Noise Impact Assessment
Encana Corporation
Encana Dawson Creek Pad Site
8-2-80-17 W6M
Revision 0

Prepared for:

Kristie Buller
EnCana Corporation

Prepared by:

Patching Associates Acoustical Engineering Ltd.
Consultants in Acoustics, Noise Control and Vibration

2015-10-14
PAAE File: 2015-4484

Notice

This report has been prepared by Patching Associates Acoustical Engineering Ltd (PAAE) in response to a specific request for service from, and for the exclusive use of, the Client to whom it is addressed. The findings contained in this report are based, in part, upon information provided by others. The information contained in this study is not intended for the use of, nor is it intended to be relied upon, by any person, firm, or corporation other than the Client to whom it is addressed, with the exception of the applicable regulating authority to whom this document may be submitted. PAAE accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this report.

Professional Authentication

Project Role: Engineer of Record
Date: 2015-10-14
Patching Associates Acoustical Engineering Ltd. **Permit to Practice:** **P05273**
Title: Principal
Name: Justin Caskey, P.Eng.

Prepared by:

Analyst and Report Author:	Samiul Choudhury, M.Sc., E.I.T.
Principal In Charge & Engineer of Record:	Justin Caskey, P.Eng.
Project Manager:	Colin Spohr, E.I.T.

Executive Summary

Encana Corporation retained Patching Associates Acoustical Engineering Ltd. (PAAE) to conduct a Noise Impact Assessment (NIA) for the Encana Dawson Creek Pad Site located at 8-2-80-17 W6M, approximately 25 km northwest of Dawson Creek, British Columbia. The site contains three (3) 3.5MMBTU/hr line heater units and one (1) temporary gas compressor unit. Encana plans on changing the permit status of the existing gas compressor unit from temporary to permanent. The objective of this NIA is to compute the noise level at the subject site and the adjacent residences in the study area to assess site compliance with the British Columbia Oil and Gas Commission (BC OGC).

The NIA was conducted through field reconnaissance and theoretical analysis. Sound Power Levels (PWL) were determined for all of the major noise sources for the facilities. Sound propagation calculations were then undertaken to determine the sound pressure level that will exist at the receivers modeled in the study area. All calculations were undertaken in octave bands. The results of the sound propagation calculations were compared to the permissible sound level to determine if the cumulative noise from the operation of all facilities after the installation of the proposed equipment meets the requirements of BC Oil & Gas Commission guidelines.

The results of the model are shown in the table below.

Table 3: Predicted Sound Levels - Residences in the Study Area

Residence	Approximate Distance & Direction from the Subject Facility	Sound Levels No Ambient (dBA)	Ambient Sound Level (dBA)	Sound Levels With Ambient (dBA)	BC OGC PSL (dBA)	dBC-dBA	Meet the PSL
R01	1000 m N	27.8	35.0	**35.8**	40.0	24.3	Yes
R02	650 m N	31.9	35.0	**36.7**	40.0	23.6	Yes
R03	1330 m WNW	30.7	35.0	**36.4**	40.0	19.3	Yes
R04	440 m NE	34.4	35.0	**37.7**	40.0	23.3	Yes
R05	970 m E	27.5	35.0	**35.7**	40.0	24.7	Yes
R06	890 m S	28.2	35.0	**35.8**	40.0	24.6	Yes

The results of this assessment indicate that the predicted cumulative sound level from the normal operation of the existing facilities is **expected to meet** the BC Oil & Gas Commission Permissible Sound Level at all of the residences modeled in the study area. The most impacted residence is R04, located approximately 440 m northeast from the subject facility boundary. No additional noise control measures are required for the Encana 8-2-80-17 W6M site to comply with the British Columbia Noise Control Best Practices Guideline.

Table of Contents

Introduction

Encana Corporation retained Patching Associates Acoustical Engineering Ltd. (PAAE) to conduct a Noise Impact Assessment (NIA) for the Encana Dawson Creek Pad Site located at 8-2-80-17 W6M, approximately 25 km northwest of Dawson Creek, British Columbia. The site contains three (3) 3.5MMBTU/hr line heater units and one (1) temporary Gas Compressor unit. Encana plans on changing the permit status of the existing Gas compressor unit from temporary to permanent. The objective of this NIA is to compute the noise level at the subject site and the adjacent residences in the study area to assess site compliance with the British Columbia Oil and Gas Commission (BC OGC).

The BC OGC recommends that this noise impact assessment be conducted as part of the facility licensing process in accordance with procedures of the BC Oil & Gas Commission British Columbia Noise Control Best Practices Guideline.

Noise Criteria

The BC Oil & Gas Commission Guideline permits specified sound levels attributable to energy industry facilities at designated receptor points. These allowable limits are dependent on the population density, proximity to heavily traveled transportation routes (motor vehicles, rail and aircraft) and other specified adjustments.

The Permissible Sound Level (PSL) is the limit that the sound emanating from a facility plus the average ambient sound level may not exceed over a specified period, as measured in the yard of the nearest, most impacted, or complainant's residence. The ambient sound level is assumed to be 35 dBA L_{eq} (nighttime) as prescribed by the Guideline. In the event that there are no residents located within a radius of 1500 metres, the PSL is limited to 40 dBA L_{eq} (nighttime) at a distance of 1500 metres from the facility.

There are several residences located within 1500 metres from the facility boundary. The PSL has been determined as 40 dBA L_{eq} (nighttime) and 50 dBA L_{eq} (daytime) at 1500 metres. See Appendix A for the BC Oil & Gas Commission Permissible Sound Level calculation. See Appendix B for a detailed explanation of the Leq index.

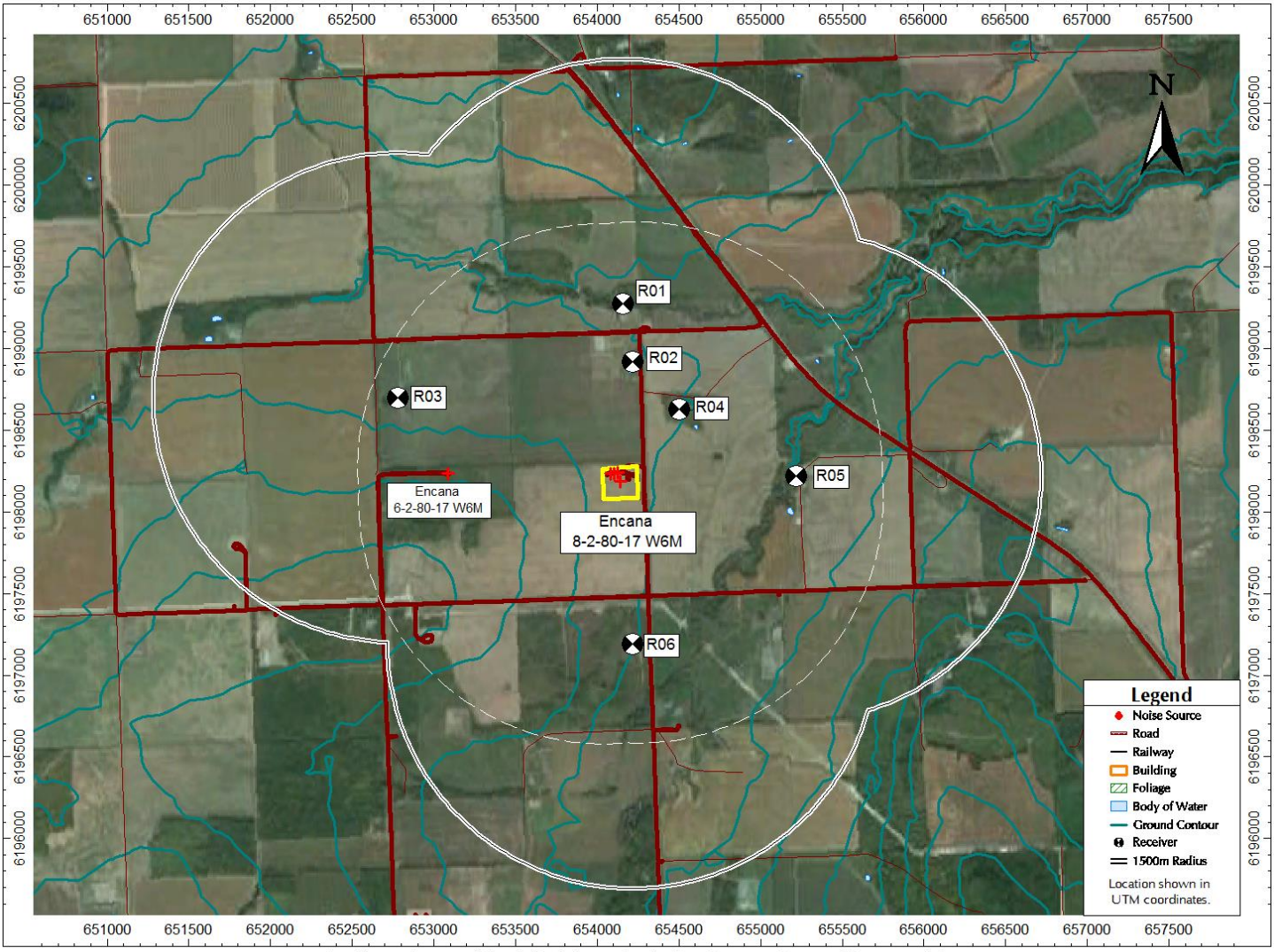
This study does not assess the potential for Low Frequency Noise (LFN) as 1/3 octave data was not available for the proposed equipment.

Study Area

The Encana Dawson Creek Pad Site is located at 8-2-80-17 W6M, approximately 25 km northwest of Dawson Creek, British Columbia. The terrain cover around the facility is mainly rolling farmland with pockets of tress. Field reconnaissance was performed by PAAE staff on October 05, 2015 to obtain information on the adjacent facilities and the location of the existing residences in the study area.

Figure 1 shows a map of the study area. The 1500 m boundary from the subject facility fenceline is shown in dotted white line. Due to the presence of several residences within 1500 m boundary, the study area is extended to include all other energy facilities (if any) that are located within 1500 m of the residences situated inside the subject facility 1500 m boundary, as shown in solid white line in Figure 1. Field reconnaissance conducted by PAAE staff in October 05, 2015 confirms that there was one adjacent energy facility owned by Encana in the study area that was operational and would be considered a significant noise source. Therefore, this facility has been included in the NIA model in order to assess the cumulative impacts from the combined operations of the energy facilities. There are several other energy facilities within 1500 m of the subject facility fenceline which contain no significant noise sources and/or not operational during the course of the survey, and hence have been excluded from the model. The residences in the study area are labeled as R01 to R06 in the NIA. The nearest residence is located approximately 440 m northeast from the subject facility boundary.

Figure 1: Study Area Map



Aerial Image Courtesy of Google Earth. Licensed to Patching Associates Acoustical Engineering Ltd.

Major Equipment

Table 1A gives details of the major equipment found at the Encana 8-2-80-17 W6M site. Table 1B lists the adjacent facility that is included in the NIA.

Table 1A: Encana 8-2-80-17 W6M Facility Major Equipment Details

Equipment Name	Equipment Details
Gas Compressor Unit	• Compressor: ANGI NG300 Series Ariel reciprocating compressor • Engine: Rated 225 HP and 1800 RPM • Cooling Unit: Assumed 11 HP, 44'' Cooler fan running at 825 RPM • Exhaust Unit: Equipped with hospital grade exhaust Silencer • Enclosure: Insulated metal building with doors closed year-round • Modeled theoretically
Line Heater Units (x3)	• Three (3) 3.5 MMBTU/hr Line Heaters • The units were modeled theoretically and calibrated with field measurements obtained by PAAE staff on October 05, 2015

Table 1B: Adjacent Facility Summary

Facility Name	Facility Summary
Encana 6-2-80-17 W6M	• A Pad Site with 4x Line Heaters • Noise emission was obtained by PAAE staff on October 05, 2015

Method

The NIA was conducted through field reconnaissance and theoretical analysis. Sound Power Levels (PWL) were determined for all of the major noise sources for the facilities. Sound propagation calculations were then undertaken to determine the sound pressure level that will exist at the receivers modeled in the study area. All calculations were undertaken in octave bands. The results of the sound propagation calculations were compared to the permissible sound level to determine if the cumulative noise from the operation of all facilities after the installation of the proposed equipment meets the requirements of BC Oil & Gas Commission guidelines.

Sound Power Level Calculations

Octave band sound power levels were calculated for all of the major noise sources that will be present in the study area. These octave band sound power levels and the source of the data are presented in Table 2.

Table 2: Source Octave Band Sound Power Levels

Noise Source	Data Source	Linear Octave Band Centre Frequency (dB)									Overall (dBA)	Overall (dBC)
		31.5	63	125	250	500	1k	2k	4k	8k		
Encana 8-2-80-17 W6M Gas Comp Unit Air Intake	Theory	102	95	93	93	94	97	98	97	89	103	105
Encana 8-2-80-17 W6M Gas Comp Unit Bldg. Open Area (Doors Closed)	Theory	88	89	95	95	94	96	97	92	85	102	103
Encana 6-2-80-17 W6M	Field	100	98	92	90	91	87	96	87	76	98	103
Encana 8-2-80-17 W6M Gas Comp Unit Cooler Inlet	Theory	103	104	103	100	95	92	85	81	75	97	108
Encana 8-2-80-17 W6M Line Heater Unit 1	Previous Study	89	99	109	99	79	79	79	69	69	96	110
Encana 8-2-80-17 W6M Line Heater Unit 2	Previous Study	89	99	109	99	79	79	79	69	69	96	110
Encana 8-2-80-17 W6M Line Heater Unit 3	Previous Study	89	99	109	99	79	79	79	69	69	96	110
Encana 8-2-80-17 W6M Gas Comp Unit Cooler Discharge	Theory	101	102	101	98	93	90	83	79	73	95	106
Encana 8-2-80-17 W6M Gas Comp Unit Bldg. Wall	Theory	105	100	101	97	95	84	83	72	65	95	106
Encana 8-2-80-17 W6M Gas Comp Unit Exhaust Tip	Manufacturer	131	109	93	81	76	82	84	73	64	94	128

Sound Propagation Calculations

The noise modeling was conducted using the noise modeling software package CadnaA (version 4.5.147) by Datakustik. CadnaA is an advanced noise propagation model that considers geometric spreading, atmospheric sound absorption, ground impedance effects, site topography and geometry, vegetation and environmental conditions. The calculations performed in CadnaA were conducted in accordance with ISO 9613. The ground cover was modeled as porous ground (ISO 9613 classification of porous ground includes ground covered by grass, trees or other vegetation, and any other ground surfaces suitable for growth of vegetation i.e. farmland). The ISO 9613 uses a slight downwind condition from each noise source to each receiver. ISO 9613 algorithm simulates wind speed between 1 m/s and 5 m/s (measured at a height of 3 m to 11 m above ground). The model temperature was set to 10ºC and a relative humidity of 80% and a ground absorption coefficient of 0.6. For areas with rivers and lakes, the ground cover was modelled as reflective ground with a ground absorption coefficient of 0. As such, the ISO 9613 model produces results representative of meteorological conditions favouring sound propagation (e.g., downwind or mild temperature inversion conditions). These conditions do not occur all the time at the receiver and the sound

levels are expected to be lower than those predicted for most of the time. Therefore the environmental conditions modeled represent "close-to-worst-case" sound propagation conditions. The CadnaA model calculates the contribution level of each noise source at the receiver location in octave bands as well as calculating the overall facility sound level.

Modeling Results

Table 3 summarizes the sound level predictions from the CadnaA model under downwind conditions for each residence modeled in the study area.

Table 3: Predicted Sound Levels - Residences in the Study Area

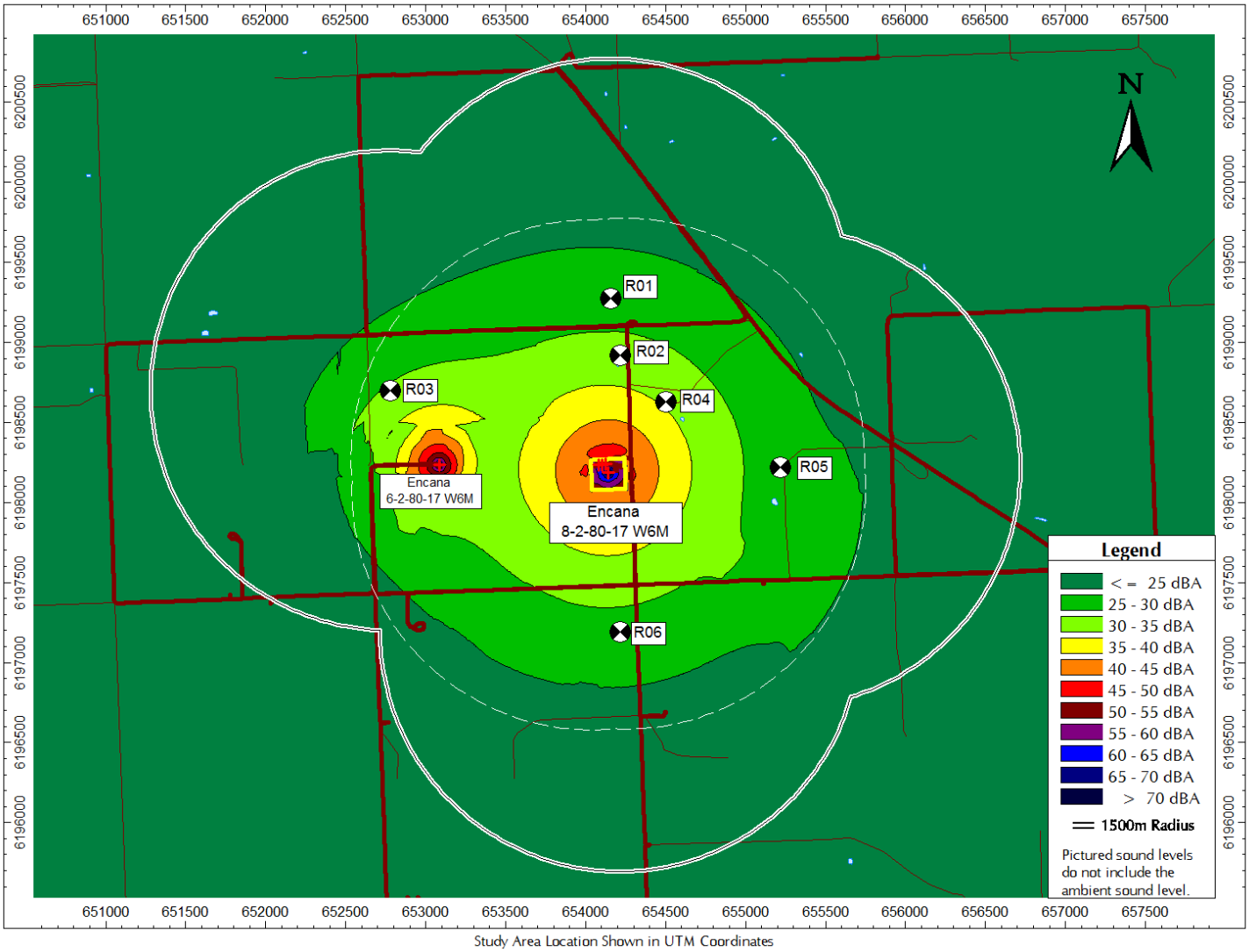
Residence	Approximate Distance & Direction from the Subject Facility	Sound Levels No Ambient (dBA)	Ambient Sound Level (dBA)	Sound Levels With Ambient (dBA)	BC OGC PSL (dBA)	dBC-dBA	Meet the PSL
R01	1000 m N	27.8	35.0	**35.8**	40.0	24.3	Yes
R02	650 m N	31.9	35.0	**36.7**	40.0	23.6	Yes
R03	1330 m WNW	30.7	35.0	**36.4**	40.0	19.3	Yes
R04	440 m NE	34.4	35.0	**37.7**	40.0	23.3	Yes
R05	970 m E	27.5	35.0	**35.7**	40.0	24.7	Yes
R06	890 m S	28.2	35.0	**35.8**	40.0	24.6	Yes

The above table indicates that the predicted cumulative sound level from the normal operation of the existing facilities is **expected to meet** the BC Oil & Gas Commission Permissible Sound Level at all of the residences modeled in the study area. The most impacted residence is R04, located approximately 440 m northeast from the subject facility boundary. No additional noise control measures are required for the Encana 8-2-80-17 W6M site to comply with the British Columbia Noise Control Best Practices Guideline.

The secondary assessment of Low Frequency Noise (LFN) is inconclusive at this stage because there are insufficient 1/3 octave band data at the receivers to determine tonality. As such, the predicted dBC-dBA values in the above table are provided for information purposes only.

Figure 2 shows the noise map of the area with noise contours produced by the noise emissions from the facilities. Ambient sound levels are excluded.

Figure 2: Noise Contour Map



Source Order Ranking

Based on the CadnaA model, the sound sources can be ranked by their individual sound level contribution at a given receiver. Table 4 lists the source order ranking for the most impacted residence R04, located approximately 440 m northeast from the subject facility boundary.

Table 4: Source Order Ranking - Residence R04

Rank	Noise Source	Sound Levels (dBA)	dBC-dBA
1	Encana 8-2-80-17 W6M Gas Comp Unit Air Intake	27.8	4.8
2	Encana 8-2-80-17 W6M Gas Comp Unit Bldg. Open Area (Doors Closed)	26.8	3.3
3	Encana 8-2-80-17 W6M Gas Comp Unit Cooler Inlet	24.7	12.0
4	Encana 8-2-80-17 W6M Line Heater Unit 1	24.4	14.9
5	Encana 8-2-80-17 W6M Line Heater Unit 2	24.2	14.9
6	Encana 8-2-80-17 W6M Line Heater Unit 3	23.9	15.0
7	Encana 8-2-80-17 W6M Gas Comp Unit Cooler Discharge	23.1	11.9
8	Encana 8-2-80-17 W6M Gas Comp Unit Bldg. Wall	22.6	12.8
9	Encana 8-2-80-17 W6M Gas Comp Unit Exhaust Tip	22.3	35.2
10	Encana 6-2-80-17 W6M	10.1	11.9
	Total Sound Level - No Ambient	**34.4**	**23.4**
	Ambient Sound Level	35.0	-
	Total Sound Level - With Ambient	**37.7**	**-**
	BC OGC PSL	40.0	-

Conclusion

Encana plans on changing the permit status of the existing Gas compressor unit from temporary to permanent at the 8-2-80-17 W6M Encana Dawson Creek Pad Site. The objective of this NIA is to compute the noise level at the subject site and the adjacent residences in the study area to assess site compliance with the British Columbia Oil and Gas Commission (BC OGC).

The results of this assessment indicate that the predicted cumulative sound level from the normal operation of the existing facilities is **expected to meet** the BC Oil & Gas Commission Permissible Sound Level at all of the residences modeled in the study area. The most impacted residence is R04, located approximately 440 m northeast from the subject facility boundary.

No additional noise control measures are required for the Encana 8-2-80-17 W6M site to comply with the British Columbia Noise Control Best Practices Guideline.

References

British Columbia Noise Control Best Practices Guideline. 2009. British Columbia, Canada.

DataKustic GmbH (DataKustic). 2014. *Cadna/A Computer Aided Noise Abatement Model*, Version 4.5.147. Munich, Germany.

International Organization for Standardization (ISO). 1993. *Standard 9613-1, Acoustics – Attenuation of Sound during Propagation Outdoors – Part 1: Calculation of Absorption of Sound by the Atmosphere*, Geneva Switzerland.

International Organization for Standardization (ISO) 1996. *Standard 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation*, Geneva Switzerland.

APPENDIX A

BC Oil & Gas Commission Permissible Sound Level Calculation

BC OIL & GAS COMMISSION
British Columbia Noise Control Best Practices Guideline
Permissible Sound Level Determination
Encana 8-2-80-17 W6M Facility
Residences in the Study Area

Basic Nighttime Sound Level

Proximity to Transportation	Dwelling Unit Density per ¼ Section of Land			Nighttime	Daytime
	1 - 8 Dwellings	9 - 160 Dwellings	>160 Dwellings		
Category 1	40	43	46	40	40
Category 2	45	48	51		
Category 3	50	53	56		
			Daytime Adjustment	N/A	10
			Basic Sound Levels	40	50

Class A Adjustments

Class	Reason for Adjustment	Value (dBA L_{eq})	Nighttime	Daytime
A1	Seasonal Adjustment (Wintertime Operation)	+5	N/A	N/A
A2	Ambient Monitoring Adjustment	-10 to +10	N/A	N/A
	Class Adjustment = Sum of A1 and A2 (as applicable), but not to exceed a maximum of 10 dBA L_{eq}			
		Total Class A Adjustments	0	0

Class B Adjustments

Class	Duration of Activity	Value (dBA L_{eq})	Nighttime	Daytime
B1	1 day	+15		
B2	7 days	+10		
B3	< or = to 60 days	+5		
B4	> 60 days	0	0	0
Class B Adjustment = one only of B1, B2, B3 or B4				
		Class B Adjustment	0	0
		PERMISSIBLE SOUND LEVEL (dBA)	**40**	**50**

Category 1: Dwelling units more than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 2: Dwelling units more than 30 m but less than 500 m from heavily travelled roads and/or rail lines and not subject to frequent aircraft flyovers.
Category 3: Dwelling units less than 30 m from heavily travelled roads and/or rail lines and/or subject to frequent aircraft flyovers.

APPENDIX B

Technical Details Regarding Sound Measurement and Analysis

Technical Details

Sound is the phenomena of vibrations transmitted through air, or other medium such as water or a building structure. The range of pressure amplitudes, intensities, and frequencies of the sound energy is very wide, and many specialized fields have developed using different ranges of these variables, such as room acoustics and medical ultrasound.

Due to the wide range of intensities, which are perceived as sound, standard engineering units become inconvenient. Sound levels are commonly measured on a logarithmic scale, with the level (in decibels, or dB) being proportional to ten times the common logarithm of the sound energy or intensity. Normal human hearing covers a range of about twelve to fourteen orders of magnitude in energy, from the threshold of hearing to the threshold of pain. On the decibel scale, the threshold of hearing is set as zero, written as 0 dB, while the threshold of pain varies between 120 to 140 dB. The most usual measure of sound is the sound pressure level (SPL), with 0 dB SPL set at 2.0×10^{-5} N/m^2 (also written 20 μPa), which corresponds to a sound intensity of 10^{-12} Watts/m^2 (or 1 picoWatt/m^2, written 1 pW/m^2).

Normal human hearing spans a frequency range from about 20 Hertz (Hz, or cycles per second) to about 20,000 Hz (written 20 KHz). However, the sensitivity of human hearing is not the same at all frequencies. To accommodate the variation in sensitivity, various frequency-weighting scales have been developed. The most common is the A-weighting scale, which is based on the sensitivity of human hearing at moderate levels; this scale reflects the low sensitivity to sounds of very high or very low frequencies. Sound levels measured on the A-weighted scale are written in A-weighted decibels, commonly shown as dBA or dB(A).

When sound is measured using the A-weighting scale, the reading is often called the "Noise level", to confirm that human sensitivity and reactions are being addressed. A table of some common noise sources and their associated noise levels are shown in Table B.

When the A-weighting scale is not used, the measurement is said to have a "linear" weighting, or to be unweighted, and may be called a "linear" level. As the linear reading is an accurate measurement of the physical (sound) pressure, the term "Sound Pressure Level", or SPL, is usually (but not universally) reserved for unweighted measurements.

Noise is usually defined as "unwanted sound", which indicates that it is not just the physical sound that is important, but also the human reaction to the sound that leads to the perception of sound as noise. It implies a judgment of the quality or quantity of sound experienced. As a human reaction to sound is involved, noise levels are usually given in A-weighted decibels (dBA). An alternate definition of noise is "sound made by somebody else", which emphasizes that the ability to control the level of the sound alters the perception of noise.

Table B: Noise Levels of Familiar Sources

Source Or Environment	Noise Level (dBA)
High Pressure Steam Venting To Atmosphere (3m)	121
Steam Boiler (2m)	90-95
Drilling Rig (10m)	80-90
Pneumatic Drill (15m)	85
Pump Jack (10m)	68-72
Truck (15m)	65-70
Business Office	65
Conversational Speech (1m)	60
Light Auto Traffic (30m)	50
Living Room	40
Library	35
Soft Whisper (5m)	20-35

The single number A-weighted level is often inadequate for engineering purposes, although it does supply a good estimate of people's reaction to a noise environment. As noise sources, control measures, and materials differ in the frequency dependence of their noise responses or production, sound is measured with a narrower frequency bandwidth; the specific methodology varies with the application. For most work, the acoustic frequency range is divided into frequency bands where the center frequency of each band is twice the frequency of the next lower band; these are called "Octave" bands, as their frequency relation is called an "Octave" in music, where the field of acoustics has its roots. For more detailed work, the octave bands, and certain standard octave and 1/3 octave bands have been specified by international agreements.

Where the noise at the receiver is steady, it is easy to assess the noise level. However, both the production of noise at the source and the transmission of noise can vary with time; most noise levels are not constant, either because of the motion of the noise source (as in traffic noise), because the noise source itself varies, or because the transmission of sound to the receiver location is not steady as over long distances. This is almost always the case for environmental noise studies. Several single number descriptors have been developed and are used to assess noise in these conditions.

The most common is the measurement of the "equivalent continuous" sound level, or L_{eq}, which is the level of a hypothetical source of a constant level which would give the same total sound energy as is measured during the sampling period. This is the "energy" average noise level. Typical sampling periods are one hour, nighttime (9 hours) or one day (24 hours); the sampling period used must be reported when using this unit.

The greatest value of the L_{eq} is that the contributions of different sources to the total noise level can be assessed, or in a case where a new noise source is to be added to an existing environment, the total noise level from new and old sources can be easily calculated. It is also sensitive to short term high noise levels.

Statistical noise levels are sometimes used to assess an unsteady noise environment. They indicate the levels that are exceeded a fixed percentage of the measurement time period measured. For example, the 10th percentile level, written L_{10}, is the levels exceeded 10% of the time; this level is a good measure of frequent noisy occurrences such as steady road traffic. The 90% level, L_{90}, is the level exceeded 90% of the time, and is the background level, or noise floor. A steady noise source will modify the background level, while an intermittent noise source such as road or rail traffic will affect the short-term levels only.

One disadvantage with the L_{eq} measure, when used alone, is that nearby loud sources (e.g. dogs barking, or birds singing) can confuse the assessment of the situation when it is the noise from a distant plant that is the concern. For this reason, the equivalent level and the statistical levels can be used together to better understand the noise environment. One such indication is the difference between the L_{eq} and the L_{90} levels. A large difference between the L_{eq} and L_{90}, greater than 10 dB, indicates the intrusion of short-term noise events on the general background level. A small difference, less than 5 dB, indicates a very steady noise environment. If the L_{eq} value exceeds the L_{10} value this indicates the presence of significant short-term loud events.

For most noise measurement, instruments are adjusted so that the time response of the instrument is similar to the response of the human ear; this is the "Fast" setting. Measurement with the "Fast" setting therefore assesses the sound environment according to the way humans would hear it and react to it. Where the noise level varies substantially and an average level is wanted without the complexity of and L_{eq} or statistical measurement, the "Slow" setting is used on the sound level meter. The "Slow" setting is also typically used in industrial settings where hearing damage is a concern. Where the noise level changes very rapidly, for example due to impacts or detonations, the "Fast" and "Slow" settings do not respond quickly enough to assess the maximum levels, and the "Impulse" meter setting us used.

The Sound Power Level (abbreviated L_w, SWL or PWL) is the decibel equivalent of the total energy emitted from a source in the form of noise. The reference level for the sound power is 10^{-12} Watts, or 1 picoWatt (abbreviated pW). The sound power level is given by:

$$L_w, \text{SWL}, \text{PWL} = 10 \times \log_{10} (\text{Emitted Power} / 1\ \text{pW})\ \text{dB}$$

Therefore, a source emitting 1 Watt of power in the form of sound would have a sound power level of 120 dB. Sound power levels can be expressed in terms of frequency bands, an overall linear-weighted level or A-weighted, as is the case for sound pressure levels. However, sound power levels are inherent to the source of noise, whereas the sound pressure level is dependent on the source, but also on the distance from the source and other environmental factors.

September 29, 2020

Via Email

Natural Resources and Energy Development
HJFFC – Room 150, 1350 Regent Street
Fredericton, NB E3C 2G6
Attention: Tom Howard, Team Lead, Mineral and Resource Development

Re: Elgin G-41 Project Description Letter

1. Company Overview

On March 4th, 2020 the shareholders of Corridor Resources Inc. ("**Corridor**") approved an investment arrangement that reconstituted the Board of Directors, replaced the management team and brought in $50 million of cash to complement Corridor's existing working capital balance of approx. $65 million. The new team, with the new name Headwater Exploration Inc. ("**Headwater**") has an extensive track record of providing a safe productive workplace for staff and contractors and sustainable development of resources in an environmentally responsible manner. Information regarding the team and previous companies can be found in the corporate presentation on the company website (www.headwaterexp.com) under the presentation heading.

2. Historical Overview

The Elgin Green Road G-41 well was drilled in November 2008 to a TD of 2422 mMD, which intersected both the Frederick Brook and Hiram Brook Shale formations. Following successful coring and logging operations the well was cased and rig released in January 2009. Upper and Lower intervals within the Frederick Brook Shale were perforated, fractured with LPG and flow tested in November 2009 to January 2010. An extended flow test was performed in January 2011 and was analysed for economic development. The well was determined to be uneconomic to produce due to the infrastructure costs associated with pipelining it to the nearest facility which was 28 km away.

In 2017 the well was further evaluated to install permanent processing facilities onsite to produce and ship Compressed Natural Gas (CNG). This evaluation was once again uneconomic due to the costs of the permanent facilities.

3. Project Proposal

Headwater is proposing to bring the Elin G-41 well back on production, produce it via portable CNG equipment to CNG trailers and truck to local markets. The portable CNG equipment is made up of a trailer mounted 210 HP compressor, gas drying system and cooler unit and would be supplied by Certarus. Headwater personnel will be operating the wellsite and each company will be responsible for the operation of their own equipment by trained personnel. HWX will perform daily in person checks on the wellsite to record well and equipment operational readings (volumes, pressures, levels) as well as safety checks. The equipment onsite will be set-up with remote status monitoring and callout capabilities. The CNG package is fully instrumented with process and safety shutdowns. There is an inlet ESD valve to isolate the package from the gas source if necessary. The package is

designed to operate safely without any input from personnel other than starting. There is remote monitoring capability so we are able to see the conditions inside the unit whenever required. The CNG unit would not be started remotely, if it is noticed to have shutdown, trained personnel are dispatched to check the unit, correct the issue and re-start the unit. This is how Certarus operates their CNG units throughout North America and has been successful. The justification for this monitoring strategy would align with the way we are operating our assets in the McCully field. Headwater staff will receive training from the Certarus personnel when the unit is commissioned and Certarus will be available as a resource for operational trouble shooting as required. The CNG truck drivers are trained on the operation of the CNG unit specifically to the connect / disconnect system. CNG truck drivers will hold a valid PTO license. The Certarus CNG compression unit is equipped with the following Safety shutdowns: High pressure/low pressure from inlet to outlet of the unit, high differential pressure inlet filter, LEL gas detection S/D, Fire Eye S/D, Engine overspeed and under speed, full engine control system (oil pressure, temperature, etc.), frame lubrication S/D's, frame oil pressure and temperature. Specific project details are listed in the table below and supporting documentation is in Appendix A.

PROJECT DESCRIPTION

Well Name UWI	Elgin Green Road G-41 **G-41 2426/G-41**
License Number	WLONG 08-12
Substance:	Natural Gas
H_2S Content:	0.00%
Emergency Response Plan (ERP):	Headwater has a Corporate Emergency Response Plan that would include this site.
Need for Proposed Development:	The proposed project will allow the Elgin G-41 well to be tested for commercial natural gas production during the winter months to supply local markets with a cost beneficial product.
Proposed Project Scheduling:	Portable CNG equipment is proposed to arrive onsite for a November 1, 2020 commissioning pending regulatory approval. Setting the equipment in place and the commissioning is expected to take 5 days. In advance of the CNG equipment arriving on site there is some well maintenance that needs to take place which will include removing the Two-way check valve (TWCV) from the tubing hanger as well as the VR plugs in the casing valves. Cameron will be performing the wellhead work. Slickline will also be utilized to shift open the sliding sleeve that is currently isolating the upper Frederick Brook zone from producing up the tubing and a P&T log will be ran. This preparation work is planned to take place starting October 1, 2020.

ADDITIONAL INFORMATION

<table>
<tr><td>Flaring Operations:</td><td>There is no flaring planned on the site. The well will be equipped with an ESD so if there are any operational upsets the well will be shut in versus diverting to a flare system. The CNG unit has the ability to unload the pressure on the system to the CNG trailers as the gas cools and the pressure decreases versus having to bleed down the system pressure. In the case of an emergency isolation and bleed down event that cannot be resolved through the CNG unit and trailer a temporary portable flare stack would be utilized.</td></tr>
<tr><td>Potential Emissions & Odours:</td><td>The CNG equipment that will be installed onsite is a closed system from the wellhead to the truck loading. The emissions from the CNG unit will be associated with the natural gas engine powering the compressor which is equipped with air fuel ratio controllers and a catalytic converter. The detailed emissions data is attached for reference.</td></tr>
<tr><td>Noise:</td><td>You may experience general construction related noise associated with the movement of heavy equipment in the area during well maintenance and equipment commissioning activities. The exhaust on the CNG unit is equipped with a Stoddard E15 Silencer and the compressor cooler is equipped with recirculation louvers. Attached also for reference is the silencer dBA data, and a reference noise impact study that was performed a couple years ago on a wellsite that had a CNG unit similar to this one, that is proposed to be installed. Any elevated noise associated with the construction and production operations should fall within the noise guidelines outlined in our ATO I-10914. Headwater will conduct a baseline noise survey in proximity of the nearby residents prior to the installation of the equipment on site. Once the equipment is in operation another survey will be conducted, based on these surveys if required noise mitigation measures will be put in place.</td></tr>
<tr><td>Traffic:</td><td>There will be an increase in traffic in the area during the wellsite preparation operations, which will include Headwater Exploration pick-up trucks, slickline unit and crew truck, wellhead crew truck and a tractor trailer unit to deliver materials to and from the site that are required for the wellhead work. There will also be some light truck traffic associated with the piping modifications to connect the well to the CNG unit. The traffic will be hauling materials and workers to install the pipeline. After the commissioning of the CNG unit the trucking schedule for the CNG product is anticipated as follows;
<table>
<tr><th>Month</th><th>Rate
mmscf/d</th><th>Rate
MMBTU/d</th><th>CNG Truck Capacity
mscf/truck</th><th># of Loads
per day</th></tr>
<tr><td>12/1/2020</td><td>2.00</td><td>2.13</td><td>360</td><td>5.6</td></tr>
<tr><td>1/1/2021</td><td>1.65</td><td>1.75</td><td>360</td><td>4.6</td></tr>
<tr><td>2/1/2021</td><td>1.15</td><td>1.22</td><td>360</td><td>3.2</td></tr>
<tr><td>3/1/2021</td><td>1.03</td><td>1.09</td><td>360</td><td>2.8</td></tr>
<tr><td>4/1/2021</td><td>0.92</td><td>0.98</td><td>360</td><td>2.6</td></tr>
</table>
The planned traffic route to and from location is from Hwy#2, south on Hwy#1 to Hwy 905, ease on 905 to the Green Road and into location.</td></tr>
</table>

Site Security and Lighting	Currently the site is secured with a locked gate at the entrance which would remain in place. The wellhead and equipment would be panelled off as required without interfering with the operation of the equipment. Headwater has a longstanding relationship with the local fire department and historically they have kept an eye on the site for security purposes. If there are any breaches in security of the site with these in place, then Headwater would look to install security cameras to monitor the site. The CNG equipment is equipped with lighting suitable to operate the equipment in a nighttime environment, lights are adjustable to reduce or increase the distance required. The CHG Unit is designed and built to the Canadian Electrical Code Class 1 Zone 2 electrical standards and is equipped with fire protection equipment as well. Headwater has inquired to get a power service to site in which a yard light and/or manual controlled lighting would be installed. If the power service is not in place at the time of commissioning, then a generator/light plant would be utilized to provide the power for the site.
On-Site Equipment:	There will be a portable 210 Hp CNG Compression Unit, generator and CNG trailers while they are filling.

SAFETY & ENVIRONMENT:

Headwater Exploration Inc. is committed to protecting the health and safety of the public, as well as its employees and contractors. All operations will be conducted in strict accordance with good oilfield practices and in compliance with all applicable technical and safety standards and regulations. Headwater Exploration Inc. personnel have been trained to recognize hazards and deal with emergency situations, so that any abnormal situation that might arise can be quickly detected and corrected. A Corporate Emergency Response Plan to address public safety operations is in place.

Headwater recognizes the value of our natural environment and the need to manage natural resources wisely. Headwater is committed to conducting all its activities in an environmentally responsible manner and works to promote employee, contractor, and public awareness about environmental issues.

CONTACT INFORMATION

Company Contact Information:	Headwater Exploration Inc. Suite 1700, 500 – 4th Avenue S.W. Calgary, AB T2P 2V6 24-Hour Emergency Phone: 1-506-433-3066 Contact Person: Brad Christman (403) 990-0842 Vice President Production

Support information attached:

1. CNG Unit layout diagram
2. CNG Unit PID
3. CNG Unit Cooler Fan Specs
4. Exhaust Silencer Data
5. CNG Unit G3306B Engine Technical Data
6. CNG Unit G3306B Tie-in Diagram
7. Noise Impact Assessment – Reference
8. CNG Unit at Compressor Site Picture
9. CNG Trailer Information

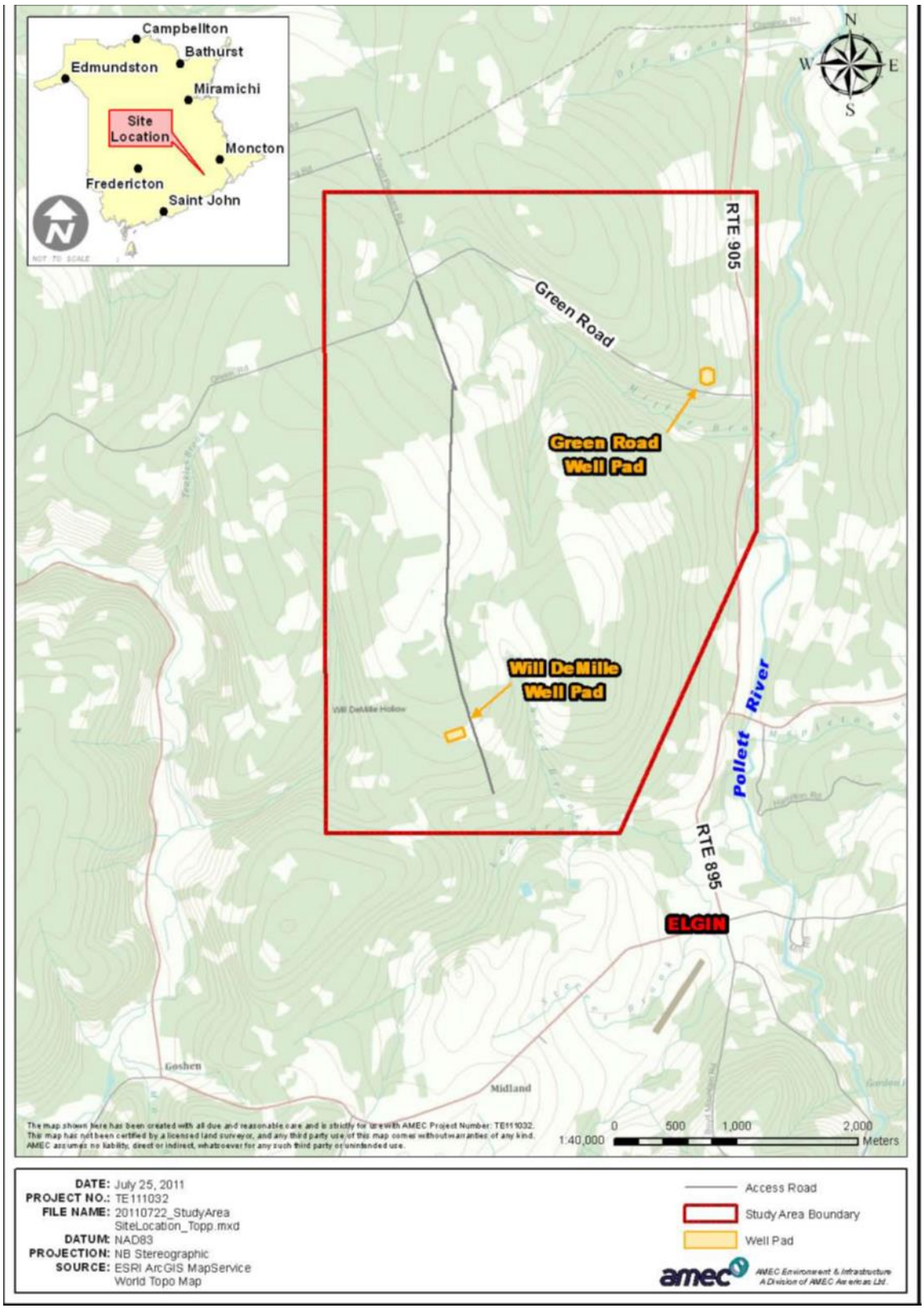
Respectfully,

Headwater Exploration Inc.

Brad Christman
VP, Production

Location of the Elgin Green Road Well Pad

PID 00601443



HEXAGON
LINCOLN

Hexagon Lincoln CNG Bulk Hauling TITAN™ Module Operation and Inspection Manual With NC Gas Venting System

P/N's: 240167-0001 & 240167-0002
ECN 32445

Service Bulletin 14-02-005 Revision B

Table of Contents

List of Figures

List of Tables

1 Using this Operational Manual

This manual must be read and understood before using the Hexagon Lincoln TITAN™ Module: P/N: 240167-0001 and 240167-0002.

The purpose of this document is to provide information about how to operate, maintain, and inspect Hexagon Lincoln TITAN™ Container: P/N: 240167-0001 and 240167-0002. In situations where this document differs from the authority having jurisdiction, the latter shall have precedence.

Boxed bolded text is used in this manual to indicate critical warnings or instructions. An example of this format is shown above this paragraph.

Throughout the procedures defined by this manual, figures are used to show the location of components.

The figures are not to be used as a reference for what position the valves are in (e.g. open vs. closed) unless it is explicitly stated. Failure to comply may result in damage, personal injury, and/or death.

The checklists in Appendix A, 0, Appendix C are to be copied and reproduced as needed. Contact Hexagon Lincoln Technical Service Engineering for electronic versions of these checklists. The information recorded in these appendices shall be kept a minimum of 5 years and is recommended to be maintained for the life of the container. The inspection information must be kept for the life of the container. This information must be provided to the person inspecting the container prior to inspection or as directed by the authority having jurisdiction.

2 In Case of Emergency Involving Fire or Venting of Cargo

CALL Emergency Response Telephone Number on Shipping Paper first. If the Shipping Paper is not available or no answer, refer to appropriate telephone number listed on page 43 under the section EMERGENCY RESPONSE TELEPHONE NUMBERS or by the authority having jurisdiction.

Hexagon Lincoln Emergency Number: 844-211-5339

3 Who to Call for Assistance (for first responders)

This section is taken from the Emergency Response Guide (ERG) 2008 Guide # 115 page 7.

Upon arrival at the scene, a first responder is expected to recognize the presence of dangerous goods, protect oneself and the public, secure the area, and call for the assistance of trained personnel as soon as conditions permit. Follow the steps outlined in your organization's standard operating procedures and/or local emergency response plan for obtaining qualified assistance. Generally, the notification sequence and requests for technical information beyond what is available in the ERG 2008 guidebook should occur in the following order.

Organization/Agency
Notify your organization/agency which may be the owner and/ or operator of the module. This will set in motion a series of events based upon the information provided. Actions may range from dispatching additional trained personnel to the scene to activating the local emergency response plan. Ensure that local fire and police departments have been notified.

Emergency Response Telephone Number
Locate and call the telephone number listed on the shipping document. The person answering the phone at the listed emergency response number must be knowledgeable of the materials and mitigation actions to be taken, or must have immediate access to a person who has the required knowledge.

National Assistance
Contact the appropriate emergency response agency listed on the inside back cover of this guidebook when the emergency response telephone number is not available from the shipping papers. Upon receipt of a call describing the nature of the incident, the agency will provide immediate advice on handling the early stages of the incident. The agency will also contact the shipper or manufacturer of the material for more detailed information and request on-scene assistance when necessary.

Collect and provide as much of the following information as can safely be obtained to your chain-of-command and specialists contacted for technical guidance:

- Your name, call back number, FAX number
- Location and nature of problem (spill, fire, etc.)
- Name and identification number of material(s) involved
- Shipper/consignee/point of origin
- Carrier name, rail car, vessel or truck number
- Container type and size
- Quantity of material transported/released
- Local conditions (weather, terrain, proximity to schools, hospitals, waterways, etc.)
- Injuries and exposures
- Local emergency services that have been notified

4 Key Warnings

Never smoke near or around this container.

Do not allow a vacuum to form in the cylinder(s) at any time.

Always ground the plumbing with a 3-gage copper wire or larger to an appropriate ground source at least 8 feet in the ground.

The owner is responsible for supplying a break-away connection on the hose.

The maximum gas density shall never be exceeded as defined by 250 barg (3626 psig) and 15 °C (59 °F).

The maximum gas temperature shall not exceed 82 °C (180 °F).

The user is responsible for specifying the minimum height clearance requirement and approved routes.

It is the user's responsibility to ensure that their Emergency Response Procedure is followed and is acceptable to the Authority Having Jurisdiction (AHJ).

It is the Owner and User's responsibility to ensure the Titan™ systems are being filled with "clean gas". The term "clean gas" used in this manual refers to the gas particulate size range of 3 to 10 microns. Hexagon Lincoln is not responsible for any failures of any components of the module if this "clean gas" specification is not met.

Any valve used on the Titan™ should not be throttled in any way. The throttling of a valve in this manual is defined as change of position of valve stem during gas flow. This can result in erosion of the valve seats and seals. It is the Owner and User's responsibility to ensure throttling of valves is not occurring with their modules. Hexagon Lincoln is not responsible for any failures of any valves on the Titan™ module if a valve shows signs of throttling.

5 Basic Layout

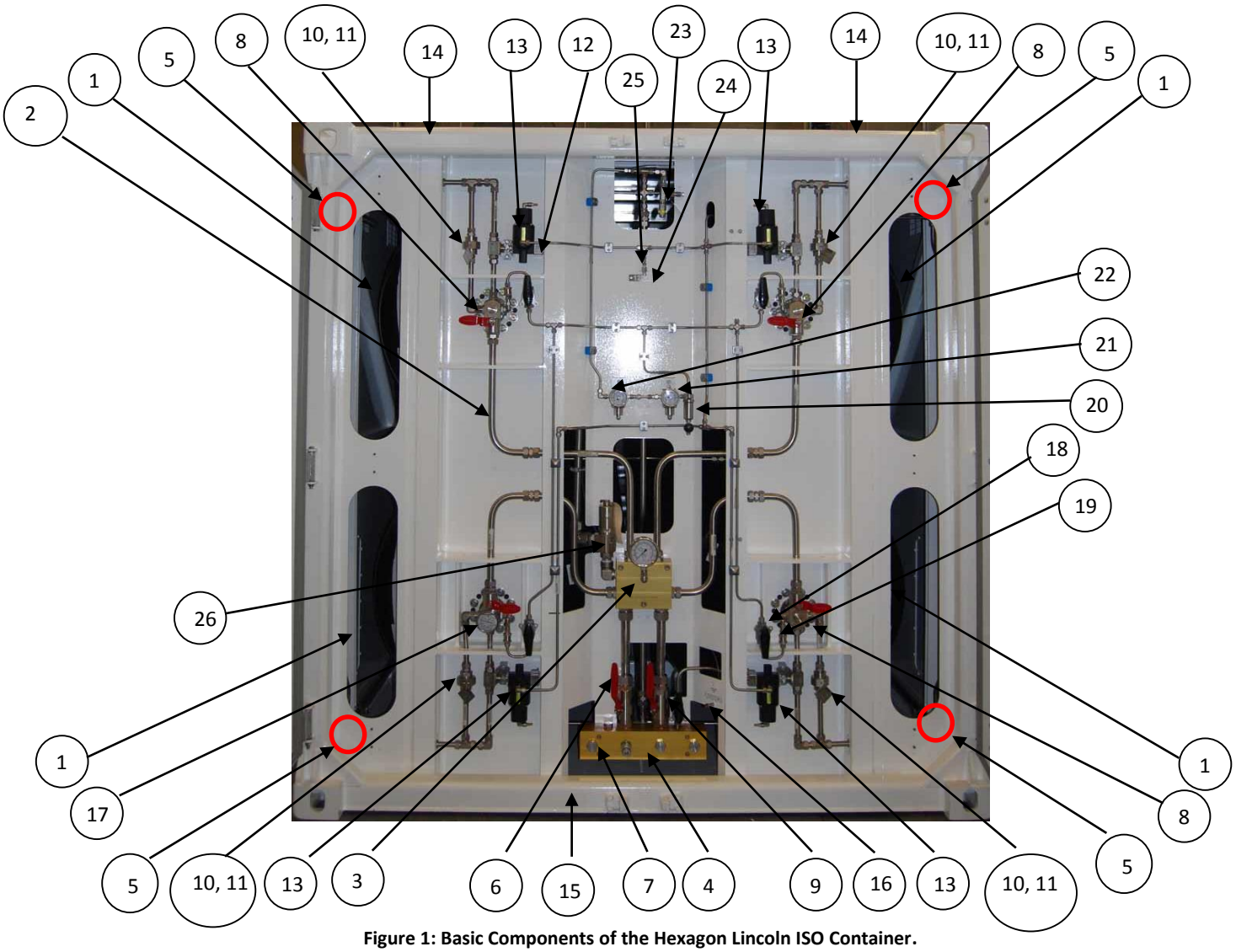


Figure 1: Basic Components of the Hexagon Lincoln ISO Container.

Table 1: Basic Components of the Hexagon Lincoln ISO Container

Item No.	Description	Item No.	Description
1	Hexagon Lincoln Gas Cylinder (qty 4)	14	Vent Lines (qty 4) (not all shown)
2	Cylinder Plumbing	15	Container Frame
3	Distribution Manifold with Pressure Gauge	16	Grounding Lug
4	Filling/Unloading Manifold	17	Temperature Gauge
5	Temperature Sensitive Line (qty 4) (not visible in view)	18	Constant Feed shut ¼ turn valve (qty 4)
6	Manifold Valve (qty 2)	19	Check Valves (qty 4)
7	Quick Disconnects	20	Filter
8	Cylinder Valve (qty 4)	21	Regulator set at 250 psig (17.2 barg)
9	Bleed/ Vent Valve	22	Regulator set at 190 psig (13.1 barg)
10	Burst Disc holder (qty 4)	23	Pressure Relief Valve set at 200 psig (13.8 barg)
11	Burst Disc (qty 4)	24	Container Serial Number Tag
12	Pneumatic Valve mechanical lock (qty 4)	25	0.030” (0.76 mm) Orifice
13	Gas Venting System Pneumatic Valves (qty 4)	26	Pressure Relief Valve set at 4500 psig (310 barg)

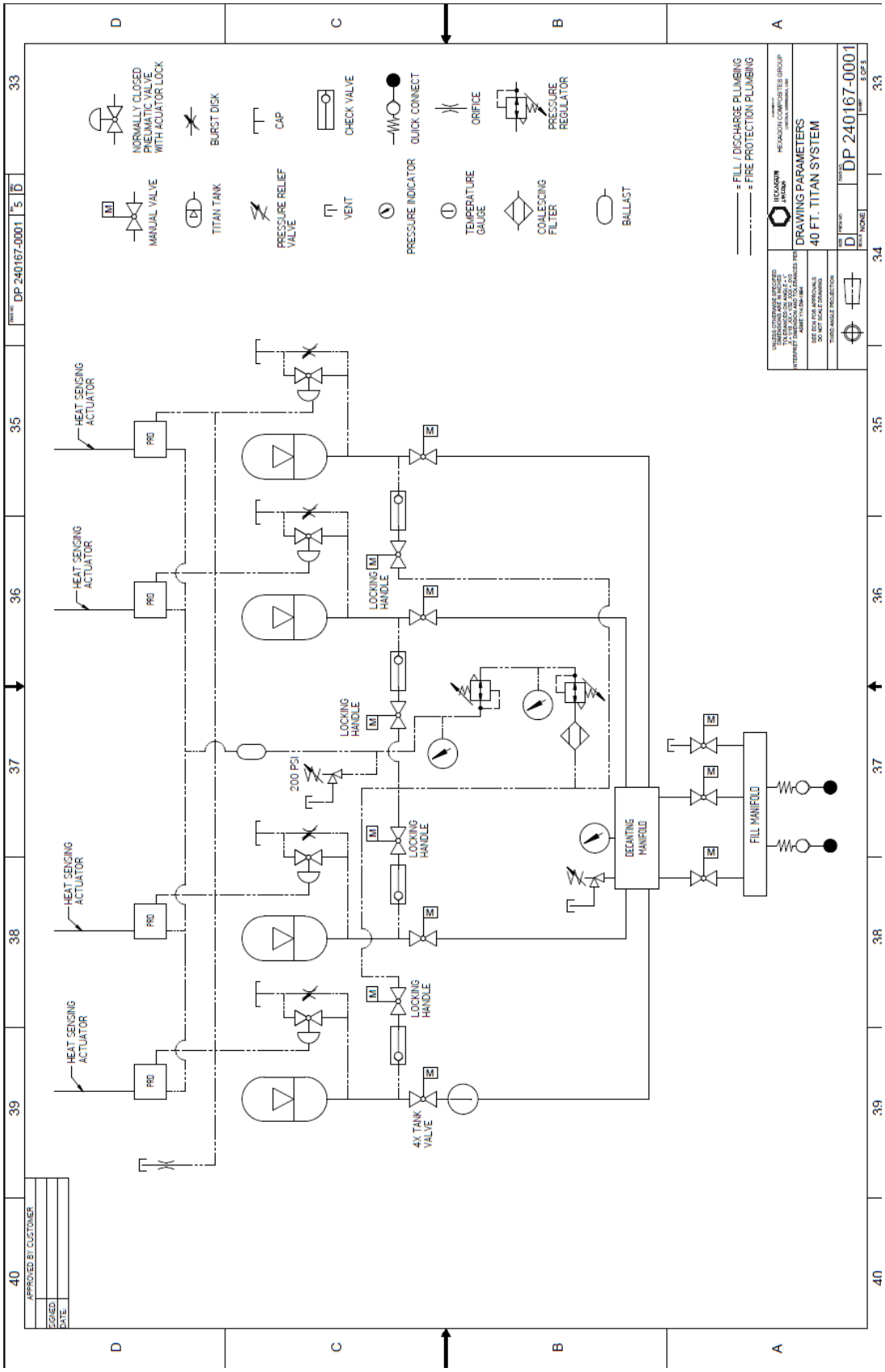


Figure 2: Flow Diagram

6 Description of Cylinder

The design construction type is a fully wrapped carbon fiber-reinforced epoxy composite pressure vessel with a high-density polyethylene (HDPE) liner. The plastic liner is a non-structural barrier for the containment of compressed gas at high pressure. The composite is the primary structural element of the design, supporting internal pressure and mounting loads, and providing the general strength and durability of the vessel. The nickel plated end bosses provide the interface for connecting the vessel to the gas system and are the means by which the vessel is mounted.

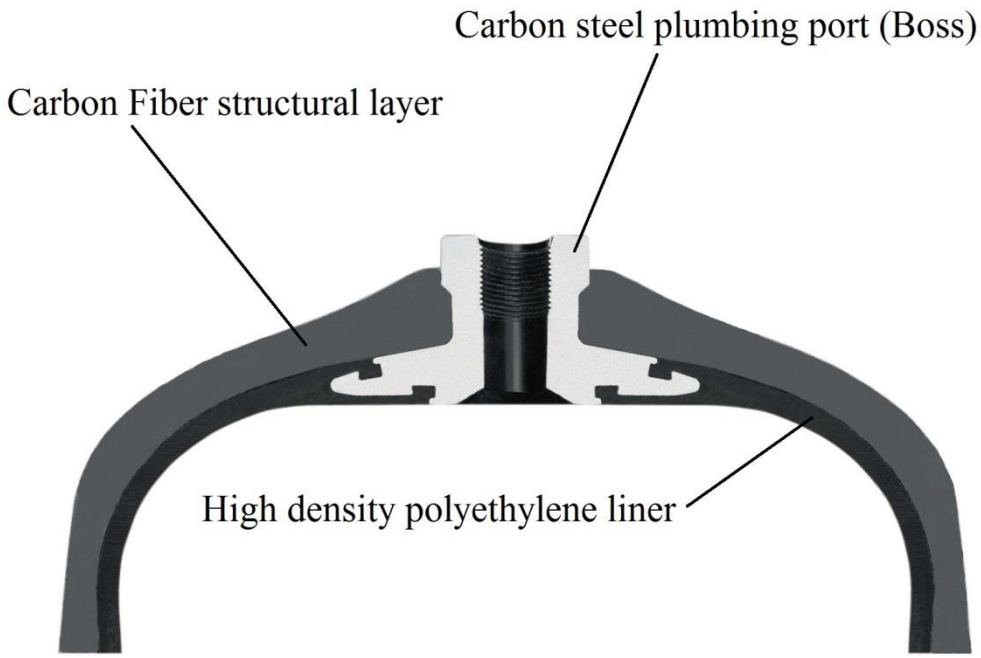


Figure 3: Cylinder Construction

7 General Specifications

Hexagon Lincoln TITAN™ Container (PN: 240167-0001 and 240167-0002) was designed to transport and store non-oxidizing compressed gasses.

The values in Table 2 are nominal and are not to be used for determining if the cylinders are filled.

Table 2: Typical Working Conditions and Properties

PN	Total Volume	Cylinder Water Volume	Service Pressure	Cylinder Empty Weight	Cylinder + Gas[1]	Tare Module Weight	Gross Module Weight[1,2]
240167-0001 240167-0002	34048 liters (2077736 in^3)	8512 liters (519434 in^3)	250 barg (3626 psig) at 15°C (59°F)	2312 kg (5097 lbs)	4168 kg (9188 lbs)	15631 kg (34460 lbs)	23,053 kg (50823 lbs)

[1]Assuming 0.72 SG and at settled temperature and pressure.
[2]Module must be equipped with aluminum roof sections.

7.1 Dimensions

Frame dimensions are per ISO 668:1995; 40 ft. x 8 ft. x 8 ft; flat bottom. Requires a Flat Chassis as shown in Figure 4. The chassis is flat from front to back. The container does not have a tunnel in it for a chassis that has a kick up for the king pin.

Figure 4 - ISO Container Flat Chassis

7.2 Pressure Range

This system is designed to a service pressure of 250 bar (3626 psig) settled at 15°C (59°F). The maximum fill pressure is 325 bar (4714 psig); with a maximum fill gas temperature of 82.2°C (180°F). Thus when filling the TITAN™ it is filled to a density because pressure is dependent on gas temperature, and typically the gas temperature is in excess of the settled temperature of 15°C (59°F). The fill chart shown in Figure 9 specifies what pressure the vessels may be filled to given the internal gas temperature.

Always fill cylinders to the working pressures or as directed by the authority having jurisdiction. Cylinders are not designed for vacuum service.

7.3 Temperature Range

The system is designed to operate within a temperature range of -40°C to 82.2°C (-40°F to 180°F). The gas temperature range for a complete temperature compensated fill is -40°C to 65°C (-40°F to 149°F). The owner is responsible for following fill chart requirements in Figure 9 for temperature range to be valid.

7.4 Service Life

240167-0001 modules are DOT approved and have a service life of 15 years. 240167-0002 modules are ABS approved and have a service life of 20 years. The maintenance and inspection requirements stated within this manual are to be met.

7.5 Approved Gases

The cylinders are designed for storage and transport of approved gases meeting the specifications for dry or wet gas as follows, and in accordance with the working conditions specified in Section 7. Gas that has been treated by deliberately adding methanol and/or glycol to suppress hydrate formation shall not be used.

Note high levels of CO2 will result in dry ice formation during defueling.

For Natural Gas:

Dry Gas

Water vapor shall be limited to less than 32 mg/m^3, a pressure dew point of -9°C (15.8°F) at 207 barg (3002 psig).

Constituent maximum limits shall be:

Hydrogen Sulfide	23 mg/m^3
Oxygen	1.0 % by volume

Wet Gas

Natural Gas that contains water content higher than that of dry gas.

Constituent maximum limits shall be:

Hydrogen Sulfide	23 mg/m^3
Oxygen	1.0 % by volume
Carbon Dioxide	4.0% by volume
Hydrogen	0.1 % by volume

Gas permeation shall be considered if a vessel operates or is stored in an enclosed space for an extended period of time. The allowable rate of natural gas permeation is 0.25 standard cubic centimeters per hour (scch) per liter of water capacity at working pressure (0.201 scm per day or 7.1 SCF per day for the module).

DANGER! NATURAL GAS IS EXTREMELY FLAMMABLE.

Natural gas is an extremely flammable gas and has the potential to cause a flash fire or explosion. It is also an asphyxiate. In high concentrations, it will displace oxygen from the breathing atmosphere, particularly in confined spaces. Signs of asphyxiation may include rapid breathing and pulse rate, headache, dizziness, visual disturbances, mental confusion, incoordination, mood changes, muscular weakness, tremors, cyanosis, narcosis and numbness of the extremities. For more information see a Material Safety Data Sheet on natural gas.

Never smoke near or around this container. Any ignition source has the capability of causing an explosion if a leak is present. Extreme caution must be used at all times during the life of this container.

7.6 Filling/Unloading Station Requirements

The filling/unloading station shall address the following requirements for safe filling and unloading of natural gas: Fire protection, electrical classification requirements, grounding/bonding requirements, safe shutdown device, overpressure protection, vent system, gas temperature control, backflow prevention, and CNG odorants.

All filling/unloading stations shall adhere to all requirements of the authority having jurisdiction.

8 Receiving the TITAN™ Container

8.1 Container Shipping Pressure

The cylinders will be filled with compressed air or nitrogen at a pressure no greater than 1.7 barg (25 psig) before leaving the factory. Refer to section 9.1.1 for filling requirements before first time fill.

8.2 Container Inspection

Thoroughly inspect the exterior and interior of the module for obvious signs of damage. Report any unusual findings to Hexagon Lincoln.

9 Operating Procedure

The operator is solely responsible for ensuring that the container is handled in a safe and responsible manner. The operator shall check all local, state, and city fire codes before attempting the work described below.

The container is not to be transported (except if cylinders are empty) or filled if there is any damage found on the container or cylinders.

Never attempt to connect or disconnect a line that is pressurized.

It is the Owner and User's responsibility to ensure the Titan™ systems are being filled with "clean gas". The term "clean gas" used in this manual refers to the gas particulate size range of 3 to 10 microns. Hexagon Lincoln is not responsible for any failures of any components of the module if this "clean gas" specification is not met.

Any valve used on the Titan™ should not be throttled in any way. The throttling of a valve in this manual is defined as change of position of valve stem during gas flow. This can result in erosion of the valve seats and seals. It is the Owner and User's responsibility to ensure throttling of valves is not occurring with their modules. Hexagon Lincoln is not responsible for any failures of any valves on the Titan™ module if a valve shows signs of throttling.

9.1 Filling Procedure

For filling multiple or single cylinders, follow the below instructions:

Filling or unloading a single cylinder must be done carefully. Opening the valves between differently pressured cylinders may cause the liner to fail if liquid natural gas is formed.

1. Obtain and complete a "Filling Checklist" (see Appendix A) while following steps 2 through 13. Keep checklist for records.

2. Position container for filling procedure ensuring that the container remains stationary (e.g. chock vehicle tires, set vehicle brake, engine off, etc.) and that the vent lines are not obstructed (e.g. sheds, coverings, etc.).

This system does not have a break-away connection. Owner is responsible for break-away connection on hose.

During a venting of the cargo, the natural gas must not be allowed to accumulate. The container must not be filled under a structure of any kind where gas is allowed to accumulate. Containers must be filled in an open air environment.

3. Open doors at rear of container to view thermometer in lower left tank.
4. Connect grounding source to grounding lug as shown in Figure 5 to prevent potential static ignition.

Figure 5: Grounding Lug

5. Verify that manifold valves are in their "closed" position as shown in Figure 6.
6. Open the bleed valve shown in Figure 6.

Manifold valves should always be in "closed" position except during filling or un-loading.

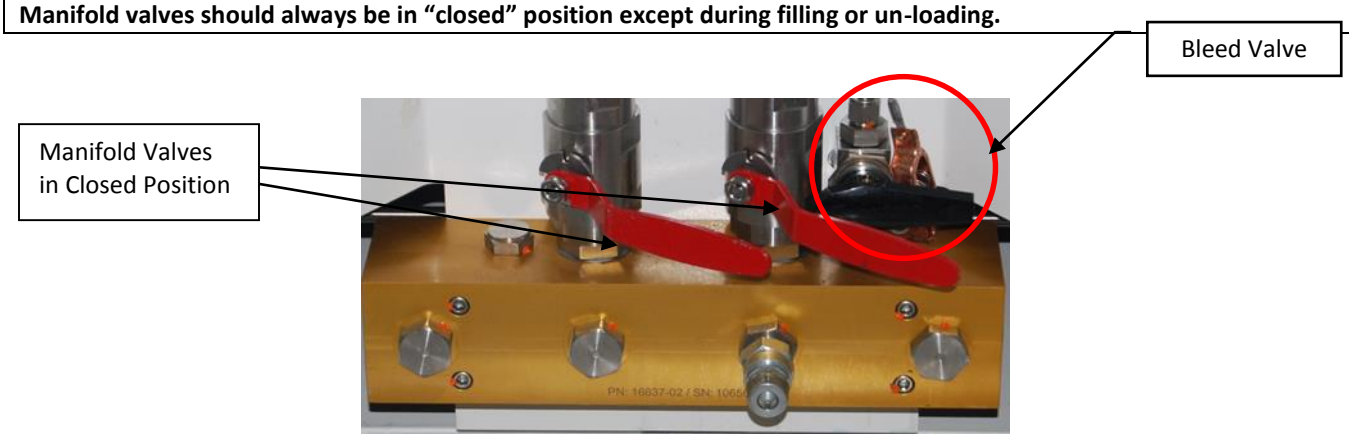


Figure 6: Manifold Valves Shown in "Closed" Position

7. Connect the station's fill line to the container's fill line. Refer to Figure 7.

Note: The container may not be shipped with a quick connector. The owner must supply a quick connector that is compatible with the system and shall connect it in accordance with their procedure. The manifold is equipped with four 1 5/16-12 SAE ports to adapt to quick connectors.

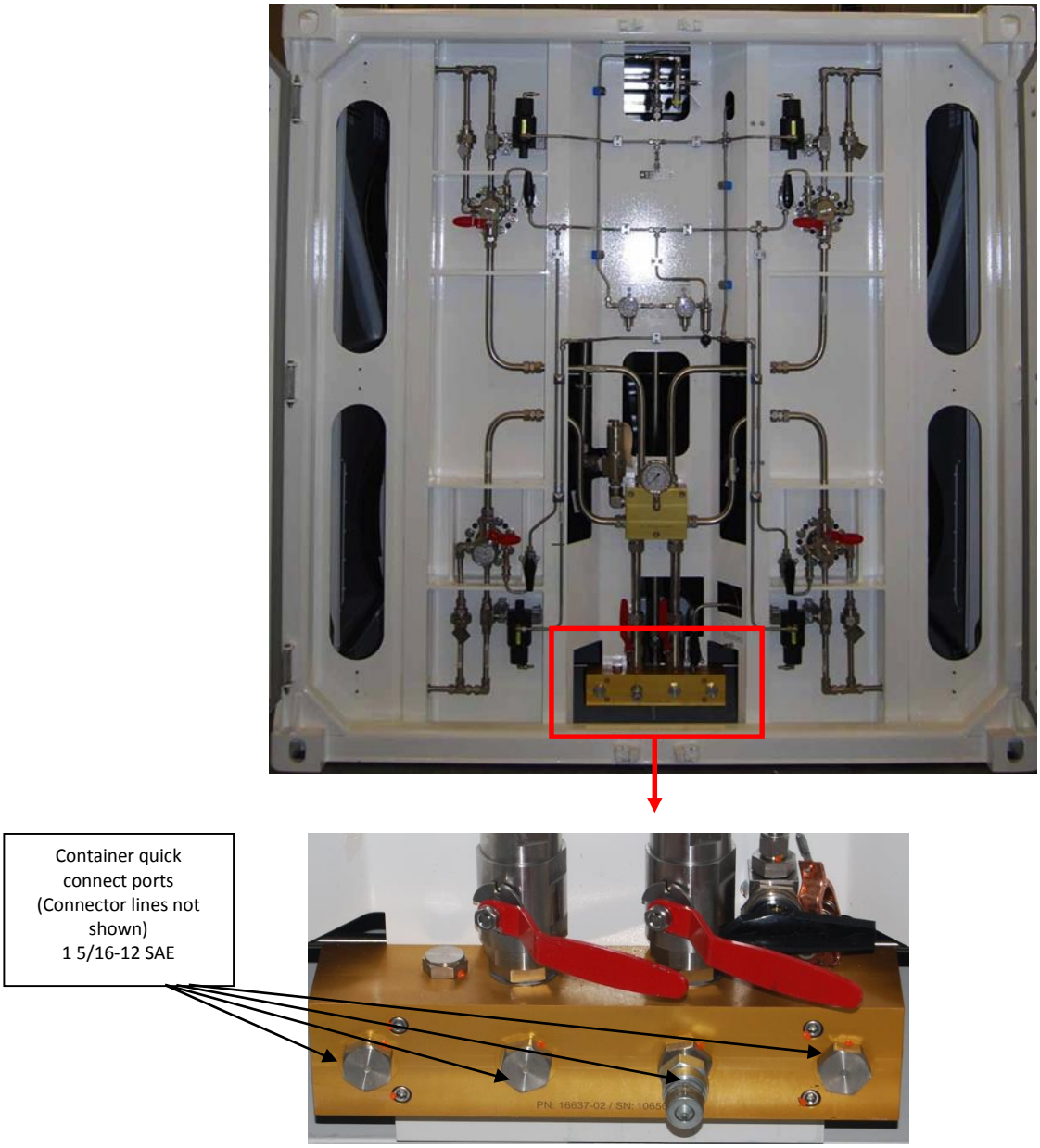


Figure 7: Container Fill Line

8. Close bleed valve.
9. Once the connection is secure, open the manifold valves shown in Figure 8.

Do not open the valve of a cylinder that has a pressure of less than 7 barg (100 psig) while another cylinder (high pressure) valve is open and when temperatures are below -12°C (10°F). This can cause liquid natural gas to form which can damage the liner of the cylinder.

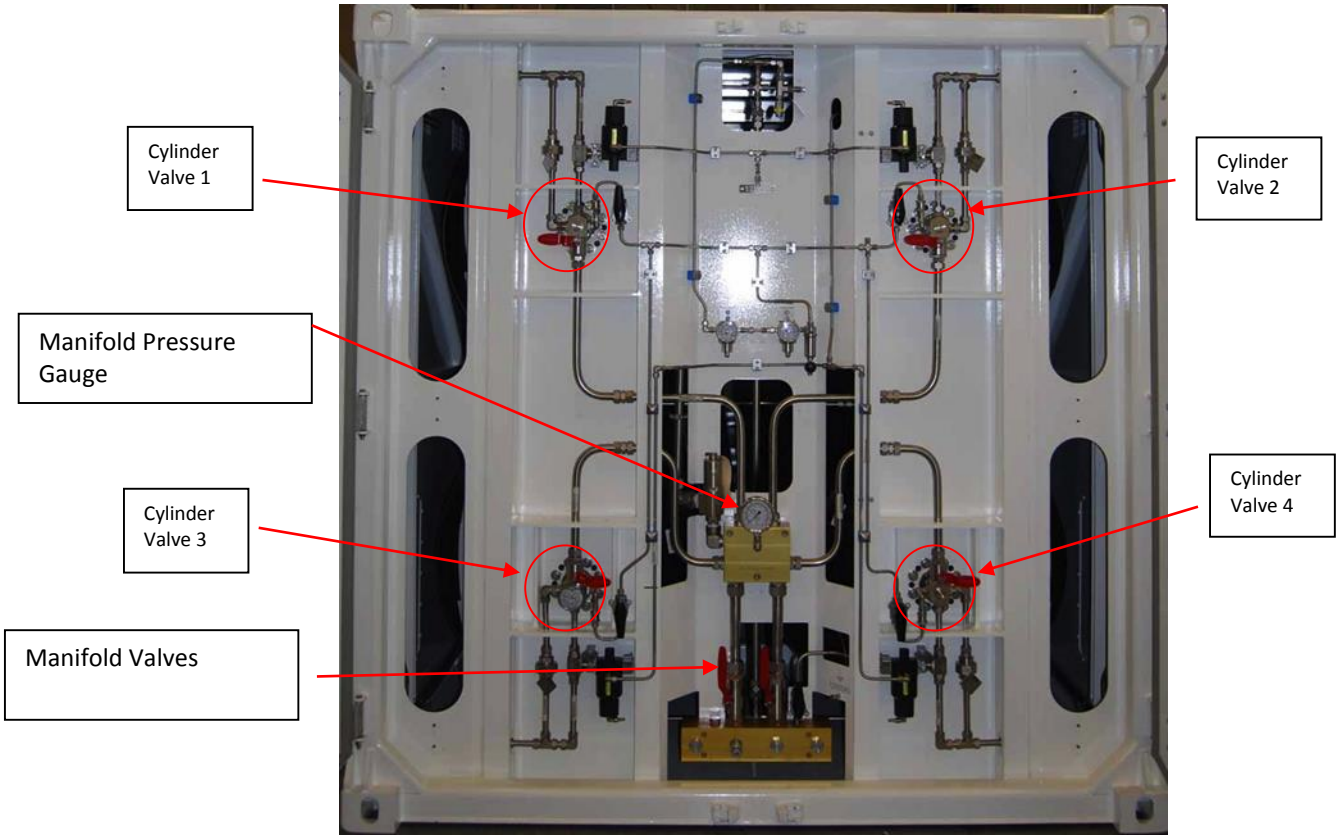


Figure 8: Cylinder Valves in "Open" Position

10. Open the cylinder valves (shown in Figure 8). The pressure in the distribution manifold can be read by the pressure gauge as shown in Figure 8.

11. Begin filling the cylinder(s) in accordance with the station's operation and safety procedures.

Filling composite cylinders of this size will generate noises that are normal. During filling, the liner will push out trapped gas between the liner and composite. This may appear as bubbles coming through the composite, but will stop after all trapped gas is evacuated. The process of removing the gas may take several hours to days depending on the amount of trapped gas. As the tank slides in the bearing it will make noise as well.

If there is any leak in the plumbing during filling, immediately close all tank valves and discontinue the filling procedure. Vent the system plumbing and repair the leak. If leak cannot be repaired contact Hexagon Lincoln technical service.

12. Continue filling the cylinder(s) until the pressure indicated by the manifold pressure gauge reaches the desired pressure. Do not exceed the maximum fill pressure/temperature combinations as shown in Figure 9.
Figure 9 may also be used when performing temperature compensated fills. For example, when filling to 276 barg (4000 psig) and approximately 60 °C (140 °F) as shown by the red circle in Figure 9 this will result in a 90% fill.

Danger

Do not exceed a tank temperature of 82.2 °C (180 °F).

Do not fill cylinders over the maximum pressure specified in Section 7.2. Failure to comply may lead to personal injury/death/property damage.

The pressure gauge is not designed for vacuum pressure and will not properly indicate vacuum conditions.

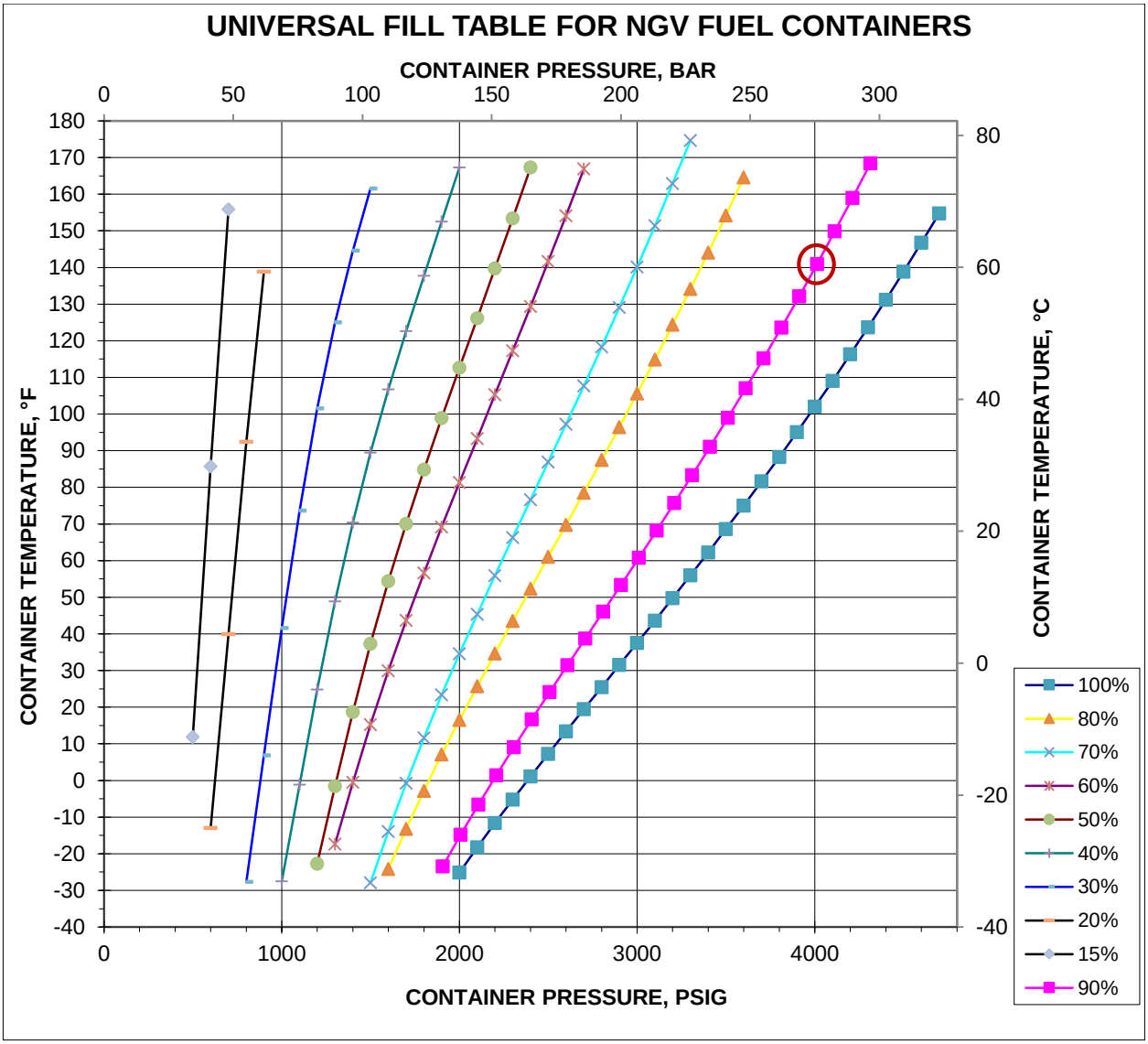


Figure 9: Percent Fill as a Function of Temperature and Pressure (SG = 0.58)

13. Once the appropriate pressure is obtained, then follow the station procedures for shutting off flow.

    If required by authority having jurisdiction, close the tanks valves and manifold valves otherwise just close manifold. Next, vent the manifold by opening the bleed valve as shown in Figure 10. Finally, disconnect the station's fill line.
14. Close the bleed valve.

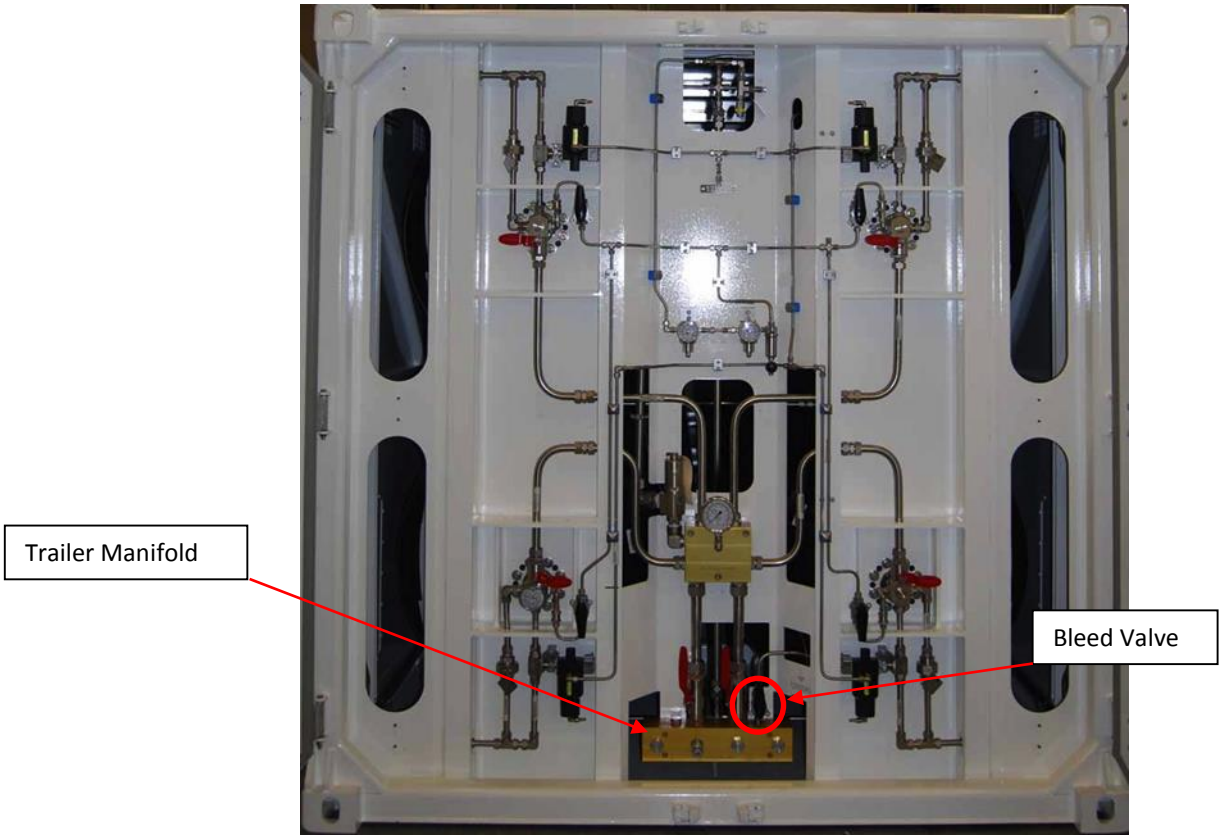


Figure 10: Bleed Valve in "Open" Position

9.1.1 Fill & Unloading Restrictions

A cylinder may only be filled when:

a. The ambient temperature is greater than -12°C (10°F), or
b. The cylinder is in service with a residual internal pressure greater than or equal to 7 barg (100 psig), or
c. The cylinder has been conditioned at a temperature above 16°C (60°F) for at least 8 hours after exposure to ambient temperatures below -12°C (10°F) with less than 7 barg (100 psig) internal pressure.

The gas density of the cylinders must not exceed the allowable density at 250 barg (3626 psig) and 15 °C (59 °F). Thus if the ambient temperature is -40 °C (-40 °F) the tanks may not be filled above 133 barg (1928 psig). At these conditions the gas may not be unloaded to less than 50 barg (725 psig) to avoid the formation of liquid methane in the cylinders and decompression system.

Cylinders starting at less than 7 barg (100 psig) internal pressure and an ambient temperature of -12°C (10°F) or less and have not been conditioned as described above should use the cold fill procedure described below. This condition could occur when first received, after maintenance work is performed, or if the cylinders have been emptied below 7 barg (100 psig).

Work Required For Cold Fill Procedure

1. Fill to 31 ± 3 barg (450 ± 50 psig) directly from a compressor (not from a cascade system).
2. Wait at least 1 hour.
3. Proceed with filling.

For ambient temperatures below -40 °C (-40 °F) please refer to Hexagon Lincoln Service Bulletin SB 14-01-001.

Do not allow a vacuum to form in the cylinders at any time. Should a vacuum occur in the cylinder, the cylinder should be opened to atmosphere and conditioned at a temperature of approximately 16°C (60°F) for 8 hours.

9.1.2 Fill Chart

The fill chart shown in Figure 9 gives the maximum pressure that each cylinder is to be filled at for certain natural gas temperatures.

If the internal gas temperature is between temperatures on the chart, always take the lower value.

Many compressor stations are not capable of achieving a full fill because of the high gas temperatures and limited upper pressure of 250 barg (3600 psig). In many cases a compressed gas cooling system must be installed to achieve a full fill. This may result in a multi-stage filling process to achieve the full fill of the module. Refer to Figure 9 to determine the level of fill that will be achieved.

The gas temperature must not exceed 65 °C (149°F) at any time unless operational procedures of the fill station are discussed with Hexagon Lincoln engineering.

9.1.3 In Case of Emergency

In case of emergency at fill station, follow the station's emergency procedure for flammable gases in accordance with the authority having jurisdiction.

9.2 Unloading Procedure

The cylinders are not designed for vacuum service. Once the cylinders have been filled, they should never be emptied below 7 barg (100 psig) of pressure. The reason for this residual pressure is to ensure the stability of the liner. If the cylinders are emptied below a pressure of 7 barg (100 psig) and the temperature is less than -12°C (10°F) then follow the Cold Fill procedure in section 9.1.1.

For unloading the contents of the containers, follow the instructions below:

1. Obtain and complete a copy of the "Unloading Checklist" (see Appendix C) while following steps 2 through 14. Keep for records.

2. Position container for unloading procedure ensuring that the container remains stationary (e.g. chock vehicle tires, set vehicle brake, engine off, etc.) and that the vent lines are not obstructed by any infrastructure (e.g. sheds, coverings, etc.).

This system is not supplied with a break-away connection. Owner is responsible for break-away connection on hose.

3. During venting of the cargo, the natural gas must not be allowed to accumulate. The container must not be under a structure of any kind.

4. Open doors.

5. Connect grounding source to grounding lug shown in Figure 5 to prevent static ignition.

6. Open the bleed valve as shown in Figure 10.

The manifold valves should always be in "closed" position except during filling or unloading.

7. Connect the unloading line to the container's quick connector. Note: This container is shipped without a connector. The owner must supply a connector and should connect it in accordance with their procedure.

Note: The port used for unloading may be the same as the containers fill port as shown in Figure 7.

8. Close bleed valve.
9. Open manifold valves. Valve position is shown in Figure 11.
10. Open the cylinder valves as highlighted in Figure 8

Figure 11 - Manifold Valves in Open Position

Do not open the valve of a cylinder that has a pressure of less than 7 barg (100 psig) with another cylinder whose valve is open when temperatures are below -12°C (10°F). This can cause liquid natural gas to form which can damage the liner of the cylinder. If the pressure gage reads 0 psi when a tank valve is opened it should be assumed the pressure in the tank is 0. A tank with 0 pressure should be filled with a compressor.

11. Unload cylinders.

If a pump is used to unload cylinder(s), ensure that the pressure in the cylinder(s) does not fall below 7 barg (100 psig). This will prevent the tank(s) from experiencing any vacuum, which would destabilize the liner. If the pressure does fall below 7 barg (100 psig) and the temperature is below -12°C (+10°F), then follow the Cold Fill Procedure in Section 9.1.1.

Allow the cylinders to depressurize to a pressure of 7 barg (100 psig) or above. If the pressure falls below 7 barg (100 psig) and the temperature is below -12°C (+10°F), then follow the Cold Fill procedure in Section 9.1.1.

If the cylinders are unloaded to a pressure below 7 barg (100 psig) and the temperature is below -12°C (+10°F), then follow the Cold Fill procedure in Section 9.1.1.

12. Close the cylinder(s) valve(s).
13. Once the cylinder valves have been closed, shut off the discharge system. Relieve pressure in the unloading manifold by opening and then closing the bleed valve.
14. Follow the stations procedures for disconnecting the discharge line.

The pressure gauge is not designed for vacuum pressure and will not properly indicate vacuum conditions.

15. Close the manifold valves.

The plumbing between the cylinder valves and the manifold valves are always to be depressurized unless the authority having jurisdiction allows manifolds to be pressurized during transportation. Follow steps 11 and 12 above to vent the plumbing.

16. Ensure that the vent valve is in the closed position.
17. Remove the ground strap.
18. Close doors.

In Case of Emergency

In case of emergency at pressure reduction station, follow the station's emergency procedure for flammable gases.

9.3 Container Transport

9.3.1 Transport Checklist

Before transporting the container a "Transportation Checklist" sheet shall be completed and kept. Do not transport the container without completing a "Transportation Checklist" (See 0).

9.3.2 Approved Routes

The owner/operator is responsible to obtain pre-approved routes of transportation that adhere to local regulatory requirements for the transporting of hazardous materials. This includes meeting the clearance requirement (see next paragraph). The owner/operator is also responsible for ensuring these pre-approved routes are followed. The owner/operator is liable for any damage/injury/death/incident caused by the container because of a failure to meet the proper requirements.

Due to the dimensions of the container, the route of transportation must meet a minimum clearance requirement depending on the configuration of the container and vehicle. The container height is 8.0 ft (2.44 meters) as specified by ISO 668. The total height of the setup is to be determined by the owner/operator. It is the responsibility of the owner/operator to find out from the authority having jurisdiction what minimum clearance is acceptable.

Pay special attention to requirements regarding the transport of hazardous materials in tunnels and the parking of hazardous materials in populated areas.

9.3.3 Inspection

A visual inspection for damage is to be made before and after each trip. This inspection is on all surfaces of the ISO container including the top and bottom. If any damage is found, refer to Section 13.

The container is not to be transported (except if cylinders are empty) if there is any damage found during this inspection.

All valves must be closed before transporting the container unless the authority having jurisdiction allows manifolds to be pressurized during transportation.

9.3.4 In Case of Emergency

Call the Emergency Response Telephone Number on the Shipping Paper first. If the Shipping Paper is not available or there is no answer, refer to the appropriate telephone number listed in Section 15 or by the authority having jurisdiction.

10 Emergency Shut Off System (If Equipped)

The purpose of this system is to remotely shut off the flow of gas at the rear of the module in case of fire at the rear of the module, or in case of a line break or disconnection at the rear of the module. This system is designed to be used in case of an emergency only. The shut off system is shown in Figure 12 below.

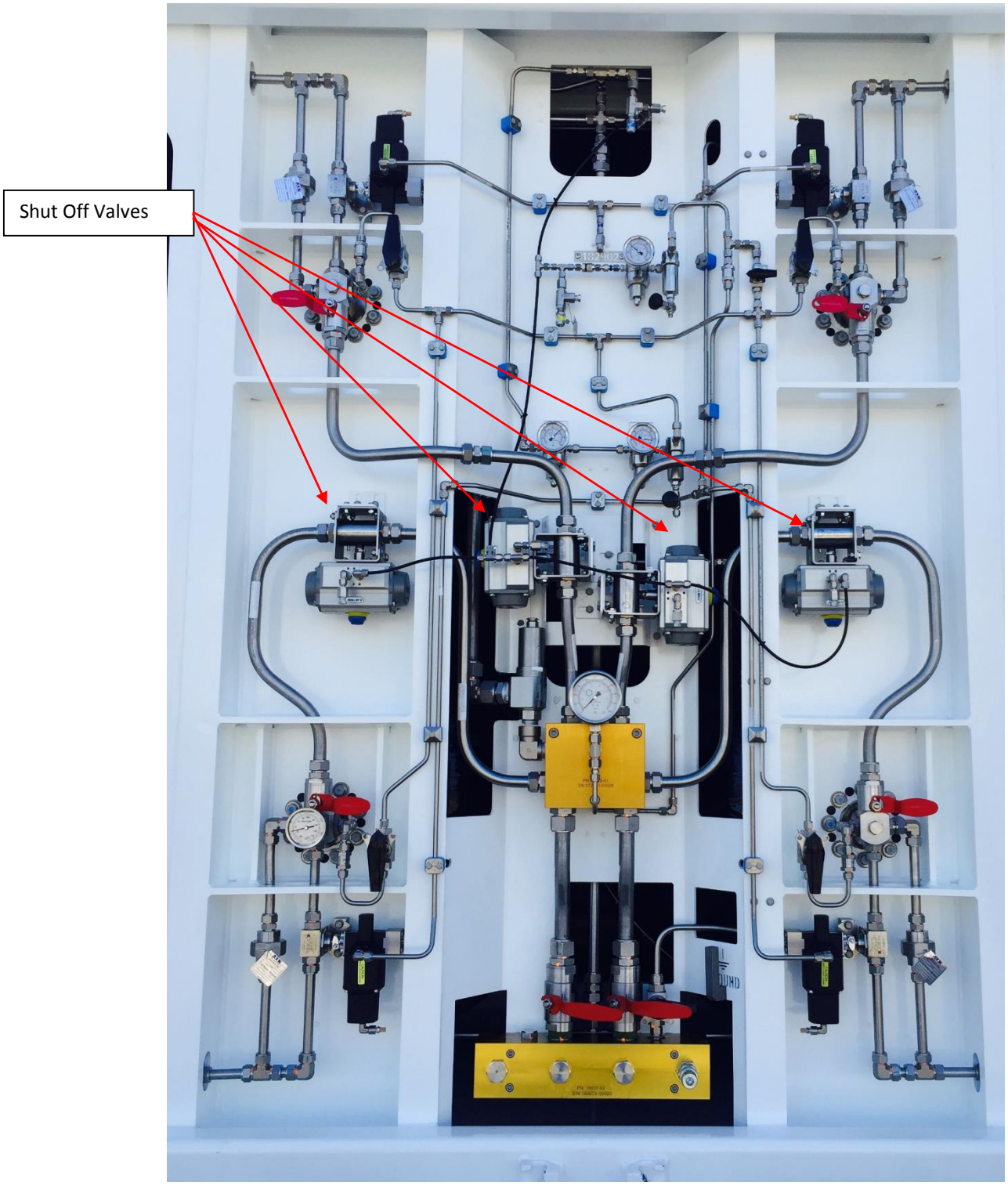


Figure 12 - Emergency Shut Off System Installed on Normally Closed Module

If there is an emergency where the Shut-Off System should be used, the shut off valve on either side of the module can be moved to the "Flow Off" position to remotely stop the flow of gas at the rear of the trailer. It will take a few seconds for the valves to actuate closed.

The shut off valves are located on both sides towards the front of the module shown in Figure 13.

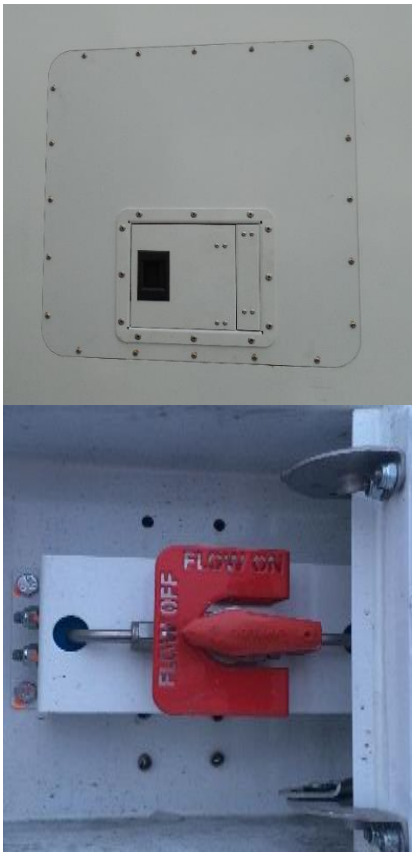


Figure 13: Valve Shown in "Flow Off" Position

When the emergency has been corrected, the valves may be re-opened by closing the valve(s) at the front of the trailer as shown in Figure 14. This will open the pneumatic valves at the rear of the trailer and allow flow in and out of the tanks.

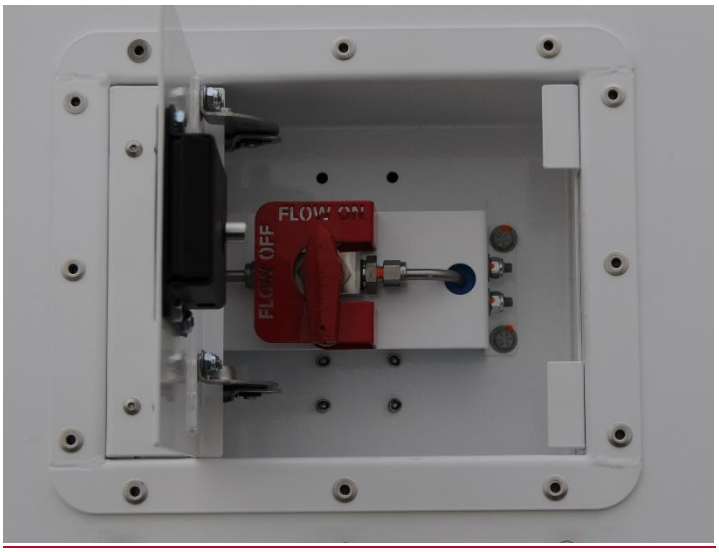


Figure 14 - Valve shown in "Flow On" Position

10.1 Filling Procedure (If equipped with Emergency Shut Off System)

For filling multiple or single cylinders, follow the below instructions:

Filling or unloading a single cylinder must be done carefully. Opening the valves between differently pressured cylinders may cause the liner to fail if liquid natural gas is formed.

1. Obtain and complete a "Filling Checklist" (see Appendix A) while following steps 1 through 24. Keep checklist for records.

2. Position container for filling procedure ensuring that the container remains stationary (e.g. chock vehicle tires, set vehicle brake, engine off, etc.) and that the vent lines are not obstructed (e.g. sheds, coverings, etc.).

This system may have a break interlock system to protect unit and station against damage (shown in Figure 8)

During a venting of the cargo, the natural gas must not be allowed to accumulate. The container must not be filled under a structure of any kind where gas is allowed to accumulate. Containers must be filled in an open air environment.

3. Open doors at rear of container to view thermometer in lower left tank.
4. Connect grounding source to grounding lug shown in Figure 15 to prevent potential static ignition.

Figure 15: Grounding Lug

5. Verify that manifold valves are in their "closed" position as shown in Figure 15.
6. Open the bleed valve as shown in Figure 16. This is to ensure there is no pressure in the manifold before connecting fill lines

Manifold valves should always be in "closed" position except during filling or un-loading.

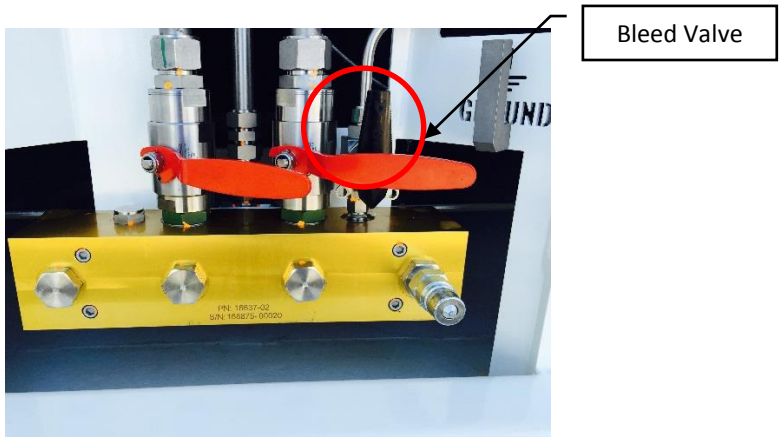


Figure 16: Bleed Valves shown "Open"

7. Connect the station's fill line to the container's quick connect(s) Refer to Figure 17.

Note: The container may not be shipped with a quick connector. The owner must supply a quick connector that is compatible with the system and shall connect it in accordance with their procedure. The manifold is equipped with four 1 5/16-12 SAE ports to adapt to quick connectors.

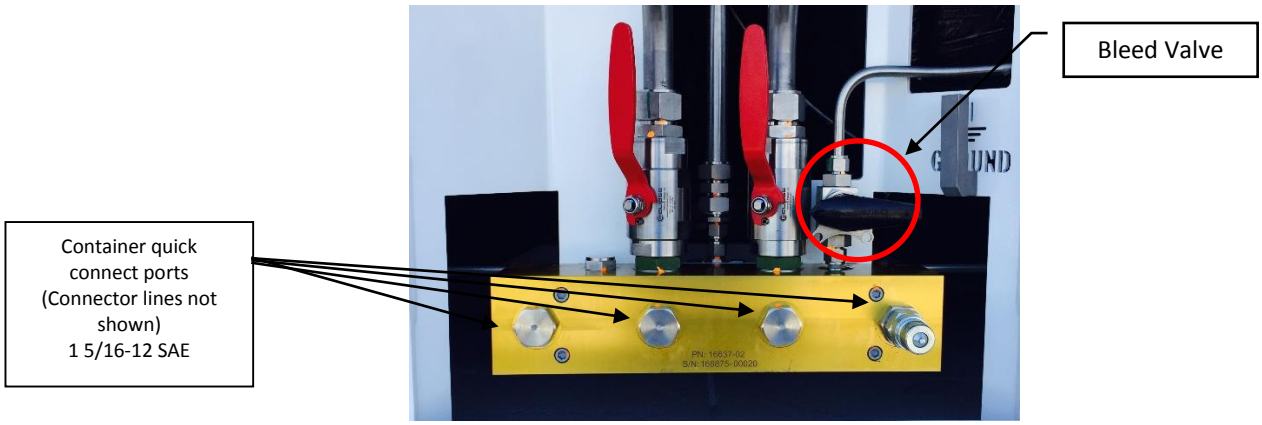


Figure 17: Connector ports and quick connect

8. Close bleed valve shown in Figure 17.
9. Be sure all Shut-Off Valves on the front of the module are in the "closed" (Flow On) position shown in Figure 19.
10. Open Manifold Valves completely instead of "throttling" the valves shown in Figure 17.

Do not open the valve of a cylinder that has a pressure of less than 7 barg (100 psig) while another cylinder (high pressure) valve is open and when temperatures are below -12°C (10°F). This can cause liquid natural gas to form which can damage the liner of the cylinder.

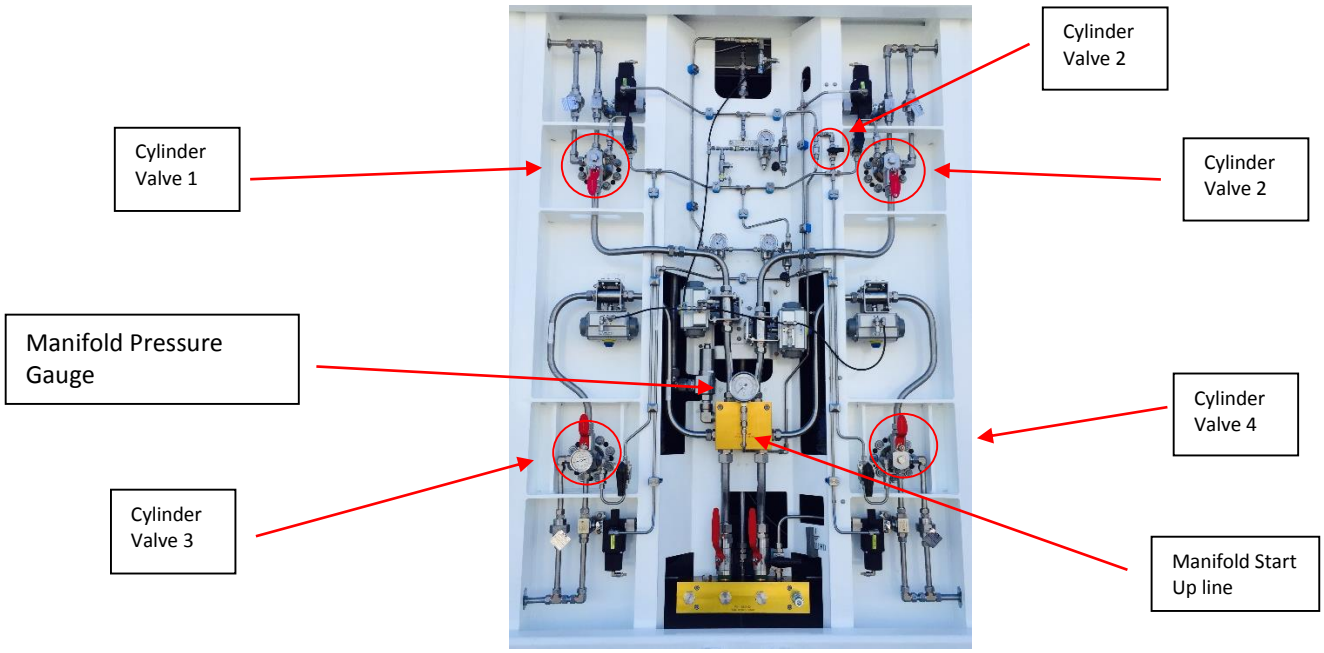


Figure 18: Cylinder Valves in "Open" Position

11. Begin charging the manifold in accordance with the station's operation and safety procedures, this will feed the Shut-Off system start up pressure and actuate the valves.
12. Open the cylinder valves shown in Figure 18. This will begin filling the cylinder(s).
13. Open constant feed ¼ turn valve while filling cylinder(s). This will need to be left open at all times.
14. Continue filling the cylinder(s) until the pressure indicated by the manifold pressure gauge reaches the desired pressure. Do not exceed the maximum fill pressure/temperature combinations as shown in Figure 9.
    Figure 9 may also be used when performing temperature compensated fills. For example, when filling to 276 barg (4000 psig) and approximately 60 °C (140 °F) this will result in a 90% fill. See Figure 20.
15. Once the appropriate pressure is obtained, then follow the station procedures for shutting off flow.
16. Close tank valves.
17. Vent the manifold by opening the bleed valve as shown in Figure 21.
18. Disconnect the station's fill line.
19. Close Manifold Valves.
20. Close the bleed valve.
21. Disconnect ground

Filling composite cylinders of this size will generate noises that are normal. During filling, the liner will push out trapped gas between the liner and composite. This may appear as bubbles coming through the composite, but will stop after all trapped gas is evacuated. The process of removing the gas may take several hours to days depending on the amount of trapped gas. As the tank slides in the bearing it will make noise as well.

If there is any leak in the plumbing during filling, immediately close all tank valves and discontinue the filling procedure. Vent the system plumbing and repair the leak. If leak cannot be repaired contact Hexagon Lincoln technical service.

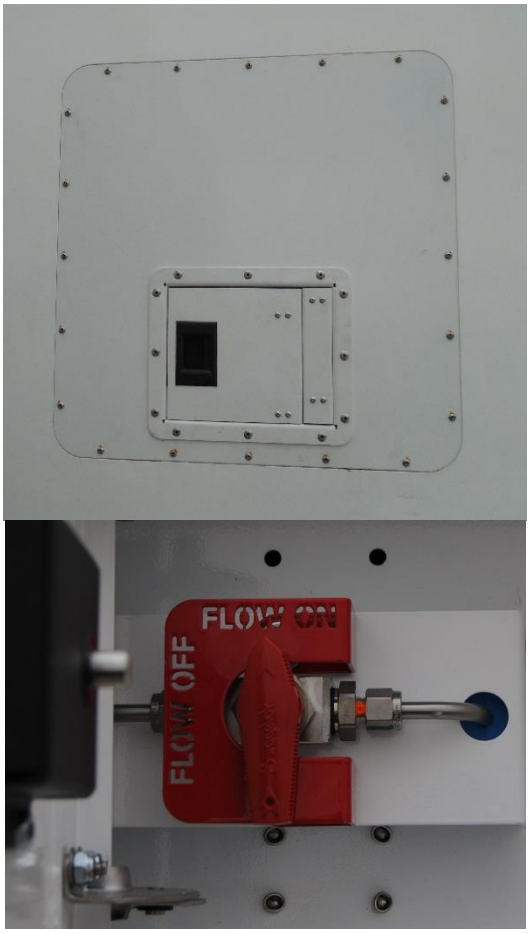


Figure 19: Shut-Off Valve "Closed" (Flow On) Position

Danger

Do not exceed a tank temperature of 82.2 °C (180 °F).

Do not fill cylinders over the maximum pressure specified in Section 7.2. Failure to comply may lead to personal injury/death/property damage.

The pressure gauge is not designed for vacuum pressure and will not properly indicate vacuum conditions.

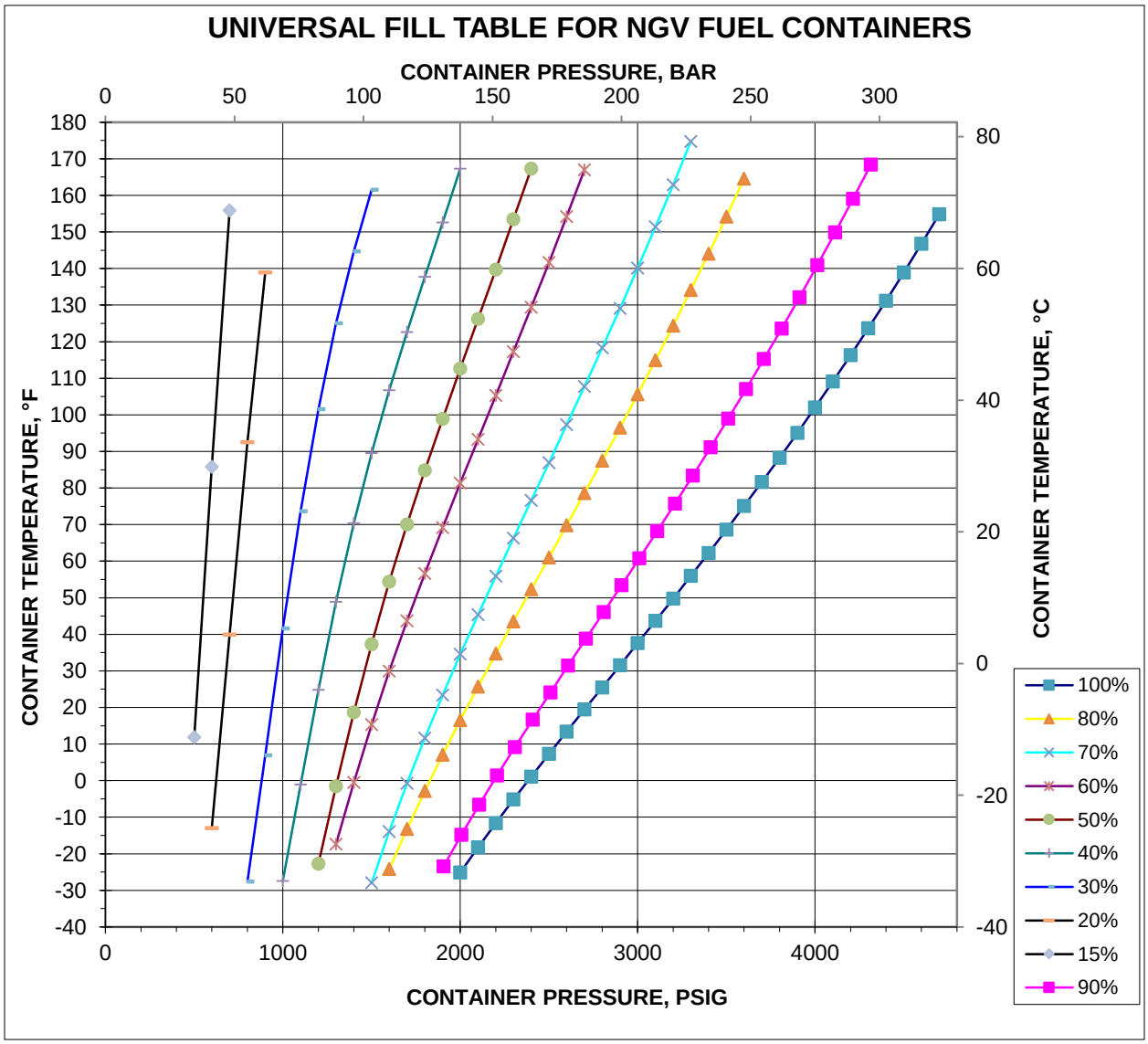


Figure 20: Percent Fill as a Function of Temperature and Pressure (SG = 0.58)

Figure 21: Bleed Valve in "Open" Position

11 Gas Venting System

A pressure relief device (PRD) is used to vent the contents of the vessels in case of fire. This particular PRD system is ***thermally activated*** and consists of 4 temperature-sensitive trigger lines that run the length of the container. The 240167-0001 and 240167-0002 configurations use an Emcara shape memory wire that is activated at 108 °C (226 °F).

The system is constantly feed with CNG and regulated at 12.4 barg (180 psig). The system is designed such that in the event of a fire, the trigger lines will activate and release pressure in the gas venting system, activating the four gas venting valves and vent the entire contents of the module. The contents of all four cylinders will vent once any one of the four lines is triggered. Venting the contents of all the cylinders may take up to 45 minutes.

The system is also designed to constantly provide supply gas and to not inadvertently vent the tank contents unless the module is in a fire. This is a normally closed system meaning the pneumatic actuated valves are normally closed and will not actuate until gas is supplied to them from the Emcara triggers.

Do not attempt to pressurize the cylinders if they are venting.

11.1 Inspection of Gas Venting System

The Gas Venting System should be inspected at every 36 months, or when maintenance is performed on the gas venting system, or if the container is involved in an accident. The inspection should include a detailed visual examination of all components that encompass the gas venting system as well as a leak test of the pressurized components. Perform the following:

1. Inspect the PRD trigger line for indications of damage. Note that these are only visible at the ends of the container. Inspect the end connections of all four trigger lines as shown in **Error! Reference source not found. Error! Reference source not found.**.

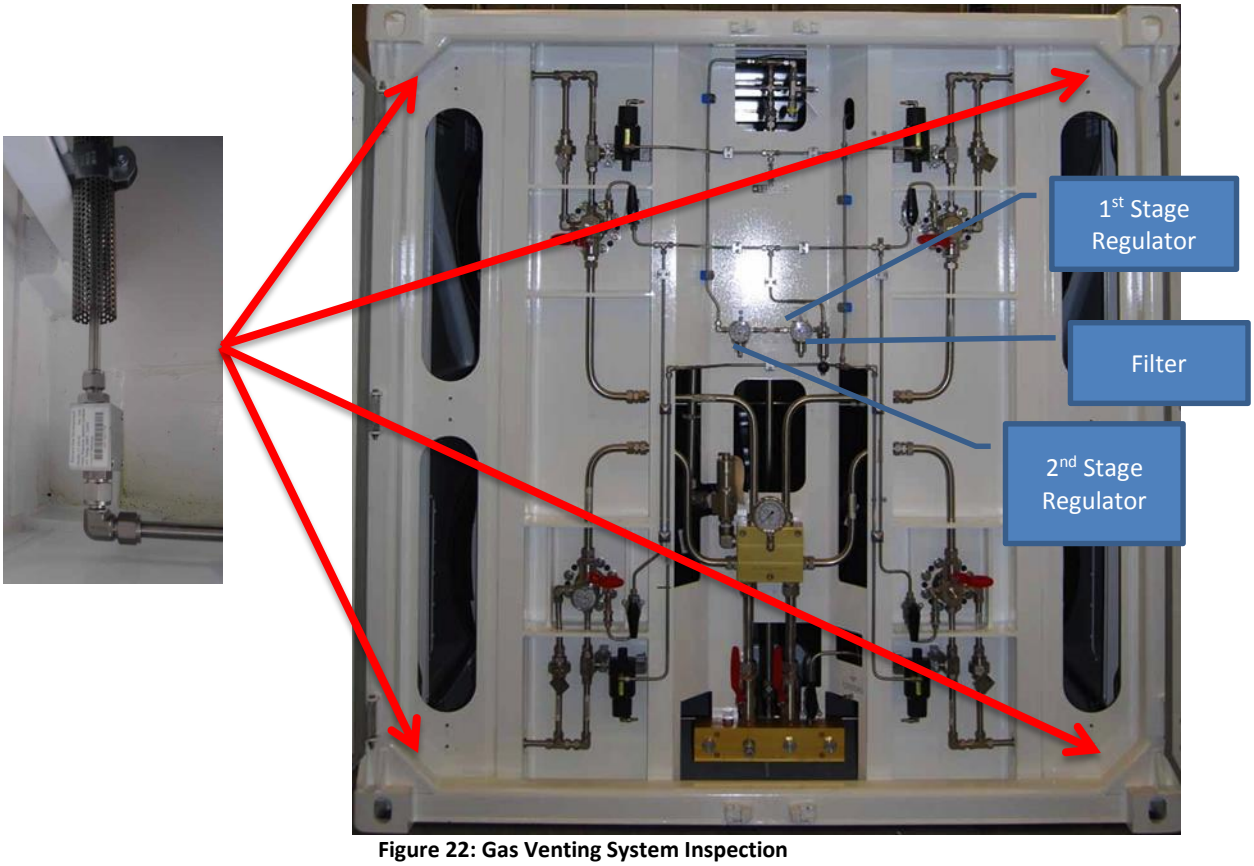


Figure 22: Gas Venting System Inspection

2. Ensure that the first stage regulator is set between 16.5 to 17.9 barg (240 to 260 psig) with an inlet pressure of 250 barg (3626 psig) minimum
3. Ensure that the second stage regulator is set between 12.8 to 13.4 barg (185 to 195 psig) with the first stage as set in step 1.
4. Use liquid leak detector and check plumbing for leaks.
5. Repair leaks as necessary.
6. Check the vent lines to make sure they are free from debris and the vent caps have o-rings to prevent water into to the vent lines.
7. Check the filter
    a. Close ¼ turn supply valves connected to tank valves
    b. Open bleed valve on bottom of filter and drain system
    c. Remove filter housing
    d. Inspect filter cartridge. If wet or replacement is necessary contact Hexagon Lincoln for PN 16977-04. **Suggested replacement interval is 6 months but is dependent on the gas water content and possible methanol addition to gas to prevent hydrate formation in cold winter months.** Maintenance

12 Required Maintenance

DOT and TC approved modules (PN 240167-0001) require hydrostatic proof testing of the TITAN tanks. Modules must be tested by Hexagon Lincoln for testing prior to 5 and 10 years of service. After 15 years the modules must be replaced. ABS approved modules (PN 240167-0002) require a visual examination at 30 months of the tanks and the outer structure. The inspection procedure is outlined in Hexagon Lincoln Service Bulletin SB 10-01-002. Module inspection may be documented in Hexagon Lincoln Service Bulleting SB 14-11-001. Recommended maintenance is documented in Hexagon Lincoln Service Bulleting SB 15-03-001.

12.1 Preventative Maintenance

12.1.1 At 6 month intervals check the tank mount bolt torque as specified in Hexagon Lincoln Service Bulleting SB 11-04-001.

12.1.2 Replace filter in gas venting system per section 10.

12.1.3 Vent Lines

The vent lines have spring-loaded pressure relief caps to prevent moisture and debris from contaminating the valves. A visual inspection of these caps should be performed during periodic maintenance to ensure they are closed and no debris is present in the line. If the pressure relief system is ever energized while there is pressure in the tanks it will blow off the o-ring under each cap and they must be replaced to prevent leakage. The location of the vent caps is shown in **Error! Reference source not found.** and a more detailed image is shown in Figure 24.

Note: Pressure in the lines may cause the o-rings on the vent caps to be damaged or lost and they must be replaced because they can no longer form a seal and keep water from entering the vent lines. Contact Hexagon Lincoln for replacement o-rings.

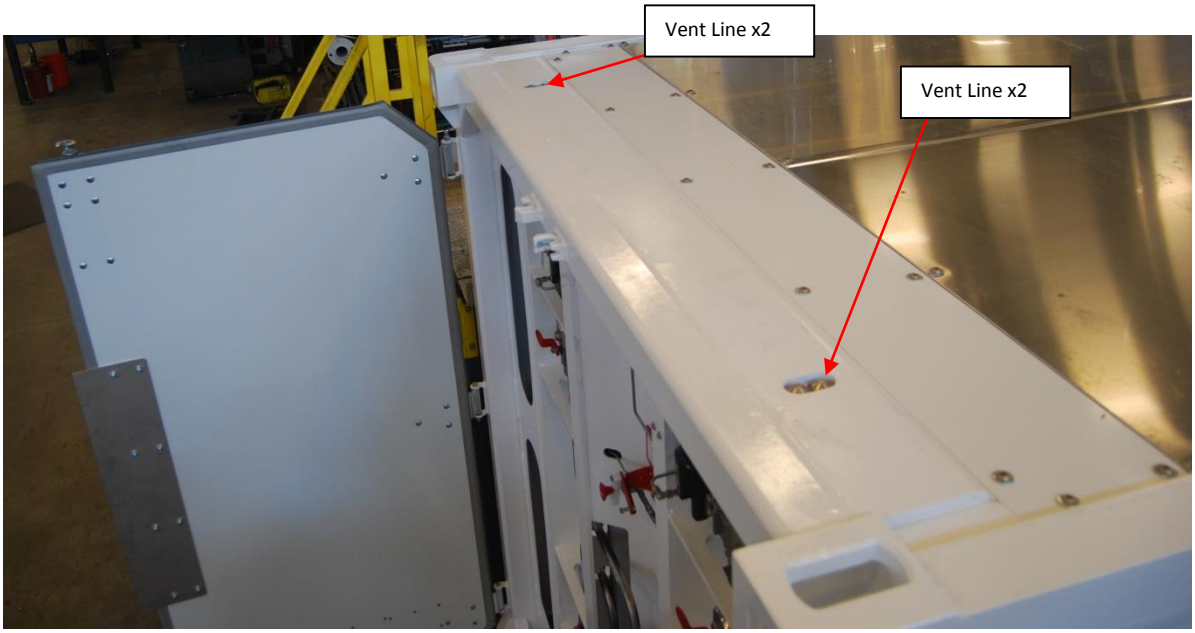


Figure 23: Location of Vent Lines

Note: Failure to replace the o-rings may result in water in the vent lines which will freeze and damage the lines in cold environments.

Figure 24: Vent Line Caps - PN 16826-12

12.1.4 Tank Draining

Over time moisture and compressor oil may accumulate in the tanks. The tanks are equipped with drain tubes that are in contact with the bottom of the tank at the front of the module. The outlet of these tubes have a needle valve as shown in Figure 25.

To drain the water out of the tanks perform the following procedure:

1. Lower the front of the trailer at least 25.4 mm (1") lower than the rear of the trailer to direct the water towards the front.
2. Close the needle valve by turning it clockwise as faced from above the handle.
3. Remove the cap on the needle valve using a 9/16" wrench.
4. Slowly open the needle valve. Note that pressure in the tanks will push water through the needle valve.
5. Allow water to drain. Note that both water and natural gas will drain simultaneously. As the water content decreases only natural gas will vent. When this occurs, close the needle valve.
6. Install the cap on the needle valve.

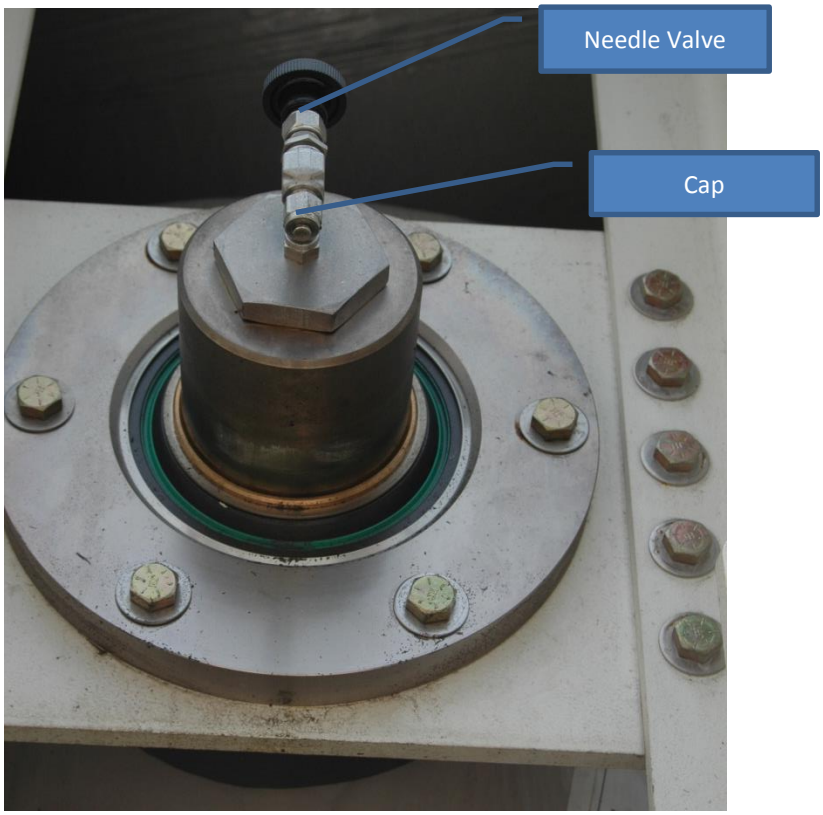


Figure 25 - Titan Tank Water Drain Valve

12.2 Replacing Plumbing Components

Many of the components can be replaced if necessary. For tubing or valve replacement, the owner must contact Hexagon Lincoln technical service.

Before replacing any plumbing component of the container, be sure that all lines or components to be replaced are depressurized. This must be done to protect the safety of the individual replacing the component.

Do not replace any pressure component while pressurized.

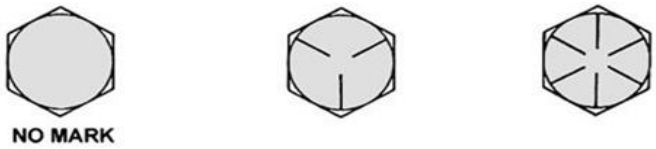
When replacing any components in the gas venting system, be sure to close the ¼ turn valves connected to the tank valves. Drain all system pressure by using the drain valve at the bottom of the filter.

12.3 Replacing Fasteners

If replacing fasteners, tighten to specified torque as shown in Table 3.

Table 3: Recommended Torque Values for Fasteners

Torque Table (ft*lbs)



Bolt Size	Grade 2	Grade 5	Grade 8
1/4-20	-	6 ± 2	6 ± 2
5/16-18	-	17 ± 2	25 ± 5
3/8-16	-	31 ± 5	44 ± 5
1/2-13	-	75 ± 5	106 ± 10
1/2-20	-	85 ± 5	120 ± 10
5/8-11	-	150 ± 10	212 ± 10
SHCS 3/8-24	-	-	49 ± 5
SHCS 3/8-16	-	-	44 ± 5
SHCS 1/2-13	-	-	106 ± 10
HH M5 X 0.8	-	6 ± 2	-
HH 10-32	6 ± 2	-	-

SAE Fittings

Fitting	Torque	Example Fittings
9/16-18	25± 5	Tube -SAE (16067-23)
3/4-16	40± 5	Tube - SAE (16067-34)
7/8-14	50± 5	Tube - SAE (16067-65)
1 1/16-12	100± 10	Tube - SAE (16067-66)
1 1/8-12	110± 10	450 L Tank Valve
1 3/16-12	120± 10	Thermowell Titan IV, Titan V
1 5/16-12	130± 10	Tube to SAE (16070-9C)
1 7/8-12	200± 10	SAE Plug (16657-02),Tank adapter
2-12	210± 10	NGV Tank Valve/Plug

Special

PN	Bolt Size	Torque Value
16008-4	1/2-13 (Cross Beam)	40 ± 5
16706-16, 174905-01	Valve Tank Head	250 ± 10
16007-5	5/8 U-Bolt (grade 2)	55 ± 5
16622-02, 16559-01	Strap pipe	6 ± 2
16671-01	clamp grounding	6 ± 2
16636-04	1/4 -20 (tamper screw- side panels)	6 ± 2
16026-8	½ - 20 x 2” grade 8	108± 10
16636-06	3/8- 16 (tamper screw- roof panels)	20 ± 2

13 Inspection

The side panels and cover are designed to provide protection to the cylinders and can be used as a way to identify damage that the container may have sustained. The side panels are permanently fastened to the frame. Inspection hatches are included to accommodate inspection requirements. The roof cover is removable and can be taken off using the four threaded lifting eye holes.

The TITAN™ side panels and covers protect the cylinders from weather, sunlight, tampering, service conditions, vandalism, and damage caused during transportation. They provide a way for the owner or user to visually check to see if any major damage has occurred. The side covers also protect the gas venting system. During a fire, the side covers shield the cylinders from direct exposure to the flame and radiant heat. This gives the gas venting system time to vent the contents of the cylinders before degradation of the cylinders occurs.

For criteria and procedures for tank inspection, follow Service Bulletin 10-01-002 (Hexagon Lincoln CNG Bulk Hauling TITAN™ Module Inspection Manual). Module inspection may be documented in Hexagon Lincoln Service Bulleting SB 14-11-001.

13.1 Module Inspection

Module (container) inspection is required after 60 months and then every 30 months thereafter. Tank and module inspections should be completed sequentially to match the inspection intervals. Additionally, a module inspection is required in any instance as defined in Service Bulletin 10-01-002 which requires a tank inspection. As with tank inspections, module inspections shall be completed by Hexagon Lincoln or personnel trained by Hexagon Lincoln. The module inspection shall include:

1. Inspection of welds
2. Inspection for rust
3. Inspection of fasteners
4. Inspection of the roof panels
5. Inspection of the doors
6. Inspection of the side access covers

13.2 Tank Inspection

13.2.1 DOT/ TC approved modules PN 240167-0001-xxx

DOT/ TC approved modules require testing of the tanks at maximum intervals of 5 years throughout their 15 year service life. The testing protocol is currently under development by Hexagon Lincoln. This service bulletin will be revised upon an approved test protocol. It is recommended that annual visual inspection is performed on the tanks and the module following the guidelines of SB 14-11-001.

13.2.2 ABS Approved Modules PN 240167-0002-xxx

ABS approved modules shall be inspected at maximum intervals of 30 months throughout their 20 year service life. This inspection shall include both the tanks and the module following the guidelines of SB 14-11-001. This inspection only requires a visual inspection of the tanks.

13.2.3 Damage Levels – Reference SB 14-11-001

Tanks involved in an accident must be returned to Hexagon Lincoln for evaluation. These tanks must be tested using Modal Acoustic Emissions (MAE). Only the Hexagon approved supplier may provide the MAE testing. If there are cuts and scratches on the tank surface from some other event, this may be evaluated using the levels shown in Table 4. Contact Hexagon Lincoln Technical Service to discuss these damage levels.

If the tanks were impacted resulting in composite delamination, the following steps should be taken:

1. Move the Module to a well-ventilated area
2. Remove covers, if applicable, and inspect for damage
3. Contact Hexagon Lincoln

Hexagon Lincoln Emergency 844-211-5339

Table 4 - Damage Levels

Damage Levels	Figures	Inches	Millimeters
Level 1	Level 1 Damage	Less than 0.020	Less than 0.52
Level 2a (Rework in the Field)	Level 2a Damage	0.021 - 0.070	0.53 - 1.78
Level 2b (Factory Inspection)	Level 2b Damage	0.071 -0.100	1.79 - 2.54
Level 3 (Condemn)	Level 3 Damage	Greater than 0.100	Greater than 2.54

14 Emergency Response Procedure

EMERGENCY RESPONSE

Hexagon Lincoln Emergency 844-211-5339

During the event of an emergency, the emergency response procedure of the authority having jurisdiction shall be carried out. The following emergency response procedure is from the Emergency Response Guide (ERG) 2008 Guide # 115. It is the owner's responsibility to find out what emergency response procedure is required of them by the authority having jurisdiction. In the case of an accident, a manual venting or a transfer of the cargo are options if the cylinders have not been damaged and there is no risk of further damage. To manually vent the cargo, use the following procedure:

1. Position container for unloading procedure ensuring that the container remains stationary (e.g. chock vehicle tires, set vehicle brake, engine off, etc.) and that the vent lines are not obstructed by any infrastructure (e.g. sheds, coverings, etc.).

2. During venting of the cargo, the natural gas must not be allowed to accumulate. The container must not be under a structure of any kind.

3. Open doors.

4. Connect grounding source to grounding lug shown in Figure 5 to prevent static ignition.

5. Open the cylinder valves as highlighted in Figure 8

6. Open the bleed valve as shown in Figure 10.

The following is taken from the ERG Guide 115 and may or may not apply:

POTENTIAL HAZARDS

FIRE OR EXPLOSION
- EXTREMELY FLAMMABLE.
- Will be easily ignited by heat, sparks or flames.
- Will form explosive mixtures with air.

CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Methane (UN1971) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.)

- Vapors may travel to source of ignition and flash back.
- Cylinders exposed to fire may vent and release flammable gas through pressure relief devices.
- Cylinders may explode when heated if not properly vented.
- Ruptured cylinders may rocket.

HEALTH
- Vapors may cause dizziness or asphyxiation without warning.
- Some vapors may be irritating if inhaled at high concentrations.
- Contact with gas or decanting gas may cause burns, severe injury and/or frostbite.
- Fire may produce irritating and/or toxic gases.

PUBLIC SAFETY
- **CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper is not available or no answer, refer to appropriate telephone number listed in section entitled "Emergency Response Telephone Numbers".**
- As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.
- Keep unauthorized personnel away.
- Stay upwind.
- Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). This is not the case for natural gas.
- Keep out of low areas.

PROTECTIVE CLOTHING
- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing will only provide limited protection.

EVACUATION

Large Spill
- Consider initial downwind evacuation for at least 800 meters (1/2 mile).

Fire
- If tank, rail car, vessel or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.

FIRE
• DO NOT ATTEMPT TO EXTINGUISH A GAS FIRE UNLESS LEAK CAN BE STOPPED.
CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame.
Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.
Small Fire
• Dry chemical or CO_2.
Large Fire
• Water spray or fog.
• Move containers from fire area if you can do it without risk.
Fire involving Cylinders
• Fight fire from maximum distance or use unmanned hose holders or monitor nozzles.
• Cool containers with flooding quantities of water until well after fire is out.
• Do not direct water at source of leak or safety devices; icing may occur.
• Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
• ALWAYS stay away from cylinders engulfed in fire.
• For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area to a safe distance threshold and let fire burn.

SPILL OR LEAK
• ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area).
• All equipment used when handling the product must be grounded.
• Do not touch or walk through spilled material.
• Stop leak if you can do it without risk.
• If possible, turn leaking containers so that gas escapes
• Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
• Do not direct water at spill or source of leak.
• Prevent spreading of vapors through sewers, ventilation systems and confined areas.
• Isolate area until gas has dispersed.

FIRST AID
• Move victim to fresh air. • Call 911 or emergency medical service.
• Give artificial respiration if victim is not breathing.
• Administer oxygen if breathing is difficult.
• Remove and isolate contaminated clothing and shoes.
• Clothing frozen to the skin should be thawed before being removed.
• In case of contact with liquefied gas, thaw frosted parts with lukewarm water.
• In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin.
• Keep victim warm and quiet.
• Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

15 EMERGENCY RESPONSE TELEPHONE NUMBERS

Hexagon Lincoln Emergency 844-211-5339

ARGENTINA

1. CIQUIME
0-800-222-2933 in the Republic of Argentina
For calls originating elsewhere, call
+54-11-4613-1100

BRAZIL

1. PRÓ-QUÍMICA
0-800-118270
(Toll-free in Brazil)
For calls originating elsewhere, call
+55-11-232-1144
(Collect calls are accepted)

COLOMBIA

1. CISPROQUIM
01-800-091-6012 in Colombia
For calls originating in Bogotá, Colombia call
288-6012
For calls originating elsewhere call
+57-1-288-6012

CANADA

1. CANUTEC
613-996-6666 (Collect calls are accepted)
*666 cellular (in Canada only)

DOMINICAN REPUBLIC

911

MEXICO

1. SETIQ
01-800-00-214-00 in the Mexican Republic
For calls originating in Mexico City and the Metropolitan Area
5559-1588
For calls originating elsewhere, call
+52-55-5559-1588

2. CENACOM
01-800-00-413-00 in the Mexican Republic
For calls originating in Mexico City and the Metropolitan Area
5128-0000 exts. 11470, 11471, 11472, 11473, 11474, 11475, 11476 and 11477
For calls originating elsewhere, call
+52-55-5128-0000 exts. 11470, 11471, 11472, 11474, 11475 and 11476

PERU

116 Fire
105 Police

UNITED STATES

1. CHEMTREC®
1-800-424-9300
(Toll-free in the U.S., Canada and the U.S. Virgin Islands)
703-527-3887 For calls originating elsewhere
(Collect calls are accepted)

2. CHEMTEL, INC.
1-888-255-3924
(Toll-free in the U.S., Canada, Puerto Rico and the U.S. Virgin Islands)
813-248-0585 For calls originating elsewhere
(Collect calls are accepted)

3. INFOTRAC
1-800-535-5053
(Toll-free in the U.S., Canada and the U.S. Virgin Islands)
352-323-3500 For calls originating elsewhere
(Collect calls are accepted)

4. 3E COMPANY
1-800-451-8346
(Toll-free in the U.S., Canada and the U.S. Virgin Islands)
760-602-8703 For calls originating elsewhere
(Collect calls are accepted)

5. MILITARY SHIPMENTS
703-697-0218 - Explosives/ammunition incidents
(Collect calls are accepted)
1-800-851-8061 - All other dangerous goods incidents

6. NATIONWIDE POISON CONTROL CENTER (United States only)
1-800-222-1222 (toll-free in the U.S.)

VIETNAM

05 Ambulance
08 Fire
03 Police

16 Description of Terms

Abrasion Damage: Damage to composite caused by wearing, grinding or rubbing away of the composite material by friction.

All-composite (Type 4) Tank: A fuel tank made from primarily non-metallic materials such as plastic and high strength fiber reinforced composites. The tank may incorporate metal ports for attachment of valves and other plumbing devices.

Boss (also referred to as "Ports"): The metal fittings at the ends of the tank, which contain the ports for installation of valves, pressure relief devices, and blank plugs.

Blunt Impact: A forceful blow to the surface of the tank, which does not cut, gouge, or significantly indent the surface. This type of impact may induce damage, such as delamination, which is not readily apparent by visual examination.

Break-away Connection: A connection used during filling or unloading that reduces plumbing damage by freely breaking away from the fill line.

Carbon Fiber: One type of reinforcement fiber used in the composite overwrap.

CNG: Compressed Natural Gas.

Condemned Tank: A tank that has been damaged beyond repair and must be removed from service and rendered unusable.

Crazing: Hairline cracking of the resin, giving it an opaque, "frosty" appearance.

Cut Damage: Damage caused by a sharp object in contact with the composite surface that breaks or cuts the composite fibers.

Cylinder: Pressure Vessel, also referred to as a tank.

Cylinder Region: The cylindrical portion of the tank.

Door: A structure hinged and latched protecting the plumbing and interface with the tanks.

Delamination: An induced separation between composite layers. This type of damage occurs from localized impact or resin burn out.

Dome: The curved end portion of the fuel tank.

Factory Inspection: An inspection and evaluation performed at an approved Hexagon Lincoln facility, utilizing comprehensive testing techniques that are not available for field inspection.

Field Inspection: Inspection performed at a location other than a Hexagon Lincoln facility.

Fill Line Assembly: A high-pressure line used to conduct gas into the tank(s) through the plumbing assembly.

Frame: General term that is used to describe the metal structure that encloses and supports the tanks, plumbing, doors, side covers, etc.

Hardware: General description of valves, PRDs and any other component that will attach to the tanks or the tank related systems.

Impact Damage: Damage caused by dropping or by a blow from another object. Impact damage may be at the surface, internal to the structure, or both.

Laminate: Fiber-resin layers that are bonded to adjacent layers.

Level 1 Damage: Minor damage that is considered inconsequential to the safe operation of the tank.

Level 2 Damage: Damage which is more severe than Level 1 damage. This level of damage is rejectable. Additional evaluation and/or rework may allow the tank to be returned to service.

Level 3 Damage: Damage which is sufficiently severe that it is not repairable and renders a tank unfit for continued service. Tanks with Level 3 damage must be condemned and destroyed.

Liner: An internal component of the tank that serves as a permeation barrier, preventing leakage of gas through the composite tank structure.

Maximum Fill Pressure: The fill pressure allowed in order to obtain a settled service pressure of 15°C (59°F).

Pressure Relief Device (PRD): A device installed in direct contact with internal pressure in the tank that will release the contained gas in specific emergency conditions. Excessive temperature, excessive internal pressure, or both may activate the device depending on the PRD design. Thermally activated pressure relief devices are required.

Qualified Inspector: An individual who has completed the Hexagon Lincoln NGV Fuel Tank Training class and is registered with Hexagon Lincoln with a certificate in response to passing the training class exam. A qualified inspector shall have received proper training and a registered stamp that will allow field inspections of Hexagon Lincoln fuel tanks.

Resin: Epoxy material in the composite overwrap which fills the space and transfers the load between individual reinforcing fibers.

Service Life: Specified number of years from the date of manufacture that the tank may be used. The expiration date for a specific tank is printed on the manufacturer's label. A fuel tank is to be destroyed at the end of its service life.

Service Pressure: The settled pressure at a uniform gas temperature of 15°C (59°F) and full gas content. Also referred to as nominal, operating, or working pressure.

Tap Test: An inspection technique in which the surface of a Hexagon Lincoln tank is tapped with a small solid object, such as a "Coin", to detect delaminations. A delamination area will emit a different sound than an area that is not damaged.

Thermally Activated PRD: A device that activates above a critical temperature.

Valve, Actuated: A device installed into one of the ports of the tank that is used to open or close off the gas flow into or out of the tank. The valve is turned on or off by a pressure-driven actuator.

Valve, Manual: A device installed into one of the ports of the tank that is used to open or close off the gas flow into or out of the tank. The valve is turned on or off manually with a handle.

Vent Caps: Metal spring loaded caps designed to keep moisture and debris out of vent lines.

Vent Line: A high-pressure line used to conduct gas from a pressure relief device to a location outside of the container where gas may be safely discharged. Vent lines are required where pressure-carrying components are installed in a closed compartment.

Trapped Gas: As referred to in this document, it is the gas or air volume that is trapped between the HDPE liner and the corresponding composite overwrap.

17 References

1. CGA C-6.2:2005, Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders. Compressed Gas Association, 4221 Walney Road, Suite 500, Chantilly, Virginia, USA 20151, www.cganet.com
2. Emergency Response Guidebook:2008, A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident. U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration, 1200 New Jersey Ave SE, East Building, 2nd Floor, Washington, DC 20590, http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Files/erg2008_eng.pdf
3. ISO 668:1995, Series 1 Freight Containers-Classification, Dimensions and Ratings. International Organization for Standardization; 1, Rue de Varembé; Case postale 56; CH-1211 Genéva 20, Switzerland; www.iso.ch
4. SB 10-01-002 Hexagon Lincoln CNG Bulk Hauling TITAN™ Module Inspection Manual. Hexagon Lincoln, 5117 NW 40th Street, Lincoln NE, 68524.

18 Contact Information

Hexagon Lincoln
5117 NW 40th Street
Lincoln, NE 68524
Phone 1-800-279-TANK
Web Address: www.hexagonlincoln.com

Hexagon Lincoln Emergency 844-211-5339

Appendix A Filling Checklist

Date/Time_____/_____
Container Location _____
Container Serial # _____
Operator Name_____
Temperature_____

1. Is the container stationary? By what means? Check if yes.
   - ☐ Brake Set
   - ☐ Wheels Chocked
   - ☐ Engine Off
   - ☐ Transmission in Park
   - ☐ Other_____

2. If the container were to vent, would its contents accumulate underneath a structure? If answer is "yes" then reposition the container to protect against accumulation during a vent. ***During a venting of the cargo, the natural gas must not be allowed to accumulate. The natural gas must have an obstruction free vent path.***
   - ☐ Yes
   - ☐ No

3. Is the grounding lug connected to an adequate ground source? See Figure 5.
   - ☐ Yes

4. Are all valves (cylinder valves, manifold valves and bleed valve) in closed position?
   - ☐ Yes
   - ☐ No

5. Connect stations fill line to the container's fill line. **This system does not include a break-away connection. Owner is responsible for break-away connection on hose or loading arm.**

6. Open valves to cylinders that are to be filled.

7. Open manifold valves.

8. Fill cylinders to pressure specified in fill chart, then record pressures.
Cylinder 1 _____ Cylinder 2_____ Cylinder 3_____ Cylinder 4_____

9. Shut off flow

10. Close cylinder valves (if used in US or Canada)

11. Close manifold valves.

12. Evacuate stations fill line by opening bleed valve.

13. Disconnect fill line.

14. Make sure all valves are closed.

Internal Gas Temperature (°F)	Internal Gas Temperature (°C)	Max Fill Pressure (psig)	Max Fill Pressure (barg)
-30	-34	1900	131
-10	-23	2200	152
10	-12	2500	172
20	-7	2700	186
30	-1	2900	200
40	4	3000	207
50	10	3200	221
60	16	3400	234
70	21	3600	248
80	27	3700	255
90	32	3900	269
110	43	4200	290
130	54	4500	310

Appendix B Transport Checklist

Date/Time_____/_____
Container Serial # _____
Operator Name _____
Origination _____
Destination _____

1. Has a pre-approved route been specified?
Route no._____ or location _____

2. Check gas venting system pressure gauge. MUST BE between 185 – 190 PSIG PRIOR TO TRANSPORT.
Pressure =_____psig

3. Check for damage to container. Do not transport container (except if cylinders are empty) if damage is found that has compromised the integrity of the container.

4. Inspect container for signs of leakage (e.g. odorant, sound of leak, visual indications of flow).

5. Check valves to ensure they are in "closed" position. Only close tank valves if used in US or Canada.

6. Check top of vent lines for plug caps. Replace plug caps if missing.

7. Close and secure doors.

8. Ensure corner locks are locked on to chassis.

9. Ensure the tractor and trailer meet the laws and codes by the authority having jurisdiction.

10. Ensure the driver meets all requirements for the authority having jurisdiction.

Notes:
_____
_____
_____
_____
_____
_____
_____

Appendix C Unloading Checklist

Date/Time_____/_____
Container Location_____
Container Serial #_____
Operator Name_____

1. Is the container stationary? By what means? Check if yes.
   - ☐ Brake Set
   - ☐ Wheels Chocked
   - ☐ Engine Off
   - ☐ Transmission in Park
   - ☐ Other_____

2. If the container were to vent, would its contents accumulate underneath a structure? If answer is "yes" then reposition the container to protect against accumulation during a vent. ***During a venting of the cargo, the natural gas must not be allowed to accumulate. The natural gas must have an obstruction free vent path.***
   - ☐ Yes
   - ☐ No

3. Is the grounding lug connected to an adequate ground source? See Figure 5.
   - ☐ Yes

4. Are all valves (cylinder valves, manifold valves, and bleed valve) in closed position?
   - ☐ Yes
   - ☐ No

5. Connect receiving line to the container's unloading manifold. **– This system does not have a break-away connection. Owner is responsible for break-away connection on hose or loading arm.**

6. Open Cylinder valves if used in US or Canada.

7. Open manifold valves.

8. Unload cylinders to pressure of 7 barg (100 psig) or above.

9. Final system pressure as read from manifold pressure gauge _____psig

10. Close cylinder valves if used in US or Canada.

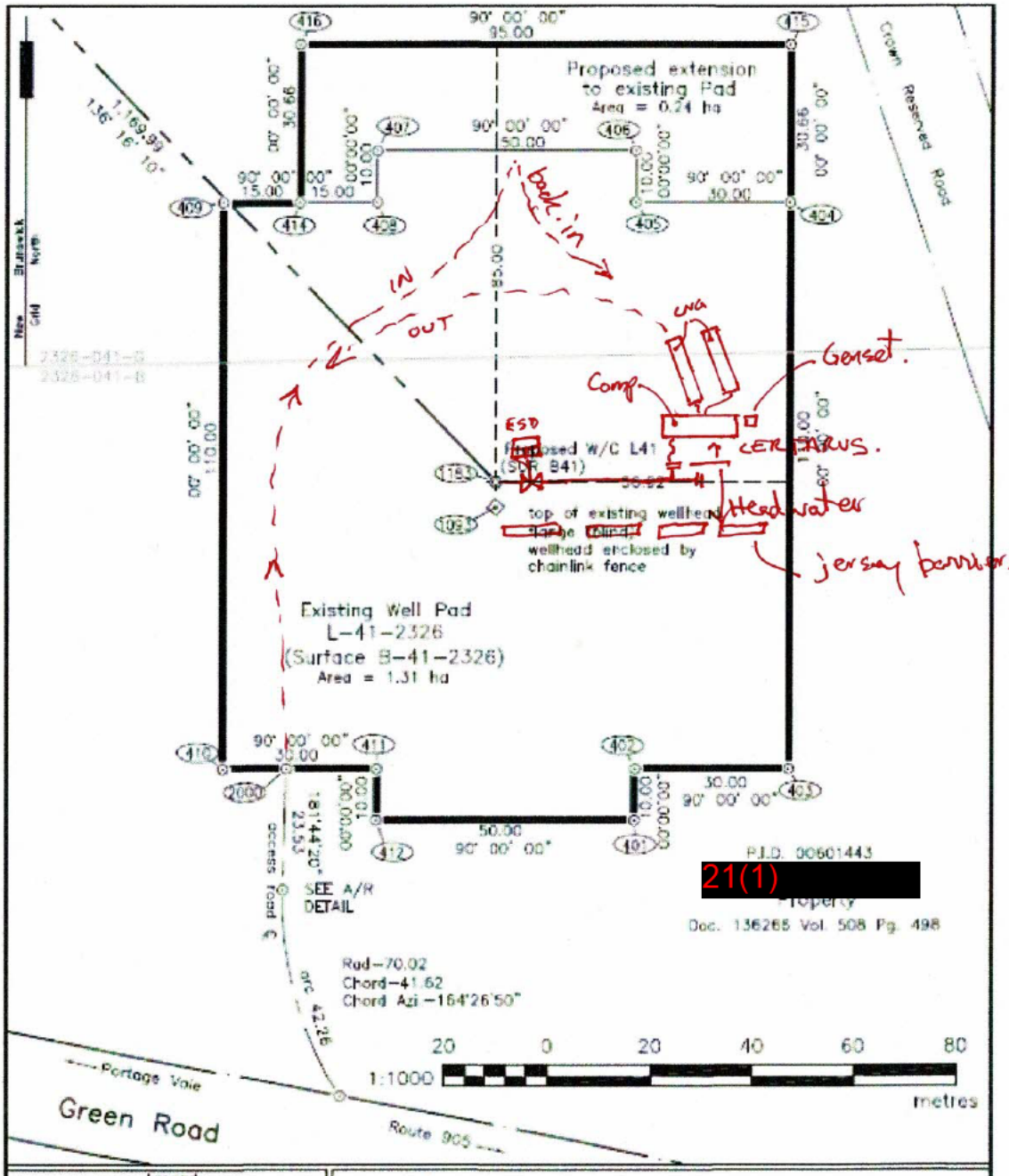
11. Close manifold valves.

12. Close receiving systems flow valve.

13. Open and close bleed valve to relieve pressure.

14. Disconnect unloading line.

Notes:
_____
_____
_____
_____



Legend

- Centre Line
- Found Iron Bar Found
- Calculated Co-Ordinate Point
- Standard Survey Marker Placed
- N.B. Grid Co-Ordinate Monument
- Street Line
- Adjacent Property Line
- Tabulated Co-Ordinate Point
- Standard Survey Marker Found
- Iron Pipe Found
- Square Iron Bar Found
- Traverse Control Point
- Foundation

Notes

1) Directions are N.B. Grid azimuths derived from observations on N.B. Grid Co-ordinate Mon. 10028. (NAD83 CSRS Adjusted Values)

2) Field survey completed on April 22, 2010.

Sketch Showing

Well Pad L - 41 - 2326

Well Site and Access Road

Located In B - 41 - 2326

Green Road , Parish of Elgin ,

Albert County , New Brunswick .

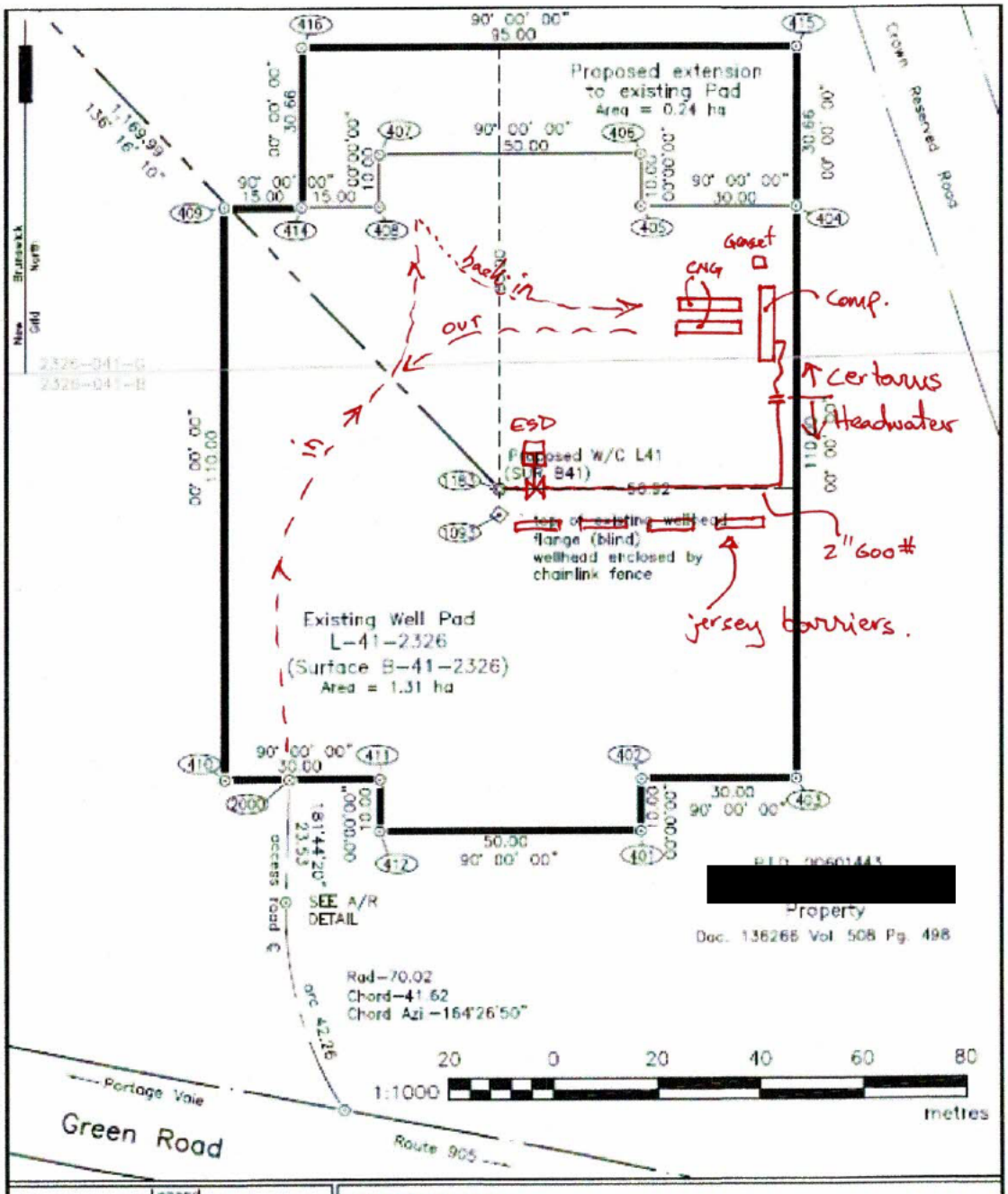
SEE PAGE 2 FOR COORDINATES

ELEVATIONS: N.W. = N.E. =
S.W. = S.E. =

DATUM – N.B. MONUMENT 10028
ELEVATION: 99.343

AREAS:

	HECTARS	ACRES
EXISTING WELLSITE:	1.31	3.2
PROPOSED EXTENSION:	0.24	0.6



Legend

- Centre Line
- Round Iron Bar Found
- Calculated Co-Ordinate Point
- Standard Survey Marker Placed
- N.B. Grid Co-Ordinate Monument
- Street Line
- Adjacent Property Line
- Tabulated Co-Ordinate Point
- Standard Survey Marker Found
- Iron Pipe Found
- Square Iron Bar Found
- Traverse Control Point
- Foundation

Notes

1) Directions are N.B. Grid azimuths derived from observations on N.B. Grid Co-ordinate Mon. 10028. (NAD83 CSRS Adjusted Values)

2) Field survey completed on April 22, 2010

Sketch Showing

Well Pad L - 41 - 2326

Well Site and Access Road

Located In B - 41 - 2326

Green Road , Parish of Elgin ,

Albert County , New Brunswick .

SEE PAGE 2 FOR COORDINATES

ELEVATIONS: N.W. = N.E. =
S.W. = S.E. =

DATUM – N.B. MONUMENT 10028
ELEVATION: 99.343

AREAS:

	HECTARS	ACRES
EXISTING WELLSITE:	1.31	3.2
PROPOSED EXTENSION:	0.24	0.6

Stoddard Silencers
1017 Progress Drive, Grayslake, Illinois 60030
Phone: 847-223-8636 FAX: 847-223-8638
e-mail: info@stoddardsilencersinc.com

ENGINE SILENCER SELECTION

Customer Name: ANGI
Phone No.:

ENGINE MANUFACTURER:
MODEL:
DUTY RATING:

Ambient conditions

AIR INLET TEMP: 68
ELEVATION [ft]: 0

Input Data:

EXH. FLOW RATE: 1022 ACFM
EXH. TEMP.: 1135 [° F]
RPM 1800
CYCLE 4
BHP: 215
NUMBER OF EXHAUST PIPE: 1
SCFM 342

ENGINE DATA

INDUCTION TYPE Turbocharged
FUEL Natural Gas
CYLINDER ARRANGEMENT In-Line

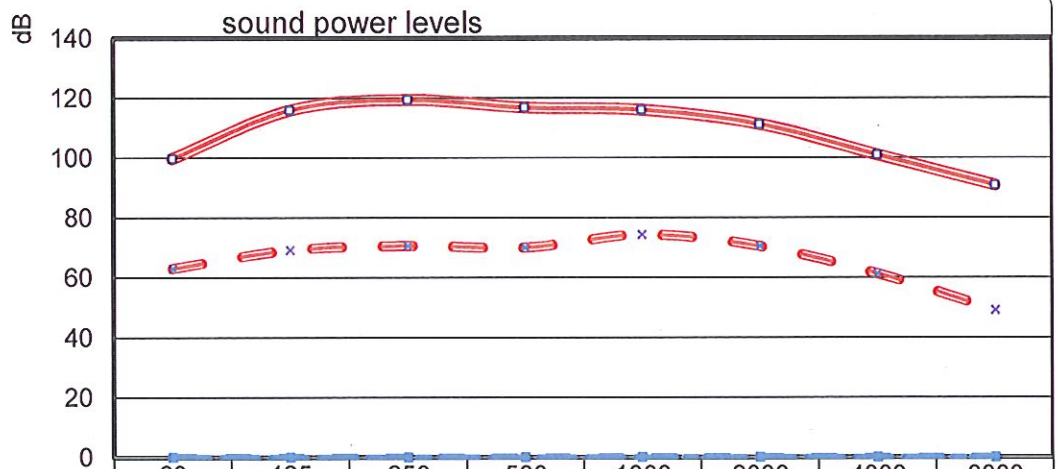
SELECTED SILENCERS

	series	size	PD "H2O	Vel-FPM
EXHAUST	E15	5	4.75	6537
Total PD=			4.8	

ACOUSTICS

			Absortive Material		TL dB:					
EXHAUST	E15	5			50	Distance From the Source [ft]:				3

EXHAUST SPL Sound pressure Levels dB vs Hz



	63	125	250	500	1000	2000	4000	8000
Unsilenced Exhaust Lp dBA	100	116	119	117	116	111	101	91
Silenced Exhaust (Lp) dBA	63	69	71	70	74	70	61	49
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0

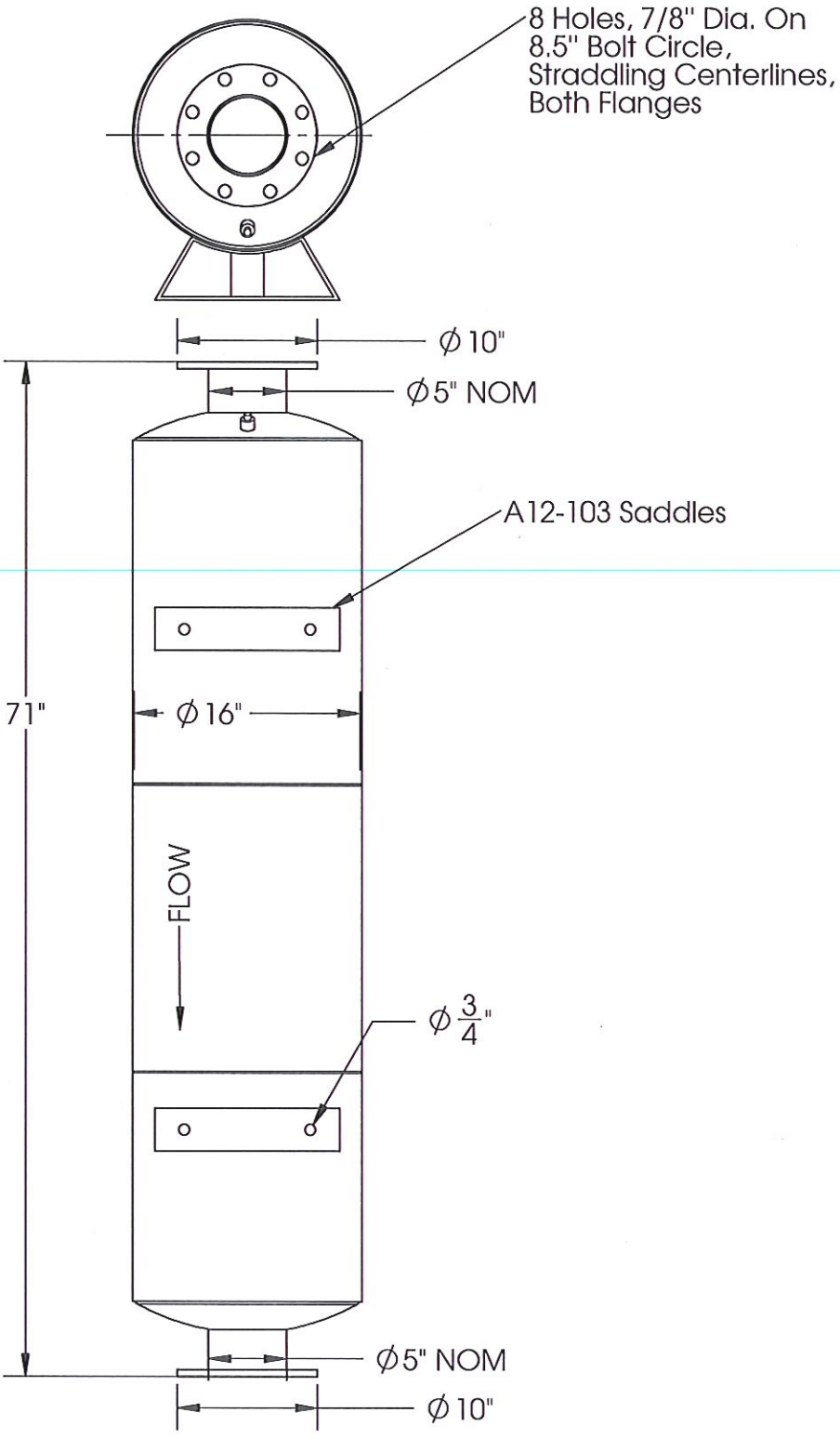
Stoddard Silencers

Name:

E15-5 Exhaust Silencer

12/13/2013

515-SSI-105



EXTERNAL DIMENSIONS CERTIFIED FOR:

CUST.

S.S. NO.

P.O. No.

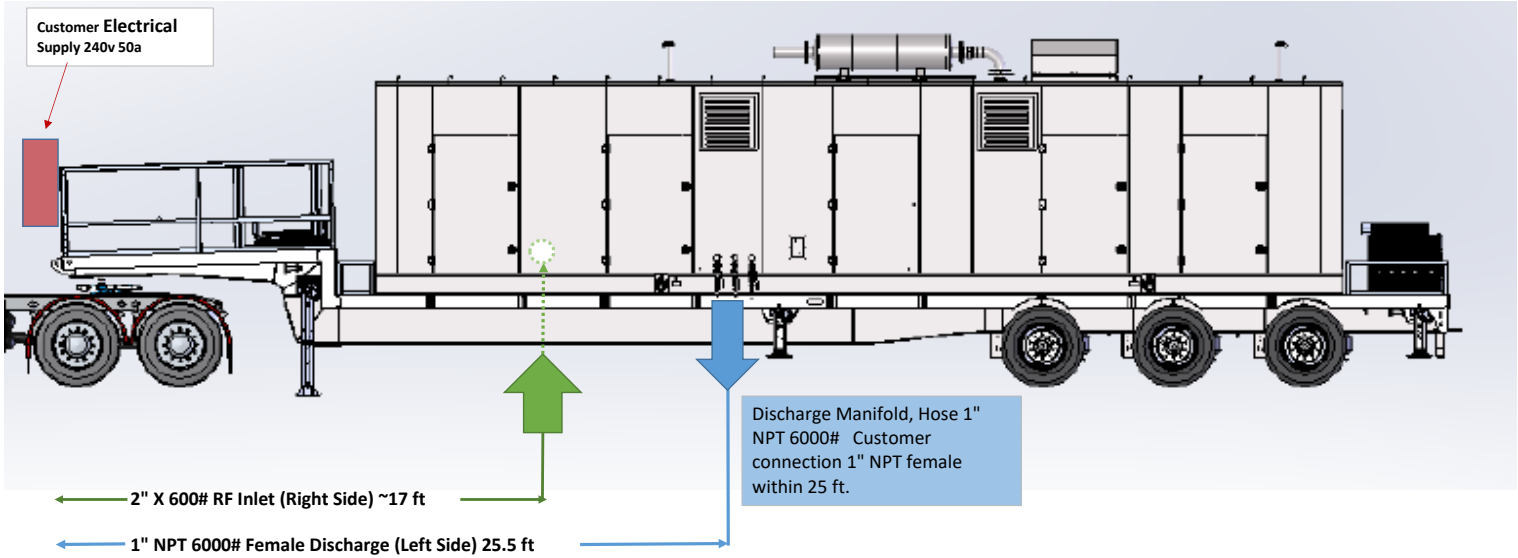
BY

Approx. Wt. 157.77 lbs.

Material: Carbon Steel

Finish: BBQ Black

Portable Compressor - 210 hp

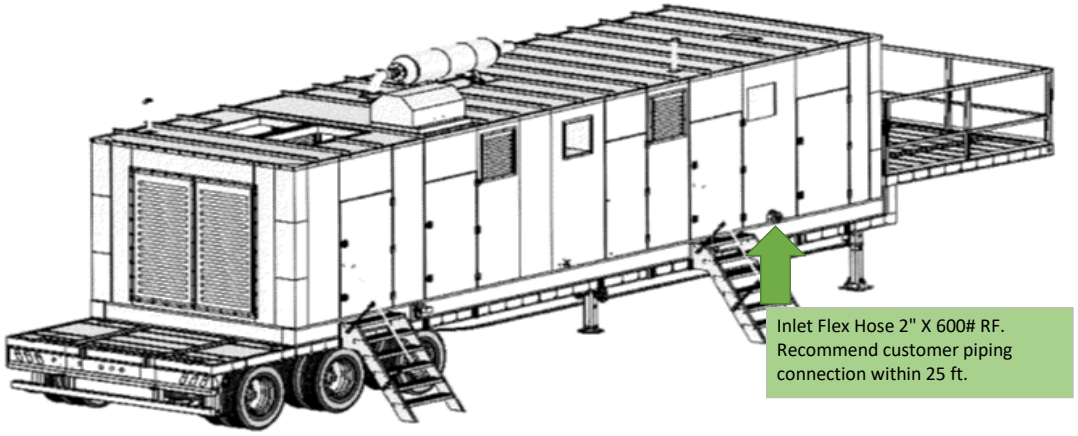


Gross Weight: ~ 90,000 lbs
~ 40800 kg

Overall Length: ~54' 6"

Overall Width: ~ 11'

Overall Height: ~ 13 ' 10"



COMPRESSOR DATA

WEIGHT: 50,000 LBS (APPROXIMATE,INCLUDING ENCL).

SHIPPING DIMENSION: 432"L x 120"W x 104"H, SILENCER WILL BE SHIPPED LOOSE .

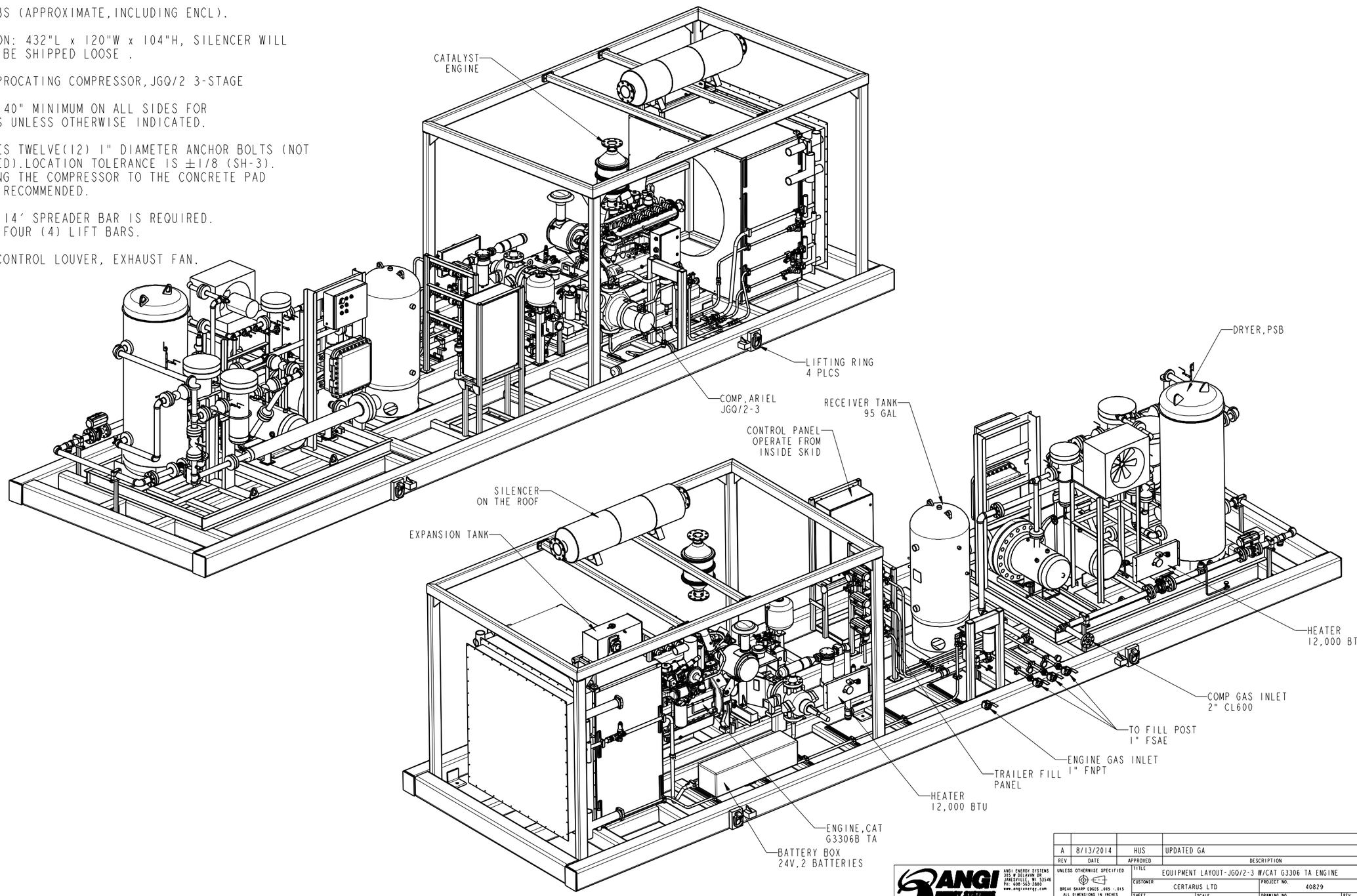
TYPE: ARIEL RECIPROCATING COMPRESSOR,JGQ/2 3-STAGE

CLEARANCE: ALLOW 40" MINIMUM ON ALL SIDES FOR ACCESS UNLESS OTHERWISE INDICATED.

MOUNTING: REQUIRES TWELVE(12) 1" DIAMETER ANCHOR BOLTS (NOT PROVIDED).LOCATION TOLERANCE IS ±1/8 (SH-3). GROUTING THE COMPRESSOR TO THE CONCRETE PAD IS NOT RECOMMENDED.

LIFTING: MINIMUM 14' SPREADER BAR IS REQUIRED. UTILIZE FOUR (4) LIFT BARS.

ENCL: PNEUMATIC CONTROL LOUVER, EXHAUST FAN.



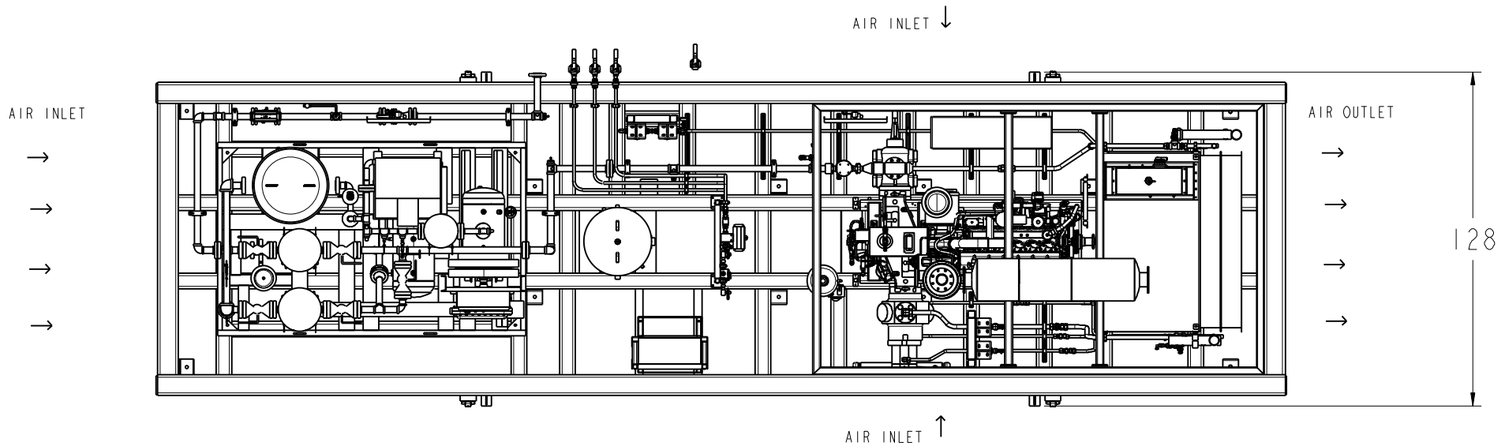
REV	DATE	APPROVED	DESCRIPTION
A	8/13/2014	HUS	UPDATED GA

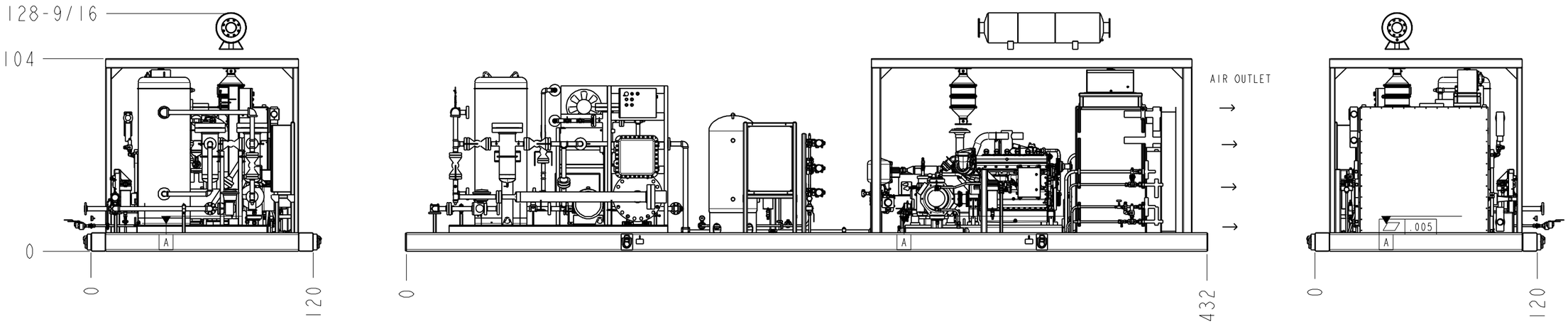
ANGI ENERGY SYSTEMS
305 W DELAVAN DR
JANESVILLE, WI 53546
PH: 608-563-2800
www.angienergy.com

THIS DRAWING AND INFORMATION THEREIN IS THE SOLE PROPERTY OF ANGI ENERGY AND SHOULD NOT BE COPIED, REPRODUCED OR SUBMITTED TO OTHERS WITHOUT WRITTEN AUTHORIZATION. ALL REPRODUCTIONS ARE SUBJECT TO RETURN ON DEMAND.

UNLESS OTHERWISE SPECIFIED
BREAK SHARP EDGES .005 - .015
ALL DIMENSIONS IN INCHES
FRACTIONAL ± 1/8
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005
ANGLES ± 1°

TITLE	EQUIPMENT LAYOUT-JGQ/2-3 W/CAT G3306 TA ENGINE
CUSTOMER	CERTARUS LTD
PROJECT NO.	40829
SHEET	1 of 3
SCALE	0.050
DRAWING NO.	A03-10-40829
REV.	A
DRAWN BY	HUS
DATE	7/15/2014





ANGI ENERGY SYSTEMS
305 W DELAVAN DR
JANESVILLE, WI 53546
PH: 608-563-2800
www.angienergy.com

UNLESS OTHERWISE SPECIFIED
BREAK SHARP EDGES .005 - .015
ALL DIMENSIONS IN INCHES
FRACTIONAL ± 1/8
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005
ANGLES ± 1°

TITLE	EQUIPMENT LAYOUT-JGQ/2-3 W/CAT G3306 TA ENGINE
CUSTOMER	CERTARUS LTD
PROJECT NO.	40829
SHEET	2 of 3
SCALE	0.038
DRAWING NO.	A03-10-40829
REV.	A
DRAWN BY	HUS
DATE	7/15/2014

G3306B

GAS COMPRESSION APPLICATION

GAS ENGINE SITE SPECIFIC TECHNICAL DATA
CERTARUS-40829

CATERPILLAR®

ENGINE SPEED (rpm):	1800	RATING STRATEGY:	STANDARD
COMPRESSION RATIO:	8:1	RATING LEVEL:	CONTINUOUS
AFTERCOOLER TYPE:	ATAAC	FUEL SYSTEM:	HPG IMPCO
SET POINT INLET MANIFOLD AIR TEMP (°F):	110		WITH AIR FUEL RATIO CONTROL
JACKET WATER OUTLET (°F):	210	**SITE CONDITIONS:**	
ASPIRATION:	TA	FUEL:	Nat Gas
COOLING SYSTEM:	JW+OC, AC	FUEL PRESSURE RANGE(psig):	12.0-24.9
CONTROL SYSTEM:	ADEM4	FUEL METHANE NUMBER:	84.8
EXHAUST MANIFOLD:	WC	FUEL LHV (Btu/scf):	905
COMBUSTION:	INTEGRATED CATALYST	ALTITUDE(ft):	5000
NOx EMISSION LEVEL (g/bhp-hr NOx):	0.5	MAXIMUM INLET AIR TEMPERATURE(°F):	110
SET POINT TIMING:	35	STANDARD RATED POWER:	211 bhp@1800rpm

				MAXIMUM RATING	SITE RATING AT MAXIMUM INLET AIR TEMPERATURE		
RATING		**NOTES**	**LOAD**	**100%**	**100%**	**75%**	**50%**
ENGINE POWER	(WITHOUT FAN)	(1)	bhp	211	211	158	105
INLET AIR TEMPERATURE			°F	109	110	110	110
ENGINE DATA							
FUEL CONSUMPTION (LHV)		(2)	Btu/bhp-hr	8048	8048	8461	9323
FUEL CONSUMPTION (HHV)		(2)	Btu/bhp-hr	8927	8927	9386	10342
AIR FLOW (@inlet air temp, 14.7 psia)	(WET)	(3)(4)	ft3/min	324	325	257	187
AIR FLOW	(WET)	(3)(4)	lb/hr	1356	1356	1072	783
FUEL FLOW (60ºF, 14.7 psia)			scfm	31	31	25	18
INLET MANIFOLD PRESSURE		(5)	in Hg(abs)	39.6	39.6	32.1	24.1
EXHAUST TEMPERATURE - ENGINE OUTLET		(6)	°F	1136	1136	1072	1008
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(WET)	(7)(4)	ft3/min	1022	1022	775	543
EXHAUST GAS MASS FLOW	(WET)	(7)(4)	lb/hr	1441	1441	1139	832
EMISSIONS DATA - CATALYST OUT							
NOx (as NO2)		(8)(9)	g/bhp-hr	0.50	0.50	0.50	0.50
CO		(8)(9)	g/bhp-hr	2.00	2.00	2.00	2.00
THC (mol. wt. of 15.84)		(8)(9)	g/bhp-hr	0.92	0.92	1.08	1.66
NMHC (mol. wt. of 15.84)		(8)(9)	g/bhp-hr	0.14	0.14	0.16	0.25
NMNEHC (VOCs) (mol. wt. of 15.84)		(8)(9)(10)	g/bhp-hr	0.09	0.09	0.11	0.17
HCHO (Formaldehyde)		(8)(9)	g/bhp-hr	0.08	0.08	0.08	0.09
CO2		(8)(9)	g/bhp-hr	501	501	528	575
EXHAUST OXYGEN		(8)(11)	% DRY	0.0	0.0	0.0	0.0
HEAT REJECTION							
HEAT REJ. TO JACKET WATER (JW)		(12)	Btu/min	9169	9169	7874	6502
HEAT REJ. TO ATMOSPHERE		(12)	Btu/min	1130	1130	891	654
HEAT REJ. TO LUBE OIL (OC)		(12)	Btu/min	1351	1351	1160	958
HEAT REJ. TO AFTERCOOLER (AC)		(12)(13)	Btu/min	969	969	641	205

COOLING SYSTEM SIZING CRITERIA			
TOTAL JACKET WATER CIRCUIT (JW+OC)	(13)	Btu/min	12878
TOTAL AFTERCOOLER CIRCUIT (AC)	(13)(14)	Btu/min	1119
A cooling system safety factor of 10% has been added to the cooling system sizing criteria.			

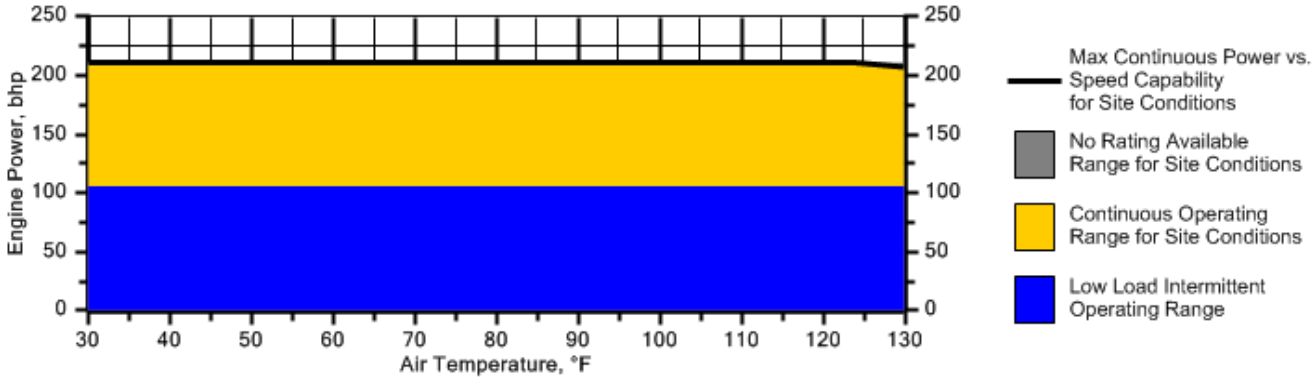
CONDITIONS AND DEFINITIONS

Engine rating obtained and presented in accordance with ISO 3046/1, adjusted for fuel, site altitude and site inlet air temperature. 100% rating at maximum inlet air temperature is the maximum engine capability for the specified fuel at site altitude and maximum site inlet air temperature. Maximum rating is the maximum capability at the specified inlet manifold air temperature for the specified fuel at site altitude and reduced inlet air temperature. Lowest load point is the lowest continuous duty operating load allowed. No overload permitted at rating shown.

For notes information consult page three.

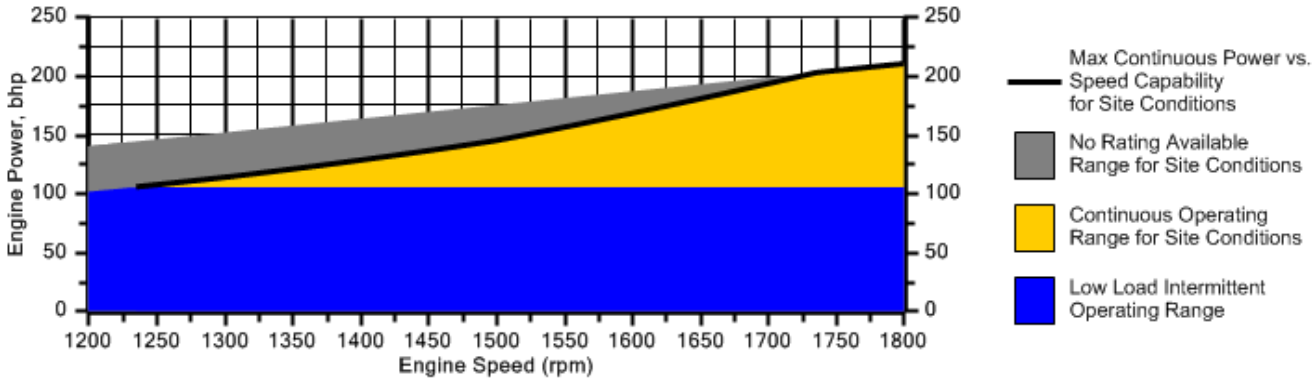
Engine Power vs. Inlet Air Temperature

Data represents temperature sweep at 5000 ft and 1800 rpm



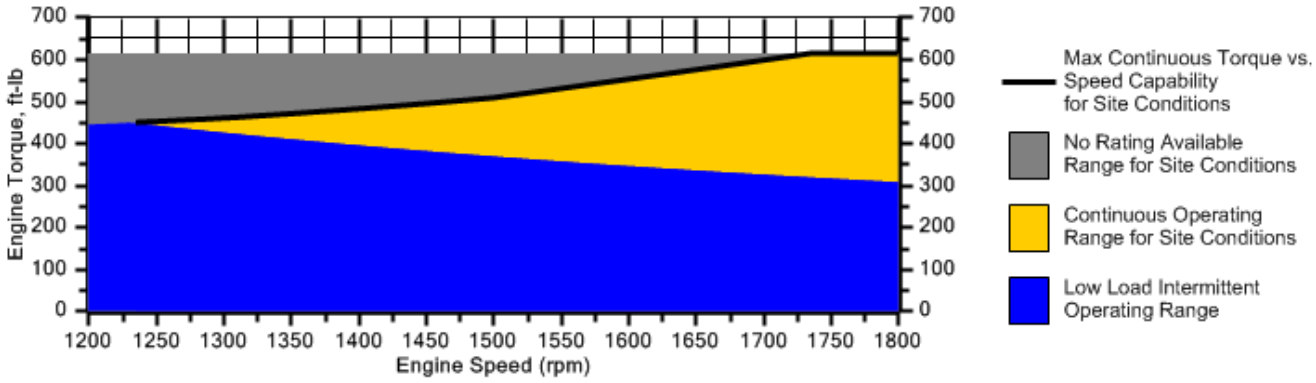
Engine Power vs. Engine Speed

Data represents speed sweep at 5000 ft and 110 °F



Engine Torque vs. Engine Speed

Data represents speed sweep at 5000 ft and 110 °F



Note: At site conditions of 5000 ft and 110°F inlet air temp., constant torque can be maintained down to 1740 rpm. The minimum speed for loading at these conditions is 1235 rpm.

NOTES

1. Engine rating is with two engine driven water pumps. Tolerance is ± 3% of full load.

2. Fuel consumption tolerance is ± 5.0% of full load data.

3. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 5 %.

4. Inlet and Exhaust Restrictions must not exceed A&I limits based on full load flow rates from the standard technical data sheet.

5. Inlet manifold pressure is a nominal value with a tolerance of ± 5 %.

6. Exhaust temperature is a nominal value with a tolerance of (+)63°F, (-)54°F.

7. Exhaust flow value is on a "wet" basis. Flow is a nominal value with a tolerance of ± 6 %.

8. Emissions data is post Caterpillar provided catalyst. Values are dependent on proper engine and catalyst maintenance.

9. Emission values are based on engine operating at steady state conditions. Fuel methane number cannot vary more than ± 3. Values listed are higher than nominal levels to allow for instrumentation, measurement, and engine-to-engine variations. They indicate "Not to Exceed" values. THC, NMHC, and NMNEHC do not include aldehydes.

10. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ

11. Exhaust Oxygen tolerance is ± 0.2.

12. Heat rejection values are nominal. Tolerances, based on treated water, are ± 10% for jacket water circuit, ± 50% for radiation, and ± 20% for lube oil circuit. Tolerance is ± 5% for aftercooler circuit.

13. Aftercooler heat rejection includes an aftercooler heat rejection factor for the site elevation and inlet air temperature specified. Aftercooler heat rejection values at part load are for reference only. Do not use part load data for heat exchanger sizing.

14. Cooling system sizing criteria are maximum circuit heat rejection for the site, with applied factory tolerances and an additional cooling system factor of 10%.

Constituent	Abbrev	Mole %	Norm
Water Vapor	H2O	0.0000	0.0000
Methane	CH4	92.2700	92.2700
Ethane	C2H6	2.5000	2.5000
Propane	C3H8	0.5000	0.5000
Isobutane	iso-C4H1O	0.0000	0.0000
Norbutane	nor-C4H1O	0.2000	0.2000
Isopentane	iso-C5H12	0.0000	0.0000
Norpentane	nor-C5H12	0.1000	0.1000
Hexane	C6H14	0.0500	0.0500
Heptane	C7H16	0.0000	0.0000
Nitrogen	N2	3.4800	3.4800
Carbon Dioxide	CO2	0.9000	0.9000
Hydrogen Sulfide	H2S	0.0000	0.0000
Carbon Monoxide	CO	0.0000	0.0000
Hydrogen	H2	0.0000	0.0000
Oxygen	O2	0.0000	0.0000
Helium	HE	0.0000	0.0000
Neopentane	neo-C5H12	0.0000	0.0000
Octane	C8H18	0.0000	0.0000
Nonane	C9H20	0.0000	0.0000
Ethylene	C2H4	0.0000	0.0000
Propylene	C3H6	0.0000	0.0000
TOTAL (Volume %)		100.0000	100.0000

Fuel Makeup:	Nat Gas
Unit of Measure:	English

Calculated Fuel Properties

Caterpillar Methane Number:	84.8
Lower Heating Value (Btu/scf):	905
Higher Heating Value (Btu/scf):	1004
WOBBE Index (Btu/scf):	1168
THC: Free Inert Ratio:	21.83
Total % Inerts (% N2, CO2, He):	4.38%
RPC (%) (To 905 Btu/scf Fuel):	100%
Compressibility Factor:	0.998
Stoich A/F Ratio (Vol/Vol):	9.45
Stoich A/F Ratio (Mass/Mass):	15.75
Specific Gravity (Relative to Air):	0.600
Specific Heat Constant (K):	1.313

CONDITIONS AND DEFINITIONS

Caterpillar Methane Number represents the knock resistance of a gaseous fuel. It should be used with the Caterpillar Fuel Usage Guide for the engine and rating to determine the rating for the fuel specified. A Fuel Usage Guide for each rating is included on page 2 of its standard technical data sheet.

RPC always applies to naturally aspirated (NA) engines, and turbocharged (TA or LE) engines only when they are derated for altitude and ambient site conditions.

Project specific technical data sheets generated by the Caterpillar Gas Engine Rating Pro program take the Caterpillar Methane Number and RPC into account when generating a site rating.

Fuel properties for Btu/scf calculations are at 60F and 14.696 psia.

Caterpillar shall have no liability in law or equity, for damages, consequently or otherwise, arising from use of program and related material or any part thereof.

FUEL LIQUIDS

Field gases, well head gases, and associated gases typically contain liquid water and heavy hydrocarbons entrained in the gas. To prevent detonation and severe damage to the engine, hydrocarbon liquids must not be allowed to enter the engine fuel system. To remove liquids, a liquid separator and coalescing filter are recommended, with an automatic drain and collection tank to prevent contamination of the ground in accordance with local codes and standards.

To avoid water condensation in the engine or fuel lines, limit the relative humidity of water in the fuel to 80% at the minimum fuel operating temperature.

G3306B

GAS ENGINE TECHNICAL DATA

CATERPILLAR®

ENGINE SPEED (rpm):	1800	RATING STRATEGY:	STANDARD
COMPRESSION RATIO:	8:1	APPLICATION:	GAS COMPRESSION
AFTERCOOLER TYPE:	ATAAC	RATING LEVEL:	CONTINUOUS
INLET MANIFOLD AIR TEMP (°F):	110	FUEL:	NAT GAS
JACKET WATER OUTLET (°F):	210	FUEL SYSTEM:	HPG IMPCO
ASPIRATION:	TA		WITH AIR FUEL RATIO CONTROL
COOLING SYSTEM:	JW+OC, AC	FUEL PRESSURE RANGE(psig):	12.0-24.9
CONTROL SYSTEM:	ADEM4	FUEL METHANE NUMBER:	80
EXHAUST MANIFOLD:	WC	FUEL LHV (Btu/scf):	905
COMBUSTION:	INTEGRATED CATALYST	ALTITUDE CAPABILITY AT 77°F INLET AIR TEMP. (ft):	7130
NOx EMISSION LEVEL (g/bhp-hr NOx):	0.5		

RATING		NOTES	LOAD	100%	75%	50%
ENGINE POWER	(WITHOUT FAN)	(1)	bhp	211	158	105
ENGINE EFFICIENCY	(ISO 3046/1)	(2)	%	31.6	30.1	27.3
ENGINE EFFICIENCY	(NOMINAL)	(2)	%	31.6	30.1	27.3

ENGINE DATA						
FUEL CONSUMPTION	(ISO 3046/1)	(3)	Btu/bhp-hr	8048	8461	9323
FUEL CONSUMPTION	(NOMINAL)	(3)	Btu/bhp-hr	8048	8461	9323
AIR FLOW (77°F, 14.7 psia)	(WET)	(4) (5)	ft3/min	306	242	177
AIR FLOW	(WET)	(4) (5)	lb/hr	1356	1072	783
FUEL FLOW (60ºF, 14.7 psia)			scfm	31	25	18
COMPRESSOR OUT PRESSURE			in Hg(abs)	43.9	40.9	36.2
COMPRESSOR OUT TEMPERATURE			°F	179	166	130
AFTERCOOLER AIR OUT TEMPERATURE			°F	109	107	104
INLET MAN. PRESSURE		(6)	in Hg(abs)	39.6	32.1	24.1
INLET MAN. TEMPERATURE	(MEASURED IN PLENUM)	(7)	°F	109	109	109
TIMING		(8)	°BTDC	35	35	35
EXHAUST TEMPERATURE - ENGINE OUTLET		(9)	°F	1136	1072	1008
EXHAUST GAS FLOW (@engine outlet temp, 14.5 psia)	(WET)	(10) (5)	ft3/min	1022	775	543
EXHAUST GAS MASS FLOW	(WET)	(10) (5)	lb/hr	1441	1139	832

EMISSIONS DATA - CATALYST OUT					
NOx (as NO2)	(11)(12)	g/bhp-hr	0.50	0.50	0.50
CO	(11)(13)	g/bhp-hr	2.00	2.00	2.00
THC (mol. wt. of 15.84)	(11)(13)	g/bhp-hr	0.92	1.08	1.66
NMHC (mol. wt. of 15.84)	(11)(13)	g/bhp-hr	0.14	0.16	0.25
NMNEHC (VOCs) (mol. wt. of 15.84)	(11)(13)(14)	g/bhp-hr	0.09	0.11	0.17
HCHO (Formaldehyde)	(11)(13)	g/bhp-hr	0.08	0.08	0.09
CO2	(11)(13)	g/bhp-hr	501	528	575
EXHAUST OXYGEN	(11)(15)	% DRY	0.0	0.0	0.0
LAMBDA	(11)(15)		0.99	1.00	0.99

ENERGY BALANCE DATA					
LHV INPUT	(16)	Btu/min	28240	22268	16358
HEAT REJECTION TO JACKET WATER (JW)	(17)(23)	Btu/min	9169	7874	6502
HEAT REJECTION TO ATMOSPHERE	(18)	Btu/min	1130	891	654
HEAT REJECTION TO LUBE OIL (OC)	(19)(23)	Btu/min	1351	1160	958
HEAT REJECTION TO EXHAUST (LHV TO 77°F)	(20)(21)	Btu/min	7227	5360	3687
HEAT REJECTION TO EXHAUST (LHV TO 350°F)	(20)	Btu/min	5345	3864	2565
HEAT REJECTION TO AFTERCOOLER (AC)	(22)(24)	Btu/min	434	287	92

CONDITIONS AND DEFINITIONS

Engine rating obtained and presented in accordance with ISO 3046/1. (Standard reference conditions of 77°F, 29.60 in Hg barometric pressure.) No overload permitted at rating shown. Consult the altitude deration factor chart for applications that exceed the rated altitude or temperature.

Emission levels are at the Caterpillar provided catalyst outlet. Values are based on engine operation at steady state conditions. Tolerances specified are dependent upon fuel quality. Fuel methane number cannot vary more than ± 3.

For notes information consult page three.

FUEL USAGE GUIDE

CAT METHANE NUMBER	30	35	40	45	50	55	60	65	70	75	80	100
SET POINT TIMING	21	22	22	23	25	27	29	31	32	34	35	35
DERATION FACTOR	0.90	0.90	0.90	0.90	0.93	0.97	1	1	1	1	1	1

ALTITUDE DERATION FACTORS AT RATED SPEED

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1	1	1	1	1	0.98	0.93	0.88	0.83	0.78	0.74	0.69	0.64
120	1	1	1	1	1	1	0.96	0.91	0.86	0.81	0.75	0.70	0.65
110	1	1	1	1	1	1	0.99	0.94	0.88	0.83	0.77	0.72	0.66
100	1	1	1	1	1	1	1	0.97	0.91	0.85	0.79	0.74	0.68
90	1	1	1	1	1	1	1	0.98	0.92	0.87	0.82	0.77	0.72
80	1	1	1	1	1	1	1	1	0.95	0.89	0.84	0.79	0.74
70	1	1	1	1	1	1	1	1	0.95	0.90	0.85	0.80	0.74
60	1	1	1	1	1	1	1	1	0.95	0.90	0.85	0.80	0.74
50	1	1	1	1	1	1	1	1	0.95	0.90	0.85	0.80	0.74

ALTITUDE (FEET ABOVE SEA LEVEL)

AFTERCOOLER HEAT REJECTION FACTORS (ACHRF)

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1.75	1.89	2.04	2.18	2.34	2.49	2.65	2.81	2.83	2.83	2.83	2.83	2.83
120	1.60	1.74	1.88	2.02	2.17	2.32	2.48	2.64	2.66	2.66	2.66	2.66	2.66
110	1.44	1.58	1.72	1.86	2.01	2.16	2.31	2.47	2.49	2.49	2.49	2.49	2.49
100	1.29	1.42	1.56	1.70	1.85	1.99	2.14	2.29	2.31	2.31	2.31	2.31	2.31
90	1.13	1.27	1.40	1.54	1.68	1.83	1.97	2.12	2.14	2.14	2.14	2.14	2.14
80	1	1.11	1.25	1.38	1.52	1.66	1.80	1.95	1.97	1.97	1.97	1.97	1.97
70	1	1	1.09	1.22	1.36	1.49	1.64	1.78	1.80	1.80	1.80	1.80	1.80
60	1	1	1	1.06	1.19	1.33	1.47	1.61	1.63	1.63	1.63	1.63	1.63
50	1	1	1	1	1.03	1.16	1.30	1.44	1.46	1.46	1.46	1.46	1.46

ALTITUDE (FEET ABOVE SEA LEVEL)

MINIMUM SPEED CAPABILITY AT THE RATED SPEED'S SITE TORQUE (RPM)

INLET AIR TEMP °F	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
130	1440	1530	1600	1680	1760	1800	1800	1800	1800	1800	1800	1800	1800
120	1400	1480	1560	1640	1710	1790	1800	1800	1800	1800	1800	1800	1800
110	1350	1440	1520	1590	1670	1740	1800	1800	1800	1800	1800	1800	1800
100	1310	1400	1480	1560	1630	1700	1770	1800	1800	1800	1800	1800	1800
90	1280	1360	1450	1530	1610	1690	1760	1800	1800	1800	1800	1800	1800
80	1220	1310	1390	1470	1560	1640	1730	1800	1800	1800	1800	1800	1800
70	1200	1290	1370	1450	1530	1620	1710	1790	1800	1800	1800	1800	1800
60	1200	1290	1370	1450	1530	1620	1710	1790	1800	1800	1800	1800	1800
50	1200	1290	1370	1450	1530	1620	1710	1790	1800	1800	1800	1800	1800

ALTITUDE (FEET ABOVE SEA LEVEL)

FUEL USAGE GUIDE:

This table shows the derate factor and full load set point timing required for a given fuel. Note that deration and set point timing reduction may be required as the methane number decreases. Methane number is a scale to measure detonation characteristics of various fuels. The methane number of a fuel is determined by using the Caterpillar methane number calculation program.

ALTITUDE DERATION FACTORS:

This table shows the deration required for various air inlet temperatures and altitudes. Use this information along with the fuel usage guide chart to help determine actual engine power for your site.

ACTUAL ENGINE RATING:

To determine the actual rating of the engine at site conditions, one must consider separately, limitations due to fuel characteristics and air system limitations. The Fuel Usage Guide deration establishes fuel limitations. The Altitude/Temperature deration factors and RPC (reference the Caterpillar Methane Program) establish air system limitations. RPC comes into play when the Altitude/Temperature deration is less than 1.0 (100%). Under this condition, add the two factors together. When the site conditions do not require an Altitude/ Temperature derate (factor is 1.0), it is assumed the turbocharger has sufficient capability to overcome the low fuel relative power, and RPC is ignored. To determine the actual power available, take the lowest rating between 1) and 2).

1) Fuel Usage Guide Deration
2) 1-((1-Altitude/Temperature Deration) + (1-RPC))

AFTERCOOLER HEAT REJECTION FACTORS(ACHRF):

To maintain a constant air inlet manifold temperature, as the inlet air temperature goes up, so must the heat rejection. As altitude increases, the turbocharger must work harder to overcome the lower atmospheric pressure. This increases the amount of heat that must be removed from the inlet air by the aftercooler. Use the aftercooler heat rejection factor (ACHRF) to adjust for inlet air temp and altitude conditions. See note 24 for application of this factor in calculating the heat exchanger sizing criteria. Failure to properly account for these factors could result in detonation and cause the engine to shutdown or fail.

MINIMUM SPEED CAPABILITY AT THE RATED SPEED'S SITE TORQUE (RPM):

This table shows the minimum allowable engine turndown speed where the engine will maintain the Rated Speed's Torque for the given ambient conditions.

NOTES:

1. Engine rating is with two engine driven water pumps. Tolerance is ± 3% of full load.
2. ISO 3046/1 engine efficiency tolerance is (+)0, (-)5% of full load % efficiency value. Nominal engine efficiency tolerance is ± 5.0% of full load % efficiency value.
3. ISO 3046/1 fuel consumption tolerance is (+)5, (-)0% of full load data. Nominal fuel consumption tolerance is ± 5.0% of full load data.
4. Air flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 5 %.
5. Inlet and Exhaust Restrictions must not exceed A&I limits based on full load flow rates from the standard technical data sheet.
6. Inlet manifold pressure is a nominal value with a tolerance of ± 5 %.
7. Inlet manifold temperature is a set point value.
8. Timing indicated is for use with the minimum fuel methane number specified. Consult the appropriate fuel usage guide for timing at other methane numbers.
9. Exhaust temperature is a nominal value with a tolerance of (+)63°F, (-)54°F.
10. Exhaust flow value is on a 'wet' basis. Flow is a nominal value with a tolerance of ± 6 %.
11. Emissions data is post Caterpillar provided catalyst. Values are dependent on proper engine and catalyst maintenance.
12. NOx values are "Not to Exceed".
13. CO, CO2, THC, NMHC, NMNEHC, and HCHO values are "Not to Exceed" levels. THC, NMHC, and NMNEHC do not include aldehydes.
14. VOCs - Volatile organic compounds as defined in US EPA 40 CFR 60, subpart JJJJ
15. Exhaust Oxygen tolerance is ± 0.2; Lambda tolerance is ± 0.05.
16. LHV rate tolerance is ± 5.0%.
17. Heat rejection to jacket water value displayed includes heat to jacket water alone. Value is based on treated water. Tolerance is ± 10% of full load data.
18. Heat rejection to atmosphere based on treated water. Tolerance is ± 50% of full load data.
19. Lube oil heat rate based on treated water. Tolerance is ± 20% of full load data.
20. Exhaust heat rate based on treated water. Tolerance is ± 10% of full load data.
21. Heat rejection to exhaust (LHV to 77°F) value shown includes unburned fuel and is not intended to be used for sizing or recovery calculations.
22. Heat rejection to aftercooler tolerance is ±5% of full load data.
23. Total Jacket Water Circuit heat rejection is calculated as: (JW x 1.1) + (OC x 1.2). Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.
24. Total Aftercooler Circuit heat rejection is calculated as: AC x ACHRF x 1.05. Heat exchanger sizing criterion is maximum circuit heat rejection at site conditions, with applied tolerances. A cooling system safety factor may be multiplied by the total circuit heat rejection to provide additional margin.

FREE FIELD MECHANICAL & EXHAUST NOISE

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
100	211	104.1	73.8	76.9	74.7	89.2	85.0	87.6	87.4	90.7	91.5	92.9
75	158	102.8	73.8	75.1	75.0	87.6	84.0	86.0	86.1	89.0	90.6	90.4
50	105	102.2	73.7	72.8	73.5	81.3	82.4	83.1	82.8	86.8	88.1	88.3

MECHANICAL: Sound Power (1/3 Octave Frequencies)

Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
100	211	92.1	96.6	93.4	94.5	94.7	91.5	90.1	91.7	86.3	85.3	84.8
75	158	90.3	96.3	92.8	93.3	92.6	90.7	89.0	86.9	85.4	83.9	81.5
50	105	89.2	97.0	91.5	92.4	92.7	90.7	89.0	87.2	85.8	82.3	79.1

EXHAUST: Sound Power (1/3 Octave Frequencies)

Percent Load	Engine Power	Overall	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz
%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
100	211	107.3	93.8	81.7	98.6	104.8	96.3	91.2	95.3	90.9	90.1	90.0
75	158	106.0	95.8	82.1	96.4	103.0	97.2	90.5	93.3	89.2	87.6	85.8
50	105	102.8	96.4	82.7	91.7	98.6	94.5	87.6	88.8	88.0	84.5	84.1

EXHAUST: Sound Power (1/3 Octave Frequencies)

Percent Load	Engine Power	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
%	bhp	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)	dB(A)
100	211	86.0	86.5	86.6	84.5	79.0	77.5	73.5	72.4	69.3	67.3	63.2
75	158	84.5	85.7	85.7	81.7	75.9	74.4	70.0	68.1	63.5	60.1	55.1
50	105	81.1	82.3	83.4	78.5	71.5	70.2	66.2	63.9	60.0	53.8	44.8

SOUND PARAMETER DEFINITION:

Sound Power Level Data - DM8702-02

Sound power is defined as the total sound energy emanating from a source irrespective of direction or distance. Sound power level data is presented under two index headings:
Sound power level -- Mechanical
Sound power level -- Exhaust

Mechanical: Sound power level data is calculated in accordance with ISO 6798. The data is recorded with the exhaust sound source isolated.

Exhaust: Sound power level data is calculated in accordance with ISO 6798 Annex A. Exhaust data is post-catalyst on gas engine ratings labeled as "Integrated Catalyst".

Measurements made in accordance with ISO 6798 for engine and exhaust sound level only. No cooling system noise is included unless specifically indicated. Sound level data is indicative of noise levels recorded on one engine sample in a survey grade 3 environment.

How an engine is packaged, installed and the site acoustical environment will affect the site specific sound levels. For site specific sound level guarantees, sound data collection needs to be done on-site or under similar conditions.

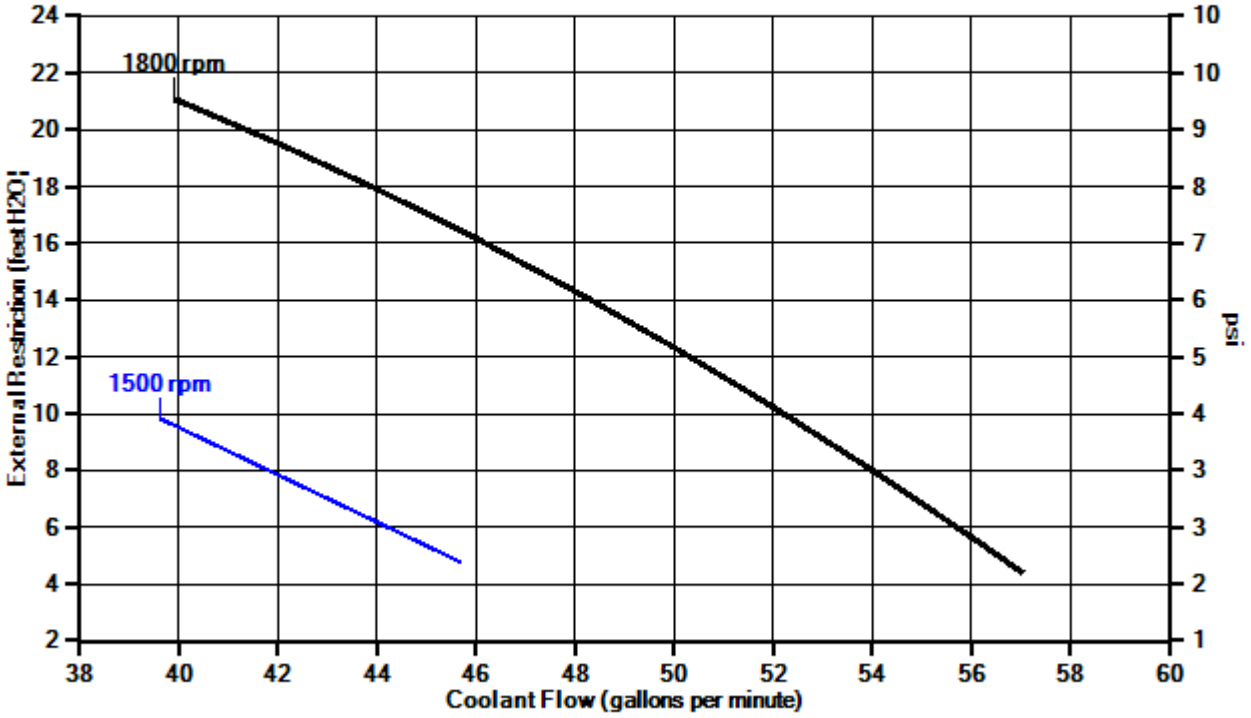
G3306B

GAS ENGINE TECHNICAL DATA

CATERPILLAR®

ENGINE POWER (bhp):	211		
ENGINE SPEED (rpm):	1800	AFTERCOOLER WATER INLET (°F):	110
EXHAUST MANIFOLD:	WC	JACKET WATER OUTLET (°F):	210
		COOLING SYSTEM:	JW+OC, AC
		INLET MANIFOLD AIR TEMP (ºC):	43

Jacket Water System



Coolant Flow vs. Allowable External Restriction

Engine Speed (rpm)	1500	**1800**
Flow (GPM)	Restriction (feet H2O)	
40	9.5	**21.0**
42	7.8	**19.5**
44	6.2	**17.9**
46		**16.2**
48		**14.3**
50		**12.3**
52		**10.2**
54		**8.0**
56		**5.7**

Notes:
- 7N6210 JW Pump
- Drive Ratio 1:1
- Curves indicate maximum allowable external resistance.
- Do not project curves beyond range shown.
- PSI conversion based on specific gravity of 1.0

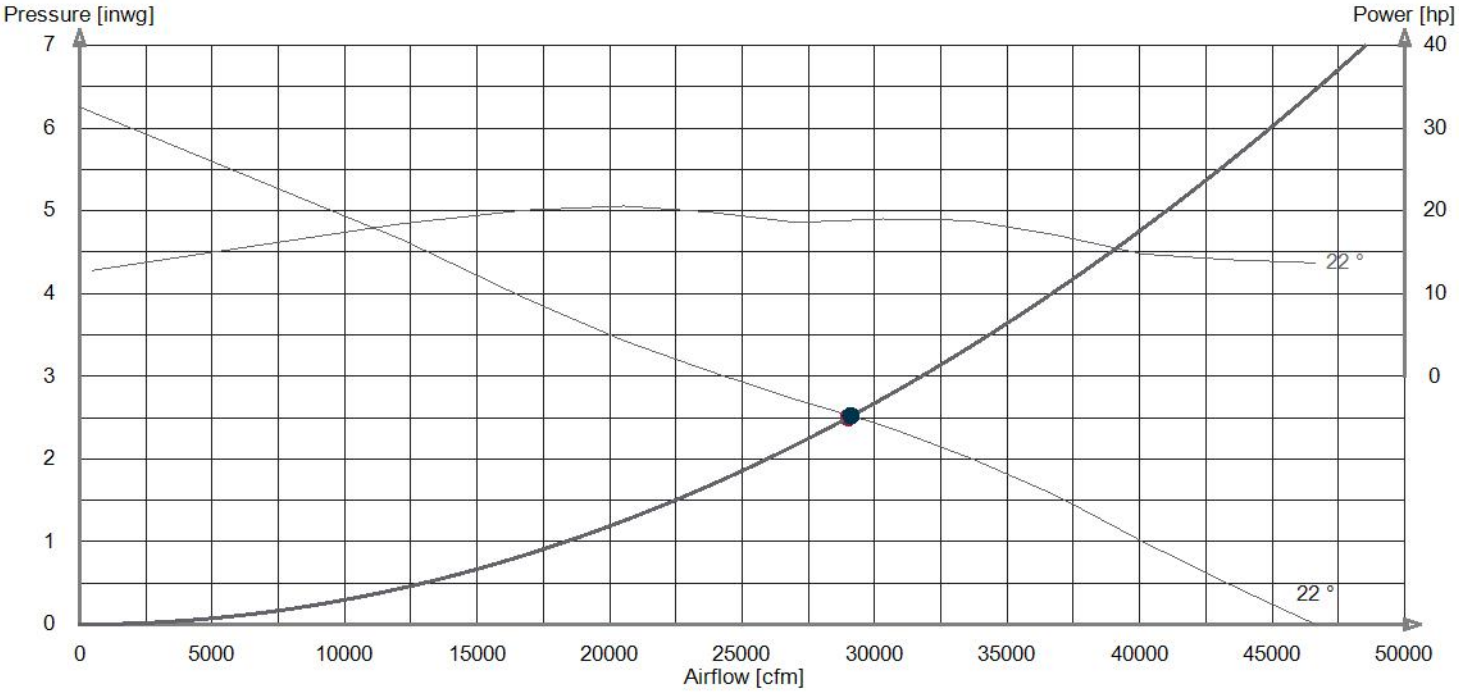
MULTI-WING OPTIMISER

48/8-8/22°/PAG/5WL/Tp 0.3 in

DATE: 8/28/2014

COMPANY: ANGI
ATTN: Helal Sarkar

FROM: Multi-Wing America, Inc.
Norm Into



IMPELLER INFORMATION:

Impeller Diameter:	48 in
No of blades:	8
Pitch:	22 °
Blade Material:	PAG
Blade Type:	5W
Impeller Rotation:	L

Tests are carried out according to methods described in ANSI / AMCA 210-99 (ISO 5801, DIN 24163)
Sound data is calculated and should be used as guideline only

APPLICATION:

Speed:	1476 RPM
Tip Clearance:	0.3 in
Temperature	140 °F
Altitude:	4000 ft
Density:	0.05708 lb/ft3

Disclaimer
Load factors in Optimiser are based on static operation.

REMARKS:

-
-
-
-
-

Multi-Wing America, Inc.
USA

P.O. Box 425
15030 Berkshire Industrial Park
Burton Ohio, 44021

440-8349400 Telephone
440-8340449 Fax
Optimiser Version: 8.5.0.42

ninto@multi-wing.net
http://www.multi-wing.net
8/21/2014 9:04:17 AM

MULTI-WING

MULTI-WING OPTIMISER

48/8-8/22°/PAG/5WL/Tp 0.3 in

DATE: 8/28/2014

COMPANY: ANGI
ATTN: Helal Sarkar

FROM: Multi-Wing America, Inc.
Norm Into

Current Working Point

Airflow	29100 cfm	Total Pres	2.78 inwg	Propagation	1/2 Spherical
Static Pres	2.52 inwg	Power	18.9 hp	Distance / Unit	25 ft
Dynamic Pressure	0.255 inwg	Efficiency	67 %	Sound Pressure	83.7 SPL dB(A)

OPERATIONAL DATA:

Tip Speed:	309 ft/s
Temperature:	140 °F
Air Velocity:	38.6 ft/s
Torque:	67.1 lbf ft
Axial Force:	182 lbf

OPERATIONAL IMPELLER LIMITS:

Tip Speed:	445 ft/s (2125 RPM)
Temperature:	-40°F - 248 °F
Diameter range:	22.3 - 48.27 in
Blade, load factor:	48.3 %
Hub, load factor:	20.7 %
Power, load factor:	N.A. %

Static impeller data:

Moment of Inertia:	22.1 lb ft2
Blade Centrifugal force:	1390 lbf
Solidity factor:	0.26
Mass with std. boss:	33 lb

IMPELLER INFORMATION:

Impeller Diameter:	48 in
No of blades:	8
Pitch:	22 °
Blade Material:	PAG
Blade Type:	5W
Impeller Rotation:	L

Tests are carried out according to methods described in ANSI / AMCA 210-99 (ISO 5801, DIN 24163)
Sound data is calculated and should be used as guideline only

APPLICATION:

Speed:	1476 RPM
Tip Clearance:	0.3 in
Temperature	140 °F
Altitude:	4000 ft
Density:	0.05708 lb/ft3

Disclaimer
Load factors in Optimiser are based on static operation.

REMARKS:

-
-
-
-
-

Multi-Wing America, Inc.
USA
P.O. Box 425
15030 Berkshire Industrial Park
Burton Ohio, 44021
440-8349400 Telephone
440-8340449 Fax
Optimiser Version: 8.5.0.42
ninto@multi-wing.net
http://www.multi-wing.net
8/21/2014 9:04:17 AM

MULTI-WING

MULTI-WING OPTIMISER

48/8-8/22°/PAG/5WL/Tp 0.3 in

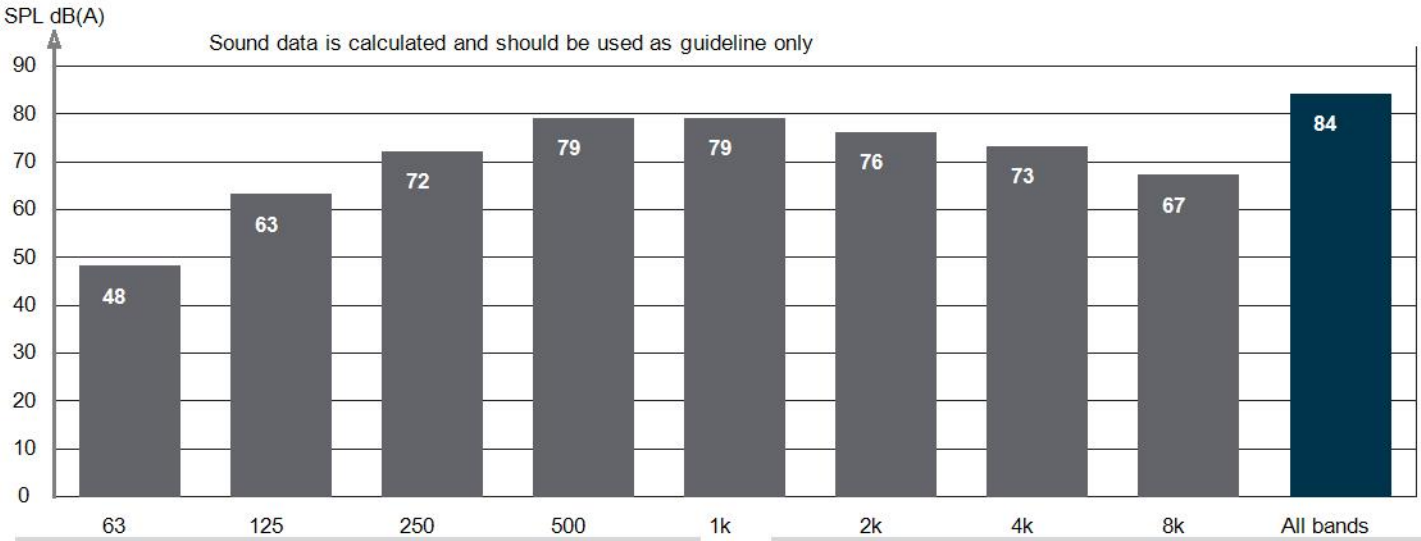
DATE: 8/28/2014

COMPANY: ANGI
ATTN: Helal Sarkar

FROM: Multi-Wing America, Inc.
Norm Into

Current Working Point

Airflow	29100 cfm	Total Pres	2.78 inwg	Propagation	1/2 Spherical
Static Pres	2.52 inwg	Power	18.9 hp	Distance / Unit	25 ft
Dynamic Pressure	0.255 inwg	Efficiency	67 %	Sound Pressure	83.7 SPL dB(A)



IMPELLER INFORMATION:

Impeller Diameter:	48 in
No of blades:	8
Pitch:	22 °
Blade Material:	PAG
Blade Type:	5W
Impeller Rotation:	L

Tests are carried out according to methods described in ANSI / AMCA 210-99 (ISO 5801, DIN 24163)
Sound data is calculated and should be used as guideline only

APPLICATION:

Speed:	1476 RPM
Tip Clearance:	0.3 in
Temperature	140 °F
Altitude:	4000 ft
Density:	0.05708 lb/ft3

Disclaimer
Load factors in Optimiser are based on static operation.

REMARKS:

-
-
-
-
-

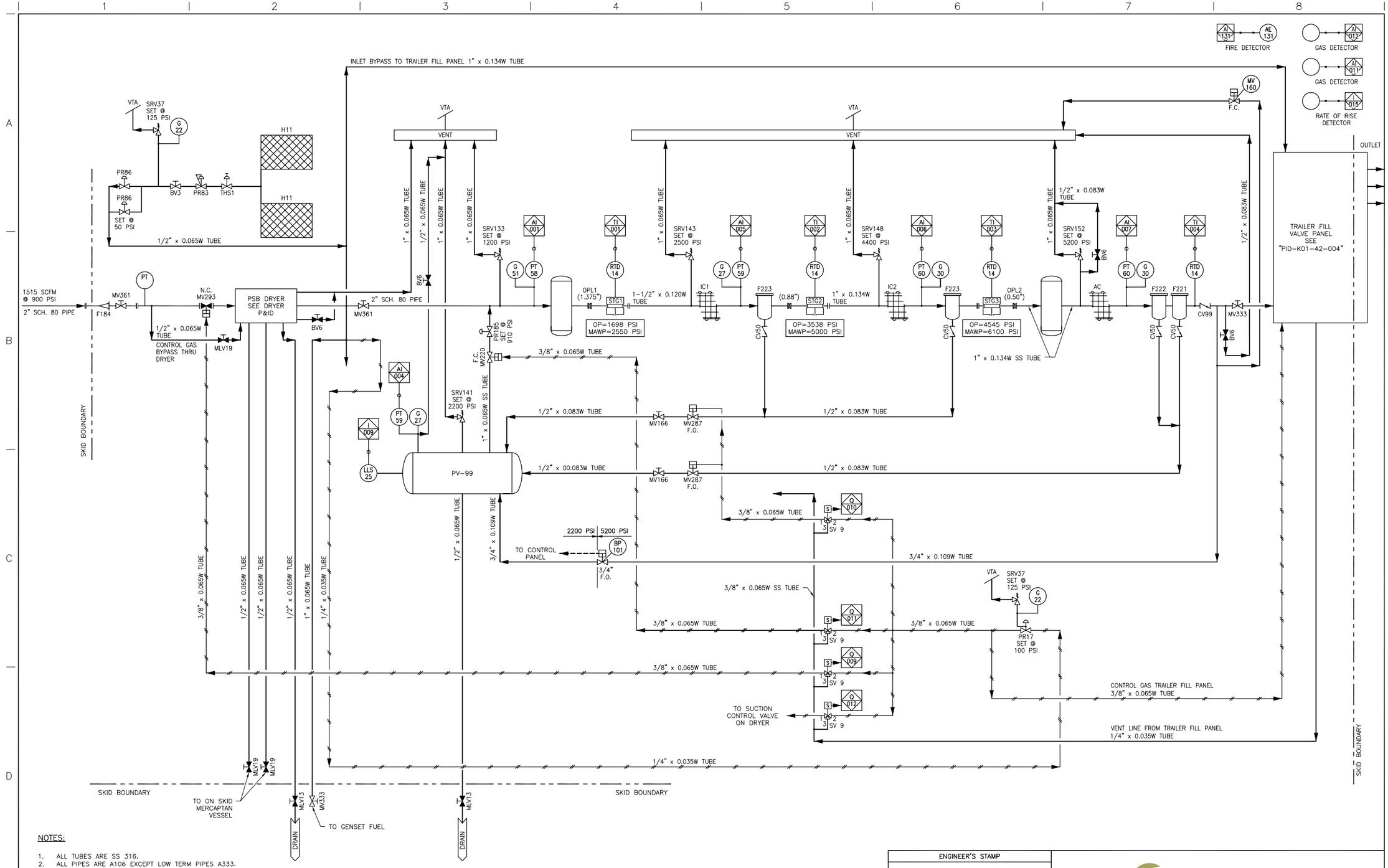
Multi-Wing America, Inc.
USA

P.O. Box 425
15030 Berkshire Industrial Park
Burton Ohio, 44021

440-8349400 Telephone
440-8340449 Fax
Optimiser Version: 8.5.0.42

ninto@multi-wing.net
http://www.multi-wing.net
8/21/2014 9:04:17 AM

MULTI-WING



NOTES:

1. ALL TUBES ARE SS 316.
2. ALL PIPES ARE A106 EXCEPT LOW TERM PIPES A333.
3. ALL SRV REPRESENTS PRV FOR AB-96 FORM.

REFERENCE DRAWINGS	DWG. NO.
–	–
–	–
–	–
–	–
–	–
–	–
–	–
–	–

NO.	DATE	PROJECT DESCRIPTION	PROJ.	BY	APPD.
0	17.06.30	AS-BUILT	102448	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–

REV. NUMBER	ISSUE STAGE	DATE	BY	CHKD.	APPD.
0	ISSUED FOR APPROVAL	17.06.30	AG	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–

ENGINEER'S STAMP

PERMIT No. –

PROFESSIONAL STAMP AFFIXED ABOVE SHALL APPLY ONLY TO REV(s) —

CERTARUS

CLIENT	SCALE	JOB No.
–	NONE	–

TITLE: CNG COMPRESSOR TRAILER MOUNTED PIPING & INSTRUMENTATION DIAGRAM (ANGI UNITS)

SKID NUMBER	FILE NO.
—	ANGI-PID-001/3

PREFILTER (26, 31)		
MAWP	1100	PSIG
DT	−20 to 250	deg F

AFTERFILTER (26, 11)		
MAWP	1100	PSIG
DT	−20 to 250	deg F

ADSORBER VESSEL (DV)		
MAWP	1100	PSIG
DT	−20 to 400	deg F

REGENERATION COOLER (16)		
MAWP	1100	PSIG
DT	−20 to 400	deg F

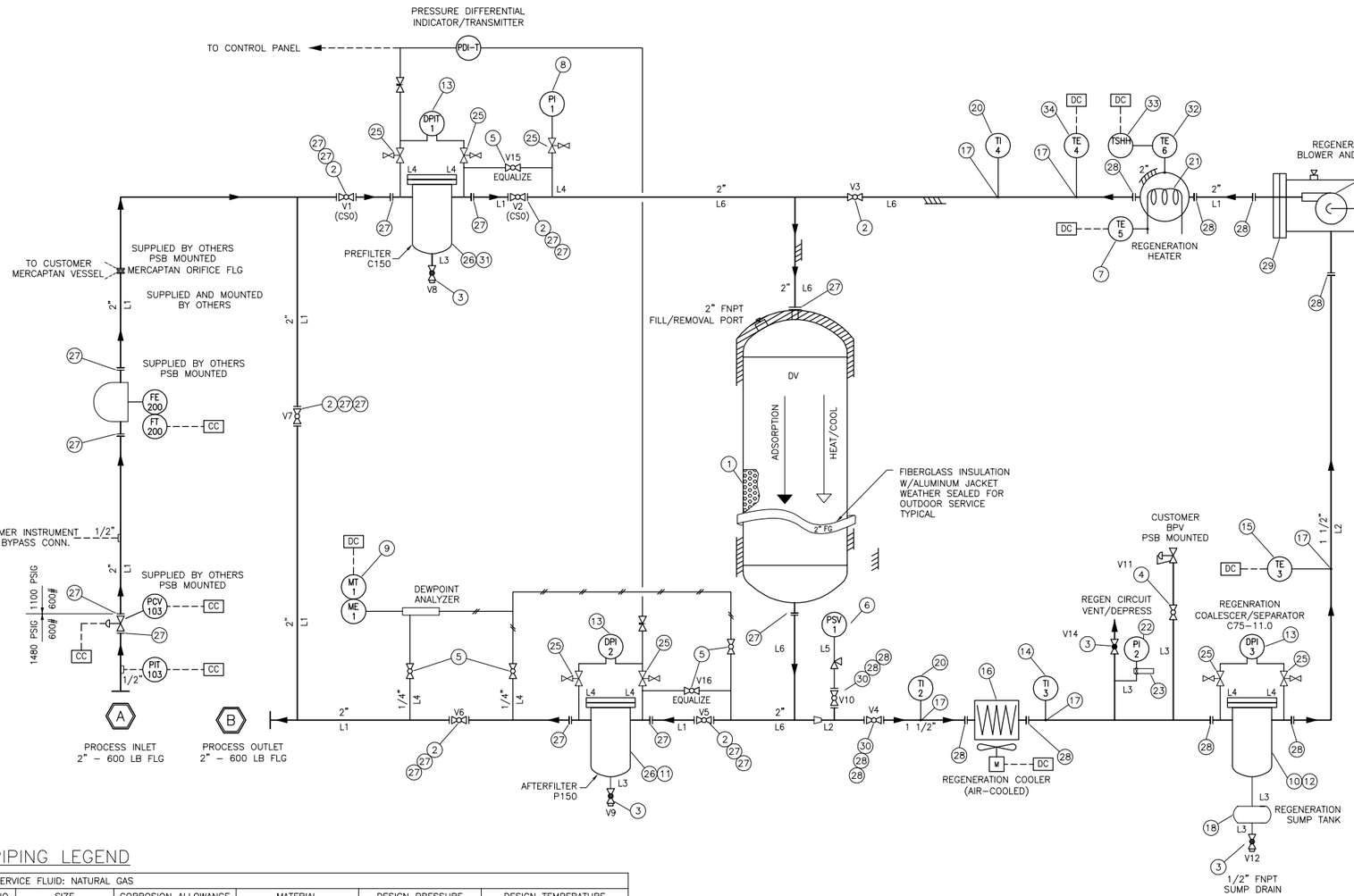
REGENERATION HEATER (21)		
MAWP	1100	PSIG
DT	−20 to 400	deg F

REGENERATION COALESCER/SEPARATOR (10, 12)		
MAWP	1100	PSIG
DT	−20 to 250	deg F

REGENERATION BLOWER (19)		
MAWP	1100	PSIG
DT	−20 to 400	deg F

PIPING		
MAWP	1100	PSIG
DT	400	deg F

REGENERATION SUMP TANK (18)		
MAWP	1325	PSIG
DT	−20 to 400	deg F



PIPING LEGEND

SERVICE FLUID: NATURAL GAS					
NO.	SIZE	CORROSION ALLOWANCE	MATERIAL	DESIGN PRESSURE	DESIGN TEMPERATURE
L1	2" SCH−80	NONE	SA−53B/SA−106B	1480/1100 PSIG.	(−20°F) TO (400°F)
L2	1 1/2" SCH−80	NONE	SA−53B/SA−106B	1100 PSIG.	(−20°F) TO (400°F)
L3	1/2" SCH−80	NONE	SA−53B/SA−106B	1100 PSIG.	(−20°F) TO (400°F)
L4	1/4" SCH−80	NONE	SA−53B/SA−106B	1100 PSIG.	(−20°F) TO (400°F)
L5	1 1/2" SCH−80	NONE	SA−53B/SA−106B	1100 PSIG.	(−20°F) TO (400°F)
L6	2" SCH−80	NONE	SA−53B/SA−106B	1100 PSIG.	(−20°F) TO (400°F)

FIND NO.	QTY REQ'D	PART NO.	NAME	DESCRIPTION		
34	1	74073−324	THERMOCOUPLE	TYPE J, 16 FT.		
33	1	70305−586	TEMP. SWITCH	LIMIT		
32	1	74073−320	THERMOCOUPLE	TYPE J, 7 FT.		
31	2	74635−592	FILTER ELEMENT	COALESING HI FLOW		
30	2	74597−1548	BALL VALVE	1 1/2" 600 LB.FLG		
29	1	71046−921	GASKET	16" – 600 LB.		
28	10	71046−148	GASKET	1 1/2" – 600 LB.		
27	20	71046−149	GASKET	2" – 600 LB.		
26	2	77305−064	FILTER HOUSING			
25	7	74049−096	BLOCK & BLEED VALVE	1/4" NPT		
24	1	70462−311	MOTOR	2 HP		
23	1	70326−749	OVERPRESS PROTECTOR	6−35 PSIG		
22	1	70326−748	PRESSURE GAUGE	0−60 PSIG		
21	1	74001−499	HEATER	15 KW @ 460/3/60		
20	2	70328−049	TEMP. GAUGE	50/550°F. 4" STEM		
19	1	70472−079	BLOWER			
18	1	70435−089	SUMP TANK	30 GAL.		
17	5	70328−170	THERMOWELL	FOR 4" STEM, 304SS		
16	1	70302−399	AFTERCOOLER	1 1/2 HP @ 460/3/60		
15	1	74073−323	THERMOCOUPLE	TYPE J, 6 FT.		
14	1	70328−347	TEMP. GAUGE	0/180°F., 4" STEM		
13	3	70326−737	DP GAUGE	0−5 PSID		
12	1	74635−592	FILTER ELEMENT	COALESCING, HI FLOW		
11	2	74635−040	FILTER ELEMENT	PARTICULATE		
10	1	77267−001	FILTER HOUSING	75−11		
9	1	70524−205	DEWPOINT TRANSMITTER	W/PROBE		
8	1	70326−736	PRESSURE GAUGE	0−1500 PSIG		
7	1	SUPL'D W/HTR	THERMOCOUPLE	DUAL TYPE J, SHEATH		
6	1	70398−627	RELIEF VALVE	1100 PSIG SET PRESS.		
5	5	74597−1551	BALL VALVE	1/4" NPT		
4	1	74597−1552	BALL VALVE	1/2" NPT		
3	5	70364−759	GLOBE VALVE	1/2" NPT		
2	6	74597−1593	BALL VALVE	2" 600 LB FLG w/LOCK HAND		
1	700 LBS	RM459−006	MOLECULAR SIEVE	TYPE 3A		

REFERENCE DRAWINGS	DWG. NO.
–	–
–	–
–	–
–	–
–	–
–	–
–	–
–	–

NO.	DATE	PROJECT DESCRIPTION	PROJ.	BY	APPD.
0	17.06.30	AS−BUILT	102448	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–

REV. NUMBER	ISSUE STAGE	DATE	BY	CHKD.	APPD.
0	ISSUED FOR APPROVAL	17.06.30	AG	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–

ENGINEER'S STAMP

PERMIT No. –

PROFESSIONAL STAMP AFFIXED ABOVE SHALL APPLY ONLY TO REV(s) —

CERTARUS

CLIENT –

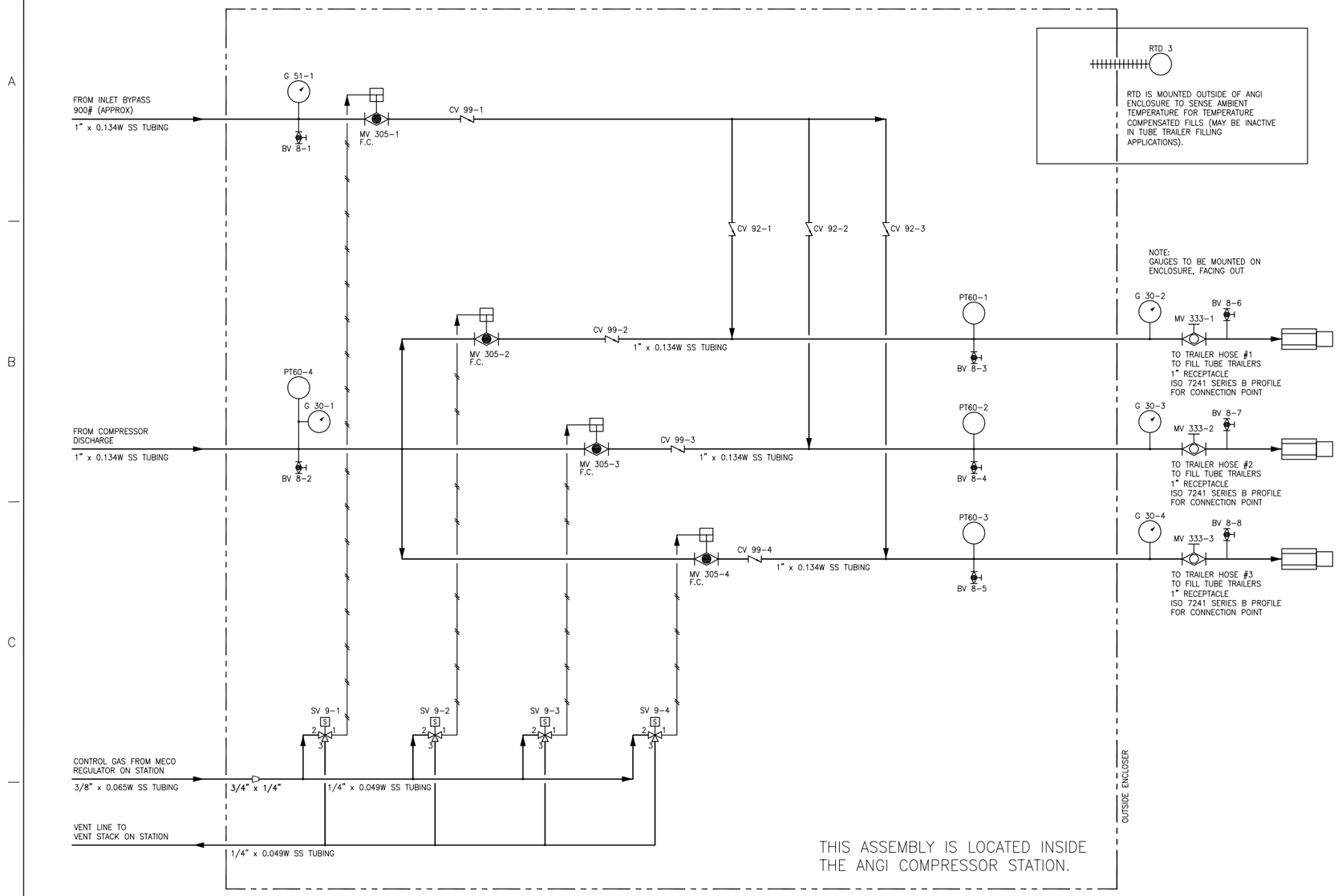
SCALE N.T.S

JOB No. –

TITLE
MODEL: NG−SR−10−2−1100−DDP−SP NATURAL GAS DRYER
PROCESS & INSTRUMENTATION DIAGRAM (ANGI UNITS)

SKID NUMBER —

FILE NO. ANGI−PID−002/3



DESIGNATOR	PART NUMBER	DESCRIPTION
BV 8	330-07312	VALVE-PURGE 7/16-20MSAE 6000# SS
CV 92	336-07321	VALVE-CHECK HOKE 1 FSAE 6000# 20# CRACKING SPRING
CV 99	336-07330	VALVE-CHECK HOKE 1 FACESEAL 6000# W/20# SPRING
G 30	741-07248	GAUGE-PRES 6000#/B BM PM GF WIKA
G 51	741-07269	GAUGE-PRES 3000#/B BM PM GF WIKA 1/4" MNPT
MV 305	334-07515	VALVE/ACT-ASSY SVF H7 SAE-16 6000#
MV 333	334-07544	VALVE-BALL SVF H7 SAE-16 6000#
PT 60	410-07298	TRANSD-AST 0-6000# AST IS/UL CL1 DIV2
RTD 3	400-07243	PROBE-TEMP 1/2 MNPT
SV 9	330-07243	VALVE-SOLENOID 3WY 1/4 150# 120V NC BRS UL
–	–	RECEPTACLE-4000# 1" HANSEN 8KP36*

* RECEPTACLE WAS SUPPLIED BY CUSTOMER & INSTALLED BY ANGI

TRAILER FILLING SEQUENCE.

THIS IS A FIRST PRIORITY FILLING TWO STAGE SEQUENCE. INLET GAS PRESSURE IS HIGH ENOUGH TO INITIALLY DIRECT FILL FROM THE GAS SUPPLY PIPE LINE, THEN FINAL FILL VIA COMPRESSOR. TUBE TRAILERS CAN ALSO FILL FROM ANY FILL POST.

1. STAGE 1 – INLET PIPE SUPPLY LINE FILLING. UP TO THREE TRAILERS CAN BE FILLING AT THE SAME TIME. THE TRAILERS WILL BE FILLED VIA THE INLET GAS BYPASS LINE, BYPASSING THE COMPRESSOR. THIS WILL FILL THE TUBE TRAILERS TO A PRE-DETERMINED SET POINT (ADJUSTABLE VIA THE HMI).

2. STAGE 2 – DIRECT FILLING VIA COMPRESSOR. WHEN FILLING FROM THE COMPRESSOR, THIS WILL BE A 1ST PRIORITY QUED FILLING SEQUENCE, FILLING ONLY ONE TUBE TRAILER AT A TIME. AS A TRAILER IS INITIALLY FILLING VIA THE BYPASS LINE, THE COMPRESSOR IS STARTED. ONCE 1ST PRIORITY TRAILER REACHES ITS CHANGE OVER SET POINT, THEN THE INLET BYPASS VALVE WILL CLOSE, (THE BYPASS WILL REMAIN OPEN IF THERE ARE MORE THAN ONE TRAILER FILLING), AND THE TRAILER FILL BALL VALVE (FP1, FP2, FP3) WILL OPEN TO FILL FROM THE COMPRESSOR. ONCE IT IS FULL THE NEXT IN LINE TRAILER WILL THEN BE VALVE OVER TO BE FILLED FROM THE COMPRESSOR. DURING THE CHANGE FROM ONE TRAILER TO ANOTHER, THE COMPRESSOR WILL RUN CONTINUOUSLY UNTIL THE LAST TRAILER IS FILLED. AFTER WHICH THE COMPRESSOR WILL GO THROUGH A NORMAL SHUTDOWN SEQUENCE. TEMPERATURE COMPENSATED FILL PRESSURE CAN BE TURNED OFF @ HMI.

NOTE: FILLING TUBE TRAILERS IS NOT USUALLY TEMPERATURE COMPENSATED. BUT INSTEAD IT IS PRESSURE COMPENSATED! FILLING TUBE TRAILERS IS COMPARED TO FILLING STORAGE CYLINDERS, NOT VEHICLES. TUBE TRAILERS HAVE A 4500# SAFETY RELIEF VALVE INSTALLED. THEY WILL NEVER BE FILLED OVER 4400# & WITH THE HEAT OF COMPRESSION, THIS WILL GIVE THE TUBE TRAILER THE CLOSEST FILL TO 3600# WHEN COOLED.

REFERENCE DRAWINGS	DWG. NO.
–	–
–	–
–	–
–	–
–	–
–	–
–	–
–	–

NO.	DATE	PROJECT DESCRIPTION	PROJ.	BY	APPD.
0	17.06.30	AS-BUILT	102448	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–
–	–	–	–	–	–

REV. NUMBER	ISSUE STAGE	DATE	BY	CHKD.	APPD.
0	ISSUED FOR APPROVAL	17.06.30	AG	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–
	–	–	–	–	–

ENGINEER'S STAMP

PERMIT No. –

PROFESSIONAL STAMP AFFIXED ABOVE SHALL APPLY ONLY TO REV(s) —

CERTARUS

CLIENT –

SCALE –

JOB No. –

TITLE
TRAILER FILL PANEL – 1" 1-IN 3-OUT, ON-SKID
W/ INLET BYPASS (ANGI UNITS)

SKID NUMBER —

FILE NO. ANGI-PID-003/3