F-2024	REV. A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2024.DWG, Wednesday, 2016-Jun-01, 11:40 AM
LAST SAVED: Wednesday, 2016-Jun-01, 10:52 AM BY: K.MANKOVETSKIY



NOTES
1. PSV IS VENTING TO ATMOSPHERE INSIDE AN ENCLOSED BUILDING. THIS IS A SAFETY HAZARD AND SHOULD RELIEVE TO A POP TANK.

REFERENCE DRAWINGS

NUMBER	TITLE

REVISIONS

NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
A	ISSUED FOR REVIEW	2016.MAR.02	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED DATE APPROVED DATE

ASHER ENGINEERING LTD

PROJ. NO.	2033
SCALE	NTS

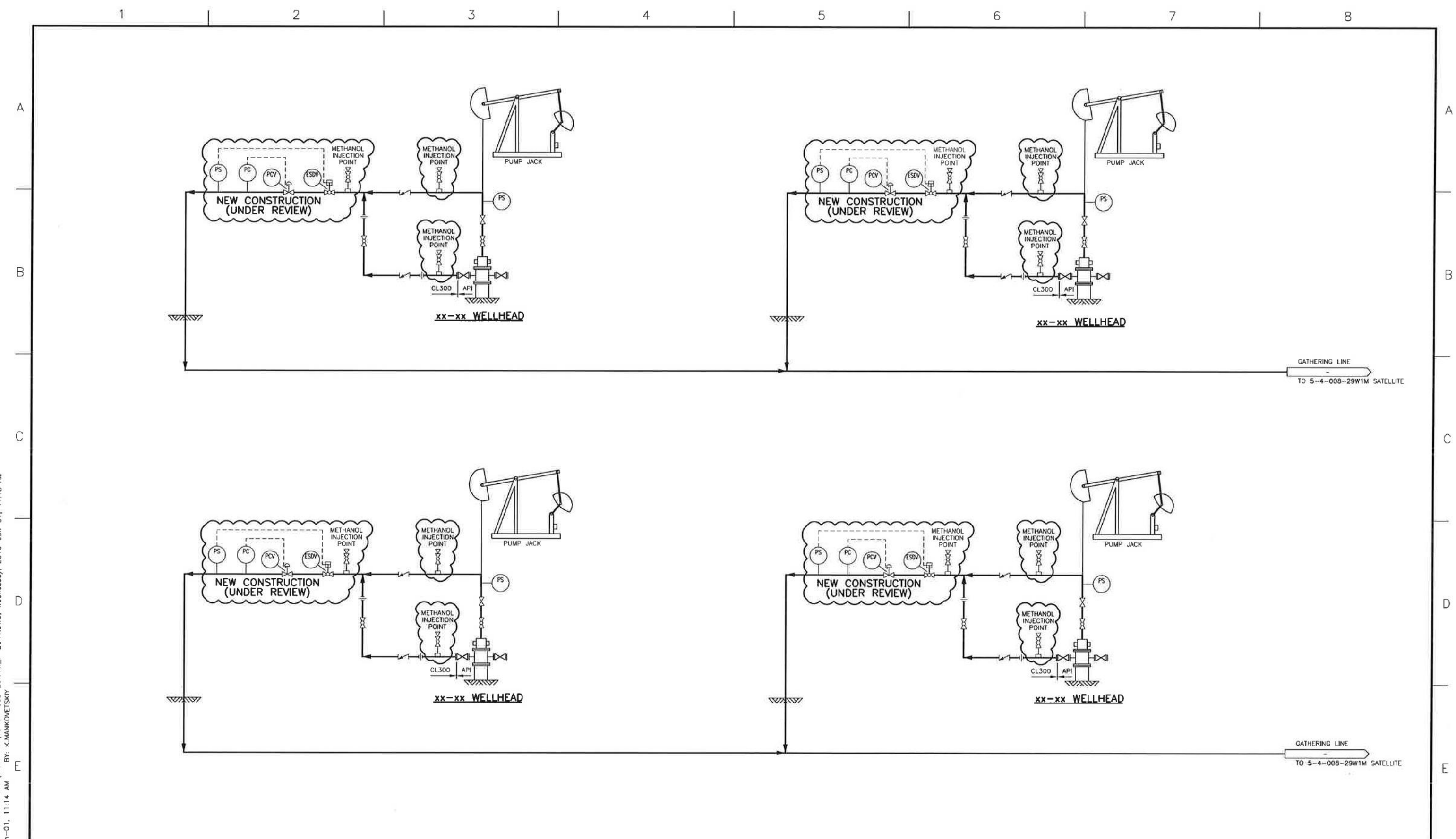
TUNDRA OIL & GAS

LSD: 03-04-008-29 W1M

SINCLAIR
03-04 & 07-04-008-29 W1M WELLSITES
PROCESS FLOW DIAGRAM

CADFILE	03-04-008-29W1M_F-2031.DWG
DRAWING NO.	03-04-008-29W1M_F-2031
REV.	A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2031.DWG, Wednesday, 2016-Jun-01, 11:11 AM
LAST SAVED: Wednesday, 2016-Jun-01, 11:10 AM BY: K.MANKOVETSKIY



NOTES

REFERENCE DRAWINGS	
NUMBER	TITLE

REVISIONS						
NO.	ISSUE	DATE	BY	CHK'D	ENG	APP'D
A	ISSUED FOR REVIEW	2016.FEB.29	GS			

PERMIT AND ENGINEER STAMP

PRELIMINARY

CHECKED	DATE	APPROVED	DATE

ASHER ENGINEERING LTD

PROJ. NO.	2033
SCALE	NTS

TUNDRA OIL & GAS

LSD: 03-04-008-29 W1M

SINCLAIR
PRODUCING WELLHEADS
PROCESS FLOW DIAGRAM

CADFILE	03-04-008-29W1M_F-2041.DWG
DRAWING NO.	03-04-008-29W1M_F-2041
REV.	A

S:\LOCATIONS\FACILITIES\MB\03-04-008-29 W1M\DRAWINGS\03-04-008-29W1M_F-2041.DWG, Wednesday, 2016-Jun-01, 11:15 AM
LAST SAVED: Wednesday, 2016-Jun-01, 11:14 AM BY: K.MANKOVETSKIY

Appendix 2

Corrosion Control Program

Planned Corrosion Control Program **

Pipelines

- Producing lines to Facility
    - Fiberglass / Composite Pipe 750 psi rating
- High Pressure CO2 Injection line
    - Yellow Jacket Carbon Steel Pipe

Facilities

- 3-4-8-29 Re-injection Facility
    - Plant piping:
        - Low Pressure – 150# Fiberglass or Internally Coated Pipe
        - High Pressure – 600# schedule 80 pipe, Stainless Steel, or Internally coated pipe
    - Valves – Full Stainless steel bodies
    - Pumping – Stainless steel valves and piston rods
    - De-hydrator – Stainless steel contactor tower and piping
        - CO2 is considered non-corrosive after the de-hydrator has removed the majority of the water content
    - Vessels – Devoe 256 internally coated, corrosion resistant materials

Injection Wellhead / Surface Piping

- Stainless Steel Surface Piping and Valves
- Stainless Steel meters and instrumentation
- Coated Wellhead – Entire injection wellhead will be ENC coated

Injection Well

- Casing cathodic protection where required – Cathodic protection system will be installed on injectors complete with rectifier, anodes and ground beds.
- Wetted surfaces coated downhole packer – Downhole injection packer will be ENC coated and annulus between tubing and casing will be circulated with corrosion inhibitor after the packer is set
- Corrosion inhibited water in the annulus between tubing / casing - annulus between tubing and casing will be circulated with corrosion inhibitor after the packer is set
- Internally coated tubing surface to packer – We will be running tubing with an inner fiberglass liner to prevent corrosion (Duoline 20).
- Surface freeze protection of annular fluid – After the well has been circulated over to inhibited fluid, the annulus surface will be circulated over to diesel. We will also be installing a heated injection shack over the wellhead which will help to prevent freezing in the winter months.
- Corrosion resistant master valve – Both master gate valves will be nickel coated to prevent corrosion.
- Corrosion resistant pipeline valve– The pipeline valve will be nickel coated to prevent corrosion.

** subject to final design and engineering

Producing Wells

- Casing cathodic protection where required
- Downhole batch corrosion inhibition as required
- Downhole scale inhibitor injection as required
- Stuffing boxes on producer wells will have built in blow-out prevention in place in the event of a broken polish rod

** subject to final design and engineering

Appendix 3

Current CO_2 WAG Operation Procedures

(Subject to revision after new equipment and site specific factors are taken into consideration)

Operation Procedures for Sinclair Field 8-04 C02 Pilot Injection Well

Normal Operating Pressure of C02 Vessels – 2,070 kPa
Maximum Frac Pressure for well – 16,000 kPa bottom hole
Preparation for CO2 Injection – the top 200 m of the annulus will be filled with a fluid suitable to exposure to -20C. I.e. Diesel Fuel.
Ensure that C02 is always above 520 kPa and -56.6 C, below these temperatures and pressures, the C02 will turn to solid (ice).

1.0 Initial Start-Up: Water to CO2

Valve Position Checklist for Water Injection	
V-801	Open
V-802	Open
V-803	Car Seal Closed during H2O injection
V-804	Closed
V-805	Closed
V-807	Open
V-808	Closed
V-809	Open
V-810	Open
V-811	Car Seal Open during H2O injection

During startup and normal flood conditions the C02 will be delivered to the wellhead at below 0 degrees C. In order to avoid freezing the water in the water-injection piping, wellhead, tubing and annulus these procedures have to be followed. In addition, to prevent the water in the tubing from becoming solid, a Nitrogen gas buffer between the water and the C02 will be necessary.

1) Tie in bottle of Nitrogen (N2) at V-307 on CO2 skid. Inject N2 until nitrogen bottle is empty or line pressure has reached 6000 kPa. Disconnect the N2 supply.
2) Close water valve (V-811).
3) Open V-801.
4) Open the C02 valve (V-803) (slowly) ensuring that the wellhead pressure has not dropped below 5000 kPa. If the pressure is below 5000 kPa, startup water injections again until the pressure is over 5,000 kPa and immediately switch to injecting C02.
5) If the pressure in the line is less than 1375 kPa use the vapor pressure off of the tanks to pressure the line by opening valve V-308 manually. If the pressure in the line is greater than 1375 kPa, use the C02 pump only to pressure up the line.
6) Open and close valve V-308 slowly to fill the entire line to the wellhead to 1375 kPa.
7) Once the pressure in the line reaches 1375 kPa, start the C02 pump slowly, at min Hz's and use the choke Actuated Ball Valve (ABV 303) to allow C02 into line slowly until it reaches the planned injection flow rate.

8) Close the vapor line by closing V-308.
9) Pump C02 until the pressure in the system stabilizes.
10) Reverse the spec blind adjacent to V-803 once the C02 injection has stabilized.

Note the physical properties of C02 change depending on pressure and temperature of the fluid. The C02 fluid will be experiencing changes in temperature and pressure as it travels from the tank, through the pump, to the wellhead and down the tubing into the reservoir. It is expected that the pump will have to speed up and slow down accordingly. C02 will **not** behave like water, injection pressure will vary.

2.0 Normal Operating for CO2 Injection

Valve Position Checklist for CO2 Injection	
V-801	Car Seal Open during CO2 Injection
V-802	Open
V-803	Car Seal Open during CO2 Injection
V-804	Closed
V-805	Open
V-807	Open
V-808	Closed
V-809	Open
V-810	Open
V-811	Car Seal Closed during CO2 injection

3.0 Shutdown of CO2 Injection

In the event of a system shutdown the surface facilities are designed to relieve pressure to protect the piping and vessels. The tubing and annulus pressure should be monitored until stabilized. The wellhead pressure may rise to about 4,500 kPa as the ground warms the top 200 m of the tubing to match its temperature. Be sure to fully understand the reasons for the shutdown prior to starting the well up again.

Additional Note: Always have spare nitrogen bottles available at the 3-04 battery for well startups. Use caution as the full N2 bottles are delivered with 15,000 kPa pressure which is considerably more than some well components.

4.0 Piping Freeze off

In the unlikely event of a freeze off in the piping, the first indication of an ice plug will be an abnormally low pressure on the downstream side of the blockage. If an ice plug is suspected, the section of the line in which the plug is located should be isolated as soon as practical. Pressure should be maintained as close to equal as possible on both sides of the plug to prevent it from being dislodged by a pressure differential and then damaging equipment downstream. Applying heat to the pipe exterior in the form of heating pads or hot air blowers can melt the plug. Be patient in dealing with plugs, as time will also break down a C02 ice plug through expansion of the C02 vapors.

5.0 CO2 to WAG Injection

This procedure will take place over the course of two days. The first day shall entail the shutdown of CO2 injection and making the facilities safe. The second day will see the commencement of water injection.

Valve Position Checklist for CO2 Injection	
V-801	Open during CO2 Injection
V-802	Open
V-803	Open during CO2 Injection
V-804	Closed
V-805	Open
V-807	Open
V-808	Closed
V-809	Open
V-810	Open
V-811	Car Seal Closed during CO2 injection

Maximum Operating Pressure on water: 6300 kPa.
Normal Start up Water Injection Rate; 5 – 10 m3/d
Maximum Rate while Converting from CO2 to Water to maintain injection: 25 m3/d
Maximum Rate while building to MOP: TBD by pattern voidage needs.

To prevent the formation of hydrates, the CO2 lines must be purged with Nitrogen gas (N2), the following procedure must be followed closely.

Day 1

1) Isolate CO2 flowline to 8-4-8-29HZ upstream of pump by closing valve V-301.
2) Tie in a bottle of N2 at Blow Down Valve BDV-303. Inject N2 until the bottle is empty, or line pressure has reached 6000 kPa. Disconnect the N2 supply.
3) At the 8-4-8-29HZ wellhead, close upper master valve (immediately below block tee).
4) Bleed down the CO2 line to atmosphere using the needle valve on end of block tee. Car Seal Close valve V-803.
5) Roll spec blind adjacent to valve V-803.
6) Ensure valves V-804 & V-805 are closed. If they are ~~bolt~~ bull plugged, the ~~bolt~~ bull plug is to be only finger tight.
7) Make CO2 skid safe. Review the procedure outlined in Section 6.0 (with the Praxair representative at this time.)
8) Make CO2 tanks safe. To be completed by Praxair. Review procedure with Praxair representative.

9) Re-pressure CO_2 line to 8-4-8-29 wellhead with N_2 to a pressure of 700 kPa to maintain an inert environment and prevent air ingress during extended CO_2 shut down?

To ensure that the wellbore fluid and piping does not freeze when water injection begins, a Methanol pill must be pumped down the wellbore. Please follow the procedure below closely.

Day 2

1) Shut in the flowline to 4-4-8-29 water injection well at the 8-4-8-29HZ well head by closing valve V-809.
2) Shut in water supply line at 8-4-8-29HZ wellhead by closing valve V-807.
3) Tie in pressure truck with Methanol at valve V-808.
4) Open valve V-810. Set choke to 100% open. Open valve V-811.
5) Begin injecting 1.5 m3 of Methanol.
6) Halt Methanol injection, close valve V-808.
7) Open water supply valve V-807 slowly. Reduce choke to bring water on at a rate of 5 – 10 m3/d to maintain a minimum wellhead pressure of 5000 kPa. (Maximum wellhead pressure of 6300 kPa) Maximum water rate to maintain injection during conversion is 25 m3/d and not to exceed 6300 kPa MOP.
8) If the wellhead pressure spikes to maximum and water injection stops, start injecting Methanol again until wellhead pressure stabilizes. Continue with water injection at stabilized pressure.
9) Once the water flow has stabilized, open valve V-809.
10) Check valve orientation against table below.

Normal Operating for H_2O Injection

Valve Position Checklist for Water Injection	
V-801	Open
V-802	Open
V-803	Car Seal Closed during H2O injection
V-804	Closed. Bolt plug finger tight.
V-805	Closed
V-807	Open
V-808	Closed
V-809	Open
V-810	Open
V-811	Open during H2O injection

6.0 CO2 Skid Safe Shutdown Procedure

In the event this skid is required to be temporarily shut down for maintenance, the following skid preparation procedure is recommended to be followed.

1. Shut down the pump via PLC "stop" button.

2. Isolate the liquid supply from tanks to CO2 pumping skid. This should be performed on the tank panels. This will also isolate the liquid return to the tank. These panels should be locked out while isolating the tanks from the skid.
3. Open V-302
4. Open BDV-303
5. Close V-302, watching PI-301. When the pressure drops below 150 psi, reopen V-302.
6. Repeat step 5 until no more liquid comes out of BDV-303. The purpose of this step is to ensure liquid has completely vacated the lines from the tank to the skid. Close BDV-303. Ensure V-302 is still open.
7. Open BDV-309
8. Once liquid has stopped flowing through BDV-309, close BDV-309
9. Open BDV-302 again, to ensure there is no more liquid at the front of the system. If there is, go back to step 4 and repeat steps 4 – 8 until no liquid is present.
10. Open BDV-309
11. Close V-302
12. When the system has completely vented (no pressure on gauges, no flow out of BDV-302 or BDV-309) the system is purged and depressurized.
13. Lockout V-302 and V-308.
14. Maintenance may now be performed on the skid.

7.0 CO2 Skid Safe Start-Up Procedure

Once maintenance has been completed on the CO2 skid and startup is required, the following skid preparations procedure is recommended to be followed:

1. Ensure all BDV's are in the closed position
2. Unlock and open V-302 and V-308
3. Allow skid to reach the same pressure as the tank pressure (check gauges). This should be between 250-300 psi. In the event PT-303 is reading below 100 psi, open V-309, V-305, and V-307 to ensure dry ice plugs do not form when introducing LCO2 into the system. Once this pressure is reached, close V-309 and V-305.
4. When there is full tank pressure at all points on the skid, open the Tank Actuated Ball Valves via the tank panels. Tank 101 panel will open actuated ball valve ABV-101 and ABV-102. Tank 201 panel will open ABV-201 and ABV-202.
5. Close V-302 and V-308
6. Go through normal start up and cool down sequence.

Appendix A

8-4-8-29HZ Wellhead Valve Diagram

Facing West